Externalizing Behavior in Post-Institutionalized Children: An Examination of Parent Emotion Socialization Practices, Respiratory-Sinus Arrhythmia, and Skin Conductance

A Dissertation
SUBMITTED TO THE FACULTY OF
UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

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May 2014

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Acknowledgements

I would like to acknowledge those people who provided invaluable support throughout my graduate career, ultimately making this dissertation possible. Thank you to my advisor, Megan Gunnar, for imparting her comprehensive knowledge of stress biology throughout the years, patiently cultivating my research skills, and truly modeling what it means to go "bench-to-bedside," translating basic research for child welfare advocates around the globe. Thank you to my committee, including Abigail Gewirtz, Bonnie Klimes-Dougan, and Maria Kroupina, for the thoughtful feedback and guidance throughout this process.

Thank you to those families from the Minnesota International Adoptions Registry and Institute of Child Development participant pool that participated in this study. Thank you to the Emotion Study team who dedicated countless hours to data collection and coding of physiological measures, especially Anna Johnson Roach, Camelia Hostinar Caudill, Laura Moorhead, and MJ Heise. Thank you to the Gunnar Lab core team, especially Bonny Donzella, Bao Moua, Kristin Frenn, and Elisa Esposito, for helping get this study off and running, answering my countless questions, and training me in the mechanics of stress physiology data collection and processing – all within the context of an ingenious, warm, and exciting lab environment. Thank you to staff at the Center for Neurobehavioral Development, especially Mike Schmidt and Paul Collins, for providing me with the resources and technical assistance needed to carry out this study.

Thank you to staff at the M.I.N.D. Institute in California, especially Stacy Goldring, Gregory Young, Sally Rogers, and Sally Ozonoff for exposing me to the world of research in the social and behavioral sciences and igniting my interest in developmental psychopathology. Thank you to Gina Holland, Leon Hall, and Rolf Unterleitner for encouraging me and countless other ethnic minority students to pursue research careers, equipping us with the skills necessary to conduct quality research through the University of California, Davis' Biology Undergraduate Scholars Program. Thank you to my informal mentors from the Infant and Early Childhood Mental Health program, particularly Anne Gearity, Susan Schultz, and Elizabeth Carlson, who inspired and challenged my conceptualization of parent-infant relationships and the impact of adverse caregiving on child development. The knowledge imparted from the 2008-2010 cohort prompted this dissertation in many ways.

And finally, thank you to the family and friends who provided me with the emotional support, nurturance, babysitting, and cheerleading necessary to succeed throughout graduate school, especially Juanita and Cleotilde Herrera, for their sacrifices to get me where I am today, Sobhi Youssef for his unfaltering belief in me, and Josie Herrera, Mike Miyama, Margaret Gonzales, Kristin Frenn, the Cobb family, Jessica Salvatore, and Andrea Youssef. Thank you to the little guy, Abraham Youssef-Herrera, who inspires me to improve the lives of children.

This research was supported by a Ruth L. Kirschstein National Research Service Award from the National Institute of Health 5-T32-MH-015755, a Diversity Supplement to Promote Health-Related Research from the National Institute of Mental Health 3R01MH080905-03S1, and a seed grant from the University of Minnesota Center for Neurobehavioral Development.

Abstract

The early experience of social and emotional neglect, such as that seen in institutions for the care of orphaned or abandoned children, is associated with altered neurobiological functioning and elevated risk for externalizing behavior problems; however, many post-institutionalized children appear resilient to these effects. This resiliency calls into question how post-adoption parenting practices may contribute to the heterogeneous outcomes seen in these children. This study examined the moderating role of current parent emotion socialization practices on the relation between early caregiving and indices of children's autonomic nervous system functioning at baseline and in response to ecologically valid challenges. Etiological factors, behavioral, and physiological correlates for externalizing behavior were also examined. The sample consisted of 8 to 9-year-olds, and compared post-institutionalized (PI) internationally-adopted children with children internationally-adopted from foster care (PFC) and children raised by their biological families (NA). Parents self-reported on their encouragement of emotional expression and distress reactions to children's negative emotions. Externalizing behavior was measured by parent report. Children's basal level of respiratory-sinus arrhythmia (RSA) and non-specific skin conductance response (NS.SCR) were measured as well as reactivity to challenge. Results indicated that under conditions of high parental distress, PI children displayed a unique autonomic pattern characterized by high basal RSA, and less RSA withdrawal and greater NS.SCR reactivity within interpersonal contexts involving their parent. High parental distress was associated with lower basal RSA for the PFC group. The PI group evidenced elevated externalizing behaviors compared to comparison groups. Greater externalizing behaviors were seen for those PI children who displayed high basal RSA and NS.SCR augmentation to challenge in the context of high parental distress. Results suggest that post-adoption parenting practices, in conjunction with the child's physiology, contribute to the emergence of externalizing problems in PI children.

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Developmental theory proposes that the presence of sensitive, responsive, and consistent caregiving early in life facilitates adaptive emotional functioning (Bowlby, 1982). Early in development, caregivers serve a critical function as behavioral and physiological coregulators for children; caregiving characterized by availability, attentiveness and sensitivity to the child's needs, structuring of the environment, and responsiveness to the child's signals, appears to mediate the body's reaction to stress (Gunnar & Donzella, 2002; Gunnar, Fisher, & The Early Experience, Stress, and Prevention Network, 2006; Hofer, 1994; Levine, 2005). Evidence from human and animal studies of early social deprivation suggest that failure to receive consistent, emotionally responsive caregiving early in life may have effects on the regulation of vulnerable neurobiological systems undergoing rapid development (reviewed in Nelson, de Haan, & Fox, 2007), programming them in ways that are adaptive within the adverse rearing context, a process known as experience-adaptive programming (Rutter, O'Connor, & the ERA Study Team, 2004). However, if the child moves to an improved caregiving environment, these neurobiological patterns may no longer be adaptive and may contribute to emotion and behavior problems (Marshall & Kenney, 2009).

Children internationally adopted from institutions provide a natural opportunity to examine how two extremely different caregiving environments, one that was socially and emotionally depriving and another rich in sensitive and responsive care, interact to influence indices of physiological functioning as well as emotionally-driven behavior.

Because the deprivation occurred during a circumscribed period early in development and the adoption into the improved environment happened later but within the first five years of life, we can also explore how the timing of caregiving experiences may impact biology and how post-adoption parenting practices may serve to reverse the damage incurred by these experiences. The level of socio-emotional neglect that institutionalized children experience varies widely. Most institutions are characterized by high child-to-caregiver ratios (e.g., > 1 to 6), frequent shift changes, and continuous staff turnover so that children are often cared for by multiple caregivers with little continuity of care (Zeanah, Smyke, & Settles, 2006). The little individual care that is provided is quick, perfunctory, and routinized; the lack of sensitive and responsive social-emotional communication occurring between child and caregiver makes it challenging for the child's emotional and social needs to be met and for attachment relationships to develop (Smyke, Dumitrescu, & Zeanah, 2002; Smyke et al., 2007; The St. Petersburg – USA Orphanage Research Team, 2005, 2008; Zeanah et al., 2006). Some institutions are particularly harsh; in addition to chronic socio-emotional neglect, children may experience physical and sexual abuse and inadequate medical care and nutrition (Johnson, 2000). Once placed in adoptive families, post-institutionalized (PI) children show significant developmental catch-up in many areas (MacLean, 2003). However, post-adoption, a minority of children exhibit elevated rates of externalizing behaviors characterized by conduct problems, oppositional defiance, and aggression which tend to persist or even worsen over time (Colvert et al., 2008; Hawk & McCall, 2010).

In addition to externalizing behavior, some PI children also exhibit disturbed neurobiological functioning, particularly in the context of social-emotional stimuli

(Wismer Fries, Shirtcliff, & Pollak, 2008; Wismer Fries, Ziegler, Kurian, Jacoris, & Pollak, 2005), prompting the current study investigating the impact of institutional care on parasympathetic (PNS) and sympathetic (SNS) branches of the autonomic nervous system. These systems serve a critical role in emotional arousal and regulation (Porges, 2001, 2003, 2007; Thayer & Lane, 2000). Little is known regarding the plasticity of the PNS and SNS but a growing body of literature suggests that caregiving experiences program these systems during sensitive periods of development (e.g., Porges & Furman, 2011). Furthermore, research suggests that the SNS and PNS exhibit different patterns of reactivity across varying contexts (Bush, Alkon, Obradović, Stamperdahl, & Boyce, 2011) and that variable response patterns are partly due to the impact of early experiences (Oosterman, Clasien de Schipper, Fisher, Dozier, & Schuengel, 2010; Pollak, Vardi, Putzer Bechner, & Curtin, 2005; Saltzman, Holden, & Holahan, 2005). Thus, the current study investigated PNS and SNS reactivity across ecologically valid social and cognitive tasks.

While the institutional environment is likely involved in the development of regulatory biological systems, the post-adoption environment may also have an ameliorative impact, though little is known regarding the specific components of post-adoption parenting that may contribute to bio-behavioral regulation. One component of parenting shown in the literature to contribute to children's emotional, behavioral, and physiological regulation is emotion socialization practices (Eisenberg, Cumberland, & Spinrad, 1998; Hastings et al., 2008). This study sought to examine the moderating role of current parent emotion socialization practices on the relationship between early socio-emotional neglect and indices of PNS and SNS functioning by comparing PI children with children adopted from foster care (PFC) and non-adopted (NA) children raised with their biological families. This study also investigated how PNS and SNS functioning and emotion socialization practices contributed to externalizing behavior in post-institutionalized children.

Externalizing Behaviors in Post-Institutionalized Children

A developmental psychopathology perspective underscores the importance of viewing abnormal behaviors as being extreme manifestations of adaptive behaviors (Cicchetti & Richters, 2003). In typically-developing samples, externalizing behaviors in the toddler years such as noncompliance, aggression toward peers and siblings, difficulty controlling anger, and poor impulse control are common complaints of parents (Koot, Van Den Oord, Verhulst, & Boomsma, 1997). These behaviors likely represent toddlers' efforts to establish autonomy, test limits, and practice social skills. For the most part, externalizing behaviors tend to be more prevalent in the younger years and show a decreasing developmental trajectory to late adolescence (Bongers, Koot, van der Ende, & Verhulst, 2004). More serious externalizing behavior problems are characterized by high frequency and severe behaviors that impact several domains of functioning and are evident across different people and contexts. Some children appear to develop externalizing problems early and these behaviors persist over the life course and may worsen over time (Aguilar, Sroufe, Egeland, & Carlson, 2000; Moffitt, Caspi, Dickson, Silva, & Stanton, 1996). It has been suggested that among many factors (i.e., temperament, genetic predisposition), psychosocial adversity and poor parenting may contribute to these early emerging and pervasive behavioral problems (Aguilar et al., 2000; Moffitt et al., 1996). In contrast, a late-onset course has also been identified in which externalizing behavior problems do not emerge until adolescence (Moffitt et al., 1996) and this later onset of problems has been associated with concurrent life stress (Aguilar et al., 2000). The age at which externalizing behaviors are first noted in children from institutional care is often unknown, mostly because adoptive parents are given very little information about their child's pre-adoptive development. Post-adoption, several studies have found that externalizing behaviors are problematic; however, a consistent developmental trajectory has not emerged.

After they move into stable families, many PI children exhibit behavior regulation within the normal limits but some studies have found higher than typical rates of externalizing behaviors, with base rates for severe clinical-level externalizing problems that are present years after adoption being higher than expected (Ames, 1997; Groza et al., 1999; Hoksbergen, Rijk, van Dijkum, & ter Laak, 2004; Stams, Juffer, Rispens, & Hoksbergen, 2000; Tan & Marfo, 2006; Verhulst, Althaus, & Versluis-den Bieman, 1990a, b, c; Verhulst, Althaus, Versluis-den Bieman, 1992; Wiik et al., 2011). In one study, very young recently adopted PI children did not show greater externalizing behaviors until they were followed up several years later, whereby conduct problems became evident 3 to 8 years post-adoption (Fisher, Ames, Chisholm, & Savoie, 1997; Maclean, 2003). In a meta-analysis, authors concluded that externalizing behaviors could be detected in PI children as early as 5 years of age (Hawk & McCall, 2010) and appear to increase with age rather than decrease (Le Mare, Audet, & Kurynik, 2007), suggestive of an early-onset trajectory. Inconsistent results have emerged with some longitudinal studies finding no effects of time on conduct disorders (Sonuga-Barke, Schlotz, & Kreppner, 2010) and other studies finding that externalizing behaviors may increase from early to late adolescence (Verhulst, 2000; Verhulst & Versluis-den Bieman, 1995). Thus, developmental trajectories of externalizing behaviors are not clear. It is notable that some PI children have shown clinical-levels of externalizing behaviors in middle childhood that appear to increase with age, suggesting that institutionalization is related to profound and enduring deficits in behavior regulation. However, some studies have documented no association between externalizing behaviors and institutional care (Cederblad, Hook, Irhammar, & Mercke, 1999; Goldney, Donald, Sawyer, Kosky, & Priest, 1996; Groza & Ryan, 2002), leading some to argue that while institutional care may be associated with problems in some areas such as attachment and inattention/hyperactivity, it is most likely not associated with externalizing-type disorders specifically (Kreppner, O'Connor, & Rutter, 2001; Rutter, Kreppner, O'Connor, 2001). The wide range of externalizing behavior seen suggests a probabilistic rather than deterministic influence of early deprivation.

It has been suggested that other factors related to institutionalization and international adoption such as age at adoption and early adverse experiences may help to explain why some PI children appear vulnerable to developing externalizing behaviors while others do not. Being older at adoption has been associated with increased rates of externalizing problems in PI children (Gunnar & van Dulmen, 2007; Hoksbergen et al., 2004; Merz & McCall, 2010; Verhulst et al., 1990b). Notably, the range of distribution of age at adoption is often limited, with various dichotomies being made as young as 6 months (Marcovitch et al., 1997) and as old as 24 months (Gunnar & van Dulmen, 2007). Marcovitch and colleagues (1997) found more total problems in children adopted after 6 months of age (range: 6 – 48 months) compared to PI children adopted before 6 months, though a specific preponderance of externalizing behaviors was not seen. In contrast, when children were 11-years-old, Colvert and colleagues (2008) found elevated rates of disruptive behaviors in PI children adopted after 6 months of age from severe globally depriving Romanian institutions, compared to children adopted before 6 months. Investigating children of various ages ranging from 4 to 17 years old, others have found elevated rates of externalizing behaviors in children adopted after 24 months compared to children adopted before 24 months (Gunnar & van Dulmen, 2007; Hoksbergen et al., 2004). Merz and McCall (2010) found higher rates of externalizing problems in 6 to 18-year-old PI children adopted later than 18 months compared to children adopted before 18 months. Taken together, these findings are in line with developmental theory, which posits that problematic parent-child relationships that span past a sensitive period are associated with later maladjustment (Bowlby, 1982), though there is still controversy on how long this sensitive window extends. In contrast, some studies have found no relationship between age at adoption and externalizing problems (Marcovitch et al., 1997; Groza, 1999).

Because age at adoption and duration of time in the institution often correlate at 0.7 or above, age at adoption serves as a proxy for duration of exposure to the institutional environment. Later age at adoption, thus, confers certain risks, the specifics of which are difficult to disentangle and may help to explain some of the inconsistencies found for the relationship between age at adoption and externalizing behavior. The behavioral problems associated with older age at adoption may be related to a child's pre-existing health or mental health problems or to the additional challenges in adapting to their new environment. Researchers often find positive associations between age at adoption and greater exposure to preadoption care risk such as abuse and neglect, leading some to suggest that the relationship between age at adoption and maladjustment following adoption may be more of a function of greater exposure to early adverse experiences (Verhulst et al., 1992). Indeed, a meta-analysis of studies of internationally adopted children reported higher scores on externalizing behavior for children adopted internationally from adverse backgrounds relative to internationally adopted children from less adverse preadoption care, while age at adoption was not a risk factor (Juffer & van IJzendoorn, 2005). Though important, it can be near impossible to separate the effects of age at adoption from those of early adverse care (Verhulst et al., 1992). Additionally, adoptive parents often know very little about the exact nature and timing of adverse experiences endured by the child, and their report of early adversity may be subject to bias by the current presentation of their child's behavior or to misinformation from official records or adoption agencies.

There is evidence to suggest that externalizing problems may not be specific to institutional care history, but to other more general factors associated with being an internationally-adopted child such as genetic factors, malnutrition and maternal stress during pregnancy, prenatal exposure to substances, disruptions in care, and mental health problems among parents who relinquish or abandon their children (Johnson, 2000). To isolate the effects of institutional care, researchers have been challenged to find appropriate comparison groups to control for these factors. One type of population that has been used is children internationally-adopted post-foster care (PFC) with little-to-no history of institutional care. Compared to PI children, PFC children are typically adopted at younger ages making it difficult to answer questions regarding timing and the impact of international adoption because age at adoption is confounded with group status. However, the PFC group still shows considerable variation with age at adoption ranging typically from 1 to 12 months. Though information regarding early care history is limited for this group, one study of children living in foster care within South Korea found that these children experienced stable foster care homes with excellent medical care, nutrition, and individualized care from trained parents (Kim, 1995). However, little is known regarding quality of care in other countries utilizing foster care that are open to international adoption such as Colombia and Guatemala. Several studies have documented similar rates of problems seen in children adopted from foster care and institutional settings (i.e., Gunnar & van Dulmen, 2007). For example, Wiik and colleagues (2011) found elevated rates of parent- and child-reported externalizing behaviors in 8- to 11-year-old children adopted from institutions (adopted between 12 and 50 months) and adopted from foster care (adopted at less than 8 months), compared to children born and raised in their biological family in the US and of similar socio-economic status to the other groups. This finding suggests that it is not just institutional care per se, but the overall impact of early adversity that may persist into middle childhood.

The lack in consensus regarding when externalizing problems emerge and their severity may be due to several factors including the types of questionnaires being used. Questionnaires used in past studies, such as the Child Behavior Checklist have focused on clinical levels of externalizing problems, potentially missing opportunities to detect lower-level problems in middle childhood before they materialize into more serious problems in adolescence. Indeed, when less extreme levels of externalizing behaviors were investigated using instruments such as the MacArthur Health and Behavior Questionnaire, younger internationally-adopted children did evidence elevated rates of problems (Wiik et al., 2011). Once PI children enter adolescence and the social and emotional pressures increase, studies find that some evidence higher clinical levels of conduct, delinquency, and externalizing problems than non-adopted adolescents and younger adopted PI children (Verhulst, 1990a). Overall, this body of evidence indicates that it would be beneficial to use assessment methods that might capture emergent problems in PI children and that middle-childhood may be an important age range to target for early identification of children who require additional support before they reach adolescence.

The past 25 years has seen an influx of international adoptions stimulating investigations into the behavioral outcomes of children with early experiences of adversity. Overall, this body of work suggests that early adversity, in the form of institutionalization taking place for longer than, at the minimum 6 months, may result in elevated levels of externalizing behaviors. Though inconsistent, both early- and late-onset trajectories of externalizing behavior have been noted. Furthermore, other forms of early adversity, such as abandonment and placement in foster care, may also result in elevated problem behaviors. Externalizing behaviors are likely to be positively associated with age at adoption and exposure to adverse care. Taking these factors into account, this study examined externalizing behavior in children adopted from institutional care between 9 and 54 months of age when they were 8 to 9 years of age, a developmental window during which these behaviors may become more problematic. PI children were compared to non-adopted children and children adopted from foster care to examine whether behaviors were due to early deprivation or other factors related to adoption. Externalizing behaviors were also examined relative to age at adoption and early care risk for all adopted children. As commented by Gunnar (2010, pp. 243), "We are never going to understand the impact of early deprivation if we continue to ask if it produces an increased risk of internalizing and externalizing disorders." To address this call, this study also examined physiological indices of regulated emotion and parent emotion socialization practices post-adoption to investigate their respective contributions to the emergence of externalizing behaviors.

Physiological substrates of emotion regulation

Understanding externalizing behaviors from a developmental psychopathology perspective requires examining how interactions at multiple levels (e.g., biological, behavioral, and social-contextual) contribute to adaptation and maladaptation. There are a number of physiological systems that influence emotional reactivity and regulation; these interact with behavioral and social constituents of emotion regulation across development. The working model of early life stress that helped to conceptualize this study is pictured in Figure 1 (reviewed in Loman & Gunnar, 2010). This model argues that caregiving experiences early in life regulate the activity of stress-sensitive systems, which in turn influence the development of systems involved in rapid appraisal and response to threat. This model proposes that experiences which threaten the child's capacity to form a relationship with a consistent, responsive, and caring adult result in chronic stress to the infant, and bias stress systems toward larger and faster defense responses (fight/flight/freeze) in order to cope. This overactivity of stress- and threat-systems may impact prefrontal and cortico-limbic regulatory systems, thereby increasing the risk for emotion-regulatory problems. The neural systems that orchestrate autonomic rapid defense responses are expected to be plastic during early childhood (Porges & Furman, 2011). If the quality of caregiving improves, stress- and threat- systems have the potential to re-organize in order to become less reactive and more modulated. However, children exposed to particularly severe and prolonged inadequate nurturance may be less capable of reorganizing with improved care and this, in turn, may make it difficult for caregivers to sustain appropriate responsiveness to the child's needs. While this model may apply to most children (and to most developing mammals), vulnerability to early adverse care and recovery in response to improved care are expected to be influenced by the child's genetic vulnerabilities.

A growing body of literature has documented associations between institutional rearing and altered neurobiological functioning of systems underlying emotional and behavioral regulation. Given that the autonomic nervous system is involved in emotion regulation and social communication and may contribute to externalizing behavior, there is surprisingly little known about PNS and SNS functioning in PI children. The following sections describe how these two branches of the ANS are related to socio-emotional functioning and regulation, as well as the research describing their plasticity in early childhood. Understanding the mechanisms linking early experience to physiological functioning is critical to elucidate how externalizing behavior unfolds.

The parasympathetic nervous system. The parasympathetic nervous system (PNS) has effects that are associated with growth and restorative processes in the body. Through innervation of internal organs via mainly cholinergic fibers, the PNS promotes vegetative functions and reduces physiological arousal. Parasympathetic neurons begin in the brainstem and spinal cord. Of specific interest to this study is the 10th cranial nerve, also called the vagus nerve, originating in the brainstem and reaching down to the viscera of the abdomen, touching the heart and major organs along the way. Eighty to 90% of fibers of the vagus nerve are responsible for sending information back-and-forth between the viscera and the brain. Parasympathetic innervation of the heart is provided by the vagus nerve. Vagal tone serves as an index of PNS functioning and can be partially estimated from respiratory sinus arrhythmia (RSA), or the ebbing and flowing of heart rate during the respiratory cycle. RSA results from increases in vagus nerve activity during exhalation, which decelerates heart rate, and decreases in vagus nerve activity during inhalation, which allows an acceleration in heart rate. Tonic RSA refers to baseline vagal tone functioning at rest and RSA reactivity refers to changes in vagal tone from baseline to challenge conditions. Greater PNS reactivity is characterized by greater decreases in RSA, which permits a faster heart rate and allows an increase in sympathetic nervous system input to the heart. Low PNS reactivity is characterized by lower decreases in RSA, which slows heart rate and counteracts SNS input.

The PNS plays a role in promoting sustained attention, self-regulation, and social engagement (Porges, 1995, 2001, 2007). Polyvagal Theory has been proposed to help understand the role of the PNS under conditions of safety and threat. This theory proposes that those portions of the vagus nerve which are myelinated and originate in the nucleus ambiguous (termed smart vagus) are recent evolutionary developments whose functions contribute to social affiliative behaviors and emotion regulation (Doussard – Roosevelt & Porges, 1999; Porges, 2007). Morphological studies indicate that myelination of vagal fibers from the NA to the sinoatrial node begins during the 3rd trimester of prenatal development and continues until adolescence with the greatest increase occurring between 32 weeks gestation until 6 months postpartum (as cited in Porges & Furman, 2011). Polyvagal theory posits that the linkage between neural regulation of the heart via the smart vagus and the visceral efferent pathways that regulate the muscles of the face, head, and neck forms an integrated ‘Social Engagement System’ (Porges & Furman, 2011). The Social Engagement System includes regulation of the eyelids (e.g., for social gaze), muscles of facial expression (e.g., emotional expression), middle ear muscles (e.g., for extracting human voice from background sounds), laryngeal and pharyngeal muscles (e.g., vocalizing, breathing), and muscles of turning the head and neck (e.g., to socially orient). Together, the coordination of these muscles allows the infant to filter social stimuli and control motor movement necessary for social engagement. When the inhibitory action of the vagus is withdrawn, this provides a physiological state that promotes engagement with the environment. Resting vagal tone has been generally viewed as the individual’s ability to maintain homeostasis and autonomic flexibility to generate adequate responses to environmental demands.

The sympathetic nervous system. The SNS is constantly active at a basic level to promote homeostasis, and its main function is to support mobilization. From the locus coeruleus, the SNS can follow two routes: a direct pathway via mainly noradrenergic innervation of visceral organs, and a slower hormonal pathway via innervation of the adrenal medulla (reviewed in Gunnar & Vazquez, 2006). Under challenging circumstances, SNS activation triggers rapid physiological (e.g., increased heart rate and sweat) and behavioral reactions associated with arousal, fight, freeze, and flight.

There are various ways to measure SNS functioning. Pre-ejection period (PEP) has been used as a cardiac measure of SNS activity: shorter PEP intervals index high SNS reactivity, which are correlated with a faster heart rate and increased cardiac output, and longer PEP intervals reflect low SNS reactivity, a slower heart rate, and less cardiac output. The present study utilized a measure of skin conductance, which refers to electrodermal activity caused by the activity of sweat glands. Electrodermal recording requires the passage of an electrical current through the skin and measures skin conductance relative to skin resistance. Greater SNS activity associated with more sweat gland activity increases moisture in the skin allowing greater skin conductance. Skin conductance was measured on the fingers, a site known to be associated with "emotional sweating" or increased sweat gland activity as a function of emotional or psychological states (reviewed in Boucsein, 2012).

The central autonomic network. Several brain regions have been identified as being key players in SNS- and PNS- mediated emotion regulation and these regions are described as being part of a Central Autonomic Network (CAN; Thayer & Lane, 2000). The brain regions associated with PNS activity include the medial and orbital regions of prefrontal cortex, anterior cingulate cortex, amygdala and extended amygdala (e.g., bed nucleus of the stria terminalis [BNST]), hippocampus, and cerebellum (Thayer, Åhs, Fredrikson, Sollers, & Wagner, 2012). Output from brain structures in the CAN travel to the sino-atrial node of the heart via SNS and PNS neurons of the stellate ganglia and vagus nerve (Thayer, Hansen, Saus-Rose, & Johnsen, 2009). Thus, there are direct paths from the prefrontal cortex to the heart. As reviewed extensively by Boucsein (2012), sweat secretion is governed by the central nervous system, particularly the paraventricular and posterior nuclei of the hypothalamus. Hypothalamic sympathetic sweat gland activity can be elicited or modified by higher-level cerebral structures. The limbic system plays a major role in emotional sweating, particularly the amygdala and hippocampus. Cortical limbic and extralimbic structures have also been found to influence sweat gland activity. The ventromedial prefrontal cortex has been implicated in eliciting sweat gland activity, particularly during restful, mentally alert states (Raichle et al., 2001) as opposed to orienting and defense responses likely elicited by amygdalar activity (Williams et al., 2001) and behavioral inhibition likely elicited by the hippocampus (Gray, 1982). There is also evidence to suggest cerebral influences on sweat gland activity from the basal ganglia and premotor cortical regions outside of cortical areas related to the limbic system (Boucsein, 2012).

The CAN and institutional rearing. PI children have been found to exhibit metabolic and connectivity deficits in areas of the brain involved in RSA and sweat gland activity, such as reduced brain metabolism in selected regions of the prefrontal cortex and temporal lobe – areas implicated in emotion regulation and inhibitory control (Chugani et al., 2001), diminished white matter connectivity in the uncinate fasciculus – a region involved in communication between brain areas associated with emotional function (Eluvanthingal et al., 2006), and reduced white matter between the PFC and amygdala (Govindan, Behen, Helder, Makki, & Chugani, 2010). Relative to non-adopted children, those experiencing institutional care have shown differential power distributions in lower power frequencies suggestive of delayed brain maturation (Marshall, Fox, & the BEIP, 2004; Tarullo, Garvin, & Gunnar, 2011) and reduced amplitude of several event-related potential (ERP) components, suggesting cortical hypoactivation (Moulson, Fox, Zeanah,

& Nelson, 2009; Moulson, Westerlund, Fox, Zeanah, & Nelson, 2009). PI children have also evidenced neuroanatomical changes in the size of the amygdala – a key structure sensitive to stressful experiences during childhood (Mehta et al., 2009; Tottenham et al., 2010).

The neurobiology underlying the ANS and those involved in the hypothalamic-pituitary-adrenal (HPA) axis are tightly functionally integrated and cross-regulated; both are centrally controlled by limbic structures, with the amygdala playing a crucial role. In the prolonged absence of species-typical caregiving, alterations in HPA axis functioning have been noted. Several studies have found that children exposed to disrupted caregiving, such as maltreatment and neglect, show chronically high or low levels of cortisol (Bruce, Fisher, Pears, & Levine, 2009; Carlson & Earls, 1997; Dozier et al., 2006; Gunnar & Vazquez, 2001; Kertes et al., 2008; Kroupina et al., 2012). Disrupted patterns of cortisol may be a sign of impaired physiological functioning of numerous systems including the autonomic nervous system.

Institutional care has also been associated with altered neurochemical production of oxytocin and arginine vasopressin (Wismer Fries, Ziegler, Kurian, Jacoris, & Pollak, 2005). These hormones have been implicated in affiliative and positive social behaviors to promote bonding (Young & Wang, 2004) and have been found to influence ANS functioning (Bales & Perkeybile, 2012). Thus, altered neurochemicals seen in PI children suggests that they might also show disrupted ANS functioning.

As proposed by the early life stress model and supported by research in animals and humans, early childhood represents a time during which biological systems are plastic. Early experience has a profound impact on neural systems that underlie ANS functioning. This is evident in the research of the effects of institutional rearing on brain regions associated with the CAN, which has documented reduced or altered metabolic, physiological, and neurochemical activity, as well as altered size of areas of the amygdala and compromised white-matter tracts suggestive of connectivity problems. This altered neurobiology may result in disrupted ANS functioning and increase risk for emotionally-driven behavior problems.

The Autonomic Nervous System and Relations with Externalizing Behavior

This section will first describe the research linking autonomic nervous system functioning with emotion regulation and social communication. For externalizing behaviors specifically, inconsistent findings have suggested that there may not be one overall pattern of ANS functioning which characterizes externalizing behavior problems. Other factors, such as the caregiving context, may help us to reconcile some of these inconsistencies found in the literature. Thus, subsequent sections will describe how the caregiving environment (first typical, then atypical) may impact ANS functioning, putting individuals at risk for developing externalizing behavior problems.

The ANS and emotion regulation. In the infant literature, higher vagal tone and greater vagal regulation to challenge have been associated with better behavioral state regulation required to facilitate social engagement, such as greater attention span, self-soothability, and more potential to react to the environment with an appropriate response (Calkins, Graziano, & Keane, 2007; DiGangi, DiPietro, Porges, & Greenspan, 1991; Porges, 1995). In older children, better vagal regulation has been associated with appropriate emotion regulation in preschool (Calkins & Keane, 2004), sustained attention (Suess, Porges, & Plude, 1994), and expressions of empathy toward others in distress

(Fabes, Eisenberg, & Eisenbud, 1993). In contrast, low vagal tone and attenuated response to challenge is proposed to more easily permit engagement of the SNS, a metabolically costly strategy that may have more negative effects on major organs.

Research indicates inconsistent associations between PNS and SNS functioning and externalizing behavior. Low resting RSA has been noted in children and adolescents with clinical levels of externalizing behavior problems (Beauchaine, 2001, Beauchaine, Gatzke-Kopp, & Mead, 2007). In terms of RSA reactivity, decreased reactivity to challenge has been noted in children with sub-clinical externalizing behavior (Calkins, Blandon, Williforn, & Keane, 2007) and clinical levels of disruptive behaviors (Degnan, Calkins, Keane, & Hill-Soderlund, 2008). Though most researchers tend to view greater vagal tone and greater vagal withdrawal during challenge as associated with more adaptive outcomes, contradictory evidence has found that these are associated with negative outcomes. For example, greater baseline RSA has been associated with greater levels of externalizing problems (Calkins et al., 2007; Dietrich et al., 2007). High RSA reactivity during a challenge has been associated with externalizing symptoms in middle childhood to early adolescence (Boyce et al., 2001; Calkins & Dedmon, 2000; Crowell et al., 2006). In terms of SNS functioning and externalizing behavior, the results are also inconsistent. For example, in subclinical samples of children, high SNS activity has been associated with reactive aggression (Hubbard et al., 2002). Findings have also emerged showing that excessively low SNS activity is associated with greater clinical and subclinical levels of conduct problems, antisocial behavior, and callous-unemotional traits (Beauchaine et al., 2007; Crowell et al., 2006; Herpertz et al., 2003; Lorber, 2004).

As of yet, it has been challenging for researchers to find consistent associations between ANS functioning and externalizing behavior. As both excessively high and excessively low PNS/SNS at rest and in response to challenge appears to confer some risk for negative outcomes, some researchers propose that ANS functioning which is *moderate* is the most adaptive, as it reflects adaptive coping skills. Unfortunately, there are no established absolute thresholds for what constitutes high or low ANS functioning across developmental periods. One likely explanation for the inconsistent findings reported in this section is that individual differences in risk for externalizing behaviors may result from interactions between multiple systems that support maladaptation in certain contexts. Thus, it has become crucial to investigate how variations in the caregiving context may impact ANS functioning and increase the risk for developing externalizing behavior problems in children who have experienced early socio-emotional neglect.

Typical variations in care and the ANS. Based on the early life stress model, institutional rearing is likely to have an impact on children's autonomic nervous system. However, in order to understand how the ANS develops over time in children exposed to adversity, it is first necessary to explore the way in which normal variations in care are related to indices of ANS functioning.

There is strong evidence to support the argument that subtle variations in parent behaviors within the first year of life contribute to the development of vagal tone regulation. Models of bio-behavioral synchrony highlight the importance of micro-regulatory patterns in infant-parent relationships. Caregiving that is sensitive, responsive, and consistent helps to shape adaptive vagal functioning, facilitating infant self-regulation and social engagement skills. Research on bio-behavioral synchrony suggests that mother and infant physiology are interrelated and coordinated by moment-to-moment behaviors within the attachment relationship (reviewed in Feldman, 2012). Examining micro-level interactions has shown that mother and infant RSA is interrelated with tighter heart rate and RSA coupling occurring when the dyads engage in touch, gaze, affect, or vocal synchrony (Feldman, Singer, & Zagoory, 2010; Feldman, Magori-Cohen, Galili, Singer, & Louzoun, 2011; Moshe & Feldman, 2006). This behavioral 'matching', while providing important external regulation and social experiences for the infant, may also help organize the infant's immature physiological functioning (Feldman, 2012). Interactive synchrony is also related to higher baseline RSA (Porter, 2003) and higher RSA withdrawal to challenge (Moore & Calkins, 2004). More general processes of typical parenting within the first year, such as overall sensitivity, responsiveness, and warmth, have been associated with greater RSA withdrawal (Moore, 2009) and even more long-term development of the ANS (Propper et al., 2008).

From 12 months to five years of age, researchers have not consistently found significant relationships between typical parenting behaviors and ANS functioning. Calkins, Graziano, Berdan, Keane, and Degnan (2008) found that mothers' hostility and less positive and responsive behavior was related to attenuated RSA reactivity in 2-year-olds and that mother-child relationship quality predicted the degree of RSA regulation at 5 years of age. While some evidence suggests that the effects of early relationships on physiology may persist into early childhood, others have not found significant associations between parenting behaviors and physiology (Kennedy, Rubin, Hastings, Maisel, 2004; Perlman, Camras, & Pelphrey, 2008) or have found minimal associations (Hastings & De, 2008).

This body of work on low-risk samples suggests that the effects of normative parenting behaviors on the ANS may be most pronounced within the first year of life, when the parent-child relationship may exert more impact on the biological growth and maturation of physiological systems during sensitive periods of vagal myelination (Porges & Furman, 2011). However, the impact of normal variations in parenting on ANS development beyond 12 months remains unclear. Many institutionally reared children are typically adopted after 12 months calling into question how the experience of socio-emotional neglect impacts ANS development and whether these effects are short-term or more lasting. Additionally, if plasticity of the ANS gradually decreases after 12 months, what impact would post-adoption parenting have on the ANS?

Risk for adverse care and the ANS. Animal studies suggest that acute stressors, long-term social/maternal separation, and disrupted maternal caregiving produce alterations in autonomic functioning (Loria, Brands, Pollock, & Pollock, 2013; Trombini et al., 2012). However, whether we would expect increased or decreased PNS and SNS functioning is not clear and appears to depend on many factors including timing and duration of the stressor and individual differences in levels of aggression, depression, and anxiety. Adult rats exposed to repeated foot shocks have been found to exhibit increased SNS tone and relatively persistent long-term increases in vagal tone, even after the stressor has been removed (Carnevali et al., 2011). The heightened vagal tone, termed "enduring vagal rebound" suggests an adaptive response to overcome the sympathetic overdrive following exposure to stress (Mezzacappa, Kelsey, Katkin, & Sloan, 2001).

However, if the stress is severe or chronic, this may result in a maladaptive phase of low vagal tone regulation and either sympathetic dominance or under-arousal. For example, rat pups exposed to chronic maternal separation have shown increased SNS tone (Loria, Brands, Pollock, & Pollock, 2013). Examining more long-term effects of early maternal separation, Trombini and colleagues (2012) found that adult rats that had experienced early maternal separation also evidenced increased SNS tone to a stressor. Interestingly, these adult rats did not show increased vagal tone following exposure to the stressor, suggesting a lack of the enduring vagal rebound phenomenon noted in the Carnevali et al. study. In other mammals, chronic stress has also shown reduced vagal tone and increased SNS tone. For example, in adult prairie voles, long-term isolation from siblings or opposite-sex partners induced 24-hour decreases in vagal tone, increases in sympathetic tone to the heart, and depressive-like behaviors compared to non-isolated voles (Grippo, Lamb, Carter, Porges, 2007a, b; Grippo et al., 2011; Grippo, Trahanas, Zimmerman, Porges, & Carter, 2009). Not all studies have found increased SNS tone following stress. For instance, in rat models of aggression, adult rats bred for highly aggressive traits were seen to exhibit lower vagal tone and reduced vagal withdrawal to stress than non-aggressive rats; however heart rates were comparable between the two groups suggesting lowered sympathetic input in the aggressive group (Carnevali et al., 2013). Thus, it appears that chronic or severe stress, particularly occurring early in life, may result in reduced vagal tone and either high or low sympathetic tone.

In children, exposure to early life stress has been associated with alterations in PNS and SNS functioning; however, like the animal work, the direction of effects has been inconsistent. Longitudinal studies suggest that children exposed to low-level chronic stressors and risk for stress (e.g., maternal depression) and more severe maltreatment (e.g., exposure to domestic violence) have not shown the normative increase in baseline RSA from infancy to childhood (Field, Pickens, Fox, & Nawrocki, 1995; Rigterink, Katz, & Hessler, 2010). Children exposed to marital conflict and foster care have been found to show lower basal RSA and attenuated RSA withdrawal to stress (Moore, 2010; Oosterman & Schuengel, 2007; Porter, Wouden-Miller, Silva, & Porter, 2003). Past early childhood and into adolescence, the association between adversity and poor vagal functioning appears to continue. Miskovic and colleagues (2009) found that female maltreated adolescents exhibited lower baseline RSA compared with their non-maltreated peers and these effects persisted over a period of 6 months. Not all studies have found at-risk caregiving to be related to lower vagal tone. Burgess, Marshall, Rubin, and Fox (2003) found that poor quality attachment status in infancy predicted higher basal RSA in preschool. Despite the inconsistencies regarding the direction of vagal tone, these studies provide evidence to support the notion that poor quality and adverse caregiving may impact long-term physiological functioning.

Only one study has published findings on indices of PNS and SNS activity in PI children. Gunnar and colleagues (2009) examined PEP and RSA at baseline and throughout a public-speaking protocol in 10- to 12-year-olds. They found that PI children adopted between 12 and 64 months exhibited lower PEP compared to non-adopted children and children adopted early from foster care. The heightened SNS tone seen in this study parallels other findings showing higher SNS activity in children exposed to maltreatment (DeBellis et al., 1999; Pollak et al., 2005; Saltzman et al., 2005). Surprisingly, no group differences were found in RSA. The Gunnar et al. study did not examine PNS/SNS associations with problem behavior, leaving open the question as to whether the heightened SNS tone might have contributed to maladjustment.

Risk for adverse care, ANS functioning, and behavior regulation. Research on the relation between indices of PNS and SNS functioning and externalizing behavior in children exposed to risk for adversity has not found consistent associations. For RSA, the research is unclear as to whether we would expect risk for adversity to be related to higher or lower RSA and SNS functioning, and like the animal literature, appears to depend on many factors including quality, timing, and severity of the exposure to risk, the developmental period assessed, and the temperament of the child (e.g., approach versus withdraw). In the toddler period, children exposed to high parental aggression that reacted with greater levels of dysregulated anger and hostility in response to the aggression exhibited higher basal RSA (Davies, Sturge-Apple, Cicchetti, Manning, & Zale, 2009). In the preschool period, studies have noted associations between attenuated RSA withdrawal to challenge, exposure to risk, and externalizing behavior. For example, children raised in the highest levels of domestic violence showed RSA augmentation to a peer provocation challenge (Katz, 2007). Vagal augmentation during the challenge was also associated with elevated conduct-related problems in those children exposed to the highest levels of domestic violence. Katz (2007) interpreted the vagal augmentation as being potentially indicative of increased attentiveness to threat within an interpersonal context.

Regarding the impact of exposure to risk for adversity on SNS functioning and externalizing behavior, the findings are mixed. Studies have noted that harsh parenting and exposure to marital conflict were associated with low skin conductance reactivity to challenge and greater levels of externalizing behavior, particularly in boys (Beauchaine, 2001; El-Sheikh, Keller, Erath, 2007; Erath et al., 2009; Erath, El-Sheikh, Hinnant, & Cummings, 2011). Indeed, El-Sheikh, Keiley, and Hinnant (2010) found that children with delinquent behavior showed gradual decreases in skin conductance across 2 years, compared to children with low levels of problem behavior. This raises the possibility that perhaps under-arousal associated with exposure to risk for adversity may contribute to externalizing behavior. However, several studies have found the opposite pattern: in the context of parental depression and marital conflict, high skin conductance reactivity to challenge served as a vulnerability factor for developing externalizing behavior (Cummings, El-Sheikh, Korous, & Keller, 2007; El-Sheikh, 2005; El-Sheikh et al., 2007; Erath et al., 2011). These findings raise another possibility: perhaps exposure to risk for adversity is associated with behavior problems for children with high SNS reactivity because they are more sensitive to environmental contingencies. Without knowing how both PNS and SNS systems work together to promote homeostasis and adaptive responses to environmental demands, it is hard to draw conclusions regarding where risk lies for developing externalizing behavior problems.

A growing number of studies have more recently shown that PNS and SNS reactivity measured concurrently can give us a better idea of how these systems interact to influence psychopathology. Rather than thinking about SNS and PNS activity as transitional blends, Bernston, Cacioppo, and Quigley (1991) have conceptualized the joint action of these systems on a flexible 2-dimensional model of autonomic space. This model posits that individuals can display either reciprocal or nonreciprocal activation of systems. Reciprocal activation is when both branches of the ANS promote the same unidirectional response in a target organ (i.e., high SNS reactivity coupled with low PNS inhibition to promote increases in heart rate). Nonreciprocal activation is when branches of the ANS promote opposing actions on target organs leading to very little change from baseline functioning (i.e., high SNS reactivity coupled with high vagal regulation to challenge). For studies that examined indices of SNS and PNS concurrently in the context of exposure to risk (marital conflict), results have suggested that low skin conductance reactivity coupled with attenuated RSA withdrawal to challenge was a risk factor for developing externalizing behavior (El-Sheikh et al., 2009). In another study of children exposed to maltreatment, Gordis, Feres, Olezeski, Rabkin, & Trickett (2009) found that combinations of low basal RSA coupled with low skin conductance reactivity or high basal RSA coupled with high skin conductance reactivity served as risk factors for aggressive behavior problems. Interestingly, both of these patterns would contribute to autonomic under-arousal. Taken together, these findings suggest that opposing PNS and SNS activity may result in ambivalent or maladaptive physiological responses to stress that do not support an organized active response. In contrast, reciprocal SNS and PNS activation may be the more adaptive response strategy that results in coordinated and consistent physiological change needed for active coping.

In summary, animal models suggest that after exposure to stress, there may be an initial recovery period during which heightened vagal tone is seen coupled with greater SNS tone. When the stress is chronic, this may result in SNS and PNS coupling that would contribute to hyperreactivity or hypoarousal. In children exposed to various forms of risk and adversity, the research has not found a consistent pattern of PNS and SNS functioning, though a relatively larger body of research documents decreased basal RSA, reduced RSA withdrawal to challenge, and heightened SNS tone. However, for children who go on to develop externalizing forms of behavior in the midst of suboptimal caregiving, there does not appear to be a consistent pattern of ANS functioning. Emergent research indicates that reciprocal PNS and SNS functioning which contributes to a strong unidirectional net effect may serve as a protective factor from developing psychopathology. Many studies only report on one branch of the ANS and examine baseline or reactivity levels. Furthermore, it is difficult to parse out whether behavior problems and individual differences in ANS functioning are a result of early or current exposure to risk. To complicate matters, many studies fail to find direct associations between indices of PNS/SNS functioning and risk for adversity. This lack of associations has prompted some to argue that ANS functioning in humans is impacted by the nature of the context within which ANS is measured and by the individual's prior experiences. Thus, ANS reactivity to challenge may depend on how the individual perceives the challenge, as a threat or as affording positive opportunities for social engagement, and this perception likely is rooted in the individual's history (Hastings et al., 2008; Obradović, Bush, & Boyce, 2011).

Individual Differences in ANS Reactivity to Laboratory Challenges

It has been suggested that physiological reactivity to laboratory stressors that match the emotional valence of stressors that children witness or struggle with in their daily lives may have ecologically different significance for adaptive functioning than reactivity to stressors with less emotional relevance (Chen, Matthews, Salomon, & Ewart, 2002; Cummings et al., 2007; El-Sheikh et al., 2007, 2009; Obradović et al., 2011). Physiological reactivity may be highly specific to the context and the individual; thus, it is important to attend to the context in which children are raised and the nature of the stimuli to which children are responding when reactivity is evoked and measured.

The current study attempts to take into consideration the unique problems PI children face in their everyday lives and how these problems may relate to their reactivity to certain types of laboratory stressors. Research has identified that PI children may struggle in situations involving negotiating emotional situations in close relationships. PI children have been reported to show problems in the following areas: establishing social bonds and secure patterns of attachment with primary caregivers and difficulties developing close friendships with peers (reviewed in Maclean, 2003), and understanding and identifying emotions, particularly concerning negative emotions (Wismer Fries & Pollak, 2004), though notably, they have exhibited heightened sensitivity and behavioral reactivity to negatively valenced faces (Maheu et al., 2010; Tottenham et al., 2011). Furthermore, children with histories of unstable or adverse caregiving may behave in ways that push caregivers away rather than seek them out when distressed (Stovall-McClough & Dozier, 2004). The studies done by Wismer Fries and colleagues suggest that close parent-child interactions may induce stress, rather than calm, in PI children. They examined neurobiological reactivity to ecologically relevant tasks, such as having the adoptive mother tickle and hug the child. Compared to non-adopted children, the PI group showed lower overall levels of arginine vasopressin, a hormone involved in recognizing familiar individuals and likely involved in forming social bonds (Wismer Fries et al., 2005). Following this social interaction with the mother, PI children failed to show greater levels of oxytocin, a hormone involved in producing calming and comforting effects to maintain social bonding (Wismer Fries et al., 2005). The PI children actually evidenced higher concentrations of urinary cortisol after physical contact with the mother (Wismer Fries et al., 2008). These studies suggest that social interactions with a primary caregiver post-adoption may pose a particular challenge for PI children, rather than buffering them against excessive and prolonged neurobiological activation. Even during more positive play situations with an experimenter, PI children have shown less positive affect than non-adopted children (Stellern, Esposito, Mliner, Pears, & Gunnar, 2014). Thus, compared to non-adopted children, PI children may have a very different emotional and physiological experience during negative- and positive-emotion evoking situations. The current study investigated the association between caregiving and ANS reactivity across different types of ecologically relevant laboratory tasks that mirror the contextual challenges these children face in everyday life.

Post-Adoption Parenting in Internationally-Adopted Children

A developmental psychopathology perspective maintains that early experiences and current experience both influence children's functioning (Rutter & Sroufe, 2000). Given the rapid cognitive and growth catch-up seen in children following adoption, researchers have concluded that the post-adoption environment serves as an intervention following severe social-emotional neglect, though little is known regarding specific aspects of the environment that contribute to these improvements. Demographic data on adoptive families indicates that compared to non-adoptive families, parents who internationally adopt tend to be older in age, married or partnered, and have higher income and education levels (Hellersedt et al., 2008). But these qualities individually do not tend to predict child adjustment (Castle, Beckett, Rutter, & Sonuga-Barke, 2010). Rather, it appears to be aspects of the environment associated with caregiver stability, consistency, and something harder to measure – the emotional tone of the parent-child relationship – that contributes to improvements in both neurobiological functioning and socio-emotional adjustment.

In children exposed to risk for adverse care and adversity such as children in the U.S. foster care system and maltreated children, interventions targeted to improve the caregiver's stability, consistency, sensitivity, and responsiveness have shown improvements in children's neurobiological and socio-emotional functioning suggesting plasticity of neural systems and potential for recovery (reviewed in Bruce, Gunnar, Pears, & Fisher, 2013). Further evidence linking improvements in care to better social and biological functioning has been noted in children who have experienced institutional care. The Bucharest Early Intervention Project has been the only randomized control trial comparing currently institutionalized Romanian children to a group randomly assigned to a high-quality foster care intervention in Bucharest, Romania. This project has shown that compared to children left in institutional care, children placed in foster care showed less decreases in total cortical white matter (Sheridan, Fox, Zeanah, McLaughlin, & Nelson, 2012) and improvement in neurophysiological functioning (Moulson, Fox, Zeanah, & Nelson, 2009; Vanderwert, Marshall, Nelson, Zeanah, & Fox, 2010). Additionally, better neural functioning was found to contribute to improved psychosocial development (Almas et al., 2012), including less externalizing behavior (McDermott et al., 2013).

Few studies have focused specifically on how improvements in caregiving are related to ANS functioning in children exposed to risk. Studies examining children living in foster care within the U.S. have found that longer placements with a single family were associated with greater increases in RSA during the reunion episode of the Strange Situation, suggesting better vagal regulation when in the presence of a stable caregiver (Oosterman and Schuengel, 2007). Using the same sample of children, researchers found that children in more secure attachment relationships with their foster parent showed less PEP reactivity and better vagal regulation throughout the Strange Situation than children with disordered attachment (Oosterman et al., 2010). Authors suggested that the experience of a more stable and secure caregiving environment may have shifted the stress system towards improved functioning to support social competence and emotion regulation.

Only one study to date has examined parenting practices in children recently adopted internationally from institutions and foster care, compared to non-adopted children. Garvin, Tarullo, Van Ryzin, and Gunnar (2012) examined how variation in adoptive-parents' emotional availability was predictive of social-emotional outcomes. Overall, parents' emotional availability was high amongst all groups. However, only for the PI group was higher emotional availability associated with better socio-emotional outcomes. The Garvin et al. study was useful in showing that parents of internationally-adopted children typically exhibit high levels of emotional availability that is similar to non-adoptive parents of high socioeconomic status. However, it has been suggested that parents of adoptive children may have to be even more sensitive than is typical of non-adoptive children, in order to improve any delays in emotional functioning. As suggested by Maclean (2003), perhaps it takes more than “good enough” parenting to ameliorate some of the more lasting effects of early institutionalization. Exhibiting heightened sensitivity and emotional availability may be difficult for these parents in light of the challenges they face in parenting a child at risk for socio-emotional problems.

There is evidence to suggest that many parents of internationally-adopted children are vulnerable to experiencing high parenting stress. The source of stress is likely due to a combination of factors such as receiving little support from mental health professionals and family members who lack awareness of the needs of internationally-adopted children, parenting a child with special needs or developmental delay, or having a child with high levels of emotional and behavioral problems (Judge, 2003; Mainemer, Gilman, & Ames, 1998; Reynolds & Medina, 2008; Rosenthal & Groze, 1994; Viana & Welsh, 2010). The physical and emotional toll that this stress takes can be high. Qualitative data found that many parents neglected self-care, to the point of becoming depressed or sick, in their mission to provide exceptional care to compensate for any adversity the child experienced in the institution (Reynolds & Medina, 2008).

Notably, externalizing behavior in PI children was found to correlate with parenting stress in several studies (Gagnon-Oosterwaal et al., 2012; Miller, Chan, Tirella, & Perrin, 2009). The negative emotions which can often accompany externalizing behaviors, such as raging tantrums and excessive crying, may be difficult for parents to cope with, particularly if the child's behavior pushes the parent away or if the parent's comforting behavior does not seem to help. Indeed, research suggests that coping with children's negative emotions has shown to be something that adoptive parents struggle with. Many parents have expressed guilt (“Did I cause my child’s distress?”) or pressure to be emotionally and physically available for the child at all times (Linville & Lyness, 2007; Palacios, Roman, Moreno, & Leon, 2009; Reynolds & Medina, 2008). Reynolds and Medina (2008) found that parents reported feeling anxiety when their children displayed strong emotions, not knowing if behaviors were due to institutionalization, or if there was something the parent was not doing well enough.

Parents affect regulation in emotion socialization. Parents serve important roles as socializers of their children's emotional development. Through their behavior, parents affect their children's understanding, experience, and expression of emotion. An aspect of emotion socialization is the way in which parents regulate their own distress in response to children's negative emotions. Through bidirectional processes associated with modeling and coercion, parents of children with externalizing problems may be more likely to respond to their child's expressions of anger by becoming angry themselves (Klimes-Dougan et al., 2007), particularly if they are under a great deal of stress. Parents who react with anxiety, anger, or sadness to their children's displays of negative emotion may model dysregulated affect and behavior that could have a negative impact on the child. Studies on normative samples have revealed that responses to children's negative emotions that consist of high parental distress are associated with children's physiological, emotional, and behavioral difficulties (Eisenberg et al., 1991; Eisenberg et al., 1999; Eisenberg, Fabes, Carlo, & Karbon, 1992; Eisenberg, Fabes, & Murphy, 1996; Gottman & Katz, 2002).

Little is known how PI children might react to variations in parental distress that are within the typical range, though we do know that these children may be more sensitive and reactive to negatively valenced stimuli such as angry faces (Tottenham, 2012). Studies of domestically adopted children have suggested that poorly regulated parent affect may negatively impact the child. In a study of children adopted within the U.S., infants at-risk for developing externalizing behavior problems exhibited increased attention to a frustrating task, but only when they had an adoptive mother high in negative affect symptoms (Leve et al., 2010). This finding suggests a complex process by which risk interacted with post-adoption affect dysregulation, resulting in an infant who reacted with increased attention to negative stimuli. This may lay the foundation for noncompliance and high reactivity to frustrating situations, whereby coercive cycles with the parent emerge and contribute to externalizing behavior in later development (Shaw et al., 1998).

Parental encouragement of child's emotions. Another type of response parents can have to their child’s negative emotions is to encourage their child to express feelings (e.g., “it’s okay to cry”) by positively reinforcing the expression of emotion. This form of socialization provides the child with information about display rules and allows the child to explore their emotions and the events surrounding them. Parental encouragement of emotional expressivity has been found to relate to more constructive coping during real-life negative emotions (Eisenberg & Fabes, 1994). This form of socialization may serve as a protective factor for children with low RSA. Indeed, Hastings and colleagues (2008) found that for children with low baseline RSA, parents' use of reward when children expressed sadness or fear was associated with greater social competence. Thus, it would be important to explore how parents' encouragement of emotional expressivity in response to children’s negative emotions may impact resiliency – at behavioral and physiological levels – in PI children.

Taken together, this body of research suggests that parents of internationally-adopted children show high quality parenting practices and a strong commitment to parenting (Garvin et al., 2012; Reynolds & Medina, 2008). Even small variations in parenting have shown relations to socio-emotional competence, suggesting a powerful role of the post-adoption environment in ameliorating the impact of early life adversity. This study sought to examine whether parent encouragement of emotional expression would serve as a protective factor for PI children in the domains of externalizing behavior and ANS functioning. Past research has also found that when confronted with difficult negative emotions from their child, parents of internationally-adopted children felt conflicting emotions of empathy mixed with anxiety, guilt, and stress which may make it difficult for them to respond with calm neutrality. When a parent becomes overwhelmed by their own emotions, it can be difficult for them to remain emotionally available to the child. Additionally, the parent's difficulty remaining calm may magnify the child's negative emotions and contribute to worse behavior. Given the risk for delays in emotional development and altered neurobiological functioning underlying emotion-regulation documented in PI children, this may make it difficult for them to effectively reorganize and respond appropriately to distress cues from their parents. Thus, this study also sought to examine how parent distress impacted externalizing behavior and children's physiological functioning.

Present Study
Objectives and Hypotheses

The Early Life Stress model discussed previously suggests that socio-emotional neglect, in the form of institutional rearing, has the potential to impact parasympathetic and sympathetic nervous systems, shaping them in ways that allow the child to quickly detect and respond to threat. While this programming may help the infant develop behavioral and emotion regulation strategies to adapt and survive within the institution, these patterns may pose challenges in the post-adoption environment. How parents respond to their children's negative emotions – in terms of encouraging emotional expressivity and remaining calm in the face of their child's distress – may contribute to improvements in physiological functioning and reductions in externalizing behavior, though perhaps to a lesser extent based on limited plasticity of physiological systems post-adoption. The overarching goal in the present study was to examine constituents of emotion regulation competence, specifically, basal and reactivity measures of RSA and skin conductance – in post-institutionalized children several years post-adoption and address how institutional rearing and parent emotion socialization practices contribute to the etiology of these regulatory variables. RSA and skin conductance reactivity were measured during three ecologically-valid tasks in order to determine if the magnitude in reactivity differed based on the nature of the challenge (emotional versus non-emotional) and the child's history of socio-emotional neglect. The three tasks were a conflict discussion with the parent, a fun conversation with the parent, and a working memory cognitive challenge. As a benchmark for their regulatory competence, PI children were examined relative to two comparison groups. The first group was children without a history of adoption who were born and raised in families of similar parental educations and family income to those who adopt internationally (non-adopted, NA). To determine whether effects were specific to institutional care or more generally addressed children with adverse early childhood experience, PI children were also compared to children adopted internationally from countries using foster care for wards of the state (post-foster care, PFC). The next objective was to explore correlates of externalizing behavior in PI children and determine whether the correlates differed in the comparison groups. Due to competing hypothesis about underlying factors of externalizing problems, contextual and physiological correlates were explored including basal and reactivity levels of RSA and skin conductance, as well as parent emotion socialization practices. Each of the hypotheses related to the objectives will now be discussed.

Parent's Emotion-Socialization Practices Objective and Hypothesis

This study sought to examine parent's emotion socialization practices, specifically their distress reactions to children's negative emotions and encouragement of the expression of negative emotions, with the goal being to determine whether differences appeared between parents of PI children versus non-adopted children, and whether any differences were unique to the PI group or shared among the PI and PFC groups. It was hypothesized that while parents in all groups would encourage emotional expression, parents of PI children might show differences in distress reactions due to the literature documenting high stress load and heightened sensitivity and attention to emotional problems in their children.

The Influence of Early and Current Experiences on Indices of ANS Functioning: Objective and Hypotheses

The plasticity of the ANS profile was tested by examining whether parent emotion socialization practices moderated the relationship between group status and physiological functioning (basal levels and reactivity to challenge). It was hypothesized that parental responses to children's negative emotions characterized as encouraging emotional expression would predict better vagal regulation and lower sympathetic input for all groups (i.e., higher basal RSA, lower basal skin conductance, stronger RSA suppression, less skin conductance augmentation during the challenge tasks), but that the impact would be stronger for the PI group. It was predicted that high parental distress would impact PI children to a greater extent than the comparison groups due to heightened sensitivity to threat, and this would be most apparent during the discussion tasks with the parent. No group differences were expected for the cognitive working memory task for RSA and skin conductance magnitude in reactivity. Because the literature has not consistently documented relations between emotion socialization practices and reactivity during cognitive tasks in older children, a hypothesis was not given regarding socialization practices as predictors of reactivity during this challenge. Associations between physiological variables, age at adoption, and early care risk were examined.

Externalizing Behavior Objective and Hypotheses

It was hypothesized that group differences would be found on externalizing behavior. Specifically, the PI group would show significantly greater rates of externalizing behaviors than the NA group. The preponderance of problematic behaviors would be a consequence of early socio-emotional neglect and not due to other factors associated with adoption (i.e., disruption in care, prenatal risk). Associations between externalizing behavior, age at adoption, and early care risk will also be examined.

It was important to elucidate the mechanisms by which some PI children were more or less susceptible to developing externalizing problems. Were risks and protective factors apparent, and if so, did they function similarly in the PI group compared to the other groups? This study sought to better understand the roles of the ANS and post-adoption environment in externalizing behaviors in this group. To distinguish among competing hypotheses about underlying factors, correlates of externalizing behavior were explored in the PI group including parent distress, parent encouragement of emotion expressivity, basal RSA and skin conductance, as well as RSA and skin conductance reactivity to ecologically-valid challenge tasks. Significant correlates were also examined in the comparison groups to see if they were unique to the PI group or applicable to the comparison groups.

Method

Participants

The participants were 98 children between the ages of 8 and 9 years of age at time of testing (*M* = 9.00, *SD* = 0.62) and met criteria for one of three groups: 1.) *Post-Institutionalized group* (*PI*: *n* = 38, 21 = female) were internationally adopted, having spent at least 75% of their lives prior to adoption in institutional care, (e.g., hospital, orphanage, or other type of institutional setting), and at the time of adoption were at least 9-months-old and no more than 53-months-old, 2.) *Post-Foster Care group* (*PFC*: *n* = 23, 10 = female) were internationally-adopted, having spent at least 71% of their lives prior to adoption in a family-based setting (e.g., foster care or relative care), were never institutionalized, and at the time of adoption were no more than 8 months old, 3.) *Non-Adopted* group (*NA*: *n* = 37, 20 = female) were never institutionalized United States born children who had been reared with their biological families. The PFC and NA groups served as comparison groups for the PI children. The inclusion of the PFC group allowed for an investigation of the effects of institutionalization, while controlling for other factors relating to being an internationally adopted child (i.e., poor prenatal health care, prenatal exposure to substances, mental health problems in biological parents). The age criteria of 9 months or older at adoption was chosen for the PI group because much of the literature involving internationally-adopted children suggests that older age at adoption (i.e., greater than 6 months) is associated with higher risk for demonstrating difficulties in emotion and behavior regulation (e.g., Colvert et al., 2008).

Age at testing. Amongst all children, groups differed in terms of age at time of testing, F (2, 95) = 3.63, $p < .05$ (see Table 3) with a trend for the PI group to be slightly older than the NA group (p = .06). Age at testing was negatively associated with several skin conductance variables; thus, this variable was entered as a covariate in analyses involving all skin conductance.

Demographics. The PI, PFC, and NA groups did not differ based on the proportion of males to females, χ^2 (2, N = 98) = 0.89, *ns*. The families of the children in the PI, PFC and NA groups were quite similar demographically (see Table 3), only differing significantly on a couple of variables. Groups differed on age of the parents, respondent: F (2, 91) = 28.25, $p < .001$; partners: F (2, 84) = 13.82, $p < .001$. Specifically, the PI and PFC groups had parents who were older in age than parents in the NA group ($p < .001$ for respondent and partners). In terms of marital status, the PI and PFC groups were combined and compared to the NA group to help balance cell frequencies. In the NA group, 100% of families were married or living with a partner. In the internationally-adopted group, 86% of families were married or living with a partner, 3.5% were separated or divorced (with date of separation unknown), 8.8% were single never married, and 1.8% were widowed (with date of death of partner unknown). To increase cell frequencies, the categories separated/divorced, single never married, and widowed were combined and compared to the married/living with partner category. There was a moderate association between marital status and group, φ = -0.24, $p < .05$, 25% of cells had an expected cell frequency less than 5. The PI, PFC, and NA groups did not differ on education level of the respondent or their partner [respondent: *F* (2, 93) = 0.16, *ns*; partners: *F* (2, 84) = 2.56, *ns*]. Additionally, groups did not differ based on annual household income, *F* (2, 91) = 2.84, *ns*. Demographic variables that differed amongst groups were not significantly related with physiological, or behavioral measures of interest and were not included in further analyses.

Adoption demographics. Tables 1 and 2 contain descriptive statistics for origin of adoption by group and adoption demographics. The adopted children differed by group in terms of their region of origin as at the time of testing, countries either invested in institutional care or foster care as their primary means of caring for wards of the state. The majority of PI children were adopted from Eastern Europe and Asia, with 42% from Russia and 40% from China. Of the PI children, the majority of Eastern European adoptees were male, and the majority of Asian adoptees were female, χ^2 (2) = 10.50, $p < .01$, 33% of cells had expected cell frequency less than 5, $\varphi = 0.53$, $p < .01$. The PFC group was primarily adopted from Asia, with the majority coming from South Korea (74%). Of the PFC children, there were similar numbers of males and females by region, $\chi^2(1) = 0.14$, 50% of cells has expected cell frequency less than 5, $\varphi = 0.08$, *ns*. The distribution for age at adoption was severely positively skewed; thus, this variable was log10 transformed. Age at adoption differed between the two groups, with the PFC group being younger than the PI group at adoption, t (59) = 11.09, $p < .001$. Compared to countries utilizing institutional care, countries utilizing a foster care system tend to have regulations in place to permit adoptions of younger children. Due to younger age of adoption, children in the PFC group also spent more time in the USA, and thus, more time in their adoptive family than PI children, t (59) = 3.37, $p < .001$. Because age at adoption and time spent in adoptive family were so highly correlated and reflected a similar underlying construct, only age at adoption was used in further analysis. Within each internationally-adopted group, age at adoption was not related to sex of the child [PFC: t (21) = 0.62, *ns*; PI: t (36) = 0.46, *ns*]. For all internationally-adopted children, parents rated the quality of care they believed their child to have experienced prior to adoption, as well as whether they believed the child had been physically or sexually abused or had experienced socio-emotional neglect. Scores were averaged to create a general index of early care risk (Table 2). Older age at adoption was significantly associated with higher early care risk scores (Table 5). Further examining early care risk scores, it was found that parents of PI children tended to report higher early care risk scores compared to parents of PFC children, t (39.90) = 8.98, $p < .001$, equal variances not assumed, as assessed by the Levene's test, $p < .001$. Notably, there was minimal variance in early care risk scores for the PFC group with almost all parents reporting that their child experienced overall good care within their foster homes, with no experiences of physical, emotional, or sexual abuse. Within the PI group, early care risk scores were not significantly related to age at adoption, $r = 0.12$, and early care risk scores did not differ among the children adopted from Eastern Europe, Asia, and Central/South America [F (2, 34) = 0.42, *ns*], and did not differ by sex [t (36) = 0.41, *ns*].

Health. Children's health status was obtained via parent report in order to examine whether pubertal status, height and weight at testing, history of heart problems, and medication use needed to be included as covariates in analyses. Parents completed the Pubertal Development Scale (Peterson, Crockett, Richards, & Boxer, 1988) to measure pubertal status and potential relations to physiological variables. There were no significant group differences in parents' report of their child's pubertal progress, F (2, 92) = 1.97, *ns*. For the entire sample, parents tended to report that physical changes in their children's bodies had barely started. According to parents, no female in the sample had experienced menarche. Controlling for the age of the child at testing, females tended to have progressed further in puberty than males, F (1, 92) = 15.08, $p < .001$, partial η^2 = .12. Puberty scores were not significantly associated with physiological or behavioral data and thus, were not considered in further analyses. Parents reported on children's medication use in terms of psychotropics, decongestants, acetaminophen, antihistamines, analgesics, cough suppressants/expectorants, antibiotics, as well as medications to control blood pressure, seizures, and asthma. Twenty percent of the entire sample was using at least one of these medications. There was tendency for medication use to be associated with group status, χ^2 (2) = 7.32, Cramer's V = .27, $p < .05$. In the PI group, 34% were taking at least one medication compared to 13% in the PFC group and 11% in the NA group. Medication use was not associated with any other physiological or behavioral measures and was not considered in further analysis. Parents reported on congenital heart defects and history of heart problems: 8% of PI children and 3% of NA children were noted to have a history of heart problems. However, history of heart problems was not correlated with any physiological variables. Height and weight were also measured at testing. Group differences in growth were found, F (4, 190) = 3.31, Pillai's Trace = 0.13, $p < .05$. Follow-up univariate ANOVAs showed that height differed among the groups, F (2, 95) = 3.57, $p < .05$. Post hoc tests revealed that the PFC group was shorter than the NA group ($p < .05$). Height at testing was not correlated with physiological or behavioral measures of interest. No group differences were found for weight.

General cognitive ability. Several studies on typically developing children have found associations between measures of cognitive ability and indices of ANS functioning (e.g., Staton, El-Sheikh, & Buckhalt, 2009). Children were administered the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) to assess general cognitive ability and to explore whether competence in this area needed to be included in analysis as a potential covariate. A Full Scale Intelligence Quotient (FSIQ-2) was calculated based on two subtests: vocabulary and matrix reasoning. The WASI FSIQ-2 has high test-retest reliability, ranging from .83 - .90 (Wechsler, 1999), as well as good concurrent validity with other tests of intelligence (Hays, Reas, & Shaw, 2002). FSIQ-2 scores for two participants (both in the NA group) were missing due to the children refusing to complete the vocabulary subtest, though they did complete the matrix reasoning portion. Group differences in FSIQ-2 were found, F (2, 89) = 3.58, $p < .05$. The PI group had significantly lower scores than the NA group, $p < .05$. To further inspect this difference in FSIQ, the vocabulary and matrix reasoning subtest scores which comprise the FSIQ score, were submitted to a one-way MANOVA to examine group differences. Group differences were found on the vocabulary and matrix reasoning scores, F (4, 178) = 3.90, Pillai's Trace = 0.16, $p = .01$, partial $\eta^2 = .10$. Follow-up univariate ANOVAs showed that vocabulary subtest scores differed among the groups (using an adjusted Bonferroni alpha level of .025), F (2, 89) = 6.50, $p < .01$, partial $\eta^2 = .13$. Post hoc tests revealed that the PI group had lower vocabulary subtest scores than the NA group ($p < .01$). No group differences were found for the matrix reasoning subtest, F (2, 89) = 0.30, *ns*. FSIQ, vocabulary, and matrix reasoning scores were not significantly correlated with physiological or behavioral variables.

Recruitment

This study was approved by the University of Minnesota's Institutional Review Board. Internationally adopted children were recruited from the International Adoption Project Registry, a database consisting of over 3,000 internationally adopted children whose families were interested in research participation. Families in the database were called and emailed information regarding the study. This study was also advertised on the International Adoptions website and in the International Adoption Project annual newsletter sent to families in the database. Children in the NA group were recruited from the Institute of Child Development Participant Pool which consists of families interested in participating in research. Flyer advertisements of the study were also distributed within St. Paul and Minneapolis businesses, schools, and community centers. Every family with a child who met criteria to be in one of the three groups, PI, PFC, and NA, was invited to participate in the study. However, children with severe learning impairments which would make it difficult to read and comprehend questionnaires were excluded from participating. In order to reduce the likelihood that group differences were due to prenatal or congenital conditions, children were also excluded if they had a known genetic disorder, pervasive developmental disorder, or medically diagnosed Fetal Alcohol Spectrum Disorder (FASD). Photographic screening using the FAS Facial Photographic Analysis Software (Astley, 2003) was also used to analyze the Center for Disease Control's guidelines regarding FASD associated facial dysmorphia (i.e., smooth philtrum, thin vermillion border, and small palpebral fissures) based on digital pictures taken during the laboratory session. No participant was identified as having facial morphology indicative of fetal alcohol exposure. Children with exposure that did not impact detectable differences in facial morphology were not identified by this method. As an additional screen for FASD, parents reported the information they had gathered which led them to believe that their child had fetal alcohol exposure. Two participants were excluded due to having a previous medical diagnosis of FASD. Another two participants were excluded based on parent-report of strong suspicions of fetal alcohol exposure (i.e., information from the adoption agency, child's medical records).

Procedure

Lab visit. The child and one parent attended a 2-hour laboratory session at the University of Minnesota's Center for Neurobehavioral Development. Informed parent consent and child assent were collected before the start of the session. During recruitment, mothers were asked to attend the session, fill out questionnaires, and participate in session activities. Ninety-seven percent of participants attended the session with their mother. For three children (one PI, one PFC, and one NA), fathers attended the session, participated with the child, and filled out questionnaires. First, growth measures were collected and then the child and experimenter filled out questionnaires together for about 30 minutes. Next, children participated in a series of tasks designed to capture baseline measures of autonomic activity as well as to elicit autonomic responses to cognitive and emotional challenge tasks. Because the cardiovascular system is activated by body movement, posture, speaking and social engagement (Bush et al., 2011; Donzella, Tottenham, & Gunnar, 2009), autonomic levels collected during each challenge task were referenced to levels collected during a "control task" which paralleled the motor and engagement demands of the challenge. Thus, autonomic reactivity indices reflect psychophysiological reactivity to each challenge, controlling for other factors which activate the ANS. The experimenter left the room and went to the data collection room where the child could be seen on a television screen. Experimenter and child communicated over a microphone. Resting baseline autonomic activity (3 minutes) was recorded as the child sat quietly. As a cognitive task (3 minutes), the child participated in a forward and backward digit-span test derived from the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999). For this task, the child heard strings of numbers spoken aloud by the experimenter over a microphone and was asked to repeat the strings of numbers as they became increasingly longer. For the cognitive control task, the child was presented with two stories on a computer screen and was asked to read each page of the story aloud (3 minutes). This control task captured autonomic activity associated with speaking and focused attending and paralleled the speaking demands of the cognitive challenge. Each story was non-emotional in nature and was written at a 1st grade reading level to reduce the risk of making this a challenge task. As a positive emotion evoking task (3 minutes), the parent and child sat in the same room and discussed a topic that would evoke positive feelings from the child. The child chose one of the following topics: plan a party, plan a perfect day, plan a parent-child outing, or plan a dream vacation. As a conflict discussion task (3 minutes), the parent and child sat in the same room and discussed one topic that was typically associated with anger or conflict, which the experimenter had pre-selected. The experimenter presented the task to the dyad saying: *"You and your parent will have a conversation about [topic]. This is a topic that one or both of you have disagreed on recently. You will have 3 minutes to talk. For the first 2 minutes, you will talk about this topic. Why is this topic a problem? How does it make you each feel? For the last minute, you will discuss solutions to the problem and* *come up with a solution that you both agree upon."* As the emotion control task, parent and child sat in separate rooms and each took turns speaking into a microphone to read aloud pages from two books selected for their 1st grade reading level and unemotional content. This control task captured physiological responding associated with speaking and social engagement. Physiological levels during this task were used as the reference when calculating reactivity to the conflict discussion and positive emotion evoking tasks. The cognitive, positive emotion, and conflict discussion tasks were presented in a counterbalanced order for each group. For the last hour of the session, the child was administered a brief IQ test and completed several more questionnaires. At the end of the session, children received $15 in Target gift certificates and a small bag filled with toys.

Measures

Respiratory sinus arrhythmia (RSA) collection. Children's RSA was obtained during the six 3-minute collection periods: resting baseline, cognitive control task, emotion control task, cognitive task, positive emotion-evoking task, and conflict discussion task. Cardiac measures were obtained from a single set of electrodes. Four spot disposable electrodes (two current, two impedance) were placed in a non-standard configuration on the child's body: attached to the nape of the neck, below the right clavicle, on the backside of the right ribcage, and on the right side of the lower abdomen. A 500-μA AC current at 50 kHz was passed through the two outer current electrodes, and both thoracic impedance (Z_0) and the first derivative of change in impedance over change in time (dz/dt) signals were acquired from the two inner electrodes. Raw ECG data were amplified using a Biopac ECG 100C amplifier set for a gain of 1000 and using low- and high-pass filters of 0.05 – 35 Hz. The data was digitized at a rate of 1000 samples per second and processed using the James Long Company's IBI Analysis System. The software automatically detected R-spikes, which were then manually edited by trained researchers who corrected spurious and missing r-spikes, as well as removed artifact. Twenty percent of the data was double-scored for reliability and artifact replacement was reliable with correlations of .98 or higher. The r-spike times were converted to inter-beat-intervals (IBIs) and then pro-rated into 125 millisecond (ms) windows. The pro-rated IBIs were de-trended using a moving polynomial algorithm that isolates IBI variability at the amplitude and period of the oscillations associated with breathing. The residuals were discrete Fourier transformed yielding spectral power attributable to RSA, reported in units of $\ln(\text{msec})^2$. Using 64-second overlapping epochs of data, IBI variance that fell in the expected frequency band for children (0.24- 1.04 Hz, Bar-Haim, Marshall & Fox, 2000) was extracted to reflect RSA or the parasympathetic input to the heart (Porges, 1995). Each 3-minute condition yielded four epochs of data. Estimates of variance were computed across the 4 epochs; variance values greater than 1 were inspected for outliers. Outlier epochs were dropped if they differed significantly from the rest of the values within a condition. Data for each condition was aggregated across the epochs to provide values of RSA for the baseline and challenge tasks.

Nonspecific skin conductance response (NS.SCR) collection. Phasic increases in skin conductance were captured by measuring exosomatic non-specific skin conductance responses (NS.SCR, expressed in microSiemens, μS) continuously for each of the six tasks using the Biopac System, Inc. MP100 unit. Two silver-silver chloride (Ag/AgCl) electrodes filled with Biopac Isotonic Recording Gel were attached with velcro bands to the volar surfaces of the distal phalanges of the second and third digits of the nondominant hand. The area of contact area between gel and skin was 1 cm in diameter. Electrodes were placed on the hand approximately 1- to 5 minutes before the start of recording and were left on the hand for the duration of the tasks (about 30 minutes). A Biopac GSR 100C DC amplifier was used to excite a constant voltage through the electrode pairs, and the current change, representing conductance, was recorded. Signals were amplified using a gain of 10 $\mu\Omega$/V, a low pass filter of 10 Hz, and a high pass filter of 0.05 Hz. Output from the amplifier was digitized at 500 samples per second and stored on a personal computer. Raw data was processed and scored using Acq*Knowledge* software (Version 3.7.3). To eliminate any high frequency noise components of the NS.SCR signal, a finite impulse response filter using a Hamming window and 2.0 Hz cutoff frequency was applied to the raw signals. NS.SCRs were visually inspected and hand scored based on the detection of peaks and troughs. Peaks with an amplitude greater than 0.05 μS and having the typical canonical shape were scored. Based on recommendations from several studies, (reviewed in Bach, Friston, & Dolan, 2010) an area under the curve (AUC) parameter was calculated to capture frequency, amplitude, and half-time recovery of each skin conductance fluctuation. AUCs for each fluctuation were summed to produce a total AUC value for each condition.

Parent-child conflict. Parent and child independently filled out the Conflict Discussion Questionnaire (CDC; Granger, Weisz, & Kauneckis, 1994). The CDC lists 18 topics thought to be potential sources of parent-child problems, such as doing homework and fighting with a sibling. Topics discussed within the past 4 weeks were rated, on a scale of 0-3, based on how angry the discussions were between the parent and child. The experimenter reviewed both respondents' CDCs and selected one topic to be used for the conflict discussion task described next. For selection, the topic had to meet the following criteria: 1.) be endorsed by child and/or parent as being a topic of recent conversation and 2.) having evoked anger from child and/or parent. The 18 discussion topics were categorized into 7 general themes; of the entire sample, fighting with siblings (28.9%) was the topic most commonly selected for the parent-child conflict task. Dyads also discussed problems at school (25.8%), chores and responsibilities (19.6%), respect of authority figures (8.2%), use of electronics (6.2%), extracurricular activities (6.2%), and allowance and money management (5.2%).

Coping with children's negative emotions (CCNES). The Coping with Children's Negative Emotions Scale (Fabes, Eisenberg, & Bernzweig, 1990) is a self-report questionnaire that measures parents' reactions to children's negative display of emotion. Parents were presented with 12 vignettes in which their child was upset but not harming anyone and were asked to rate the likelihood on a scale of 1 (very unlikely) to 7 (very likely) of responding in two particular ways: distress reactions ($\alpha = 0.73$) and expressive encouragement ($\alpha = 0.76$). Distress reactions refer to the degree to which the parent becomes distressed when their child expresses negative emotions. Expressive encouragement reflects the degree to which parents accept the child's display of negative emotion. Previous research has found the CCNES to have good internal and test-retest reliability and good concurrent and construct validity (Eisenberg & Fabes, 1994; Fabes, Poulin, Eisenberg, & Madden-Derdich, 2002). Although the CCNES was created for use with preschool children, several studies have supported its use in middle childhood (e.g., Jones, Eisenberg, Fabes, & MacKinnon, 2002).

Externalizing behavior. Parents completed the MacArthur Health and Behavior Questionnaire for Late Childhood and Adolescence version 2.1 (HBQ-P v.2.1; Boyce et al., 2002; Essex et al., 2002). The HBQ-P assesses symptoms occurring within the past 6 months on a 0 ('never or not true') to 2 ('often or very true') scale and has been found to show strong psychometric properties (Essex et al., 2006; Shirtcliff & Essex, 2008). The externalizing subscale (α = .85) consisted of items indexing overt hostility, relational aggression, conduct problems, and oppositional defiant behavior. The percentage of children meeting the clinical cutoff of 0.68 for externalizing behavior was examined. This cutoff was set based on analysis of the HBQ-P with children of approximately the same age as the present study (Lemery-Chalfant et al., 2007).

Analysis Plan

Missing data. The percentage of missing RSA and NS.SCR data by group status are listed in Table 6. Statistics are summarized for child refusal rates and unusable data due to artifact, misplacement/displacement of the ECG electrodes, or other sources of equipment malfunction at the time of testing. The groups did not differ in rates of missing RSA and NS.SCR due to refusal or data usability. Additionally, analyses of whether those with missing data differed from those without missing data were conducted for each of the predictive measures, and none of these measures was significant. Thus, the data were assumed to be missing at random. Because the percentage of missing RSA data was low in the PI and NA groups, original values were used in further analyses. However, a significant percentage of NS.SCR data was missing; therefore, missing skin conductance data was multiply imputed and used in further regression analysis.

Missing data were imputed using multivariate imputation by chained equations

(MICE; version 2.0; van Buuren & Groothius-Oudshoorn, 2000) software in R version 2.11.2 (R Development Core Team, 2010). The Gibbs sampler algorithm was implemented to fill out the missing data. MICE employed fully conditional specification (FCS), which specified the multivariate imputation model on a variable-by-variable basis by a set of conditional densities, one for each incomplete variable. FCS draws imputations by iterating over the conditional densities. For this dataset, 10 iterations were used for 10 imputed datasets, a recommended amount to achieve healthy convergence of the Gibbs sampler algorithm (van Buuren, Oudshoorn, & Rubin, 2006). Variables were imputed using predictive mean matching, a general purpose semi-parametric imputation method (Little, 1988). Its main virtue is that imputations are restricted to the observed values. To assess convergence, imputed variables were examined to determine that each of the 10 streams of imputed data freely intermingled with each other, without showing any definite trends. The means and variances of the imputations for each variable were visually inspected; no trends were apparent and across the 10 streams of iterated data, the streams mingled very well right from the start. The missing at random assumption could not be tested from the observed data. Despite this, each imputation was checked to verify plausibility. The densities of both the observed and imputed values of all variables were plotted and found to be reasonable.

Covariates. Group differences were found in age at testing. Because this variable was also found to be correlated with baseline NS.SCR and NS.SCR during the positive task, it was included as a covariate in all analysis involving skin conductance. Sex was entered as a covariate in all regression analysis.

Physiological reactivity to challenges. It was necessary to determine whether the three challenge tasks were successful in eliciting significant change in children's levels of RSA and NS.SCR, compared to levels measured during the control tasks. To investigate reactivity during the challenge tasks, a repeated-measures analyses of variances (ANOVA) was performed for RSA examining the following unstandardized values as dependent variables: talking control, social control, conflict discussion, positive emotion, and cognitive levels. Significant findings were examined using three planned contrasts comparing: 1.) social control task to the conflict discussion task, 2.) social control task to the positive emotion task, and 3.) talking control task to the cognitive task. NS.SCR values for the baseline, conflict discussion, positive emotion, and cognitive tasks were positively skewed. Raw values were submitted to a log10 transformation, then a repeated-measures ANOVA was performed with the following transformed values as dependent variables: baseline, conflict discussion, positive emotion, and cognitive levels. Significant findings were probed using three planned contrasts comparing levels elicited by the challenge tasks to the baseline level.

Group differences in emotion socialization. A multivariate analysis of covariance (MANCOVA) was performed examining group status as a between-subjects factor, sex as a covariate, and the parent distress and expressive encouragement scores as the dependent variables.

Predicting baseline physiological functioning and reactivity to challenge. Hierarchical multiple regression analyses were used to examine the moderating effects of parents' distress reactions and expressive encouragement to children's negative emotions on the relationship between group status and baseline levels of RSA and NS.SCR as well as RSA and NS.SCR reactivity to the three challenge tasks. A total of eight hierarchical regressions were computed. Step 1 contained any necessary covariates. Step 2 contained the main effects of group status (PI group served as the reference group). Step 3 contained the main effects of parent distress and expressive encouragement. Step 4 considered the centered interactions of group status with parents' distress responses and group status with expressive encouragement. For all analyses, significant interaction effects were tested using procedures outlined by Baron and Kenny (1986) and further examined using the simple slopes technique proposed by Aiken and West (1991). Pearson product-moment correlations were computed to examine relations between physiological and emotion socialization variables with age at adoption and early care risk.

Correlates of externalizing behavior. Scores for externalizing behavior were positively skewed and were transformed using a log10 transformation. A univariate analysis of covariance (ANCOVA) was used to examine group differences in externalizing behavior, controlling for sex. Planned contrasts with Bonferroni corrections were used to examine differences between the PI and comparison groups. Pearson product-moment correlations were computed examining relations among externalizing behavior, age at adoption, and early care risk.

Pearson product-moment correlations were computed within the PI group examining relations between externalizing behavior with the following variables: baseline RSA and NS.SCR, reactivity scores for RSA and NS.SCR across the three challenge tasks, parent distress, and expressive encouragement. When significant associations between physiological variables and externalizing behaviors were found, they were followed up to examine how parental distress and expressive encouragement might impact the association (either mediation or moderation analysis depending on which was appropriate). Due to low sample size, only one physiological variable could be examined at a time. Because sex was associated with externalizing behavior, sex was controlled in all mediation and moderation analyses. Correlations within the NA and PFC groups were also performed using the same procedures.

Results

Group Differences in Parent Emotion Socialization Results

The descriptive statistics and bivariate correlations for parents' distress reactions and expressive encouragement scores are listed in Tables 5 and 7. The MANCOVA revealed no significant main effect for group status, controlling for sex [distress reaction: F (2, 92) = 1.02, *ns*; expressive encouragement: F (1, 92) = 0.34, *ns*]. Thus, parents' report of their emotion socialization practices did not vary by group status. Examining just the internationally-adopted children, bivariate correlations revealed that parents' distress reactions and expressive encouragement were not significantly associated with age at adoption or early care risk scores.

Physiological Reactivity to Challenges Results

For NS.SCR, the assumption of sphericity was violated, as assessed with Mauchly's test of sphericity, $\chi^2(5) = 25.55$, $p < .01$. Therefore, a Huynh-Feldt correction was applied ($\varepsilon = 0.84$). Results revealed that NS.SCR levels changed across the baseline and challenge tasks, F (2.53, 179.29) = 37.29, $p < .001$, partial $\eta^2 = .34$. Specifically, compared to baseline levels, NS.SCR significantly increased for the conflict discussion, positive emotion, and cognitive tasks ($p < .001$ for each). See Figure 2 for NS.SCR mean levels across tasks. RSA also showed evidence of change across tasks, F (4, 340) =

16.51, $p < .001$, partial $\eta^{2} =$ .16. During the conflict discussion and positive emotion tasks, RSA levels significantly decreased from the social control task ($p < .001$). RSA increased during the cognitive task compared to the talking control task ($p < .001$). See Figure 3 for RSA mean levels across tasks.

Standardized residual scores were computed for each challenge task by regressing values elicited during each challenge task on the respective control task values. Descriptive statistics for residual scores are listed in Table 4.

Predicting RSA Baseline and Reactivity Results

Descriptive statistics and bivariate correlations for the baseline RSA analyses are summarized in Tables 4 and 5. Multiple regression results are summarized in Table 8. The addition of group status in step 2 led to non-significant changes in R^2. When parents' distress reaction and expressive encouragement variables were entered in step 3, they were also found to be non-significant predictors. The addition of interactions in step 4 resulted in a significant increase in R^2. There was a significant interaction of parents' distress reaction by group status for the PI versus NA comparison, when sex was in the model. Examination of simple slopes revealed a significant positive association between parents' distress reactions to children's negative emotions and baseline RSA for the PI group, $b = 1.01$, $p < .01$, 95% CI: 0.33 – 1.69. As shown in Figure 4, PI children showed higher baseline RSA in the context of high parental distress reactions and lower baseline RSA in the context of low parental distress. There was a significant interaction of parents' distress reaction by group status for the PI versus PFC comparison, when sex was in the model. The simple slope for the PFC group was significant, $b = -1.26$, $p < .01$, 95% CI: -2.04 – -0.49. Examination of Figure 4 shows that for the PFC group, parent distress was negatively associated with basal RSA. The slope for the NA group was not significant, *b* = -0.20, *p* = .43. The interactions for group status and parental expressive encouragement were not significant. Overall, the predictors in step 4 accounted for 25% of the variance in baseline RSA. RSA was not significantly correlated with age at adoption or early care risk (Table 5).

Because parent distress was correlated with externalizing behavior ($r = .37$), it was important to ensure that significant interactions were associated with parent distress and not being driven by the child's behavior. The externalizing variable was substituted for parent distress in the regression equation, which included group status and sex. Main effects and interactions were not found to be significant predictors of baseline RSA. To test the robustness of the significant interaction of parent distress and group status in predicting RSA, basal levels of RSA for the challenge conditions were used as dependent variables. For each regression, the interaction of group status and parent distress remained a significant predictor for both PI versus NA and PI versus PFC comparisons with comparable unstandardized *B* coefficients.

For RSA reactivity to the three tasks, descriptive statistics and bivariate correlations for the variables are summarized in Tables 7 and 5. The multiple regression results for RSA during the conflict discussion task are listed in Table 9. Results revealed no significant main effects for group status in step 2. The addition of the distress reaction and expressive encouragement variables in step 3 resulted in non-significant changes in R^2. Step 4 resulted in a marginally significant change in R^2. The interaction of group status for the PI versus NA group and parent distress, as well as the interaction of group status for the PI versus PFC group and parent distress were significant. Examination of simple slopes for the PI group revealed a positive association between parent distress and RSA reactivity, $b = 0.57$, $p < .05$. The slopes for the NA and PFC groups were not significantly different than zero. Overall, the predictors in step 4 accounted for 7% of the variance in RSA reactivity. RSA reactivity during the conflict task was negatively associated with early care risk scores, $r(55) = -.28$, $p < .05$. However, when just the PI group was examined, RSA during this task was not significantly associated with early care risk scores.

For RSA during the positive and cognitive tasks, results were similar showing that when sex was controlled for, group status, parent distress, and expressive encouragement were not significant predictors of RSA reactivity. When interactions were added in step 4, this resulted in a non-significant change in R^2. Reactivity scores for these tasks were not significantly correlated with age at adoption or early care risk for the internationally-adopted children.

Predicting NS.SCR Baseline and Reactivity Results

Descriptive statistics and bivariate correlations for the variables in the multiply imputed dataset for non-specific skin conductance response are summarized in Tables 4 and 5. Tables 12 – 15 summarize the results of the multiple regressions predicting baseline NS.SCR and NS.SCR during the three challenge tasks. For the four multiple regressions predicting skin conductance at baseline and reactivity to the challenges, the addition of group status resulted in a non-significant change in R^2. The addition of parents' support response in step 3 and the interaction of parents' support responses by group status in step 4 led to non-significant changes in R^2.

Predicting Externalizing Behavior Results

Descriptive statistics and bivariate correlations for externalizing behavior are summarized in Tables 7 and 5. Eleven percent of PI children scored above clinical cutoff for externalizing behaviors. No children in either comparison group scored above the clinical cutoff. Controlling for sex, group differences in externalizing behavior were found, F (2, 93) = 10.81, $p < .001$, partial $\eta^2 = .19$. Planned comparisons revealed that the PI group scored significantly higher in externalizing behavior than both the NA and PFC groups. Externalizing behavior was correlated with age at adoption and early care risk when all internationally-adopted children were examined. However, because group status was confounded with age at adoption, and there was very little variability in early care risk scores within the PFC group, bivariate correlations were examined within each group separately. Within the PI group, externalizing behavior was not correlated with age at adoption or early care risk. Externalizing behavior was also not related to these variables in the PFC group.

Predicting externalizing behavior from parent emotion socialization and physiology within each group. Within the PI group only, baseline RSA was positively correlated with externalizing behavior ($r(36) = 0.34$, $p < .05$), and parent distress was related to both baseline RSA ($r(36) = 0.46$, $p < .01$) and externalizing behaviors ($r(37) = 0.52$, $p < .01$), suggesting a potential mediational role of parent distress. Using the program PROCESS for SPSS (Hayes, 2012), total, direct, and indirect effects were calculated. Controlling for sex, the total effect of baseline RSA on externalizing behaviors was significantly different from zero, $b = .02$, $p < .05$. The direct effect of baseline RSA on externalizing behavior, controlling for sex was not significantly different from zero. To test the indirect effect of baseline RSA on externalizing behavior, a bootstrap approach was favored over more traditional tests because this approach makes fewer unrealistic assumptions regarding the shape of the sampling distribution of the indirect effect and is more powerful (Preacher & Hayes, 2008). The indirect effect was 0.01, with a bias corrected 95% bootstrap confidence interval of 0.0034 – 0.0317, based on 1,000 resamples. Thus, results revealed support for a mediating effect, such that higher RSA was associated with more externalizing behaviors, as a result of the effect of high parent distress on RSA, which in turn, influenced externalizing behaviors. For skin conductance, only NS.SCR during the positive task was related to externalizing behavior, $r(28) = 0.37$, $p = .05$. NS.SCR was not significantly associated with parent distress indicating that parent distress was not a mediator. It was tested whether parent distress served as a moderator of the relationship between NS.SCR and externalizing behavior. A regression analysis was conducted examining the main effects and interaction of parent distress and NS.SCR in predicting externalizing behavior. The interaction term accounted for a significant portion of the variance in R^2 (12%), $B = 0.05$, $p < .05$. The Johnson-Neyman approach was used to probe the interaction (Hayes & Matthews, 2009). This approach identified values of parent distress where the conditional effect of NS.SCR on externalizing behavior transitioned from non-significant to significant ($\alpha = .05$). Recall that distress scores range from 1 = highly unlikely to react with distress to 7=very likely to react with distress. When distress scores were at 2.68 or less, there was no significant association between NS.SCR and externalizing scores. For distress scores above 2.69, there was a significant positive association between NS.SCR and externalizing scores. For the NA and PFC groups, no significant associations between externalizing behavior and physiological variables were found.

Pearson product-moment correlations between RSA and NS.SCR at baseline and reactivity during the challenge tasks were examined within the PI group. RSA and NS.SCR reactivity during the positive emotion task were significantly correlated, $r(25) = .42$, $p < .01$. This relationship was subjected to a zero-order partial correlation controlling for the effects of parent distress. The partial correlation was found to be significant, $r(22) = .41$, $p = .05$, indicating that a modest relationship between RSA and NS.SCR during the positive task was apparent above and beyond the effects of parent distress, but that the relationship was lessened by the distress variable. Significant correlations between RSA and NS.SCR were not found in the NA and PFC groups.

Discussion

The present study sought to better understand the role of early caregiving and parent emotion socialization practices in shaping two indirect indices of ANS functioning: respiratory-sinus arrhythmia and skin conductance at baseline and across several types of ecologically valid tasks. Group differences in parent emotion socialization practices were not found. Parent distress was found to moderate the relationship between early care and RSA. This study also sought to compare the PI to the NA and PFC groups on levels of externalizing behavior. The PI group showed higher levels of externalizing behavior than both NA and PFC groups. Furthermore, within this group, RSA, skin conductance, and parent distress were found to play important roles in predicting externalizing behavior. The results are reviewed with implications for future research.

Group Differences in Post-adoption Emotion Socialization Practices

It was hypothesized that the PI group would differ from the comparison groups on emotion socialization practices, though the direction of difference was not predicted. The present study did not find evidence to support this claim. Group differences were not found on parent distress or expressive encouragement, nor were these practices found to correlate with age at adoption or early care risk. Thus, group status alone did not seem to explain substantial variability in parents' use of emotion socialization practices. This finding is consistent with others showing that compared to non-adoptive parents, parents of internationally-adopted children show comparable rates of non-hostility and sensitivity (Garvin et al., 2012).

Group Differences in Externalizing Behavior

It was predicted that children adopted from institutions would show higher levels of externalizing problems than non-adopted children and children adopted from foster care. Results confirmed that the PI group showed higher levels of externalizing behavior compared to both NA and PFC groups. It is assumed that the PI group endured caregiving that is typical of institutional life: routine care from rotating staff with little responsive and contingent socio-emotional interaction. That the PI group showed more problematic behavior than the PFC group lends to the notion that the lack of sensitive and responsive care early in life, and not other factors related to international adoption, were major contributors to behavioral outcomes. However, because this is a correlational and not experimental study, the causal relation between institutional care and later outcomes is always open to question. It should be noted that the present finding is in direct contrast to the Wiik et al. (2011) study which concluded that since PI and PFC groups showed higher levels of parent-reported externalizing behavior on the HBQ, that general adversity early in life was the contributing factor and not socio-emotional neglect per se. Interestingly, the PFC group in the present study exhibited the lowest level of externalizing behavior, whereas 11% of PI children scored in the clinical range and the NA group fell in-between. The percentage of children scoring in the clinical range is comparable to that found in the Wiik et al. study which found that 9% of PI children scored above the clinical cutoff. However, the lower levels of externalizing behaviors found for the PFC group in the current study was surprising. In both the present study and the Wiik et al. study, the PFC groups were adopted before 8 months of age and came from similar parts of the world, so comparable rates of externalizing behavior were expected. It could be that the PFC children in the Wiik et al. study were exposed to more risk; unfortunately, early risk scores were not reported leaving it unknown whether exposure to adversity was a contributing factor. In the present study, we do know that when early care risk scores were examined for the PI and PFC groups separately, they were unrelated to externalizing behavior. The children in the Wiik et al. study were slightly older (8-11 years) than in this study. It has been suggested that behavior problems of internationally-adopted children may emerge with entry into adolescence (Colvert et al., 2008). Though correlations between age at testing and externalizing behavior were not reported in the Wiik et al. study, perhaps more externalizing behaviors emerged with age in their PFC group.

In the present study, age at adoption was positively correlated with externalizing behavior; however, this finding is difficult to interpret because group status was confounded with age at adoption. To address this challenge, the two groups were investigated separately and neither group showed significant associations between the two variables. Thus, the present study suggests that age at adoption for the PI group showed no significant association with externalizing behavior and is in line with several other reports (Juffer & Van IJzendoorn, 2005; Groza 1999; Marcovitch et al., 1997; Kreppner et al., 2007). However, it is likely that there was not sufficient variability in age at adoption to detect a dose-response relationship, as most of the PI group was adopted between 12-18 months.

Did the challenge tasks engage the PNS and SNS systems?

Engagement of the PNS was explored to examine whether the challenge tasks utilized in this study were successful in eliciting RSA responses relative to tasks that controlled for the effects of speech, motor movement, attending, and social engagement in order to obtain purer measures of reactivity to emotional and cognitive stimuli (Bush et al., 2011; Donzella et al., 2009). For this study, skin conductance reactivity was compared to resting baseline level, with results showing that there were significant increases in skin conductance during the challenges compared to baseline levels. Interestingly, the three challenges did not elicit significantly different skin conductance levels. It has been suggested that NS.SCR may be best suited to measure general arousal as a unitary construct. It has also been hypothesized that NS.SCR may be regarded as a sensitive and valid indicator of variations in arousal in the lower range, as it appears to reflect small, mostly cognitively determined variations in arousal. As moisture in the skin increases due to high arousal, NS.SCR may become less sensitive to small variations in sweat gland activity (Boucsein, 2012). Perhaps it was the case that all the tasks in the current study elicited more than mild arousal, so that subtle variations in NS.SCR to the different task demands were not detectable. Erath and colleagues (2011) noted similar findings: children did not show skin conductance reactivity differences between a star-tracing challenge and listening to a simulated inter-adult argument, again calling into question how sensitive skin conductance is to negatively valenced stimuli. In order to better interpret arousal based on NS.SCR, more research is need examining neural processes in conjunction with skin conductance during various tasks, as neural activity can better explicate whether the arousal is cognitively or emotionally-driven. Additionally, more basic research is needed investigating to what extent skin conductance is influenced by contextual factors such as different emotion induction tasks, social versus non-social conditions, movement, and focused attending.

Interestingly, reading a story independently into a microphone (controlling for attention and speech) led to greater RSA withdrawal than the cognitive challenge of repeating back short strings of digits. This is somewhat similar to what Bush and colleagues found (2011) when comparing their cognitive task to its control task. In that study, children showed greater RSA withdrawal and lower PEP when repeating back single digits compared to when they repeated back longer strings of digits. Perhaps the cognitive challenge employed in the current study was not challenging enough and it was really just measuring attention – and its associated control task recruited too much cognitive effort or focus. Although the story chosen for the cognitive control was at a 1st grade reading level, it was observed that several children had difficulty reading it and having to read aloud into a microphone might have been interpreted as threatening. If this was the case, then reactivity to the cognitive challenge would be masked and we would not have a valid measure of RSA reactivity. Indeed, the cognitive control task appeared to elicit RSA withdrawal similar in magnitude to the conflict discussion and positive emotion tasks.

Children displayed RSA appropriate withdrawal to the positive and conflict discussion tasks. This is similar to what other studies have found when using tasks that require the child to engage with their parent, watch emotionally-evocative film clips, or engage in a discussion with an experimenter (Bush et al., 2011; Calkins et al., 2008; Obradović et al., 2011) suggesting that interpersonal situations tend to engage the vagal system. These tasks led to greater RSA withdrawal compared to the social control task of reading a story with the parent when parent and child were in different rooms. Notably, the social control task elicited a RSA withdrawal compared to resting baseline which was expected, but again, the magnitude of this response was great and could have potentially masked the reactivity to the emotion tasks because of the cognitive effort required to read the stories with the parent. Another unexpected finding was that just reading the story with the parent elicited a significant increase in RSA compared to the cognitive control where the child read alone. Did the parent act as a calming agent? Based on the Polyvagal Theory's idea of vagal tone supporting a social engagement system, would not we expect more RSA withdrawal when the child engaged with the parent, as other studies have found (e.g., Calkins et al., 2008; Hastings et al., 2008)? Taken together, these findings suggest that RSA is highly sensitive to the effects of manipulating laboratory conditions, and when conditions are not properly controlled, it is difficult to understand what stimuli participants are reacting to. To date, we have just a general impression of what basal RSA and RSA reactivity actually signify and our interpretations become tenuous when challenge tasks are not properly controlled for.

Expressive Encouragement as a Predictor of Child Physiology

Assuming that the autonomic system remains relatively plastic throughout childhood, it was hypothesized that group status would interact with parent emotion socialization practices to predict RSA and skin conductance. Parents' expressive encouragement was not found to predict RSA or skin conductance, nor was it found to interact with group status to predict these variables at baseline or in response to challenge. In general, the literature in normative samples has found few significant correlations between positive supportive emotional socialization practices and child physiology, particularly in older children. When significant correlations are found, they tend to be between indices of physiology and negative socialization practices (e.g., Hastings & De, 2008). For the present study, parent distress did seem to be a better predictor of outcomes rather than expressive encouragement.

Parent Distress as a Predictor of Child Physiology in the NA and PFC Groups

Parent distress moderated the relationship between group status and basal RSA. Though the NA and PFC groups served as comparisons, they each displayed unique patterns and will be discussed separately.

NA group. Examination of simple slopes for each group showed that for the NA group, basal RSA was unrelated to parent distress, which is in-line with several studies in community samples of low-risk families where strong relations between emotion socialization behaviors and RSA have not been found, particularly in older children (e.g., Hastings & De, 2008; Kennedy et al., 2004; Rubin et al., 1997). Considering the developmental progression of emotion regulation competence, it could be that while parental socialization efforts remain important throughout the child's life, there are other more salient socialization agents (e.g., peers, siblings, media) in this specific developmental period. The NA children may have also relied more on internal regulating processes, such as cognitive suppression and reappraisal, rather than on external processes to help them cope. Additionally, only two socializing practices were measured. It could be that other practices, such as parental negative control, would serve as better predictors of RSA (Hastings et al., 2008).

PFC group. For the PFC group, a significant negative association was found between basal RSA and parent distress. Higher parent distress was related to lower baseline RSA. This negative association is comparable to animal and human studies on at-risk samples, which have shown lower baseline RSA and poorer RSA suppression under conditions of early maternal separation (Trombini et al., 2012), marital conflict (Porter et al., 2003), maltreatment (Skowron et al., 2011), and foster care within the US (Oosterman & Schuengel, 2007). Unfortunately, the level of early life risk for the PFC group is poorly understood. The reliance on parent report of early care was a limitation of this study, as parents have been found to know very little of their child's pre-adoption quality of care. Though it is assumed that they did not endure the severity of socio-emotional neglect seen in institutions, they are vulnerable to experiencing the same type of risk factors associated with foster care in the U.S., such as multiple placements and poor caregiver-child relationships (Dozier, Zeanah, & Bernard, 2013). This study found that parents who responded to PFC children's negative emotions with calm neutrality were more likely to have children with higher vagal tone. Because physiology was only measured at one time point several years post-adoption, it is impossible to know the exact contributions of the pre- and post-adoption environments on SNS and PNS functioning over time. Given the limitation of this cross-sectional study, this finding suggests several different implications. The first is that having a calm parent buffered these children from exhibiting the low vagal tone characteristic of children who have experienced disruptions in caregiving. Underlying this possibility are assumptions that 1.) the PNS remained plastic post-adoption allowing for developmental programming, and 2.) these children were more physiologically reactive or sensitive to their parent's distress, more so than the NA group. This is in line with several studies on children exposed to aberrant caregiving which shows that children fine tune neurobiological and perceptual systems to process aspects of their environment that have become salient through their learning of social experiences (Pollak, 2008). Furthermore, the theory of Biological Sensitivity to Context (BSC; Boyce & Ellis, 2005) supports the possibility that early life stress interacts with genetics and shapes neurobiological systems, allowing for more sensitivity to context to support adaptation. Longitudinal research is needed investigating biological systems in pre- and post-adoptive environments, along with genetic information, to really find evidence for these hypotheses; for now, we can only speculate as to the mechanisms driving the relationship between parent distress and RSA. Under the BSC theory, if caregiver distress was salient for these children within the foster home, they would have developed a neurobiological sensitivity to stress resulting in low vagal tone to allow easier engagement of the SNS to cope. The neurobiological sensitivity to context would carry over to the post-adoption environment; PFC children would flourish in a post-adoption environment rich in sensitive and responsive care but show poor adjustment if the environment were less than optimal. Under conditions of low parental distress, the child may have felt comfortable displaying negative emotions without fear of being rejected; this could have fostered improvement of the Social Engagement System and enhanced vagal tone. However, if the child easily distressed the parent, this would support and maintain low vagal tone, allowing the child quick access to SNS mediated behaviors to support vigilance and active coping. This study did not find group differences in SNS functioning as measured by skin conductance; however, Gunnar and colleagues (2009) reported a trend for higher SNS tone as measured by pre-ejection period among children internationally-adopted from foster care compared to non-adopted children, particularly for those with more growth delay at adoption. Maintaining relatively normal growth at adoption (sign of resilience) was related to lower cortisol levels during a stressor task. The Gunnar et al. study highlights the need to investigate functioning across multiple systems (e.g., HPA, ANS, behavior) and the advantage of using more objective measures of allostatic load to quantify early life stress in order to investigate how stress gets under the skin (see Johnson, Bruce, Tarullo, & Gunnar, 2011).

Another possible reason explaining the RSA-parent distress relationship was that PFC children with higher RSA exhibited better emotion and behavior regulation competence, eliciting calmer responses from the parent. Unfortunately, this study was limited in that only one dimension of behavior was measured, and for the PFC group, neither basal RSA nor parental distress was related to externalizing behavior. It remains unknown how basal RSA might have contributed to child adjustment and how characteristics of the child may have elicited more or less parental distress. On measures of socio-emotional competence, these children often score worse than NA children and slightly better than, or similar to, PI children (Bruce, Tarullo, & Gunnar, 2009; Tarullo, Bruce, & Gunnar, 2007) and have been shown to display more internalizing and externalizing behaviors (Wiik et al., 2011). Thus, they appear to be a group at-risk for emotional and behavioral problems. Further investigation examining factors and mechanisms that contribute to physiological and emotion regulation competence in this sub-population is warranted.

Associations Among Physiology, Emotion Socialization, and Externalizing Behavior in the PI Group

Summary. The PI group exhibited different levels of baseline RSA than the PFC and NA groups, and this difference was only evident when the post-adoption parenting context was taken into account. Unlike the PFC group, the PI group showed a significant positive association between basal RSA and parent distress responses. Additionally, during the conflict discussion task, RSA and parent distress were positively related such that RSA augmentation was seen under conditions of high parent distress, and RSA withdrawal was seen under low parent distress. PI children also exhibited greater levels of externalizing behavior than both NA and PFC groups, as discussed previously. Upon further examination, results revealed that parent distress mediated the relationship between basal RSA and externalizing behavior. Thus, higher basal RSA was associated with greater parent distress, which then contributed to greater externalizing behavior. It was found that parent distress moderated the relationship between skin conductance during the positive task and externalizing behavior. For PI children with high parent distress, those children showing skin conductance augmentation to the positive emotion task were more likely to also exhibit more externalizing behavior. For the children with very moderate to low parent distress, there was no association between skin conductance and externalizing behavior. Correlations controlling for parent distress within the PI group revealed that RSA reactivity was significantly associated with skin conductance reactivity during the positive task.

Protective factors for PI children. Because lower externalizing behavior was found for children with low basal RSA in the context of having a low distress parent, these two variables, together, may protect PI children from developing behavior problems. In the context of low parental distress, PI children's skin conductance during the conflict task was unrelated to externalizing behavior. Furthermore, having a calm parent was related to greater RSA withdrawal during the conflict task, suggestive of appropriate vagal regulation to support coping. Given that the literature does not often document low basal RSA as being adaptive in typical and at-risk samples, several theories of stress regulation were explored to better understand how these two variables might have conferred adaptation and adjustment for these children.

Models such as the Adaptive Calibration Model (ACM) have extended the Biological Sensitivity to Context model to help explain how individual differences in stress-system functioning represent conditional adaptation (reviewed in Del Giudice, Ellis, & Shirtcliff, 2010). The ACM posits that the stress response system encodes information from the environment, resulting in adaptive patterns of responsivity and individual differences in behavior. This model suggests that aversive and threatening environments early in life, such as those characterized by institutional care, may be associated with a vigilant, hyperreactive pattern of stress system responding. However, when the stress is chronic or severe, hyperreactivity may switch to hyporeactivity later in life and contribute to physiological patterns which appear blunted or unusually low. The physiological and behavioral profiles of hyper- and hypo- reactivity will be discussed, along with how these profiles may have been maintained in various environments to support adaptation.

Under the AMC, low vagal tone coupled with the experience of early life stress is suggestive of a hyperreactive pattern – low vagal tone to more easily engage the SNS system. This physiological profile might be adaptive within the institutional environment where children need to keep a vigilant watch on caregivers to know when to approach and when to keep their distance, or may prompt the child to display dysregulated behavior, which would result in receiving more attention from caregivers. Within the post-adoption environment, a child with this presentation of responsivity may flourish when they have a parent who reacts promptly and calmly to their negative displays of emotion, which may help to explain why these children with lower RSA, coupled with low parental distress, evidenced low levels of externalizing behavior. The low RSA may have contributed to the child showing clear signs of fear, anger, or sadness that the parent could discern, address, and eventually calm. Additionally, vigilance and attentiveness to the environment are not necessarily negative qualities when the child has a calm parent. In this case, the low RSA may contribute to greater sensitivity to the parent's reactions of calmness. During distressing situations, the calm parent may help regulate the child, allowing the sensitive child to absorb any positive emotion regulation strategies the parent has to offer. Evidence to support the notion that low RSA in combination with higher quality parenting may benefit the child comes from a study conducted by Bagner et al. (2012). They examined preschool children who were born prematurely and who also presented with elevated externalizing problems. Compared to children in the waitlist control condition, those children with the lowest RSA whose parents received the Parent-

Child Interaction Therapy (PCIT) intervention showed the lowest levels of disruptive behavior problems following intervention. Authors suggested that perhaps the low RSA contributed to more child emotion dysregulation that motivated the parents to want to use the skills learned in the PCIT intervention. The low RSA may have also allowed the child to be more sensitive to improvements in parenting, allowing the effects of the intervention on behavior. In sum, low RSA may be associated with the child showing signs of negative affect that the calm parent can detect and address, and the child being sensitive to threat but also to the best qualities the parent has to offer.

In the current study, the finding that greater RSA withdrawal was associated with low skin conductance during the positive emotion task is promising, suggesting that the engagement of the PNS was sufficient to cope with the challenge. Further investigation of other measures of child adjustment are needed as well as direct observation of parent-child interactions, to examine how low parent distress protects the child from developing externalizing behavior.

Risk factors for externalizing behavior in PI children. The associations between high RSA, high parent distress, and more externalizing behavior are complicated to sort out. Additionally, greater skin conductance reactivity during the positive emotion task, indexing more arousal and SNS input, was associated with more externalizing behavior but only under the condition of high parent distress. Controlling for parent distress, greater skin conductance during the positive task was associated with greater RSA augmentation as well, suggesting that the SNS and PNS were functioning against each other rather than in a reciprocal fashion. According to the Autonomic Space model, a type of nonreciprocal activation would be co-activation resulting in high RSA coupled with high skin conductance, which is what the PI group evidenced during the positive task. During the conflict task, those PI children with a high distress parent showed the least RSA withdrawal. Controlling for parent distress, skin conductance and RSA were marginally correlated (r = .35), indicative of this co-activating pattern during the conflict task. In the literature, high basal RSA and a co-activating reactivity pattern in the context of risk for exposure to adversity has been associated with externalizing behavior (El-Sheikh, 2007; El-Sheikh et al., 2009; El-Sheikh & Whitson, 2006; Gordis et al., 2009). Thus, the following sections will discuss various speculations regarding how ANS functioning may have conferred adaptation and maladaptation in different contexts.

Is high vagal tone and SNS activation a sign of enduring vagal rebound? In animal models of exposure to brief stress in adulthood, rats displayed the phenomenon of "enduring vagal rebound", characterized as high vagal tone, vagal augmentation to stress, and increased SNS tone (Carnevali et al., 2011). This type of co-activation was posited to be an adaptive response to stress in order to help the organism down-regulate the over-activity of sympathetic drive. There have been relatively few studies examining enduring vagal rebound in humans, and these have focused on adults (e.g., Mezzacappa, Kelsey, Katkin, & Sloan, 2001). It is unknown whether children would also display this phenomenon and further longitudinal research is required examining RSA recovery following different levels of stress. But it can be speculated that perhaps due to the early institutional care coupled with exposure to a high distress parent, high vagal RSA was being maintained to help down-regulate the heightened SNS tone.

Is high vagal tone a sign of vigilance? It has also been suggested that high RSA is indicative of increased attention to surroundings. For at-risk individual, this may take the form of heightened vigilance. For example, compared to non-abused children, maltreated children showed greater decreases in heart rate when they heard an inter-adult argument in the background (Pollak et al., 2005). In another study, vagal augmentation to a peer provocation task was associated with more conduct problems, but only in the context of high exposure to domestic violence (Katz, 2007). These studies suggest that high basal RSA and RSA augmentation may reflect anticipatory monitoring of the environment to assess threat. This could help explain the increased behavioral and neurobiological sensitivity to threatening faces documented in PI children (Tottenham, 2012).

Is this physiological profile a sign of under-arousal? It has also been suggested that high basal RSA and co-activation in response to threat reflects under-arousal. The ACM posits that when stress remains chronic, high responsivity can switch to hyporesponsivity (Gunnar & Vasquez, 2006; Kessler et al., 2005; Tarullo & Gunnar 2006; Del Giudice, Ellis, & Shirtcliff, 2010). The ACM describes this pattern of unresponsivity as unemotional with a physiological profile that is more or less unresponsive via sympathetic input during most situations but becomes incredibly activated by threat. This takes the form of the co-activation pattern described previously: high PNS input to remain behaviorally calm coupled with high SNS input to remain vigilant and respond at a moments notice. Autonomic nervous system co-activation has been found in adults engaging in high-intensity or fear inducing situations who need to remain behaviorally calm but simultaneously prepared for action such as is required for sky-diving and spaceflight (Allison et al., 2012; Robertson, Convertino, & Vernikos, 1994). Thus, in normative samples, this type of response might be required to calmly handle stressful situations. However, when this type of pattern is used all of the time, it may be an indication of hyporeactivity hypothesized to result from chronic stress. A small body of evidence supports the argument that high vagal tone may reflect under-arousal (Dietrich et al., 2007; Dietrich et al., 2009). Low arousal associated with high RSA may also be indicative of fearlessness, potentially impairing one's ability to learn from punishment. In support of this argument, high RSA in adults has been found to relate to reduced fear-potentiated startle during an unpredictable shock, suggestive of decreased aversive responding to threat (Gorka et al., 2013). Interestingly, PI children (aged 8-9 years) have also been shown to display reduced fear-potentiated startle amplitude compared to non-adopted children (Johnson et al., 2011). They have also shown hypoactivity in other domains such as reduced cortical activity and blunted cortisol patterns at adoption and several years post-adoption (Carlson & Earls, 1997; Gunnar, 2001; Kroupina et al., 2012; Marshall, Reeb, Fox, Nelson, & Zeanah, 2008; Tarullo et al., 2011). This blunted cortisol pattern has been found in other samples of children who have been exposed to chronic stress such as maltreatment and foster care and those diagnosed with traumatic stress disorder (Cicchetti & Rogosch, 2001; DeBellis et al., 1999). Within PI children, this blunted pattern of cortisol activity has been associated with more externalizing problems and greater parenting stress around managing children's difficult behavior (Kroupina et al., 2012).

Under-arousal in biological systems may also confer hyporesponsiveness to rewards and contribute to sensation-seeking behaviors associated with poor executive function and impulsivity. Evidence from animal models suggests that early social deprivation causes abnormalities in brain regions that support effortful control abilities and systems critical to reward, motivation, and attention such as the prefrontal cortex, its associated areas, and the mesocorticolimbic dopamine system. An indication that these brain regions may be altered in PI children is correlational evidence suggesting that they are at elevated risk for problems in effortful control, such as impulsive behavior, sustained attention, action monitoring, and hyperactivity (Bruce et al., 2009; Colvert et al., 2008; Loman, Johnson, Quevedo, Lafavor, & Gunnar, in press; Merz & McCall, 2010; McDermott, Westerlund, Zeanah, Nelson, & Fox, 2012; Pollak et al., 2010). If high RSA constitutes low arousal, this may contribute to increased impulsivity, sensation-seeking, and approach behaviors to bring arousal up to optimal levels, but at the same time, might also put them in situations likely to evoke externalizing behavior. One recent study found that for PI youth and not comparison groups, sensation-seeking was positively associated with conduct problems (Loman et al., in press). If sensation-seeking approach behavior is a phenotype of high RSA, this might help to explain the inhibitory control and hyperactivity problems prevalent in PI children. Because PI children are also at-risk for delays in emotion understanding and social cognition, their approach behavior may evoke negative responses from others. If you combine an impulsive sensation-seeking child who also displays poor social skills with a parent prone to showing anger and anxiety, coercive processes may take place resulting in elevations in externalizing problems. It will be important for future studies to examine effortful control, temperament, and neurobiological correlates, and how they might contribute to parent-child dyadic processes putting PI children at-risk for psychopathology.

Is this physiological profile a sign of proactive aggression? An *externalizing-type problems* is broad term to describe a heterogeneous mixture of behaviors that differ on a continuum of impulsivity, labiality, delinquency, and aggression (Beauchaine, 2001; Frick et al., 2003). Unfortunately, due to the nature of the HBQ used in the present study, more nuanced forms of externalizing types of behavior could not be examined. Despite this limitation, speculations can be made regarding the significance of physiological patterns and specific forms of aggression. One type of externalizing behavior associated in the literature with under-arousal and co-activating patterns of ANS functioning is proactive aggression (Scarpa, Hayden, & Tanaka, 2010). Proactive aggression can take the form of a "cold-temper," reflecting non-emotional aggression used to intimidate others to obtain a desired goal and is often associated with more pre-meditated and manipulative behavior (Vitiello & Stoff, 1997). This type of aggression is often accompanied with decreased fear of punishment, uninhibited temperament, and thrill-seeking behaviors, and may require that the child exhibit very tightly controlled emotion in order not to let others see their motives. Indeed, several studies have found that PI 15-year-olds adopted after 6 months evidenced elevated rates of callous unemotional traits (Kumsta, Sonuga-Barke, & Rutter, 2012; Sonuga-Barke et al., 2010). This tightly controlled presentation might require high basal RSA, but it is unclear if we would expect lower SNS tone or higher. Scarpa, Haden, and Tanaka (2010) found that proactive aggression in children was associated with higher basal RSA and high basal skin conductance, which is similar to what the present study found in terms of high basal RSA, and greater skin conductance reactivity and RSA augmentation during the positive conversation with parent. Investigating the specifics of externalizing behavior and how exactly it manifests (e.g., cold versus hot temper, impulsive versus premeditated) will help researchers better understand how to best help PI parents and children.

Physiological functioning in the context of a distressed parent. Bidirectional influences between parent and child are likely taking place contributing to externalizing behavior; therefore, it is important to consider what high parent distress might add to the process.

Parent distress and child under-arousal. If the PI child did manifest physiological under-arousal, particularly if it is combined with a proneness to stimulation-seeking and reduced threat aversion, this may encourage the parent to amplify their response during moments of limit-setting in order to change the child's behavior. As the parent becomes more emotionally aroused, they may model dysregulated behaviors for the child, while also setting the stage for coercive interactions, which all contribute to externalizing behavior.

Parent distress and child suppression of emotion. It could be the case that the child is suppressing emotion and maintaining high vagal tone so as not to upset the parent who is easily distressed. Parents who score highly in distress also tend to score higher in other negative socialization practices that can send the message that displaying negative emotions is wrong, inappropriate, or invalid. This may result in the child suppressing negative emotion until it gets released in highly intense ways, such as externalizing behavior (Gottman, 1997; Gross & Levenson, 1993). Indeed, Fabes, Leonard, Kupanoff, and Martin (2001) found that parent distress, when coupled with harsh socialization practices, resulted in children exhibiting fewer negative emotions, but when they did express themselves, very intense emotional displays were exhibited. Interestingly, the PI group actually *increased* RSA during the conflict discussion task when they had a parent with high distress. Perhaps the PI children were suppressing negative emotions to not upset the parent and to avoid negative consequences. That this association was found in only the PI group suggests that perhaps, due to their earlier experiences of institutional care, they are more likely to increase RSA to either help support the distressed parent or to avoid harsh consequences from a high distress parent. Future research examining observed expressions of emotion in both parent and child are warranted to examine dyadic processes and how they may influence behavior problems.

Examining the various environments the child has encountered is helpful when making speculations as to how this co-activating pattern may have been supported. Within the institutional environment, it may have been adaptive for the child to suppress strong negative emotions in order to avoid punishment and enhance their chance of being cared for. Neutral emotions exhibited by children may be the preferred affect to get caregiver's attention, whereas crying and tantrums, which are inefficient ways of energy expenditure, may instigate a frightening or ignoring response from the caregiver (Vorria et al., 2003). Thus, it would have been adaptive for children to display neutral or positive affect, supported by high RSA, but also to be on alert, as supported by greater SNS input. When a sample of institutionalized infants and toddlers in Romania were observed in the presence of institution staff, they displayed less interactive behavior and more watchful behavior, perhaps to remain vigilant (Smyke et al., 2007). Others have noted that institutionalized children appeared flatter in affect, with a restricted range of expressed emotions. It could be that those children who display more "social moves" are more likely to attract more sensitive responsive care from staff. In a study of children in residential group care, children who appeared "happier" and more social were also more likely to have a secure attachment relationship with a staff member (Vorria et al., 2003).

Children within institutions have also been found to show compulsive caregiving which may take the form of a child showing falsely brighter affect and leading parent-child interactions when the caregiver is withdrawn or unresponsive and not meeting the child's needs (Chisholm, 1998, 2000). Taken together, this body of research suggests that within the institutional environment, children are less likely to show strong clear contingent signs of positive or negative affect but rather show more neutral to positive tone, perhaps to increase their opportunities for social engagement or to obtain scarce resources. This tight control of emotions and vigilance may carry over to the post-adoption environment and remain supported by a high distressed parent. In a recent study, recently adopted PI toddlers were exposed to fear-inducing stimuli and more positive enjoyable stimuli (e.g., bubbles). Compared to non-adopted children, PI children tended to react with more freezing behavior. Freezing behavior has been found to be associated with amygdala functioning and is supported by strong SNS-mediated pathways. Interestingly, greater freezing behavior was not associated with increased negative affect. Additionally, the PI group showed less positive affect than non-adopted children during the positive situations (Stellern et al., 2014). This incongruence between behavior and expressed emotion could indicate either that the children were afraid but suppressing the facial emotion, or that they were uncertain of how to react and rather than turning to their caregiver for reassurance, they stood alone. Both of these types of responses would be supported by the type of co-activation pattern seen in the current study.

Limitations

The results incorporating parent distress and externalizing behavior must be interpreted with caution due to the reliance on parent reports, which were submitted by the same parent and subject to informant bias. Parents who report high levels of unsupportive responses to children's negative emotions have been found to perceive their children as displaying more negative emotions (Eisenberg et al., 1996). It is likely that the relationship between parent distress and children's difficult behavior was bidirectional such that children's externalizing elicited more distress from the parent, and parents' escalating distress evoked children's acting out behavior leading to a coercive cycle of parent-child interaction (Larson, Viding, Rijsdijk, & Plomin, 2008; Patterson et al., 1992). Indeed, the NA group showed the same correlation between parent distress and externalizing behavior suggesting that the association was not unique to PI families. It was curious that expressive encouragement was found not to uniquely predict key variables; it could be that there was a ceiling effect on this measure with little variability. Perhaps a more nuanced measure investigating specific aspects of positive emotion socialization practices was needed. Future studies utilizing observational measures of parent-child interactions and child socio-emotional adjustment are needed in order to replicate and extend the current findings.

The reliance on parent-report for the emotion socialization measures leaves open the question as to whether parents might have over-reported using expressive encouragement or under-reported their levels of distress. In a psychometric study of the CCNES questionnaire, it was found that out of the six subscales of emotion socialization, only parent distress was significantly related to measures of social desirability (Eisenberg et al., 1996; Fabes et al., 2002). The parents in the current study reported similar levels of distress and expressive encouragement as has been noted in other studies on low-risk samples. Although the range of distress scores was in the lower end (very unlikely to moderately likely to respond with distress), this subtle difference was enough to account for significant variability in children's autonomic and behavioral functioning. However, what does high parent distress as reported by this questionnaire really mean? The CCNES does not differentiate between felt emotion and expressed emotion. Thus, two parents may have both felt anger when their child broke a toy and cried, but how this anger was dealt with and expressed in the family could have been very different. The child's experience of a parent who angrily lashes out is much different from a parent who takes a deep breath and leaves the room. It is critically important that these findings be followed up with more observational measures of parent-child dyadic interactions, particularly surrounding negative emotions. Also, it is not enough that researchers measure parent stress levels. We also need to examine how parents cope with their own difficult emotions in the face of their child's distress in order to best address the needs of adoptive parents.

Another limitation is that this study focused on the impact of the mother as the primary socialization agent; however, children learn about emotions through a wide variety of people such as fathers, siblings, and teachers. Research is beginning to elucidate the meaningful ways that, for instance, fathers socialize emotions in their children and how this is related to autonomic system functioning (e.g., Hastings & De, 2008). Moreover, studies on the impact of parenting in internationally-adopted children mainly examine mothers, even when it is the partner who is doing most of the caregiving. Future research examining post-adoption parenting should include information on both parents, as both play important caregiving and socialization roles in children's lives.

For all groups, the sex of the child did not appear to impact parent emotion socialization practices. This finding is consistent with research finding no significant differences based on the gender of the child (Eisenberg & Fabes, 1994; Eisenberg et al., 1996). However, there is a rich body of literature documenting gender effects. For example, parents tend to put more pressure on boys to suppress or change negative emotions and encourage girls to express their negative emotions (Fivush, Brotman, Buckner, & Goodman, 2000). Mothers and fathers have been found to differ in socialization strategies depending on the sex of the child. For instance, mothers have been found to become more distressed when their daughters display sadness compared to their sons (Cassano & Perry-Parish, 2007). This study only tested three fathers so the influence of parent gender on use of distress and expressive encouragement could not be examined. However, because of the documented sex differences, future research is needed examining how parent and child sex may contribute to adjustment in internationally-adopted children.

Regarding the measurement of RSA and skin conductance, it should be emphasized that these are only indirect indices of PNS and SNS functioning to give us a small window into understanding the full extent of functioning of stress systems. Emerging research has suggested that repeated stress is associated with asymmetry between biological systems and that the pattern of asymmetry is related to atypical development (Bauer, Quas, & Boyce, 2002). It is important for researchers to not only measure indices of PNS and SNS functioning in the same model, but to also examine interactions between these two systems. Furthermore, future studies should examine stress reactivity across multiple stress systems (e.g., HPA, ANS) and how they function interactively to support adaptive and maladaptive outcomes. Due to low sample size in the current study, indices of PNS and SNS functioning could not be examined concurrently to see how their joint action contributed to externalizing behavior.

Another limitation of this study was that it only examined three broad measurements of environmental factors that could contribute to ANS functioning. However, there are genetics and health factors not measured by this study that contribute to regulatory functioning and influence RSA and skin conductance, and these different factors interact at various points across development (e.g., Propper et al., 2008). Longitudinal research is needed to understand how the interactive effects between biology and different adverse experiences in internationally-adopted children impact individual differences in ANS functioning across developmental periods and to understand the processes by which interactive effects impact short- and long-term maladaptation.

A major problem with interpreting findings based on RSA and skin conductance is that these measure have been linked with an array of general processes that make it challenging to specify their functions. Basal RSA has been described as measuring openness to the environment, approach tendencies, arousability, aversive responding, engagement, attention, stress-reactivity, emotion regulation, and social competence. RSA reactivity is even more poorly conceptualized and has been described as measuring emotion regulation, adaptive responding, and general reactivity to the environment. Skin conductance has been interpreted in conflicting ways as well (reviewed in Boucsein, 2012). While some studies have used it to index arousability and active engagement, others have used it as a marker for “fight/flight” tendencies, associating it with fear or aversive responding to threat. There is also a growing literature documenting the need to measure perceived threat in addition to indices of PNS and SNS functioning because whether the individual perceives a stimulus as safe or threatening will aid in interpretation of physiological responses (Porges, 2007). For example, the SNS system is activated by threat to mobilize fight/flight responses, but it is also activated by thrilling situations to mobilize "excite and delight" responses (Allison et al., 2012). More basic research on indices of ANS functioning is needed examining physiological, behavioral, and contextual influences on individual differences in ANS functioning, to help researchers validate what exactly they are measuring.

Conclusion

The associations between physiology and poor parent-child emotion regulation in the PI and PFC groups suggest that post-adoption experiences played a role in shaping ANS development. Furthermore, for the PI group, high basal RSA and high parent distress to children's negative emotions contributed to elevated levels of externalizing behavior. Higher levels of skin conductance reactivity to a positive emotion conversation with their parent also predicted more externalizing problems, but only for children who also had a parent high in distress. Conversely, low basal RSA coupled with low parent distress appeared to protect the child from exhibiting elevated levels of externalizing behavior. These findings do not support the notion of an optimal universal profile of ANS functioning irrespective of environment demands. Rather, these findings underscore the importance of considering the ANS in concert with other systems to facilitate emotion regulation. We cannot view ANS functioning as simply a static trait that confers risk for or resilience from developing psychopathology. Individual differences in ANS functioning are better conceptualized as resulting from dynamic processes that develop over time, that are influenced by interactions among multiple levels, so that at any given time, a measurement of ANS functioning reflects the history of interactions which has shaped the ANS and maintained a certain level of adaptation up until that point.

The results of the present study are promising because they implicate that the child's biology remains open to influence from caregiving experiences later in life. For internationally-adopted children in particular, relational experiences post-adoption may help to regulate biological functioning and reduce risk for behavior problems. The findings on the associations of parent distress with differences in ANS functioning and externalizing behavior emphasizes the need for healthy and supportive environments during childhood, which may shape, support, and maintain healthy emotion regulation needed for successful adaptation. Given that a substantial body of evidence has documented the great deal of stress and strain that some parents of internationally-adopted children experience, extensions of the current study are needed examining relations between general parenting stress and parent affect regulation in response to children's problem behavior. We also need to better understand how children with histories of socio-emotional neglect interpret, respond to, and cope with negative affect in their parents. If the findings on parent distress can be replicated and extended in future research, this has the potential to inform preventive interventions that will support the mental health of parents of internationally-adopted children, which in turn, may also support children's physiological functioning and reduce parent-child processes that may increase the risk for externalizing behavior.

References

Aguilar, B., Sroufe, L. A., Egeland, B., Carlson, E. (2000). Distinguishing the life-course/persistent and adolescent-limited antisocial behavior types: From birth to 16 years. *Development and Psychopathology, 12,* 109-132.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions.* Newbury Park, CA: Sage.

Allison, A. L., Peres, J. C., Boettger, C., Leonbacher, U., Hastings, P. D., & Shirtcliff, E. A. (2012). Fight, flight, or fall: Autonomic nervous system reactivity during skydiving. *Personality and Individual Differences, 53*, 218 – 223.

Ames, E. W. (1997). *The development of Romanian orphanage children adopted into Canada*. Ottowa: National Welfare Grants.

Astley, S. J. (2003). *FAS Facial Photographic Analysis Software Version 1.0.0.* Seattle, WA: FAS Diagnostic & Prevention Network, University of Washington.

Bach, D. R., Friston, K. J., & Dolan, R. J. (2010). Analytic measures for quantification of arousal from spontaneous skin conductance fluctuations. *International Journal of Psychophysiology, 76*, 52-55.

Bagner, D. M., Graziano, P. A., Jaccard, J., Sheinkopf, S. J., Vohr, B. R., & Lester, B. M. (2012). An initial investigation of baseline respiratory sinus arrhythmia as a moderator of treatment outcome for young children born premature with externalizing behavior problems. *Behavior Therapy, 43*, 652-665.

Bales, K. L. & Perkeybile, A. M. (2012). Developmental experiences and the oxytocin receptor system. *Hormones and Behavior, 61,* 313–319.

Bar-Haim, Y., Marshall, P. J., & Fox, N. A. (2000). Developmental changes in heart period and high-frequency heart period variability from 4 months to 4 years of age. *Developmental Psychobiology, 37*, 44–56.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51,* 1173–1182.

Bauer, A. M., Quas, J. A., & Boyce, W. T. (2002). Associations between physiological reactivity and children's behavior: Advantages of a multisystem approach. *Journal of Developmental and Behavioral Pediatrics, 23,* 102–113.

Beauchaine, T. P. (2001). Vagal tone, development, and Gray's motivational theory: Toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology*, *13*, 183 – 214.

Beauchaine, T. P., Gatzke-Kopp, L., & Mead, H. K. (2007). Polyvagal theory and developmental psychopathology: Emotion dysregulation and conduct problems from preschool to adolescence. *Biological Psychology*, *74*, 174-184.

Berntson, G., Cacioppo, J., & Quigley, K. (1991). Autonomic determinism: The modes of autonomic control, the doctrine of autonomic space, and the laws of autonomic constraint. *Psychological Review, 98*, 459–487.

Blair, R. J. (1999). Responsiveness to distress cues in the child with psychopathic tendencies. *Personality and Individual Differences 27*, 135–145.

Bongers, I. L., Koot, H. M., van der Ende, J., & Verhulst, F. C. (2004). Developmental trajectories of externalizing behaviors in childhood and adolescence. *Child Development*, *75*, 1523 – 1537.

Boucsein, W. (2012). *Electrodermal activity* (2nd ed.). New York, NY: Springer.

Bowlby, J. (1982). Attachment and loss: Vol. 1. Attachment. New York: Basic Books.

Boyce, W. T., & Ellis, B. J. (2005). Biological sensitivity to context: I. An evolutionary–developmental theory of the origins and functions of stress reactivity. *Development and Psychopathology*, *17*, 271–301.

Boyce, W. T., Essex, M. J., Woodward, H. R., Measelle, J. F., Ablow, J. C., Kupfer, D. J., et al. (2002). The confluence of mental, physical, social, and academic difficulties in middle childhood. Exploring the "headwaters" of early life morbidities. *Journal of the American Academy of Child and Adolescent Psychiatry*, *41*, 580–587.

Boyce, W. T., Quas, J., Alkon, A., Smider, N., Essex, M., & Kupfer, D. J. (2001). Autonomic reactivity and psychopathology in middle childhood. *British Journal of Psychiatry*, *179*, 144–150.

Bruce, J., Fisher, P. A., Pears, K. C., & Levine, S. (2009). Morning cortisol levels in preschool-aged foster children: Differential effects of maltreatment type. *Developmental Psychobiology, 51,* 14-23.

Bruce, J., Gunnar, M. R., Pears, K. C., & Fisher, P. A. (2013). Early adverse care, stress neurobiology, and prevention science: Lessons learned. *Prevention Science, 14,* 247-256.

Bruce, J., Tarullo, A., & Gunnar, M. R. (2009). Disinhibited social behavior among internationally adopted children. *Development and Psychopathology*, *21*, 157–171.

Burgess, K. B., Marshall, P. J., Rubin, K. H., & Fox, N. A. (2003). Infant attachment and temperament as predictors of subsequent externalizing problems and cardiac physiology. *Journal of Child Psychology and Psychiatry, 44,* 819–831.

Bush, N. R., Alkon, A., Obradović, J., Stamperdahl, J., & Boyce, W. T. (2010). Deconstructing psychobiological reactivity: The contributions of psychomotor activity and stress response in five-year-old children. *Journal of Experimental Child Psychology, 110*, 62 – 79.

Calkins, S. D., Blandon, A. Y., Williford, A. P., & Keane, S. P. (2007). Biological, behavioral, and relational levels of resilience in the context of risk for early childhood behavior problems. *Development and Psychopathology, 19*, 675-700.

Calkins, S. D., & Dedmon, S. E. (2000). Physiological and behavioral regulation in two-year-old children with aggressive/destructive behavior problems. *Journal of Abnormal Child Psychology, 28*, 103–118.

Calkins, S. D., Graziano, P. A., Berdan, L. E., & Keane, S. P., & Degnan, K. A. (2008). Predicting cardiac vagal regulation in early childhood from maternal-child relationship quality during toddlerhood. *Developmental Psychobiology, 50,* 751-766.

Calkins, S. D., Graziano, P. A., & Keane, S. P. (2007). Cardiac vagal regulation differentiates among children at risk for behavior problems. *Biological Psychology, 74*, 144–153.

Calkins, S. D., & Keane, S. P. (2004). Cardiac vagal regulation across the preschool period: Stability, continuity, and implications for childhood adjustment. *Developmental Psychobiology, 45*, 101–112.

Carlson, M., & Earls, F. (1997). Psychological and neuroendocrinological sequelae of early social deprivation in institutionalized children in Romania. *Annals of the*

New York Academy of Science, 807, 419–428.

Carnevali, L., Bondarenko, E., Sgoifo, A., Walker, F. R., Head, G. A., Lukoshkova, E. V. . . . & Nalivaiko, E. (2011). Metyrapone and fluoxetine suppress enduring behavioral but not cardiac effects of subchronic stress in rats. *American Journal of Physiology: Regulatory, Integrative, & Comparative Physiology*, *301*, R1123–1131.

Carnevali, L., Trombini, M., Porta, A., Montano, N., de Boer, S. F., & Sgoifo, A. (2013). Vagal withdrawal and susceptibility to cardiac arrhythmias in rats with high trait aggressiveness. *PLoS ONE 8*, e68316.

Cassano, M., & Perry-Parish, C. (2007). Influence of gender on parental socialization of children's sadness regulation. *Social Development, 16*(2), 210-231.

Castle, J., Beckett, C., Rutter, M., & Sonuga-Barke, E. J. (2010). VIII. Post- adoption environmental features. *Monographs of the Society for Research in Child Development*, *75*, 167–186.

Cederblad, M., Hook, B., Irhammar, M., & Mercke, A. M. (1999). Mental health in international adoptees as teenagers and young adults. An epidemiological study. *Journal of Child Psychology and Psychiatry, 40*, 1239–1248.

Chen, E., Matthews, K., Solomon, K., & Ewart, C. (2002). Cardiovascular reactivity during social and nonsocial stressors: Do children's personal goals and expressive skills matter? *Health Psychology, 21*, 16–24.

Chisholm, K. (1998). A 3-year follow-up of attachment and indiscriminate friendliness in children adopted from Romanian orphanages. *Child Development, 69*, 1092–1106.

Chisholm, K. (2000). Attachment in children adopted from Romanian orphanages: Two case studies. In P. M. Crittenden & A. H. Claussen (Eds.), *The organization of attachment relationships: Maturation, culture, and context* (pp. 171–189). New York: Cambridge University Press.

Chugani, H. T., Behen, M. E., Muzik, O., Juhasz, C., Nagy, F., & Chugani, D. C. (2001). Local brain functional activity following early deprivation: A study of post-institutionalized Romanian orphans. *NeuroImage, 14,* 1290–1301.

Cicchetti, D. & Richters, J. E. (1993). Developmental considerations in the investigation of conduct disorder. *Development and Psychopathology, 5*, 331_344.

Cicchetti, D., & Rogosch, F., (2001). Diverse patterns of neuroendocrine activity in maltreated children. *Developmental Psychopathology, 13,* 677–720.

Colvert, E., Rutter, M., Beckett, C., Castle, J., Groothues, C., Hawkins, A., et al. (2008). Emotional difficulties in early adolescence following severe early deprivation: Findings from the English and Romanian Adoptees study. *Development and Psychopathology, 20,* 547–567.

Crowell, S., Beauchaine, T. P., Gatzke-Kopp, L., Sylvers, P., Mead H., & Chipman-Chacon, J. (2006). Autonomic correlates of attention-deficit/hyperactivity disorder and oppositional defiant disorder in preschool children, *Journal of Abnormal Psychology, 115*, 174–178.

Cummings, E. M., El-Sheikh, M., Kouros, C. D., & Keller, P. S. (2007). Children’s skin conductance reactivity as a mechanism of risk in the context of parental depressive symptoms. *Journal of Child Psychology and Psychiatry, 48*, 436-445.

DeBellis, M. D., Baum, A. S., Birmaher, B., Keshavan, M. S., Eccard, C. H., Boring, A.

M., et al. (1999). A. E. Bennett Research Award. Developmental traumatology. Part I: Biological stress systems. *Biological Psychiatry, 45*, 1259–1270.

Degnan, K. A., Calkins, S. D., Keane, S. P., & Hill-Soderlund, A. L. (2008). Profile of disruptive behavior: Contributions of frustration reactivity, physiological regulation, and maternal behavior. *Child Development, 79,* 1357 – 1376.

Del Giudice, M., Ellis, B. J., & Shirtcliff, E. A. (2011). The Adaptive Calibration Model of stress responsivity. *Neuroscience & Biobehavioral Reviews, 35*, 1562–1592.

Dietrich, A., Riese, H., Sondeijker, F. E., Greaves-Lord, K., van Roon, A. M., Ormel, J. . . . & Rosmalen, J. G. M. (2007). Externalizing and internalizing problems in relation to autonomic function: A population-based study in preadolescents. *Journal of the American Academy of Child and Adolescent Psychiatry, 46,* 378–386.

Dietrich, A., Riese, H., van Roon, A. M., Minderaa, R. B., Oldehinkel, A. J., Neeleman, J. . . . & Rosmalen, J. G. M. (2009). Temperamental activation and inhibition associated with autonomic function in preadolescents. The TRAILS study. *Biological Psychology, 81,* 67-73.

DeGangi, G. A., DiPietro, J. A., Greenspan, S. I., & Porges, S. W. (1991). Psychophysiological characteristics of the regulatory disordered infant. *Infant Behavior and Development, 14,* 37-50.

Donzella, B., Tottenham, N., & Gunnar, M. R. (2009). *Is that a stress response, or was I just talking? The importance of controlling for speech conditions during the TSST.* In Symposium conducted at the biannual meeting of the Society for Research in Child Development, Denver, CO.

Dozier, M., Manni, M., Gordon, M.K., Peloso, E., Gunnar, M. R., Stovall-McClough, K. C., et al. (2006). Foster children's diurnal production of cortisol: An exploratory study. *Child Maltreatment, 11*, 189–197.

Dozier, M., Zeanah, C. H. and Bernard, K. (2013), Infants and Toddlers in Foster Care. *Child Development Perspectives, 7*, 166–171.

Eisenberg, N., Cumberland, A., & Spinrad, T. L. (1998). Parental socialization of emotion. *Psychological Inquiry, 9*(4), 241-273.

Eisenberg, N., & Fabes, R. A. (1994). Mothers' reactions to children's negative emotions: Relations to children's temperament and anger behavior. *Merrill-Palmer Quarterly, 40*, 138-156.

Eisenberg, N., Fabes, R. A., Carlo, G., & Karbon, M. (1992). Emotional responsivity to others: Behavioral correlates and socialization antecedents. In N. Eisenberg & R.A. Fabes (Eds.). *Emotion and its regulation in early development* (pp.57-73). San Francisco: Jossey-Bass.

Eisenberg, N., Fabes, R. A., & Murphy, B. C. (1996). Parents' reactions to children's negative emotions: Relations to children's social competence and comforting behavior. *Child Development, 67,* 2227–2247.

Eisenberg, N., Fabes, R. A., Schaller, M., Carlo, G., & Miller, P. A. (1991). The relations of parental characteristics and practices to children's vicarious emotional responding. *Child Development*, *62*, 1393–1408.

Ellis, B. J., Essex, M. J., & Boyce, W. T. (2005). Biological sensitivity to context: II. Empirical explorations of an evolutionary–developmental theory. *Development and Psychopathology, 17,* 303–328.

El-Sheikh, M. (2005). The role of emotional responses and physiological reactivity in the marital conflict-child functioning link. *Journal of Child Psychology and Psychiatry, 46,* 1191-1199.

El-Sheikh, M., Harger, J., & Whitson, S. M. (2001). Exposure to interparental conflict and children's adjustment and physical health: The moderating role of vagal tone. *Child Development, 72,* 1617-1636.

El-Sheikh, M., Keller, P. S., & Erath, S. A. (2007). Marital conflict and risk for child maladjustment over time: Skin conductance level reactivity as a vulnerability factor. *Journal of Abnormal Child Psychology, 35*, 715–727.

El-Sheikh, M., Kouros, C. D., Erath, S., Cummings, E. M., Keller, P., & Staton, L. (2009). Marital conflict and children's externalizing behavior: Interactions between parasympathetic and sympathetic nervous system activity. *Monographs of the Society for Research in Child Development*, *74*(1, Serial No. 292).

El-Sheikh, M., & Whitson, S. A. (2006). Longitudinal relations between marital conflict and child adjustment: Vagal regulation as a protective factor. *Journal of Family Psychology, 20,* 30-39.

Eluvathingal, T. J., Chugani, H. T., Behen, M. E., Juhasz, C., Muzik, O., Maqbool, M., …Makki, M. (2006). Abnormal brain connectivity in children after early severe socioemotional deprivation: A diffusion tensor imaging study. *Pediatrics, 117,* 2093–2100.

Erath, S. A., El-Sheikh, M., & Cummings, E. M. (2009). Harsh parenting and child externalizing behavior: Skin conductance level reactivity as a moderator. *Child Development*, *80,* 578 –592.

Erath, S. A., El-Sheikh, M., Hinnant, B. J., & Cummings, M., E. (2011). Skin conductance level reactivity moderates the association between harsh parenting and growth in child externalizing behavior. *Developmental Psychology, 47*(3), 693-706.

Essex, M. J., Boyce, T. W., Heim Goldstein, L., Armstrong, J. M., Kraemer, H. C., & Kupfer, D. J. (2002). The confluence of mental, physical, social, and academic difficulties in middle childhood.II. Developing the MacArthur Health and Behavior Questionnaire. *Journal of the American Academy of Child and Adolescent Psychiatry, 41*, 588–603.

Essex, M.J., Kraemer, H.C., Armstrong, J.M., Boyce, T.M., Goldsmith, H.H., Klein, M.H., Woodward, H., & Kupfer, D.J. (2006). Exploring risk factors for the emergence of children's mental health problems. *Archives of General Psychiatry, 63*, 1246–1256.

Fabes, R.A., Eisenberg, N., & Bernzweig, J. (1990). The Coping with Children's Negative Emotions Scale: Procedures and scoring. Unpublished document available from the first author, Arizona State University, Tempe.

Fabes, R. A., Eisenberg, N., & Eisenbud, L. (1993). Behavioral and physiological correlates of children's reactions to others in distress. *Developmental Psychology, 29*, 655-663.

Fabes, R. A., Leonard, S. A., Kupanoff, K., & Martin, C. L. (2001). Parental Coping with Children's Negative Emotions: Relations with Children's Emotional and Social

Responding. *Child Development*, *72*, 907-920.

Fabes, R. A., Poulin, R., Eisenberg, N., & Madden-Derdich, D. A. (2002). Psychometric properties of the Coping with Children's Negative Emotions Scale. *Marriage and Family Review, 34,* 285 – 310.

Feldman, R. (2012). Bio-behavioral synchrony: A model for integrating biological and microsocial behavioral processes in the study of parenting. *Parenting, Science and Practice*, *12*(2-3), 154-164.

Feldman, R., Magori-Cohen, R., Galili, G., Singer, M., & Louzoun, Y. (2011). Mother and infant's heart rhythms synchronize during episodes of face-to-face affect synchrony. *Infant Behavior and Development, 34*, 569–577.

Feldman, R., Singer, M., & Zagoory, O. (2010). Touch attenuates infants' physiological reactivity to stress. *Developmental Science, 13*, 271–278.

Field, T., Pickens, J., Fox, N. A., & Nawrocki, T. (1995). Vagal tone in infants of depressed mothers. *Development and Psychopathology*, *7*, 227–231.

Fisher, L., Ames, E. W., Chisholm, K., & Savoie, L. (1997). Problems reported by parents of Romanian orphans adopted to British Columbia. *International Journal of Behavioral Development, 20,* 67–82.

Fivush, R., Brotman, M., Buckner, J., & Goodman, S. (2000). Gender differences in parent–child emotion narratives. *Sex Roles, 42,* 233–253.

Frick, P. J., Cornell, A. H., Bodin, S. D., Dane, H. A., Barry, C. T., & Loney, B. R. (2003). Callous-unemotional traits and developmental pathways to severe conduct problems. *Developmental Psychology, 39,* 246–260.

Gagnon-Oosterwaal, N., Cossette, L., Smolla, N., Pomerleau, A., Malcuit, G., Chicoine,

J. . . & Séguin, R. (2012). Pre-adoption adversity, maternal stress, and behavior problems at school-age in international adoptees. *Journal of Applied Developmental Psychology, 33*, 236-242.

Goldney, R. D., Donald, M., Sawyer, M. G., Kosky, R. J., & Priest, S. (1996). Emotional health of Indonesian adoptees living in Australian families. *Australian and New Zealand Journal of Psychiatry, 30*, 534–539.

Gordis, E. B., Feres, N., Olezeski, C. L., Rabkin, A. N. & Trickett, P. K. (2009). Skin conductance reactivity and respiratory sinus arrhythmia among maltreated and comparison youth: Relations with aggressive behavior. *Journal of Pediatric Psychology, 35*, 547 – 558.

Gorka, S. M., Nelson, B. D., Sarapas, C., Campbell, M., Lewis, G.F., Bishop, J. R. . . . & Shankman, S. A. (2013). Relation between respiratory sinus arrythymia and startle response during predictable and unpredictable threat. *Journal of psychophysiology 27*, 95–104.

Gottman, J. (1997). *The heart of parenting: How to raise an emotionally intelligent child*. New York: Simon and Schuster.

Govindan, R. M., Behen, M. E., & Helder, E., Makki, M. I., & Chugani, H. T. (2010). Altered water diffusivity in cortical association tracts in children with early deprivation identified with tract-based spatial statistics (TBSS). *Cerebral cortex, 20*(3), 561-569.

Granger, D. A., Weisz, J. R., & Kauneckis, D. (1994). Neuroendocrine reactivity, internalizing behavior problems, and control-related cognitions in clinic-referred children and adolescents. *Journal of Abnormal Psychology, 103*, 267–276.

Gray, J. A. (1982). *The neuropsychology of anxiety: An inquiry into the functions of the septo- hippocampal system*. Oxford: Clarendon.

Grippo, A. J., Carter, C. S., McNeal, N., Chandler, D. L., LaRocca, M. A., Bates, S. L., & Porges, S. W. (2011). 24-Hour autonomic dysfunction and depressive behaviors in an animal model of social isolation: Implications for the study of depression and cardiovascular disease. *Psychosomatic Medicine*, 73, 59-66.

Grippo, A. J., Lamb, D. G., Carter, C. S., Porges, S. W. (2007a). Cardiac regulation in the socially monogamous prairie vole. *Physiology and Behavior. 90*, 386—393.

Grippo, A. J., Lamb, D. G., Carter, C. S., Porges, S. W. (2007b). Social isolation disrupts autonomic regulation of the heart and influences negative affective behaviors. *Biological Psychiatry 62*, 1162— 1170.

Grippo, A. J., Trahanas, D. M., Zimmerman, R. R., Porges, S. W., & Carter, C.S. (2009). Oxytocin protects against negative behavioral and autonomic consequences of long-term social isolation. *Psychoneuroendocrinology, 34*, 1542-1553.

Gross, J. J., & Levenson, R. W. (1993). Emotional suppression: Physiology, self-report, and expressive behavior. *Journal of Personality and Social Psychology, 64,* 970 - 986.

Grossman, P., & Taylor, E. W. (2007). Toward understanding respiratory sinus arrhythmia: Relations to cardiac vagal tone, evolution, and biobehavioral functions. *Biological Psychology, 74*, 263–285.

Groza, V. (1999). Institutionalization, behavior, and international adoption. *Journal of Immigrant Health, 1*, 133–143.

Groza, V., & Ryan, S. D. (2002). Pre-adoption stress and its association with child behavior in domestic special needs and international adoptions. *Psychoneuroendocrinology, 27*, 181–197.

Gunnar, M. R. (2001). Effects of early deprivation: Findings from orphanage-reared infants and children. In C. A. Nelson & M. Luciana (Eds.), *Handbook of developmental cognitive neuroscience* (pp. 617-629). Cambridge, MA: MIT Press.

Gunnar, M. R. (2010). A commentary on deprivation-specific psychological patterns: Effects of institutional deprivation. *Monographs of the Society for Research in Child Development, 75*, 232–247.

Gunnar, M. R., & Donzella, B. (2002). Social regulation of the cortisol levels in early human development. *Psychoneuroendocrinology, 27,* 199–220.

Gunnar, M. R., Fisher, P. A., & The Early Experience, Stress, and Prevention Network (2006). Bringing basic research on early experience and stress neurobiology to bear on preventative interventions for neglected and maltreated children. *Development and Psychopathology, 18*, 651–677.

Gunnar, M. R., van Dulmen, M. H. M., & The International Adoption Project Team. (2007). Behavior problems in postinstitutionalized internationally adopted children. *Development and Psychopathology, 19,* 129-148.

Gunnar, M. R., & Vazquez, D. M. (2001). Low cortisol and a flattening of expected daytime rhythm: Potential indices of risk in human development. *Development and Psychopathology, 13*, 515–538.

Gunnar, M. R., & Vazquez, D. M. (2006). Stress neurobiology and developmental psychopathology. In D. Cicchetti & D. Cohen (Eds.), *Developmental psychopathology*: Vol. 2. Developmental neuroscience (2nd ed., pp. 533–577). New York: Wiley.

Gunnar, M. R., Wewerka, S., Frenn, K., Long, J. D., & Griggs, C. (2009). Developmental changes in HPA activity over the transition to adolescence: Normative changes and associations with puberty. *Development and Psychopathology, 21*, 69–85.

Hastings, P. D., De, I., (2008). Parasympathetic regulation and parental socialization of emotion: Biopsychosocial processes of adjustment in preschoolers. *Social Development 17*, 211–238.

Hastings, P. D., Sullivan, C., McShane, K.E., Coplan, R.J., Utendale, W.T., Vyncke, J.D., (2008). Parental socialization, vagal regulation and preschoolers' anxious difficulties: Direct mothers and moderated fathers. *Child Development 1*, 45–64.

Hawk, B., & McCall, R. B. (2010). CBCL behavior problems of post-institutionalized international adoptees. *Clinical Child and Family Psychology Review, 13*, 199–211.

Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling [White paper]. Retrieved from http://www.afhayes.com/public/process2012.pdf

Hayes, A. F., & Matthes, J. (2009). Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. *Behavior Research Methods, 41*, 924-936.

Hays, R. J., Reas, D. L., & Shaw, B., J. (2002). Concurrent validity of the Wechsler Abreviated Scale of Intelligence and the Kaufman Brief Intelligence Test among psychiatric inpatients. *Psychological Reports, 90,* 355-359.

Hellerstedt, W. L., Madsen, N. J., Gunnar, M. R., Grotevant, H. D., Lee, R. M., & Johnson, D. E. (2008). The International Adoption Project: Population-based surveillance of Minnesota parents who adopted children internationally. *Maternal Child Health Journal, 12,* 162–171.

Herpertz, S. C., Mueller, B., Wenning, B., Qunaibi, M., Lichterfeld, C., & Herpertz-Dahlmann, B. (2003). Autonomic responses in boys with externalizing disorders. *Journal of Neural Transmission, 110,* 1181– 1195.

Hofer, M. A. (1994). Early relationships as regulators of infant physiology and behavior. *Acta Paediatrica Supplement, 397,* 9–18.

Hoksbergen, R., Rijk, K., Van Dijkum, C., & Laak, J. T. (2004). Adoption of Romanian children in the Netherlands: Behavior problems and parenting burden of upbringing for adoptive parents. *Developmental and Behavioral Pediatrics, 25,* 175–180.

Hubbard, J. A., Smithmyer, C. M., Ramsden, S. R., Parker, E. H., Flanagan, K. D., Dearing, K. F., et al. (2002). Observational, physiological, and self-reported measures of children's anger: Relations to reactive versus proactive aggression. *Child Development 73,* 1101–1118.

Johnson, A. E., Bruce, J., Tarullo, A. R., & Gunnar, M. R. (2011). Growth delay as an index of allostatic load in young children: Predictions to disinhibited social approach and diurnal cortisol activity. *Development and Psychopathology, 23*(Special Issue 03), 859-871.

Johnson, A. E., Quevedo, K., Loman, M. M., Lafavor, T. L., Moua, B., &

Gunnar, M. R. (2011, April). *Affective processing in internationally adopted youth at the pubertal transition: A study of startle and postauricular reflexes.* Paper presented at the SRCD Biennial Meeting in Montreal, QC.

Johnson, D. E. (2000). The impact of orphanage rearing on growth and development. In C. A. Nelson (Ed.), *The Effects of Adversity on Neurobehavioral Development: Minnesota Symposia on Child Psychology* (Vol. 31, pp. 113-162). Mahwah, NJ: Lawrence Erlbaum.

Jones, S., Eisenberg, N., Fabes, R. A., & MacKinnon, D. P. (2002). Parents' reactions to elementary school children's negative emotions: Relations to social and emotional functioning at school. *Merrill-Palmer Quarterly, 48*(2), 133-159.

Judge, S. (2003). Determinants of parental stress in families adopting children from Eastern Europe. *Family Relations, 52*, 241–248.

Juffer, F., & Van Ijzendoorn, M.H. (2005). Behavior problems and mental health referrals of international adoptees. *Clinician's Corner, 293*, 2501–2515.

Katz, L. F. (2007). Domestic violence and vagal reactivity to peer provocation. *Biological Psychology*, *74*, 154—164.

Kennedy, A. E., Rubin, K. H., Hastings, P. D., & Maisel, B. (2004). Longitudinal relations between child vagal tone and parenting behavior: 2 to 4 years. *Developmental Psychobiology 45*(1), 10–21.

Kertes, D. A., Gunnar, M. R., Madsen, N. J., & Long, J. D. (2008). Early deprivation and home basal cortisol levels: A study of internationally adopted children. *Development and Psychopathology*, *20*, 473-491.

Kim, W. J., Shin, Y. J., & Carey, M. P. (1999). Comparison of Korean-American adoptees and biological children of their adoptive parents: A pilot study. *Child Psychiatry and Human Development, 29,* 221–228.

Klimes-Dougan, B., Brand, A. E., Zahn-Waxler, C., Usher, B., Hastings, P. D., Kendziora, K., & Garside, R. B. (2007). Parental emotion socialization in adolescence: Differences in sex, age and problem status. *Social Development, 16,* 326–342.

Koot, H. M., Van Den Oord, E. J., Verhulst, F. C., & Boomsma, D. I. (1997). Behavioral and emotional problems in young preschoolers: Cross-cultural testing of the validity of the Child Behavior Checklist/ 2-3. *Journal of Abnormal Child Psychology, 25,* 183-196.

Kreppner, J. M., O'Connor, T. G., Rutter, M., Beckett, C., Castle, J., & Croft, C. (2001). Can inattention/overactivity be an institutional deprivation syndrome? *Journal of Abnormal Child Psychology, 29,* 513–528.

Kreppner, J. M., Rutter, M., Beckett, C., Castle, J., Colvert, E., Groothues, C., et al. (2007). Normality and impairment following profound early institutional deprivation: A longitudinal follow-up into early adolescence. *Developmental Psychology, 43,* 931–946.

Kroupina, M. G., Fuglestad, A. J., Iverson, S. L., Himes, J. H., Mason, P. W., Gunnar, M. R., . . . Johnson, D. E. (2012). Adoption as an intervention for institutionally reared children: HPA functioning and developmental status. *Infant Behavior & Development, 35(*4), 829-837.

Larsson, H., Viding, E., Rijsdijk, F., & Plomin, R. (2008). Relationships between a parental negativity and childhood antisocial behavior over time: A bidirectional effect model in a longitudinal genetically informative design. *Journal of Abnormal Child Psychology, 36*, 633–645.

Le Mare, L., Audet, K., & Kurytnik, K. (2007). A longitudinal study of service use in families of children adopted from Romanian orphanages. *International Journal of Behavioral Development, 31(3),* 242–251.

Lemery-Chalfant, K., Schreiber, J. E., Schmidt, N. L., VanHulle, C. A., Essex, M. J., & Goldsmith, H. H. (2007). Assessing internalizing, externalizing, and attention problems in young children: Validation of the MacArthur HBQ. *Journal of the American Academy of Child and Adolescent Psychiatry, 46,* 1315–1323.

Leve, L., Kerr, D., Shaw, D., Ge, X., Neiderhiser, J., Scaramella, L. . . Reiss, D. (2010). Infant pathways to externalizing behavior: Evidence of genotype x environment interaction. *Child Development, 81*, 340–356.

Levine, S. (2005). Developmental determinants of sensitivity and resistance to stress. *Psychoneuroendocrinology, 30,* 939–946.

Levy-Shiff, R., Zoran, N., & Shulman, S. (1997). International and domestic adoption: Child, parents, and family adjustment. *International Journal of Behavioral Development, 20,* 109–129.

Linville, D., & Lyness, A. P. K. (2007). Twenty American families' stories of adaptation: Adoption of children from Russian and Romanian institutions. *Journal of Marital and Family Therapy, 33*(1), 77-93.

Little, R. J. A. (1988). Missing data adjustments in large surveys. *Journal of Business Economics and Statistics, 6,* 287-301.

Loman, M. M., & Gunnar, M. R. (2010). Early experience and the development of stress reactivity and regulation in children. *Neuroscience & Biobehavioral Reviews, 34,* 867-876.

Loman, M. M., Johnson, A. E., Quevedo, K., Lafavor, T. L., & Gunnar, M. R. (in press). Risk-taking and sensation-seeking propensity in postinstitutionalized early adolescents. *Journal of Child Psychology and Psychiatry.*

Lorber, M. F. (2004). Psychophysiology of aggression, psychopathy, and conduct problems: A meta-analysis. *Psychological Bulletin, 130*, 531–552.

Loria, A.,S., Brands, M. W., Pollock, D. M., & Pollock, J. S. (2013). *American Journal of Physiology: Renal Physiology, 305,* F390 – F395.

Maclean, K. (2003). The impact of institutionalization on child development. *Development and Psychopathology, 15,* 853-884.

Maheu, F. S., Dozier, M., Guyer, A. E., Mandell, D., Peloso, E., Poeth, K., ... & Ernst, M. (2010). A preliminary study of medial temporal lobe function in youths with a history of caregiver deprivation and emotional neglect. *Cognitive, Affective, and Behavioral Neuroscience, 19*, 34–49.

Mainemer, H., Gilman, L. C., & Ames, E. W. (1998). Parenting stress in families adopting children from Romanian orphanages. *Journal of Family Issues, 19*, 164–180.

Marshall, P. J., Fox, N. A., & the Bucharest Early Intervention Project Core Group. (2004). A comparison of the electroencephalogram between institutionalized and community children in Romania. *Journal of Cognitive Neuroscience, 16,* 1327–1338.

Marshall, P. J., & Kenney, J. W. (2009). Biological perspectives on the effects of early psychosocial experience. *Developmental Review, 29,* 96–119.

Marshall, P. J., Reeb, B. C., Fox, N. A., Nelson, C. A., & Zeanah, C. H. (2008). Effects of early intervention on EEG power and coherence in previously institutionalized children in Romania. *Development and Psychopathology, 20,* 861–880.

Marcovitch, S., Goldberg, S., Gold, A., Washington, J., Wasson, C., Krekewich, K., et al. (1997). Determinants of behavioral problems in Romanian children adopted in Ontario. *International Journal of Behavioral Development, 20,* 17–31.

McDermott, J. M., Westerlund, A., Zeanah, C. H., Nelson, C. A., & Fox, N. A. (2012). Early adversity and neural correlates of executive function: Implications for academic adjustment. *Developmental Cognitive Neuroscience, 2S,* S59–S66.

Mehta, M. A., Golembo, N. I., Nosarti, C., Colvert, E., Mota, A., Williams, S. C. R., . . . Sonuga-Barke, E. J. S. (2009). Amygdala, hippocampal and corpus callosum size following severe early institutional deprivation: The English and Romanian Adoptees Study Pilot. *Journal of Child Psychology and Psychiatry, 50(8),* 943-951.

Merz, E. & McCall, R. (2010). Behavior problems in children adopted from psychosocially depriving institutions. *Journal of Abnormal Child Psychology, 38(4),* 459-470.

Mezzacappa, E. S., Kelsey, R. M., Katkin, E. S., and Sloan, R. P. (2001). Vagal rebound and recovery from psychological stress. *Psychosomatic Medicine, 63,* 650–657.

Miller, L., Chan, W., Tirella, L., & Perrin, E. (2009). Outcomes of children adopted from Eastern Europe. International Journal of Behavioral Development, 33(4), 289-298.

Moffitt, T.E., Caspi, A., Dickson, N., Silva, P., & Stanton, W. (1996). Childhood-onset versus adolescent-onset antisocial conduct problems in males: Natural history from ages 3 to 18 years. *Development and Psychopathology, 8,* 399-424.

Moore, G. A. (2009). Infants' and mothers' vagal reactivity in response to anger. *Child Psychology and Psychiatry, 50*(11), 1392-1400.

Moore, G. A. (2010). Parent conflict predicts infants' vagal regulation in social interaction. *Development and Psychopathology, 22,* 23 – 33.

Moore, G. A., & Calkins, S. D. (2004). Infants' vagal regulation in the still-face paradigm is related to dyadic coordination of mother-infant interaction. *Developmental Psychology, 40,* 1068 – 1080.

Moriceau, S., & Sullivan, R. M. (2006). Maternal presence serves as a switch between learning fear and attraction in infancy. *Nature Neuroscience, 9,* 1004–1006.

Moulson, M. C., Fox, N. A., Zeanah, C. H., & Nelson, C. A. (2009). Early adverse experiences and the neurobiology of facial emotion processing. *Developmental Psychology, 45,* 17–30.

Moulson, M. C., Westerlund, A., Fox, N. A., Zeanah, C. H., & Nelson, C. A. (2009). The effects of early experience on face recognition: An event-related potential study of institutionalized children in Romania. *Child Development, 80,* 1039-1056.

Obradović, J., Bush, N. R., & Boyce, T. W. (2011). The interactive effects of marital conflict and stress reactivity on externalizing and internalizing symptoms: The role of laboratory stressors. *Development and Psychopathology, 23,* 101 – 114.

O'Connor, T. G., Rutter, M., & the English and Romanian Adoptees Study Team. (2000). Attachment disorder behavior following early severe deprivation:

Extension and longitudinal follow-up. *Journal of the American Academy of Child and Adolescent Psychiatry, 39,* 703–712.

Oosterman, M., De Schipper, J., Fisher, P., Dozier, M. & Schuengel, C. (2010) Autonomic reactivity in relation to attachment and early adversity among foster children. *Development and Psychopathology, 22,* 109-118.

Oosterman, M. & Schuengel, C. (2007). Autonomic reactivity of children to separation and reunion with foster parents. *Journal of American Academy of Child and Adolescent Psychiatry, 46,* 1196 – 1203.

Palacios, J., Roman, M., Moreno, C., & Leon, E. (2009). Family context for emotional recovery in internationally adopted children. *International Social Work, 52,* 609–620.

Palacios, J., & Sánchez-Sandoval, Y. (2006). Stress in parents of adopted children. *International Journal of Behavioral Development, 30*, 481–487.

Parker, S. W., Nelson, C. A., & the Bucharest Early Intervention Project Core Group. (2005). The impact of deprivation on the ability to discriminate facial expressions of emotion: An event-related potential study. *Child Development, 76,* 54–72.

Patterson, G. R., Reid, J. B., & Dishion, T. J. (1992). *Antisocial boys*. Eugene, OR: Castalia.

Perlman, S., Kalish, C. W., & Pollak, S. D. (2008). *The role of maltreatment experience in children's understanding of the antecedents of emotion. Cognition and Emotion, 22,* 651–670.

Petersen, A. C., Crockett, L., Richards, M., & Boxer, A. (1988). A self-report measure of pubertal status: Reliability, validity, and initial norms. *Journal of Youth and Early*

Adolescence, 17(2), 117-133.

Pollak, S. D., Nelson, C. A., Schlaak, M. F., Roeber, B. J., Wewerka, S. S., Wiik, K.L., ... & Gunnar, M. R. (2010). Neurodevelopmental effects of early deprivation in post-institutionalized children. *Child Development, 81*, 224–236.

Pollak, S. D., & Sinha, P. (2002). Effects of early experience on children's recognition of facial displays of emotion. *Developmental Psychology*, *38*, 784–791.

Porges, S.W. (1995). Cardiac vagal tone: A physiological index of stress. *Neuroscience and Biobehavioral Reviews, 19*, 225–233.

Porges, S. W. (1996). Physiological regulation in high-risk infants: A model for assessment and potential intervention. *Development & Psychopathology, 8*, 29 – 42.

Porges, S. W. (2001). The polyvagal theory: Phylogenetic substrates of a social nervous system. *International Journal of Psychophysiology, 42*, 123–146.

Porges, S. W. (2003). The polyvagal theory: Phylogenetic contributions to social behavior. *Physiology & Behavior, 79*, 503–513.

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, *74*, 116 – 143.

Porges, S. W., Doussard-Roosevelt, J. A., Portales, A. L., & Greenspan, S. I. (1996). Infant regulation of the vagal ‘‘brake’’ predicts child behavior problems: A psychobiological model of social behavior. *Developmental Psychobiology, 29*, 697 – 712.

Porges, S. W. & Furman, S. A. (2011). The early development of the autonomic nervous system provides a neural platform for social behavior: A polyvagal perspective. *Infant and Child Development*, *20*, 106 – 118.

Porter, C. L. (2003). Coregulation in mother-infant dyads: Links to infants' cardiac vagal tone. *Psychological Reports, 92*, 307 – 319.

Porter, C. L., Wouden-Miller, M., Silva, S. S., & Porter, A. E. (2003). Marital harmony and conflict: Links to infants' emotional regulation and cardiac vagal tone. *Infancy, 4*, 297 – 307.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*, 879-891.

Propper, C. B., Moore, G. A., Mills-Koonce, W. R., Halpern, C., Hill, A., Calkins, S. D., et al. (2008). Gene-environment contributions to the development of vagal functioning: An examination of DRD2 and maternal sensitivity. *Child Development, 79,* 1377 – 1394.

Propper, C., Willoughby, M., Halpern, C. T., Cox, M., & Carbone, M. A. (2007). Parenting quality, DRD4, and the prediction of externalizing and internalizing behaviors in early childhood. *Developmental Psychobiology, 49*, 619 – 632.

R Development Core Team. (2010). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from http://www.R-project.org

Raichle, M. E., MacLeod, A. M., Snyder, A. Z., Powers, W. J., Gusnard, D. A., & Shulman, G. L. (2001). A default mode of brain function. *Proceedings of the National Academy of Sciences USA, 98,* 676–682.

Reynolds, J., & Medina, S. (2008). Challenges and resiliency factors of families with internationally adopted children. In G. R. Walz, J. C. Bleuer, & R. K. Yep (Eds.), Compelling counseling interventions: Celebrating VISTAS' fifth anniversary (pp. 81-90). Ann Arbor, MI: Counseling Outfitters, LLC.

Rigterink, T., Katz, L. F., & Hessler, D. M. (2010). Domestic violence and longitudinal associations with children's physiological regulation abilities. *Journal of Interpersonal Violence, 25*(9), 1669-1683.

Robertson, D., Convertino, V. A., & Vernikos, J. (1994). The sympathetic nervous system and the physiological consequences of spaceflight: A hypothesis. *American Journal of the Medical Sciences, 308,* 126–132.

Rosenthal, J.A., & Groze, V.K. (1994). A longitudinal study of special-needs adoptive families. *Child Welfare Journal, 73*, 689–706.

Rubin, K. H., Hastings, P. D., Stewart, S. L., Henderson, H. A., & Chen, X. (1997). The consistency and concomitants of inhibition: Some of the children, all of the time. *Child Development, 68,* 467–483.

Rutter, M. L., Kreppner, J. M., & O'Connor, T. G. (2001). Specificity and heterogeneity in children's responses to profound institutional privation. *British Journal of Psychiatry, 179*, 97–103.

Rutter, M., O'Connor, T. G., & the English and Romanian Adoptees (ERA) Study Team. (2004). Are there biological programming effects for psychological development? Findings from a study of Romanian adoptees. *Developmental Psychology, 40(1),* 81-94.

Rutter, M., Colvert, E., Kreppner, J., Beckett, C., Castle, J., Groothues, C., et al. (2007). Early adolescent outcomes for institutionally-deprived and non-deprived adoptees. I: Disinhibited attachment. *Journal of Child Psychology and Psychiatry,* *48*, 17–30.

Rutter, M. L., & Sroufe, L. A. (2000). Developmental psychopathology: Concepts and challenges. *Development and Psychopathology, 12,* 265–296.

Scarpa, A., Haden, S. C., & Tanaka, A. (2010). Being hot-tempered: autonomic, emotional, and behavioral distinctions between childhood reactive and proactive aggression. *Biological Psychology, 84*, 488– 496.

Scarpa, A., & Raine, A., (2004). The psychophysiology of child misconduct. *Pediatric Annals, 33*, 296–304.

Schuengel, C., Oosterman, C., & Sterkenburg, P. S. (2009). Children with disrupted attachment histories: Interventions and psychophysiological indices of effects. *Child and Adolescent Psychiatry and Mental Health*, *3(26),* 1-10.

Shannon, K. E., Beauchaine, T. P., Brenner, S. L., Neuhaus, E., & Gatzke-Kopp, L. (2007). Familial and temperamental predictors of resilience in children at risk for conduct disorder and depression. *Development and Psychopathology, 19*, 701–727.

Shaw, D. S., Winslow, E. B., Owens, E. B., Vondra, J. I., Cohn, J. F., & Bell, R. Q. (1998). The development of early externalizing problems among children from low-income families: A transformational perspective. *Journal of Abnormal Child Psychology, 26*, 95-107.

Sheridan, M. A., Fox, N. A., Zeanah, C. H., McLaughlin, K. A., and Nelson, C. A. (2012). Variation in neuronal development as a result of exposure to institutionalization in early childhood. *Proceedings of the National Academy of Sciences of the United States of America*, *109*, 12927–12932.

Shirtcliff, E. A., & Essex, M. J. (2008). Concurrent and longitudinal associations of basal and diurnal cortisol with mental health symptoms in early adolescence. *Developmental Psychobiology, 50*, 690–703.

Skowron, E. A., Loken, E., Gatzke-Kopp, L. M., Cipriano, E. A., Woehrle, P. L., Van Epps, J. J. . . & Ammerman, R. T. (2011). Mapping cardiac physiology and parenting processes in maltreating mother-child dyads. *Journal of Family Psychology, 25*, 663–674.

Smyke, A. T., Dumitrescu, A., & Zeanah, C. H. (2002). Attachment disturbances in young children. I: The continuum of caretaking casualty. *Journal of the American Academy of Child and Adolescent Psychiatry, 41*, 972-982.

Smyke, A. T., Koga, S. F., Johnson, D. E., Fox, N. A., Marshall, P. J., Nelson, C.A., et al. (2007). The caregiving context in institution-reared and family-reared infants and toddlers in Romania. *Journal of Child Psychology and Psychiatry, 48*, 210–218.

Sonuga-Barke, E. J., Schlotz, W. & Kreppner, J. (2010). V. Differentiating developmental trajectories for conduct, emotion, and peer problems following early deprivation. *Monographs of the Society for Research in Child Development, 75*(1), 102-124. http://dx.doi.org/10.1111/j.1540-5834.2010.00552.x

Stams, G. J. M., Juffer, F., Rispens, J., & Hoksbergen, R. A. C. (2000). The development and adjustment of 7-year-old children adopted in infancy. *Journal of Psychological Psychiatry and Allied Disciplines, 41*, 1025–1037.

Staton, L., El-Sheikh, M., & Buckhalt, J. A. (2009), Respiratory sinus arrhythmia and cognitive functioning in children. *Developmental Psychobiology, 51*(3), 249-258.

Stovall-McClough, K. C., & Dozier, M. (2004). Forming attachments in foster care:

Infant attachment behaviors during the first two months of placement. *Development and Psychopathology*, *16,* 253–271.

Suess, P. E, Porges, S. W., & Plude, D. J. (1994). Cardiac vagal tone and sustained attention in school age children. *Psychophysiology 31*, 17-22.

Tan, T. X., & Marfo, K. (2006). Parental ratings of behavioral adjustment in two samples of adopted Chinese girls: Age-related versus socio-emotional correlates and predictors. *Applied Developmental Psychology, 27,* 14–30.

Tarullo, A. R., Bruce, J., & Gunnar, M. R. (2007). False belief and emotion understanding in post-institutionalized children. *Social Development*, *16*, 57–78.

Thayer, J.F., Åhs, F., Fredrikson, M., Sollers, J.J. 3rd. & Wager, T.D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Research, 36,* 747-756.

Thayer, J. F., Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders 61*, 201–216.

The St. Petersburg–USA Orphanage Research Team. (2005). Characteristics of children, caregivers, and orphanages for young children in St. Petersburg, Russian Federation. *Journal of Applied Developmental Psychology, 26*, 477–506.

The St. Petersburg-USA Orphanage Research Team. (2008). The effects of early social-emotional relationship experience on the development of young orphanage children. *Monograph of the Society for Research in Child Development*, *73,* Serial No. 291(3).

Tottenham, N. (2012). Human amygdala development in the absence of species-expected caregiving. *Developmental Psychobiology, 54*(6), 598-611.

Tottenham, N., Hare, T. A., Millner, A., Gilhooly, T., Zevin, J. D., & Casey, B. J. (2011). Elevated Amygdala Response to Faces Following Early Deprivation. *Developmental Science, 13*, 46-61.

Tottenham, N., Hare, T. A., Quinn, B. T., McCarry, T., Nurse, M., Gilhooly, T., . . . Casey, B. J. (2010). Prolonged institutional rearing is associated with atypically large amygdala volume and emotion regulation difficulties. *Developmental Science, 13*(1), 46 – 61.

Trombini, M. M., Hulshof, H. J., Graiani, G. G., Carnevali, L. L., Meerlo, P. P., Quaini, F. F., & Sgoifo, A. A. (2012). Early maternal separation has mild effects on cardiac autonomic balance and heart structure in adult male rats. *Stress: The International Journal On The Biology Of Stress, 15*(4), 457-470.

Vanderwert, R. E., Marshall, P. J., Nelson III, C. A., Zeanah, C. H., & Fox, N. A. (2010). Timing of intervention affects brain electrical activity in children exposed to severe psychosocial neglect. *PLoS ONE, 5(7),* e11415.

van Buuren S., Brand, J. P.L., Groothuis-Oudshoorn, C. G. M., & Rubin, D. B. (2006). Fully conditional specification in multivariate imputation. *Journal of Statistical Computation and Simulation, 76*(12), 1049-1064.

van Buuren, S., & Groothuis-Oudshoorn, K. (2000). Mice: Multivariate Imputation by Chained Equations in R. *Journal of Statistical Software*, *45*(3), 1-67. URL http://www.jstatsoft.org/v45/i03/

van Goozen, S. H. M., Fairchild, G., Snoek, H., & Harold, G.T., (2007). The evidence for a neurobiological model of childhood antisocial behavior. *Psychological Bulletin,* *133*, 149–182.

Verhulst, F. C. (2000). Internationally adopted children: The Dutch longitudinal adoption study. *Adoption Quarterly, 4,* 27–44.

Verhulst, F. C., Althaus, M., & Versluis-den Bieman, H. J. M. (1990a). Problem behavior in international adoptees: I. An epidemiological study. *Journal of American Academy of Child and Adolescent Psychiatry, 29*, 94–103.

Verhulst, F. C., Althaus, M., & Versluis-den Bieman, H. J. M. (1990b). Problem behavior in international adoptees: II. Age at placement. *Journal of American Academy of Child and Adolescent Psychiatry, 29,* 104–111.

Verhulst, F. C., Althaus, M., & Versluis-den Bieman, H. J. M. (1992). Damaging backgrounds: Later adjustment of international adoptees. *Journal of the American Academy of Child and Adolescent Psychiatry, 31*, 518–524.

Verhulst, F. C., & Versluis-den Bieman, H. J. M. (1995). Developmental course of problem behaviors in adolescent adoptees. *Journal of American Academy of Child and Adolescent Psychiatry, 34*, 151–159.

Viana, A. G., & Welsh, J. A. (2010). Correlates and predictors of parenting stress among internationally adopting mothers: A longitudinal investigation. *International Journal of Behavioral Development, 34*, 363–373.

Vitiello, B., & Stoff, D. M., (1997). Subtypes of aggression and their relevance to child psychiatry. *Journal of the American Academy of Child and Adolescent Psychiatry 36,* 307–315.

Vorria, P., Papaligoura, Z., Dunn, J., van IJzendoorn, M. H., Steele, H., Kontopoulou, A., & Sarafidou, Y. (2003). Early experiences and attachment relationships of Greek infants raised in residential group care. *Journal of Child Psychiatry and Psychology, 44*, 1208–1220.

Wechsler, D. (1999). *Wechsler Abbreviated Scale of Intelligence (WASI).* San Antonio, TX: Harcourt Assessment.

Whitson, S. M., & El-Sheikh, M. (2003). Moderators of family conflict and children's adjustment and health. *Journal of Emotional Abuse, 3*, 47–73.

Wiik, K. L., Loman, M. M., Van Ryzin, M. J., Armstrong, J. M., Essex, M. J., Pollak, S. D., & Gunnar, M. R. (2011). Behavioral and emotional symptoms of post-institutionalized children in middle childhood. *Journal of Child Psychology and Psychiatry, 52(1),* 56-63.

Williams, L. M., Phillips, M. L., Brammer, M. J., Skerrett, D., Lagopoulos, J., Rennie, C. . . . & Gordon, E. (2001). Arousal dissociates amygdala and hippocampal fear responses: Evidence from simultaneous fMRI and skin conductance recording. *NeuroImage, 14*, 1070–1079.

Wismer Fries, A. B., & Pollak, S. D. (2004). Emotion understanding in postinstitutionalized Eastern European children. *Development and Psychopathology, 16*, 355 – 369.

Wismer Fries, A. B., Shirtcliff, E. A., & Pollak, S. D. (2007). Neuroendocrine dysregulation following early social deprivation in children. *Developmental Psychobiology*, 588-599.

Wismer Fries, A. B., Ziegler, T. E., Kurian, J. R., Jacoris, S., & Pollak, S. D. (2005). Early experience in humans is associated with changes in neuropeptides critical for regulating social behavior. *Proceedings of the National Academy of Science, 102*, 17237-17340.

Young, L. J., & Wang, Z. (2004). The neurobiology of pair bonding. *Nature Neuroscience, 7,* 1048–1054.

Zeanah, C. H. (2000). Disturbances of attachment in young children adopted from institutions. *Development and Behavioral Pediatrics, 21*, 230−236.

Zeanah, C. H., Egger, H. L., Smyke, A. T., Nelson, C. A., Fox, N. A., Marshall, P. J., & Guthrie, D. (2009). Institutional rearing and psychiatric disorders in Romanian preschool children. *American Journal of Psychiatry, 166*(7), 777-785.

Zeanah, C. H., Smyke, A. T., & Settles, L. (2006). Children in orphanages. In K. McCartney & D. A. Phillips (Eds.), *Handbook of Early Childhood Development* (pp. 224-254). Malden, MA: Blackwell Publishing.

Appendix 1: Tables

Table 1

Country of Origin by Group and Sex

	Post-institute *n* = 38		Post-foster care *n* = 23	
Country	n (female)	% (% female)	n (female)	% (% female)
China	15 (12)	39.5 (80.0)	0	0
South Korea	0	0	17 (7)	73.9 (41.2)
Vietnam	1 (1)	2.6 (100)	0	0
India	1 (1)	2.6 (100)	0	0
Russia	16 (5)	42.1 (31.3)	0	0
Ukraine	1 (0)	2.6 (0)	0	0
Kazakhstan	1 (0)	2.6 (0)	0	0
Colombia	0	0 (0)	1 (1)	4.3 (100)
Guatemala	2 (1)	5.3 (50)	5 (2)	21.7 (40)
Ethiopia	1 (1)	2.6 (100)	0	0

Table 2

Early Care Experience

Variable	Post-institute *M (SD; Range)*	Post-foster care *M (SD; Range)*
Months in institution	18.46 (10.77; 9 - 53)	0
Months in foster care	0	5.07 (1.34; 3 - 7.5)
Age at adoption (months)**	19.14 (10.78; 9 - 53)	5.60 (1.50; 3 - 8)
Early care risk factors**	1.68 (0.45; 1 - 2.83)	1.01 (0.07; 1 - 1.33)
Years in USA at time of testing**	7.60 (1.14; 4.46 - 8.95)	8.39 (0.68; 7.43 - 9.60)

**$p < .001$.

Table 3

Demographic Characteristics by Group

Characteristic	Post-institute	Post-foster care	Non-adopted
Age of child (years) at testing *M (SD)**	9.20 (0.57) $_1$	8.86 (0.70)	8.87 (0.58) $_2$
Age of parent *M (SD)*			
Respondent**	48.57 (4.72) $_1$	46.67 (3.59) $_1$	40.59 (4.98) $_2$
Partner**	48.84 (6.19) $_1$	48.44 (3.79) $_1$	41.96 (6.54) $_2$
Parent Education (% college degree)			
Respondent	100	95.70	94.60
Partner	100	95.70	81.10
Annual Household Income *Median*	$100,001 - 125,000	$100,001 - 125,000	$75,001 - 100,000
Marital Status (% married or living with partner)* [a]	78.90 $_1$	95.70 $_1$	100 $_2$
History of Heart Problem (%)	7.90	0.00	2.70
Child Medicine Use*	34.20 $_1$	13.00	10.80 $_2$
Weight (kg) at testing	28.15 (4.83)	29.47 (6.12)	30.51 (4.99)
Height (cm) at testing*	132.42 (7.09)	130.51 (8.28) $_1$	136.07 (9.39) $_2$

* $p < .05$, ** $p < .01$.
[a] Post-institute and post-foster care groups were combined and compared to non-adopted group.

Table 4

Descriptive Statistics for Physiological Variables

Variable	Min.	Max.	*M*	*SD*	*N*
Average Scores [a]					
NS.SCR baseline	1.00	2.16	1.63	0.34	85
NS.SCR conflict task	1.00	2.37	1.89	0.23	77
NS.SCR positive task	1.00	2.25	1.86	0.03	79
NS.SCR cognitive task	1.00	2.28	1.90	0.25	80
RSA baseline	3.55	9.71	7.10	1.31	93
RSA talk control	3.64	8.47	6.45	1.16	90
RSA talk/social control	4.12	8.91	6.75	1.08	93
RSA conflict task	3.51	8.97	6.40	1.18	93
RSA positive task	3.05	9.25	6.39	1.18	89
RSA cognitive task	3.55	9.14	6.63	1.17	91
Standard Residual Scores					
NS.SCR(con)-R	-2.87	1.77	0.00	0.99	75
NS.SCR(pos)-R	-2.50	1.99	0.02	0.91	76
NS.SCR(cog)-R	-3.11	2.30	0.00	0.99	77
RSA(con)-R	-4.29	2.20	0.00	0.99	92
RSA(pos)-R	-2.68	2.87	0.00	0.99	89
RSA(cog)-R	-2.48	2.75	0.00	0.99	90

[a] NS.SCR mean values are log 10 transformed. RSA = Respiratory-sinus arrhythmia; NS.SCR = Non-specific skin conductance response. NS.SCR(pos) = reactivity score during positive task; NS.SCR(con) = reactivity score during conflict task; NS.SCR(cog) = reactivity score during cognitive task; RSA(pos) = reactivity score during positive task; RSA(con) = reactivity score during conflict task; RSA(cog) = reactivity score during cognitive task.

Table 5

Intercorrelations Among Key Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Age at testing	-														
2. Age at adoption	.18	-													
3. Early care risk	.21	.60**	-												
4. Sex (male=1, female =2)	-.12	.14	.13	-											
5. NS.SCR	-														
baseline	.23*	-.44*	-.37**	-.07	-										
6. NS.SCR(pos)	-.14	-.03	.01	-.12	.02	-									
7. NS.SCR(con)	-.07	-.06	-.11	.04	.00	.54**	-								
8. NS.SCR(cog)	-.14	-.08	-.14	.14	.00	.36**	.36**	-							
9. RSA baseline	.12	-.14	-.13	-.07	.04	-.09	-.19	-.08	-						
10. RSA(pos)	.10	-.15	-.10	.22*	.07	.14	.25*	.13	.15	-					
11. RSA(con)	-.17	-.12	-.28*	.10	.04	-.01	.03	.03	.09	.48**	-				
12. RSA(cog)	-.04	-.15	-.06	.03	.08	.12	-.03	.06	.22*	.17	.24*	-			
13. Ext	-.02	.40**	.37**	-.19t	-.03	.10	.02	-.01	.11	.01	-.05	-.02	-		
14. Distress	-.15	.18	.03	-.04	.13	.28*	.07	.09	-.08	-.03	.00	-.14	.37**	-	
15. Express encourage	-.07	.07	.11	.05	-.03	0.18	.12	-.08	.11	.01	.05	.09	-.14	-.26**	-

t $p < .10$; * $p < .05$; ** $p < .01$. RSA = Respiratory-sinus arrhythmia; NS.SCR = Non-specific skin conductance response. NS.SCR(pos) = standard residual reactivity score during positive task; NS.SCR(con) = standard residual reactivity score during conflict task; NS.SCR(cog) = standard residual reactivity score during cognitive task; RSA(pos) = standard residual reactivity score during positive task; RSA(con) = standard residual reactivity score during conflict task; RSA(cog) = standard residual reactivity score during cognitive task; Ext = Externalizing score

Table 6

Missing Physiological Data by Group

	Post-institution		Post-foster care		Non-adopted	
Variable	% Refuse	% Unusable	% Refuse	% Unusable	% Refuse	% Unusable
Skin Conductance						
Baseline	0	16	0	9	0	14
Positive emotion task	3	21	4	17	0	14
Conflict discussion task	5	18	9	13	0	16
Cognitive task	5	16	9	17	0	11
Respiratory Sinus Arrhythmia						
Baseline	0	6	0	9	0	3
Positive emotion task	3	6	4	17	0	0
Conflict discussion task	0	6	4	9	0	0
Cognitive task	3	6	4	13	0	0
Talking control	0	9	4	4	0	0
Talking/social control	0	6	4	9	0	0

Table 7

Descriptive Statistics of Variables by Group

	Post-institution				Post-foster Care				Non-adopted			
Variable	Min.	Max.	*M*	*SD*	Min.	Max.	*M*	*SD*	Min.	Max.	*M*	*SD*
WASI IQ*	69.00	130.00	106.29_1	15.45	86.00	136.00	111.22	12.62	90.00	141.00	115.1_2	12.77
WASI Vocabulary **	29.00	74.00	49.57_1	10.80	37.00	70.00	55.70	9.10	21.00	80.00	59.00_2	12.21
WASI Matrix Reasoning	24.00	72.00	54.83	12.30	23.00	69.00	54.18	12.33	25.00	70.00	56.42	9.74
Puberty Score	1.00	2.25	1.34	0.33	1.00	2.50	1.42	0.36	1.00	2.50	1.51	0.39
Distress reaction	1.83	4.25	3.00	0.62	1.33	4.25	2.73	0.76	1.00	4.50	2.81	0.84
Expressive encouragement	3.83	6.50	5.32	0.72	3.67	6.42	5.14	0.80	2.75	6.92	5.16	1.07
Externalizing (log10 transformed)**	1.00	1.34	1.11_1	0.08	1.00	1.2	1.06_2	0.05	1.00	1.19	1.05_2	0.05

*p < .05; **p < .01.

Table 8

Hierarchical multiple regression predicting baseline respiratory-sinus arrhythmia

	Step 1		Step 2		Step 3		Step 4	
Variable	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Child sex	-0.19	0.27	-0.17	0.28	-0.19	0.28	-0.07	0.26
NA group			-0.12	0.31	-0.11	0.32	-0.13	2.50
PFC group			0.27	0.36	0.25	0.37	5.6t	3.02
Distress					-0.10	0.20	0.92**	0.35
Express encourage					0.15	0.16	-0.18	0.29
NA X Distress							-1.02*	0.44
PFC X Distress							-2.21***	0.52
NA X Express encourage							0.57	0.35
PFC X Express encourage							0.15	0.45
Multivariate *F* for model	*F* (1, 91) = 0.50		*F* (3, 89) = 0.54		*F* (5, 87) = 0.60		*F* (9, 83) = 3.00**	
Total R^2	0.01		0.02		0.03		0.25	
(ΔR^2)			0.01		0.02		0.21***	

*p < .05, **p < .01. NA = Non-adopted; PFC = Post-foster care.

Table 9

Hierarchical multiple regression predicting respiratory-sinus arrhythmia reactivity during conflict discussion task

	Step 1		Step 2		Step 3		Step 4	
Variable	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Child sex	0.19	0.21	0.22	0.21	0.22	0.21	0.26	0.21
NA group			0.07	0.24	0.08	0.24	5.42**	2.03
PFC group			0.37	0.28	0.38	0.29	5.41*	2.52
Distress					0.06	0.15	0.72**	0.28
Express encourage					0.07	0.13	0.42t	0.24
NA X Distress							-0.90**	0.36
PFC X Distress							-0.99*	0.42
NA X Express encourage							-0.52t	0.29
PFC X Express encourage							-0.42	0.37
Multivariate *F* for model	F (1, 90) = 0.87		F (3, 88) = 0.89		F (5, 86) = 0.60		F (9, 82) = 1.40	
Total R^2	0.02		0.03		0.03		0.07	
(ΔR^2)			0.02		0.00		0.10t	

t $p < .10$, *$p < .05$, **$p < .01$. NA = Non-adopted; PFC = Post-foster care.

Table 10

Hierarchical multiple regression predicting respiratory-sinus arrhythmia reactivity during positive emotion task

	Step 1		Step 2		Step 3		Step 4	
Variable	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Sex	0.43*	0.21	0.49*	0.21	0.48*	0.21	0.51*	0.22
NA group			0.08	0.23	0.07	0.23	1.25	2.10
PFC group			0.55ŧ	0.28	0.55ŧ	0.29	0.17	2.62
Distress					-0.01	0.15	0.06	0.28
Express encourage					0.00	0.12	0.06	0.25
NA X Distress							-0.19	0.36
PFC X Distress							0.10	0.43
NA X Express encourage							-0.12	0.30
PFC X Express encourage							0.03	0.39
Multivariate *F* for model	F (1, 87) = 4.22*		F (3, 85) = 2.77*		F (5, 83) = 1.62		F (9, 79) = 0.95	
Total R^2	0.05		0.09		0.09		0.10	
(ΔR^2)			0.04		0.00		0.01	

ŧ p = .05, * $p < .05$. NA = Non-adopted; PFC = Post-foster care.

Table 11

Hierarchical multiple regression predicting respiratory-sinus arrhythmia reactivity during cognitive task

Variable	Step 1 *B*	Step 1 *SE*	Step 2 *B*	Step 2 *SE*	Step 3 *B*	Step 3 *SE*	Step 4 *B*	Step 4 *SE*
Sex	0.05	0.21	0.05	0.21	0.03	0.21	-0.003	0.23
NA group			0.31	0.24	0.30	0.24	0.59	2.16
PFC group			0.20	0.29	0.16	0.29	0.63	2.68
Distress					-0.51	0.15	-0.16	0.30
Express encourage					0.07	0.13	0.13	0.25
NA X Distress							0.07	0.38
PFC X Distress							-0.16	0.44
NA X Express encourage							-0.10	0.30
PFC X Express encourage							-0.01	0.40
Multivariate *F* for model	F (1, 88) = 0.07		F (3, 86) = 0.60		F (5, 84) = 0.71		F (9, 80) = 0.45	
Total R^2	0.001		0.02		0.04		0.05	
(ΔR^2)			0.02		0.02		0.01	

NA = Non-adopted; PFC = Post-foster care.

Table 12

Hierarchical multiple regression predicting baseline skin conductance using multiply imputed data

Variable	Step 1 *B*	Step 1 *SE*	Step 2 *B*	Step 2 *SE*	Step 3 *B*	Step 3 *SE*	Step 4 *B*	Step 4 *SE*
Child age at testing	-.13	0.08	-.12	0.08	-.12	0.08	-0.12	0.07
Sex	-0.06	0.08	-0.05	0.08	-0.04	0.09	-0.06	0.08
NA group			-0.06	0.09	-0.06	0.09	0.10	0.88
PFC group			0.14	0.12	0.15	0.13	0.84	1.00
Distress					0.03	0.06	0.04	0.13
Express encourage					0.01	0.05	0.05	0.10
NA X Distress							0.02	0.17
PFC X Distress							-0.10	0.20
NA X Express encourage							-0.04	0.12
PFC X Express encourage							-0.08	0.15
Pooled (ΔR^2) [a]			0.00		0.01		0.01	

t *p* < .10. NA = Non-adopted; PFC = Post-foster care.
[a] Values based on multiply imputed data. Only ΔR^2 available.

Table 13

Multiple regression predicting skin conductance reactivity during conflict discussion task using multiply imputed dataset

	Step 1		Step 2		Step 3		Step 4	
Variable	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age at testing	-0.10	0.27	-0.10	0.29	-0.06	0.31	-0.12	0.32
Sex	0.03	0.33	-0.17	0.34	-0.12	0.35	-0.14	0.34
NA group			0.05	0.33	-0.10	0.38	-1.08	2.66
PFC group			-0.02	0.42	0.13	0.43	-4.69	3.11
Distress					0.11	0.21	-0.13	0.41
Express encourage					0.14	0.18	-0.02	0.32
NA X Distress							0.21	0.56
PFC X Distress							0.61	0.55
NA X Express encourage							0.07	0.38
PFC X Express encourage							0.61	0.50
Pooled ΔR^2			0.01		0.02		0.01	

NA = Non-adopted; PFC = Post-foster care.

Table 14

Multiple regression predicting skin conductance reactivity during positive task using multiply imputed dataset

	Step 1		Step 2		Step 3		Step 4	
Variable	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age at testing	-0.18	0.25	-0.18	0.27	-0.14	0.27	-0.11	0.27
Sex	-0.17	0.26	-0.17	0.27	-0.14	0.27	-0.14	0.29
NA group			0.05	0.33	0.07	0.33	-3.35	3.12
PFC group			-0.02	0.42	0.02	0.45	-3.40	3.22
Distress					0.19	0.22	-0.06	0.51
Express encourage					-0.08	0.21	-0.39	0.31
NA X Distress							0.43	0.72
PFC X Distress							0.23	0.59
NA X Express encourage							0.42	0.38
PFC X Express encourage							0.52	0.50
Pooled ΔR^2			0.002		0		0.01	

NA = Non-adopted; PFC = Post-foster care.

Table 15

Multiple regression predicting skin conductance reactivity during cognitive task using multiply imputed dataset

	Step 1		Step 2		Step 3		Step 4	
Variable	*B*	*SE*	*B*	*SE*	*B*	*SE*	*B*	*SE*
Age at testing	-0.16	0.25	-0.16	0.27	-0.14	0.27	-0.11	0.28
Sex	0.23	0.32	0.25	0.34	0.26	0.34	0.30	0.34
NA group			-0.01	0.39	-0.09	0.40	-1.08	3.22
PFC group			0.17	0.60	0.19	0.61	-2.68	3.64
Distress					0.10	0.22	-0.15	0.58
Express encourage					-0.06	0.19	-0.15	0.34
NA X Distress							0.19	0.80
PFC X Distress							0.64	0.94
NA X Express encourage							0.08	0.42
PFC X Express encourage							0.21	0.52
Pooled ΔR^2			0.01		0.02		0.01	

NA = Non-adopted; PFC = Post-foster care.

Appendix 2: Figures

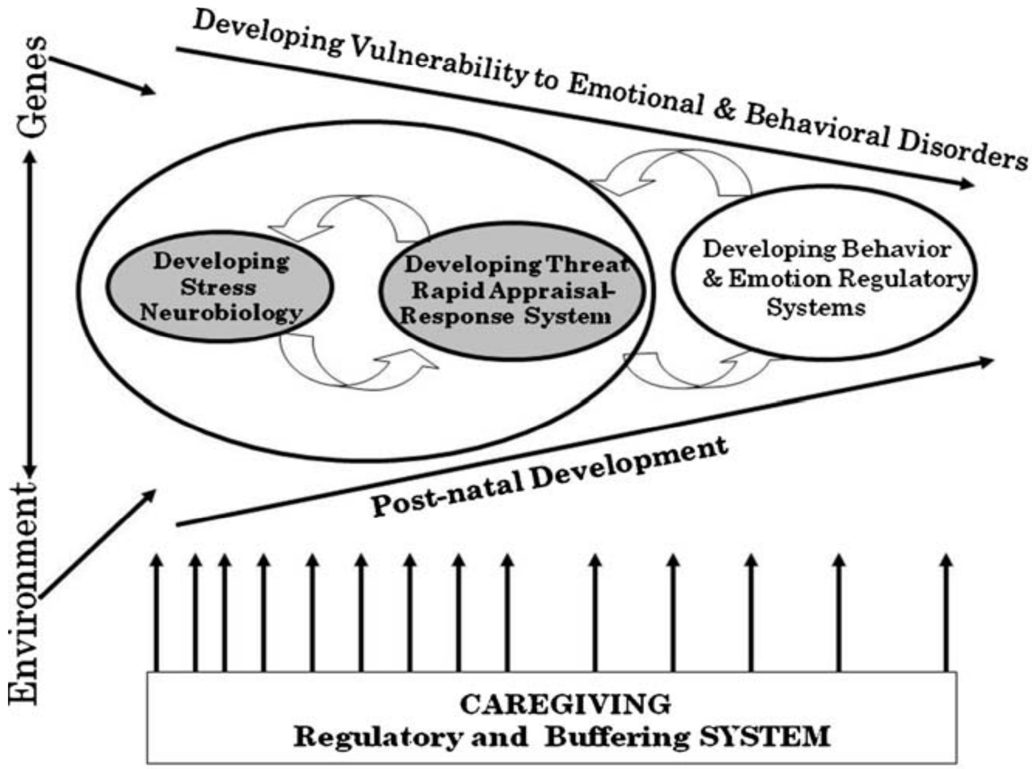

Figure 1. Conceptual model of early life stress. From "Early Experience and the Development of Stress Reactivity and Regulation in Children," by M. M. Loman & M. R. Gunnar, 2010, *Neuroscience & Biobehavioral Reviews, 34*, p. 869. Copyright © 2009 by Elsevier Science. Reprinted with permission.

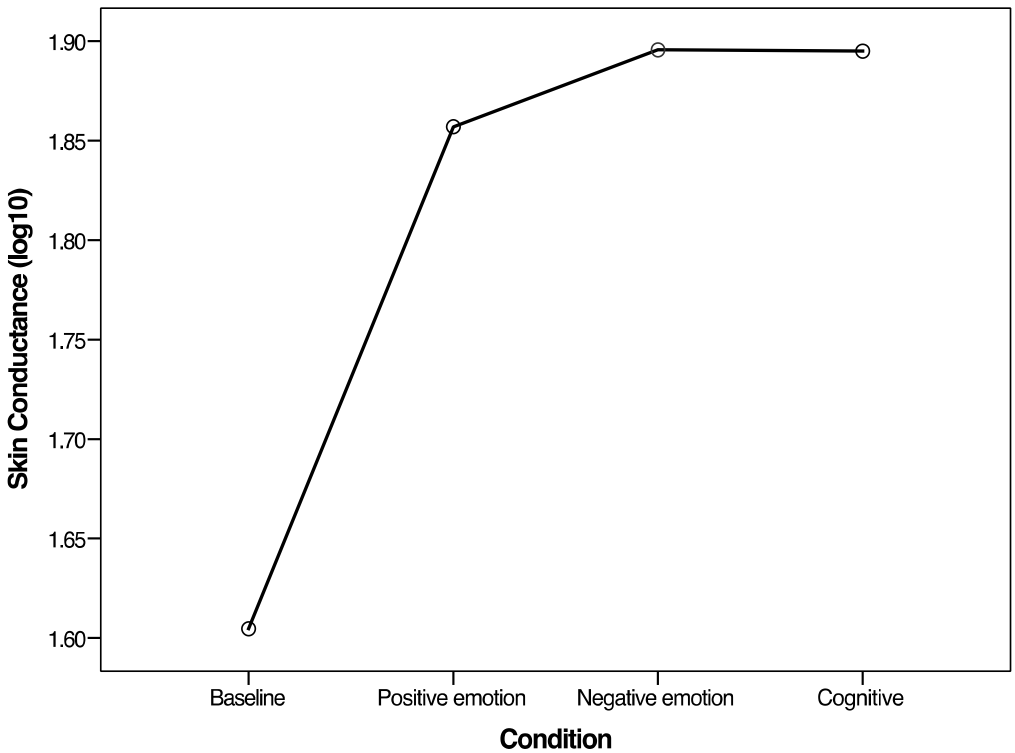

Figure 2. Mean levels of non-specific skin conductance (log 10 transformed) across conditions.

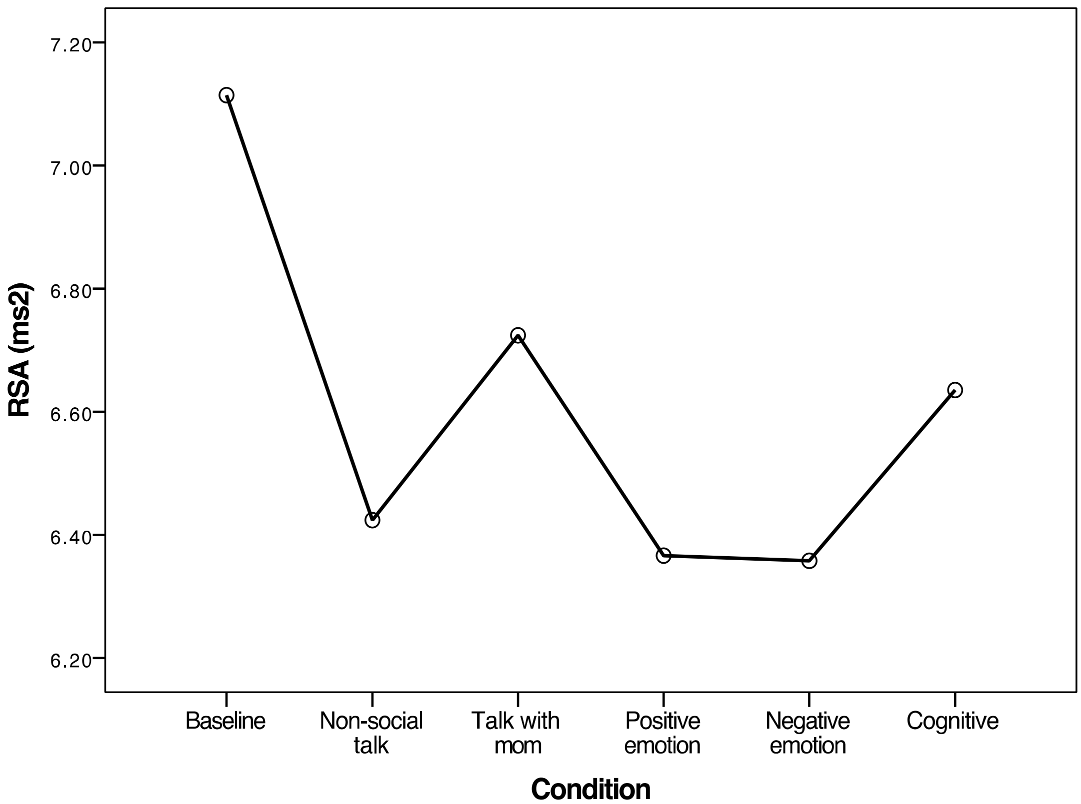

Figure 3. Mean levels of respiratory-sinus arrhythmia (ms^2) across conditions.

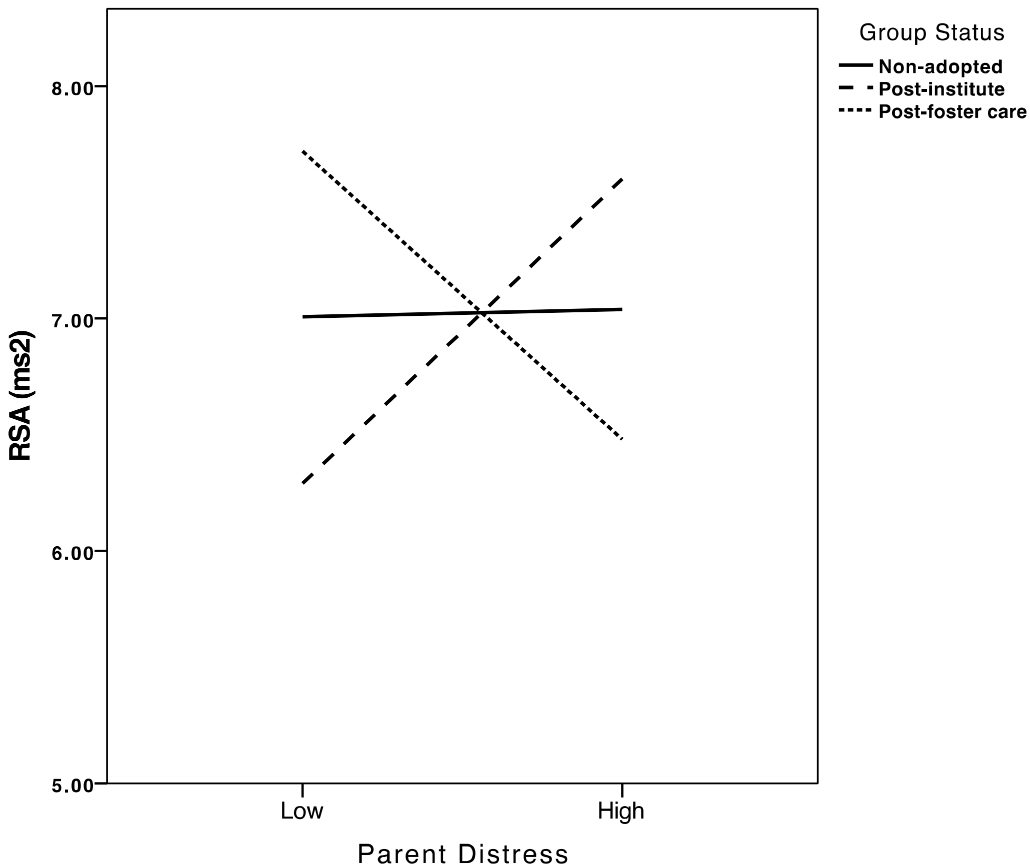

Figure 4. The interaction of group status and parent distress to children's negative emotions in predicting respiratory-sinus arrhythmia (RSA) during the baseline condition. The results of the hierarchical multiple regression analysis, with sex of child and expressive encouragement in the model, are plotted using procedures described by Aiken and West (1991) by graphing parent distress at 1 *SD* below and above the mean for each group.

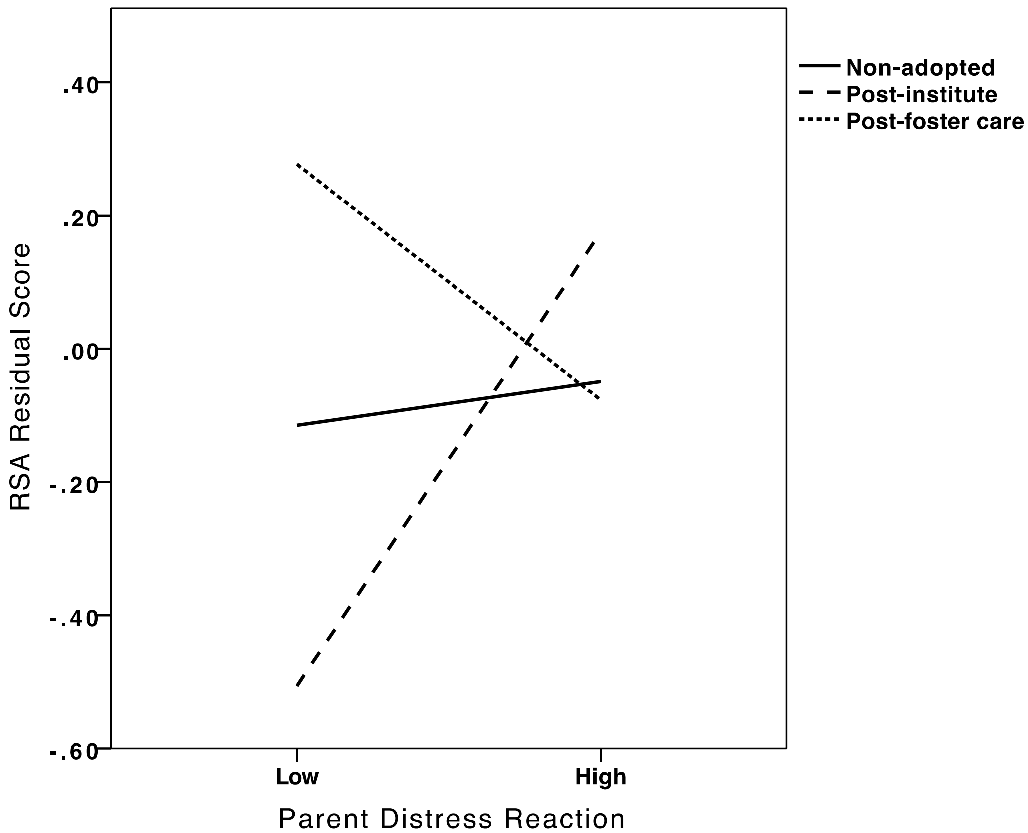

Figure 5. The interaction of group status and parent distress reaction to children's negative emotions in predicting respiratory-sinus arrhythmia (RSA) during the conflict discussion condition. The results of the hierarchical multiple regression analysis, with sex of child and expressive encouragement in the model, are plotted using procedures described by Aiken and West (1991) by graphing parent distress at 1 *SD* below and above the mean for each group.