In:

CHAPTER 3

"HIDDEN TRAUMA" IN INFANCY

Attachment, Fearful Arousal, and Early Dysfunction of the Stress Response System

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The traditional perspective on trauma views trauma from the perspective of the traumatic event and its characteristics. How life threatening was the event? How unanticipated? How often repeated? Who was the perpetrator? The psychological sequellae of trauma are thus most often viewed as following from the characteristics of the event. Characteristics of the child experiencing the trauma, as well as his or her social context, have received less attention except that a consensus exists that large individual differences do exist in how traumatic events are experienced.

In this chapter we do not focus on characteristics of traumatic events or trauma responses. Instead, we argue here that the impact of trauma on the developing child cannot be understood apart from the social and psychological resources available to buffer the effects of fearful arousal on the child's psychobiological functioning. In early childhood the primary attachment relationship serves that function. Therefore, physiological and psychological responses to threatening events in early childhood can be understood fully only in reference to the quality of psychobiological regulation available within primary attachment relationships.

We intend to elaborate the view here that trauma in infancy has special characteristics and must be defined differently than trauma at later ages. According to the fourth edition of the *Diagnostic and Statistical Manual of*

Mental Disorders (DSM-IV) a traumatic event involves threat to the physical integrity of oneself or another person (American Psychiatric Association, 1994). In human infancy, however, experienced threat is closely related to the caregiver's affects and availability rather than to the actual degree of physical or survival threat inherent in the event itself. Equipped with limited behavioral and cognitive coping capacities, the very young infant is dependent on external regulation to avoid overwhelming levels of physiological arousal that exceed available coping capacities.

Thus, the relevant traumas of infancy most often result from the "hidden traumas" of caregiver unavailability and interactive dysregulation. These hidden traumas are woven into the fabric of interaction between the caregiver and the infant and do not necessarily stand out as salient events to the observer. However, the physiological evidence reviewed below indicates that these more subtle traumatic events of infancy engender similar physiological consequences in stress response systems during the infancy period as do the more obvious threat events salient to older children and adults.

Finally, new evidence suggests that the infant does not come equipped with a particular level of stress tolerance at birth that continues into the preschool and school years. Instead, the expression of the infant's genetic predisposition appears to be substantially under the influence of caregiver regulation. The sensitively attuned caregiver, able to navigate the pathway from heightened states of arousal to homeostatic recovery, shapes the infant's psychobiological response to environmental stressors, creating an infant who is able to tolerate challenges to his or her internal psychobiological milieu. Conversely, insensitive caregiver response to heightened infant arousal may promote dysregulated response to stress in the infant, characterized by under- or overactivity in the stress response system. Sensitively attuned caregiver regulation effectively resets the infant's propensity to react to stressors with more enduring states of arousal. Therefore, these subtle regulatory events of early infancy shape the subsequent functioning of neuroendocrine stress response systems in enduring ways. Specifically, these hidden traumas of infancy contribute to the early hyper- or hyporegulation of stress responses mediated through the hypothalamic–pituitary–adrenocortical (HPA) axis.

In developing a view of the regulatory processes in the caregiver–infant system that contribute to dysregulation, we integrate insights from the literature on early brain development and early dysfunction of the HPA axis with an intersubjective and bioregulatory model of the early functioning of the attachment system. We recontextualize the functioning of the attachment relationship over the first year within a revised evolutionary framework. This framework anticipates dual-level mechanisms embedded in the infant–caregiver relationship governing the regulation of fearful arousal in infancy, including both direct physiological mechanisms and intersubjective processes.

ATTACHMENT RELATIONSHIPS AND REGULATION OF FEARFUL AROUSAL

In this chapter we integrate various strands of the developmental literature to advance a model of the likely mechanisms through which caregiver behavior impacts the stress response system in human infancy. The literature most central to such a model is the literature on the development of the attachment relationship. The infant's attachment behavioral system is viewed as the set of infant behaviors that mediates felt security, or reductions in fearful arousal. by maintaining proximity or contact with the caregiver. In-depth reviews of this literature are available elsewhere (Cassidy & Shaver, 1999; Lyons-Ruth & Jacobvitz, 1999). Here we reference this literature selectively in regard to the interface of attachment behavior and the regulation or dysregulation of the stress response system, as evidenced by activity in the HPA system.

The caregiving system has received considerable attention from attachment theorists over the past 40 years. John Bowlby put forth the critical concept of an attachment motivational system that functions to promote the infant's proximity to the caregiver and thereby to regulate both the infant's actual safety and the infant's sense of "felt security" in the environment. He asserted that infants are biologically predisposed to become attached to their caregivers and that early disturbances in primary attachment relationships could lead to emotional insecurity and later disturbances in the development of meaningful relationships (Bowlby, 1969, 1973, 1980).

Ainsworth, Blehar, Waters, and Wall (1978) developed a means of classifying the quality of a child's attachment to a caregiver, referred to as the "Strange Situation" procedure. Twelve- to 18-month-old infants' responses to brief separations from and reunions with the caregiver allow the researcher to classify the infant's attachment organization as *secure*, *avoidant*, or *resistant/ambivalent*. The mother's sensitivity to the infant's signals and communications in the home predicted secure organization, whereas maternal rejection and unpredictability predicted detached avoidance and overtly anxious resistance/ambivalence, respectively (Main, 2000).

Mary Main and Judith Solomon subsequently developed a fourth category of infant strange situation behavior, called *disorganized/disoriented*. These infants exhibited an array of odd, disoriented, and overtly conflicted behaviors in the presence of a parent. Main and Hesse (1990) hypothesized that for these infants the caregiver was both the source of comfort and a source of alarm, so that these infants experienced a simultaneous need to approach and to flee their parent. Lyons-Ruth, Bronfman, and Atwood (1999) have noted that absence of caregiver regulation also leads to infant disorganization, so that absence of regulation rather than fear of the caregiver per se may be the more general mechanism related to disorganization. Consistent with these hypotheses regarding caregiver behavior, studies have indicated that 83% of abused or neglected infants display disorganized at-tachment behaviors toward the parent (V. Carlson, Cicchetti, Barnett, & Braumwald, 1989). However, it is likely that caregiver behaviors less ex-treme than overt maltreatment are involved as well. Approximately 15% of infants in low-risk samples demonstrate disorganized attachment patterns (van IJzendoorn, Schuengel, & Bakermans-Kranenburg, 1999). While a subset of these infants may have been maltreated, Hesse and Main (2000) have speculated that other parents may demonstrate anomalous forms of threatening, fearful, and/or dissociative behavior related to unresolved trauma in their own histories.

A large body of research on fearful arousal has documented the range of individual coping responses to fear displayed by different individuals when they are exposed to severe stressors. These have been captured by the summary label "fight or flight." In addition, Seligman (1975) and others have described "freezing" and "learned helplessness" as responses occur-ring when more active coping responses are unavailable or ineffective. More recently, Taylor and colleagues (2000) have advanced a "tend-or-befriend" hypothesis regarding primary responses to threat among social primates, arguing that "fight or flight" may be more relevant to the stress responses of males while various forms of affiliative responses may be more common stress responses of females.

This entire array of coping or defensive responses appears in some form in the infant behaviors that are part of the disorganized spectrum. For example, freezing, huddling on the floor, and other depressed behaviors are part of the coding criteria for disorganized behaviors, as are contradictory approach–avoidance behaviors that often mix angry resistance with avoidant behaviors such as running away or hiding under a chair. Not surprisingly, in-fants exhibiting disorganized attachment strategies often demonstrate atypi-cal physiological responses to stressors, as detailed in a later section.

As is evident from these descriptions, disorganized infants can look very different from one another. Within this broad array of behaviors, there are at least two distinct subgroups. Disorganized attachment behaviors may occur in concert with other insecure behaviors that are part of an avoidant or ambivalent attachment strategy, resulting in a primary classifi-cation of disorganized attachment and a secondary classification of avoid-ant or ambivalent (referred to hereafter as D-insecure). However, disorga-nized behaviors may also be displayed in the context of behaviors that are usually part of a secure strategy, such as protesting separation, seeking con-tact with mother at reunion, and ceasing distress after being picked up, as shown in Table 3.1. This disorganized subgroup is given a secondary classi-fication of secure (referred to hereafter as D-secure). In the National Insti-tute of Child Health and Human Development child care study (K. McCartney, personal communication, April, 1993), D-Secure infants made up 52% of the disorganized group.

There are parallel differences in the maternal behaviors associated with infant disorganization. Mothers of D-insecure infants have displayed significantly higher rates of role confusion, negative-intrusive behavior, and frightening behavior than mothers of D-secure infants. In contrast, mothers of D-secure infants have exhibited significantly higher rates of withdrawal than mothers of D-insecure infants (Lyons-Ruth, Bronfman, & Atwood, 1999). These two profiles of maternal behavior have been referred to as "hostile–self-referential" and "helpless–fearful." The behaviors contribut-ing to these profiles are described in more detail in Lyons-Ruth, Bronfman, and Atwood (1999).

The subtle nature of the helpless–fearful profile of maternal behavior is important to note, as is the subtlety of many of the disorganized behaviors of D-secure infants. The more hostile–self-referential maternal behaviors and the more avoidant and ambivalent disorganized infant behaviors are much easier to identify as maladaptive, yet recent data indicate that these behaviors characterize less than half of mothers and infants who experience disorganized attachment relationships.

Another form of atypical attachment behavior that is likely to be pre-dictive of long-term impairment in social behavior is the indiscriminate at-tachment behavior seen among infants reared in institutional settings with very poor care and with no selective attachment figure available (O'Connor, Rutter, & the English and Romanian Adoptees Study Team [ERA], 2000). However, a lack of selectivity in attachment behavior is also noted clinically among high-risk home-reared infants and can be observed in the standard attachment assessment in the infant's tendency to accept comfort from an unfamiliar lab assistant even though actively distressed.

From this body of attachment research, we understand trauma in a 12- to 18-month-old infant to be related both to the directly traumatic experi-ence of maltreatment as well as to effects of parental behaviors that are frightening, frightened, withdrawing, role reversed, or otherwise atypical.

TABLE 3.1. Subgroups of Disorganized Attachment in Infancy

Disorganized–secure ("pseudo-secure")	Disorganized–insecure ("avoidant–resistant [A/C]")
Disorganized behaviors	• Disorganized behaviors
Little avoidance or resistance	• Avoidance, resistance, or both
Distress to separation	• Often appears quite conflicted
Calms in parent's presence	• May combine marked separation distress with marked avoidance at reunion
Some proximity seeking	
May appear passive, depressed, aimless, hesitant, or apprehensive	

Unlike mildly rejected or inconsistently treated infants, who demonstrate inadequate stress-reducing behavioral strategies, the infant whose caregiver has been unable to provide basic regulation around fearful arousal fails to develop any coherent behavioral attachment strategies for retaining organization and reducing physiological arousal in the face of moderate stress.

While these data have been compelling in establishing a relational basis for the infant's regulation of fearful arousal by the end of the first year, this literature has two limitations. First, attachment security cannot be assessed prior to the end of the first year of life because the standard assessment depends on the infant's display of particular types of behavioral organization not available to younger infants. Second, while the assessment of attachment security claims to index "felt security," we have had little in the way of converging physiological indicators of the infant's states or "felt" experience. Instead, those experiences have had to be inferred primarily from how the infant organizes his or her emotional displays and behavioral responses. However, contemporary research (Spangler & Schieche, 1998; Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996) suggests that observed behavioral and emotional responses are not always reliably associated with underlying physiological indicators of felt security or fearful arousal, as reviewed below. Measures of infant physiological states provide opportunity to assess internal psychobiological states more directly, regardless of displayed behavior or changes in behavioral capacities, during the first year of life.

How might we elaborate our model of attachment and trauma during the first year of life to incorporate the caregiver's earliest environmental contributions to fundamental biological and behavioral systems in the infant? The caregiving environment impacts the infant's development much earlier and in a more physiological manner than the pioneer attachment theorists were able to demonstrate. As our neuroscientific tools accumulate, we can begin to elaborate a model of attachment and trauma during the first years of life that is more sensitive to very early psychobiological and developmental processes, as well as to distinguish that model from the models that are more reflective of processes at later ages.

THE ENVIRONMENT'S ROLE IN REGULATION OF GENE EXPRESSION

Findings from a decade of developmental neuroscience indicate that experience shapes neuronal function and brain architecture (Kandel, 1992; LeDoux, 2002: Greenough & Black, 1992). We no longer believe that brain anatomy matures on a fixed ontogenetic calendar. Instead, we recognize environmental experience to be critical to the differentiation of brain tissue itself. We now view the infant brain as an open, nonlinear dynamic system in which an initial set of genetic predispositions serve as a constraint on an open system that takes its organization partially from the organization of the surrounding environment of care. During the prenatal period and first months of life, the primary caregiver essentially defines the environment for the altricial human infant.

Research indicates considerable plasticity in neuronal development in infancy. Mechanisms mediating such experience-expectant change in neuronal development include sensitive periods, behavioral induction, synaptic overproduction, and subsequent pruning (Greenough & Black, 1992; Huttenlocher, 1994; Nelson, 1999). Plasticity may involve not only the creation of new synaptic connections among neurons but also growth of new neurons across the lifespan (Ericksson et al., 1998).

Recently, a number of studies using animal models have generated compelling data that the quality of early caregiving can alter infant physiology, including basic gene expression (Francis, Diorio, Liu, & Meaney, 1999; Liu et al., 1997; Caldji et al., 1998). For example, rat pups separated from their mothers in the first 2 weeks of life incurred a permanent increase in the expression of genes controlling the secretion of corticotropin-releasing factor (CRF), a factor related to effective stress response (Plotsky & Meaney, 1993). In addition, among nonseparated pups, dams who showed increased care of their pups by licking and grooming them during nursing seemed to provide them with a life-long protection from stress, whether or not the pup and dam were genetically related. This latter process appeared to be mediated through the enhanced expression of genes regulating glucocorticoid receptors and the consequent suppression of genes regulating CRF synthesis (Liu et al., 1997). Similar effects of maternal care on offspring CRF have been reported in primates (Coplan et al., 1996).

John Bowlby himself presaged the last decade's findings concerning a socially constructed brain some 40 years ago when he called for a deeper understanding of the ways that an immature organism is critically shaped by its primordial relationship with a mature, adult member of its species. He suggested that the infant's emerging social, psychological, and biological capacities could not be understood apart from its relationship with the mother. More specifically, Bowlby (1958) inquired into the mechanisms by which the infant forms a secure bond characterized by emotional communication with the mother and how this early socioemotional learning is then internalized in the form of an enduring capacity to regulate states of emotional security.

STRESS AND THE HYPOTHALAMIC–PITUITARY–ADRENOCORTICAL SYSTEM

Bowlby (1969) also noted more than 30 years ago that the attachment relationship directly influenced the infant's capacity to cope with stress through the maturation of a control system in the infant's brain that comes to regulate the attachment behavioral system. This behavioral control system is now understood to have complex feedback relations with the hypothalamic–pituitary–adrenocortical (HPA) system, which takes a central role in managing perceived threats to well-being.

Stress describes both the subjective experience induced by a novel, potentially threatening or distressing situation and the behavioral and/or neurochemical reactions to it (Weinstock, 1997). The stress response involves a cascade of biochemical and hormonal events that has evolved to restore homeostasis and promote survival. While successful adaptation often requires the integrated action of most of the regulatory systems of the body, including the autonomic nervous system, the immune system, the neuroendocrine system, and behavioral coping systems, the main systems of the stress response are the norepinephrine-sympathetic adrenomedullary (NE-SAM) system and the hypothalamic–pituitary–adrenocortical (HPA) system. These two systems work together to restore the well-being of the organism by increasing energy resources through increasing heart rate; metabolizing fat and protein stores; and inhibiting digestion, the immune system, and the growth system.

Although both systems are vital to restoring internal homeostasis (Chrousos & Gold, 1992; Stratakis & Gold, 1995), the HPA system has been widely studied in children because its end product, cortisol, provides a marker of the stress response to a perceived homeostatic disruption that can be measured nonintrusively in samples of saliva. Exposure to traumatic events in later childhood and adulthood has been clearly related to alterations in the functioning of the HPA axis, including alterations toward both hypo- and hyperresponsive functioning (Gunnar & Donzella, 2001). Accordingly, in this chapter, we focus on the HPA axis and develop a model of the events associated with its dysregulation in infancy.

Corticotropin-Releasing Hormone and the Hypothalamic–Pituitary–Adrenocortical Axis

Corticotropin-releasing hormone (CRH) is the principal hypothalamic regulator of the pituitary–adrenocortical axis. Produced in the paraventricular nucleus (PVN) of the hypothalamus, CRH, together with the synergistic actions of vasopressin (VP), stimulates the secretion of adrenocorticotropic hormone (ACTH) and endorphins by the anterior pituitary (Chrousos, 1997). Cells on the cortex of the adrenal gland respond to ACTH leading to the release of glucocorticoids. In primates, cortisol is the primary glucocorticoid. In nonprimates, corticosterone is the primary glucocorticoid released. Circulating glucocorticoids complete a negative feedback loop to shut off the current HPA axis activity and to modulate HPA axis activation through their actions at glucocorticoid receptors distributed at

different levels of the HPA axis, including the pituitary, hypothalamus, hippocampus, and frontal cortex.

Glucocorticoids

Normally, glucocorticoids are responsible for restraining the stress response by inhibiting HPA axis activation. Glucocorticoids prevent the consequences of prolonged or excessive stress response. At basal or resting levels, glucocorticoids tend to restore or permit processes that support homeostatic defense mechanisms (Munck & Naray-Fejes-Toth, 1994; Gunnar, 2000). Glucocorticoid increases in this basal range generally promote mental and physical health and development (Gunnar, 2000; deKloet, Rots, van den Berg, & Oitzl, 1994). Higher, stress-related elevations in glucocorticoids have suppressive and potentially destructive effects (Sapolsky, 1997; Gunnar, 2000). The regulatory effects of higher glucocorticoid levels may be necessary to prevent overreaction of other body systems, which, if unchecked, lead to injury (Munck & Naray-Fejes-Toth, 1994). These opposing permissive versus suppressive effects appear to operate in part through different receptor systems (Sapolsky, 1997), mineralocorticoid receptors (MRs) and glucocorticoid receptors (GRs).

MRs are largely occupied when glucocorticoids are low and mediate many of the protective functions of the hormone. Basal levels of cortisol follow a daily rhythm mediated in part through the activity of MRs in the hippocampus (Gunnar, 2000). Response to stress, which provokes elevations in cortisol over baseline daily levels, is contained in part through GRs. GRs are highly responsive to increasing levels of glucocorticoids, and their binding is related to termination of CRH production by the PVN of the hypothalamus, reduction of ACTH from the pituitary, and consequently the termination of glucocorticoid production (Liu et al., 1997). The differential properties of MRs and GRs suggest that a balance between the occupation of the MRs and GRs is important to the functioning of the HPA system (DeKloet, Vreugdenhil, Citel, & Joek, 1998).

Assessment of Cortisol Secretion as a Marker of Stress Response Functioning

In humans, the final product of the HPA system is the adrenocortical steroid hormone cortisol. Although cortisol secretion provides only a partial understanding of the activity of the neuroendocrine system, its regulation appears to bear importantly on human growth and development (Gunnar & Donzella, 2001).

Studies of the HPA system in young children require the use of noninvasive measures. CRH has never been assessed in children because it involves sampling cerebrospinal fluid. Similarly, assessment of ACTH requires blood sampling (Dahl et al., 1991). Measurement of salivary cortisol, conversely, offers a noninvasive and relatively simple method for assessing cortisol production in young children (Schwartz, Granger, Susman, Gunnar, & Laird, 1998; Gunnar & Donzella, 2001). Reliance on salivary cortisol measures imposes limitations on our understanding of the regulation and dysregulation of the HPA system in children. The HPA, for example, often maintains normal cortisol levels in response to chronic stressors, while pituitary levels of ACTH often reveal significant effects of chronic stress (Heim, Ehlert, & Hellhammer, 2000). Nevertheless, a considerable literature on the social regulation of cortisol activity has emerged over the past 15 years, during which the assessment of salivary cortisol has entered into common use (Gunnar & Donzella, 2001).

There are two important features of cortisol secretion that typically are considered in the assessment of this hormone. First, cortisol exhibits a typical daily secretion that is unrelated to a stressful challenge, whereby cortisol levels are highest on awakening and lowest at the end of the daily activity phase (Bailey & Heitkemper, 1991). Second, cortisol secretion is activated when a stressful environmental challenge is identified.

First, we examine typical daily cortisol production. As with other hormones in the body, cortisol has a circadian rhythm that is unrelated to stressful challenge. Under typical conditions, mature cortisol levels peak in the morning, are at half of morning levels by late afternoon, and are negligible by midnight (Bailey & Heitkemper, 1991; Knutsson et al., 1997; Sikes, 1992). Cortisol levels should be close to zero in the evening at the end of the activity cycle. Failure to bring cortisol concentrations to low levels at this time of day is believed to reflect a fundamental dysregulation of the stress physiology system. Indeed, elevations in evening levels have been found in some children evidencing psychological disorder (Brent, Ryan, Dahl, & Boris, 1995; De Bellis et al., 1999).

Notably, young children do not evidence a fully adult pattern of basal cortisol production. Newborns exhibit two peaks 12 hours apart that are not correlated with time of day (Sippell, Becker, Versmold, Bidlingmaier, & Knorr, 1978). Typically, the single early morning peak in cortisol is reliably established by 3 months of age (Price, Close, & Fielding, 1983), although Larson, White, Cochran, Donzella, and Gunnar (1998) report an early morning peak in cortisol production as early as 6 weeks of age when group averages are taken. A reliable decrease in cortisol from morning to afternoon is evident by about 4 years of age, reflecting the development of mature sleep–wake patterns by this age (Gunnar & Donzella, 2001).

In contrast to its generally stable daily secretion pattern, cortisol levels generally increase in response to a stressor (although we later discuss a number of exceptions evidenced in recent investigations). Adaptive response to stress typically involves a number of behavioral and physiological responses dedicated to the provision of energy necessary to overcome an identified challenge. A brisk elevation in cortisol production is viewed as one aspect of the organism's adaptive effort to reestablish homeostasis in the face of challenge. Notably, the ability to appropriately regulate the stress response may be as important as the ability to initiate it. Containment of the stress response is crucial to avoid the behavioral and physical consequences of the mobilization of behaviors and resources (Johnson, Kamilaris, Chrousos, & Gold, 1992).

An efficient HPA system is thought to be one that expresses moderate basal glucocorticoid levels, elevated glucocorticoid response when stressors arise, and quick response termination when stressors subside. The development of this efficient HPA system is highly dependent on a healthy GR system (DeKloet, 1991; DeKloet & Reul, 1987). GRs have a low affinity for glucocorticoids and are primarily responsible for reactive negative feedback following an acute stressor. Suppressive, potentially destructive effects of glucocorticoids become more pronounced when GRs are occupied for longer periods of time (Sapolsky, 1997). An inverted U-function has been found for many effects of glucocorticoids. Small increases in the hormone, or brief elevations even to high levels, often enhance behavioral performance and support health-promoting physiological processes. Larger increases, particularly if they result in prolonged occupation of GRs, lead to impairments and threats to health (Gunnar, 2000).

Caregiving and Neuroendocrine Regulation in Nonhuman Mammals

A large body of rodent research has shown that separation of the pup from the dam for prolonged periods, particularly when such separation disrupts maternal behavior, leads to heightened responsivity and poorer regulation of the HPA axis into the adulthood of the animal (Caldji et al., 1998; Levine, 1994; Plotsky & Meaney, 1993). When rat pups are separated from the dam on a daily basis for 3-hour periods, the separation produces hyperstress reactivity (Plotsky & Meaney, 1993). Rats subjected to this paradigm demonstrate reduced GR numbers, increased CRH activity, and larger and longer glucocorticoid responses to restraint stress and novel environments (Liu et al., 1997). Moreover, as noted above, pups reared by mothers who engage in less licking and grooming show larger HPA axis responses to restraint stress, heightened fear, and reduced GR-mediated negative feedback containment of the glucocorticoid stress response (Caldji et al., 1998).

Early experiences in nonhuman primates also appear to affect the development of reactivity and regulation of the HPA axis. Rhesus monkeys raised under conditions of deprivation on cloth surrogates or raised only with peers exhibit larger and more prolonged elevations in cortisol to stressful stimulation (Higley, Suomi, & Linnoila, 1992). Similarly, the presence of the rhesus mother provides a powerful buffer against cortisol reactivity to stressors like capture, separation, and handling—even if the infant cannot physically contact her (Bayart, Hayashi, Faull, Barchas, & Levine, 1990). Disturbing mother–infant interaction by making maternal food supply unpredictable has also been shown to lead to increases in CRH levels measured when the offspring are adults (Coplan et al., 1996). Although mother–infant separations produce striking increases in HPA activity in nonhuman primates, a discontinuity has been noted between hormonal and behavioral manifestations of stress following the initial separation and after multiple separations. Hennessy (1986) found that young monkeys continue to respond to separation hormonally but not vocally, even after having been separated 80 times before. Behavior then, particularly vocalization, may be a less sensitive index of the distress caused by long-term maternal deprivation than endocrine reactivity.

Human Caregiving and Regulation of the Neuroendocrine Stress Response System

While the evidence that early experiences have long-term effects on the HPA axis comes largely from animal research, other research with human infants also suggests that events embedded in daily typical interactions between the caregiver and the infant affect the development of the HPA system. A growing body of literature suggests that HPA axis activity in infants and young children varies with characteristics of the caregiving environment and the quality of the child's relationships with the caregiver (Spangler & Schieche, 1998; Nachmias et al., 1996; Ashman, Dawson, Panagiotides, Yamadar, & Wilkinson, 2002; Gunnar, Mangelsdorf, Larson, & Hertsgaard, 1989).

Caregiver-Regulated Stress Hyporesponsivity

While the human newborn demonstrates a highly reactive adrenocortical response to stressors (Gunnar, 1992), there is evidence that reactivity of the HPA system gradually dampens over the first year of life as a function of quality caregiving (Gunnar & Donzella, 2001). Indeed, attempts to elicit elevations in cortisol to psychosocial stressors in the second year of life have often met with failure (Gunnar et al., 1989; Gunnar & Nelson, 1994; Spangler & Grossmann, 1993). Sensitivity, responsiveness, and attention from primary caregivers appears crucial to sustaining low cortisol activity during this period (Gunnar & Donzella, 2001). As with the infant rat, which also exhibits a period of relative stress hyporesponsivity between postnatal days 4 and 14 (Rosenfeld, Suchecki, & Levine, 1992), the absence of an available and sensitive caregiver may lead to significant elevations in glucocorticoid levels, larger than those observed in older children and adults (Gunnar & Donzella, 2001).

Attachment Quality and the Hypothalamic–Pituitary–Adrenocortical Axis

As noted by Spangler and Schieche (1998), research on adrenocortical function in the Strange Situation suggests, when taken together, that infants classified as securely attached do not demonstrate elevations in cortisol levels (Spangler & Grossmann, 1993). Indeed, the pattern typically observed is one of decreasing cortisol levels from the beginning to 30 minutes after the end of the procedure. In contrast, studies examining disorganized patterns of attachment behavior have found that these children produce larger increases in cortisol than do children classified as securely or insecurely attached (Spangler & Grossmann, 1993; Hertsgaard, Gunnar, Erickson, & Nachmias, 1995). Children classified as insecurely attached exhibited more equivocal and complicated results. The findings suggest an interplay between attachment and temperamental factors. Infants with low behavioral inhibition, both secure and insecure, did not exhibit adrenocortical responses. Adrenocortical activation was observed in behaviorally inhibited infants with an insecure attachment, both ambivalent and avoidant, but not in those with secure relationships. These findings suggest that secure attachment relationship may function as a social buffer against less adaptive temperamental dispositions.

Normal Disjunction between Behavioral and Physiological Responses in Early Development

Spangler and Schieche's (1998) own research suggests that emotional distress and adrenocortical activity are unrelated in secure infants. However, high distress is associated with adrenocortical activation in ambivalent, avoidant, and disorganized infants. Unlike emotional expression in securely attached children, it appears that emotional expression in children with insecure and disorganized attachment patterns does not fulfill its social function as a means to manage fearful arousal through the help of a caregiver.

Similarly, Nachmias and colleagues (1996) found that 18-month-olds who responded fearfully to a series of strange, novel events were likely to show elevations in cortisol only if they were insecurely attached to the parent who accompanied them and helped them to manage their emotional responses to events. No differences in fearful or wary behavior were noted as a function of attachment security. These data tend to be more consistent with the view that secure relationships buffer the HPA axis in early childhood, rather than the view that temperamental differences in fearfulness or inhibition produce the differences in attachment classification and/or elevations in cortisol to strange and potentially threatening events.

Thus, as with nonhuman primate data, it appears that a sensitive and responsive caregiving system can provide a HPA axis buffer for the human infant and toddler. When this system functions correctly the young child appears to be able to experience conditions that elicit behavioral distress and that produce inhibition of approach or fearfulness without producing increases in glucocorticoids. This point is elaborated by Spangler and Grossmann (1999), who argue that securely attached infants possess appropriate stress-reducing behavioral strategies and therefore exhibit negligible increases in cortisol levels when aroused. Insecurely attached infants who demonstrate inadequate behavioral strategies and disorganized infants who demonstrate no coherent strategies must both rely on physiological response to arousal in the wake of inadequate behavioral response.

Dozier and colleagues (2001) also report disjunction in the opposite direction between overt affective/behavioral expression and underlying physiological responses in a group of maltreated children beginning relationships with new foster mothers. These children evidence secure-appearing behavioral responses to separations and reunions while still evidencing extremely aberrant hyper- or hyporesponsive HPA functioning.

Hypercortisolism in Early Childhood

Ashman and colleagues (2002) presented evidence that a mother's depression in the first 2 years of the child's life is the best predictor of cortisol elevations at age 7 years. Similarly, in a study of 282 children 4.5 years old, Essex, Klein, Eunsuk, and Kalin (2002) reported that maternal depression beginning in infancy was the most potent predictor of children's cortisol levels at 4.5 years of age. Other research indicates that when a depressed mother interacts with her infant, she typically expresses less positive and more negative affect, sometimes in intrusive behavioral patterns and sometimes in more withdrawn patterns (Cohn, Matias, Tronick, Connell, & Lyons-Ruth, 1986; Lyons-Ruth, Zoll, Connell, & Grunebaum, 1986). A depressed mother is also likely to respond less contingently to her infant's emotional responses (Dawson & Ashman, 2000; Lyons-Ruth et al., 1986). Ashman and colleagues (2002) hypothesize that early exposure to the more negative and unpredictable caretaking of a depressed mother sensitizes the neural pathways that mediate the stress response and increases vulnerability to depression. This explanation is consistent with the animal models of effects associated with disturbed caregiving described earlier.

Hypocortisolism

Despite the central tenet that stress is associated with elevated levels of cortisol production, accumulating evidence suggests that some children demonstrate blunted cortisol responses to challenge. As recently reviewed by Gunnar and Vasquez (2001), some highly stressed children and adults evidence a hyporesponsive rather than hyperresponsive cortisol pattern, in which baseline cortisol levels can be low and fail to increase in response to acute stressors. In addition, a flattening of the usual daytime rhythm of cortisol release also appears to occur in these groups. These flatter daily patterns are due largely to lower early morning cortisol values as opposed to higher or elevated values at the nadir of the cycle. As Gunnar and Vasquez (2001) also note, such responses are sometimes, but not always, found in children or adults who have experienced more severe, acute or chronic adverse life histories. The occurrence of these hyporesponsive patterns is frequent enough that more work is needed to understand their psychosocial, genetic, and biomolecular etiological contributors.

Hypothalamic–Pituitary–Adrenocortical Axis Functioning among Orphanage-Reared Children

Children reared in orphanages in Romania have been the focus of several studies of the relation between environmental regulation and HPA axis activity. Ten years ago, Romanian orphanages were described as grossly depriving, that is, lacking in social stimulation, physical stimulation, and opportunities for attachment relationships (Ames, 1990). M. Carlson and her colleagues (Carlson et al., 1995a, 1995b; Carlson & Earls, 1997) assessed salivary cortisol levels among toddlers in Romanian orphanages over several days at wakeup, noon, and late afternoon/evening in a group of 2-year-olds who had lived in the orphanage for most of their lives. Compared to home-reared 2-year-old Romanian children, the orphanage-reared children showed no evidence of the expectable daily rhythm in cortisol levels (a peak in the morning, at half of morning levels by late afternoon, and negligible levels by midnight) over the daytime hours. Moreover, cortisol levels of the orphanage-reared children were not clearly elevated over those of family-reared children. Instead, many of the orphanage-reared children appeared to have lower than expected morning levels of cortisol.

In a different study, Romanian children reared in orphanages and then adopted into homes in British Columbia were studied 6.5 years after adoption (Gunnar, Morison, Chisholm, & Schuder, 2001). All of the children had lived in orphanages for over 8 months prior to adoption and most were under 3 years of age when adopted. Parents collected saliva samples at wakeup, noon, and before bed for 3 days. Averaging over days, the orphanage-adopted children showed the expected daily rhythm, or slope, in cortisol production but had higher morning, afternoon, and evening levels than both Romanian children adopted near birth ("early-adopted") and Canadian-born children reared in their families of origin. Additionally, orphanage stay was positively associated with cortisol level, so that the length of time that the orphanage-adopted Romanian children had lived in orphanages prior to adoption predicted their levels of cortisol 6.5 years later.

Unfortunately, we have no information as to whether children who continue to live in orphanages begin to show elevated cortisol levels as they get older or whether a more typical daily rhythm of cortisol production emerges. Nor can we be certain whether there is a causal relation between immersion in an enriched family environment and the emergence of a normal daily rhythm in cortisol production. However, as reported by Gunnar et al. (2001), Russian children under the age of 4 years living in orphanage settings evidence a similarly absent daily rhythm is cortisol production (Kroupina, Gunnar, & Johnson, 1997). In contrast, Bruce, Kroupina, Parker, and Gunnar (2000) found lower bedtime than wakeup cortisol levels in a small group of infants and toddlers who had been adopted after some 4–18 months of orphanage care and had been living in their adoptive families for approximately 2 months. Taken together, these findings suggest that orphanage rearing fails to support the development of a normal daily rhythm in cortisol production in young children whereas adoption into a family may promote the emergence of an expected daily rhythm. This hypothesis awaits further investigation, as most of the information presented above is based on small samples and/or pilot data.

These findings from orphanage rearing studies, however, are consistent with reports of daytime cortisol patterns for neglected infants reared in their families of origin (Gilles, Berntson, Zipf, & Gunnar, 2000) and a foster care intervention study with preschool-age children (Fisher, Gunnar, Chamberlain, & Reid, 2000). Gilles and colleagues investigated daytime cortisol levels in family-reared children who were characterized either as high-risk infants (i.e., risk factors for neglect but not meeting criteria for neglect), low-risk infants, or neglected. Salivary cortisol was assessed in the morning, at noon, and in the evening. Both the neglected and high-risk groups had a flatter and lower pattern of daytime cortisol production than did the low-risk infants. Neglected infants demonstrated the lowest early morning levels and also had the flattest pattern of daytime cortisol production. Fisher and colleagues found that preschool-age children placed in foster care exhibited a less marked daytime rhythm in cortisol production than did home-reared children, but this rhythm became more typical in children who had been placed with foster families specifically trained to work with behaviorally and emotionally disturbed children.

BRIDGING NORMAL AND ABNORMAL DEVELOPMENT: HIDDEN REGULATORS AND "TIPPING POINTS"

The data reviewed thus far clearly point to a role for caregiver regulation in the normal development of HPA axis function. Attachment research and associated studies of mutual regulatory processes between parents and infants have provided a very general model of how parental sensitive responsiveness leads to the development in the infant of organized coping strategies in the face of stress and to confidence in the caregiver's availability.

However, the existing data do not yet allow for a detailed specification of how sensitive and responsive caregiving acts at the physiological level to facilitate normal HPA axis development. In addition, while sensitive parenting and its correlates have been extensively studied, little is known about the "tipping points" where inadequate regulation precipitates qualitatively different forms of physiological organization in the developing infant. These tipping points would be the points where less adequate caregiving regulation crosses the line to become a hidden trauma of infancy, in that the infant's developing stress response system would be reset in a negative and enduring way.

Identification of developmental tipping points in human infancy is complicated both by the difficulty of conducting experimental studies and by the complexity of the human caregiving process. The concept of sensitive responsiveness itself has shown only a limited, though quite consistent, ability to explain infant outcomes, probably due in part to its very general definition and operationalization in attachment research (van IJzendoorn, 1995). At the other extreme, researchers have investigated abusive or neglecting caregiving and, again, consistent results emerge. However, these extreme family environments conflate many sources of adverse care and can go only a limited way toward identifying the tipping points that precipitate alternative forms of physiological function in the infant.

Since it is increasingly clear that critical parameters of HPA functioning are being set during the first year of life, a more detailed account of the regulation of fearful arousal through the attachment relationship is critical to a model of what constitutes trauma during the vulnerable period of infancy. Two levels of mechanisms for the regulation of fearful arousal are likely to be embedded in the early infant–caregiver relationship: direct physiological regulators and intersubjective regulators. We next address each of these in turn.

Direct Physiological Mechanisms as Hidden Regulators of Attachment and Fearful Arousal

The findings regarding early regulation of the HPA axis by the primary caregiver reviewed above are consistent with Myron Hofer's (1995) contention that the evolutionary survival value of proximity to the caregiver goes well beyond protection (Bowlby, 1969) or felt security (Sroufe & Fleeson, 1986). Hofer's central thesis is that different specific aspects of the experience of proximity to or separation from the caregiver affect different specific features of an infant's response to separation from the caregiver. These physiological regulatory processes are hidden within the more overt transactions between the mother and the infant. He proposes that the attachment relationship provides an opportunity for the mother to shape both the developing physiology and the behavior of her infant through discrete regulatory pathways that he refers to as "hidden regulators of attachment" (Hofer, 1995).

Hofer conceptualizes attachment first as a biological event. He reminds us that attachment has an evolutionary history among social mammals as a physiological process long before humans evolved the capacity to communicate intersubjectively and to cognitively represent the attachment experience. The point is particularly relevant when we consider the underdeveloped cognitive systems of very young infants. The absence of sophisticated cognitive awareness means that the young infant is constrained to deal with the vicissitudes of the attachment relationship at an affective and physiological level. As noted earlier, the very young infant has extremely limited coping strategies, whether behavioral or cognitive. A few examples will illustrate Hofer's contention.

While studying the development of autonomic cardiovascular regulation in rats, Hofer (1973b) reported that a dam escaped from the maternity cage overnight and the next morning the cardiac rates of her 2-week-old pups were 40% below the norm for their age. The pups were slowed and hyporesponsive, and appeared to be experiencing the "conservation withdrawal" phase of response to loss.

Suspecting that the slow heart rates could be due to cooling of the cardiac pacemaker cells, Hofer heated the cage floor, maintaining the core temperature of the separated pups throughout a 24-hour separation period. Cardiac rates remained the same; however, the rat pups became hyperactive. Thus, a period of 24 hours of separation could result in either depressed or overreactive behavior, depending on whether one aspect of maternal care, warmth, was available to the pups (Hofer, 1975).

Curious as to what aspects, if any, of maternal care might regulate cardiac rate, Hofer conducted a series of further experiments, ultimately revealing that a supply of milk prevented the pups' cardiac response to separation but had no effect on behavioral hyperactivity. Instead, the pups' hyperactivity was found to be prevented by the presence of a nonlactating foster mother who failed to influence the pups' reduced cardiac rates (Hofer, 1973a, 1973c).

These results led Hofer to conclude that different aspects of the separation experience affected different features of the pups' bioregulatory systems. The pups' behavioral activity was regulated by the amount of warmth supplied by their mother. Their cardiac rates could be "set" anywhere from normal to 40% below normal by adjusting the rate at which milk was infused to the separated pups through a gastric canula.

Rather than responding to a single cue or signal of the dam's absence with an integrated behavioral and physiological response, then, it appeared that different systems in the separated pups responded to different signals of the mother's absence. As with primates, loss of all regulators at once produced a complex web of responses in different systems, their direction, timing, and magnitude varying with the characteristics of individual systems (Kraemer, 1992). The pups' response to separation then could be viewed as an assemblage of different processes reflecting the withdrawal or loss of a number of different regulatory processes that had been hidden within the pups' relationship with their mother.

Maternal Regulators of Hyporesponsiveness to Stress

There are also discrete hidden mechanisms embedded within the attachment relationship that regulate stress hyporesponsiveness at the beginning of life. As noted previously, many species of animals, including humans, demonstrate a period of hyporesponsiveness to stress. This period is characterized by little or no response to stressors, as evidenced by the level of corticosterone in nonhuman animals and by the levels of cortisol in humans. Newborn rats typically show vigorous corticosterone response to mild and severe stress from 0 to 4 days after birth but then demonstrate very little response to such stressors from 4 to 14 days after birth—the stress hyporesponsive period.

However, researchers have demonstrated that 7- to 14-day-old maternally separated pups show a vigorous corticosterone response rather than the typical hyporesponsiveness demonstrated in nonseparated pups. Two different regulators, maternal milk and tactile interaction, were discovered to be responsible for the loss of the pups' hyporesponsive period. Maternal milk delivery acted at the level of the adrenal cortex, and tactile stimulation acted at the hypothalamic and/or pituitary level. Two different regulators, then, maternal milk and touch, hidden within the normal mother–infant interaction, act individually on different levels of the HPA axis to ensure a hyporesponsive period to stress in the young pup (Hofer, 1995).

Maternal Regulators of Stereotyped Rocking Behavior

Another example of the hidden regulators concept comes from research with a group of maternally deprived rhesus monkeys. Many kinds of monkeys, whether raised alone or with inanimate artificial mothers, develop a distinctive stereotyped pattern of body rocking (Mason & Berkson, 1975). Mason and Berkson hypothesized that the body rocking was the consequence of release from a particular maternal regulator, in this case a mobile mother. These researchers decided to raise a group of rhesus monkeys for a year without any maternal interaction. Instead, half of the monkeys were given a standard terry cloth surrogate and the other half were given the same surrogate except that the surrogate was suspended on a rope a few inches off the floor so the surrogate would swing if jumped on or pushed.

Results of the investigation indicated that although both groups of monkeys looked identical on a number of behaviors typical of maternal deprivation, the "surrogate on a rope" group failed to demonstrate any of the stereotypical rocking behavior typically evidenced by deprived monkeys (and humans).

Peer Rearing of Nonhuman Primates

Several prospective longitudinal studies have found that peer-reared monkeys consistently exhibit more extreme behavioral, adrenocortical, and noradrenergic reactions to social separations than do their mother-reared cohorts, even after living in the same social group for extended periods (Higley & Suomi, 1989). Peer-only-reared monkeys, for example, exhibit larger cortisol responses to psychosocial stressors as adults than do mother-reared infants (Higley & Suomi, 1989). Similarly, research attempting to identify neurochemical substrates that may be regulated by the primate caregiver suggests that maternal separation may produce cytoarchitechtural changes in dopamine (DA), norepinephrine (NE), and serotonin (5-HT)—collectively referred to as the biogenic amine systems—that result in functional dysregulation of these systems (Kraemer & Clarke, 1990). Kraemer, Ebert, Schmidt, and McKinney (1989) conducted a longitudinal study examining the levels of cerebrospinal fluid (CSF) NE in rhesus monkeys reared in three different rearing conditions (mother-deprived, mother-reared/peer-reared, and mother-reared/peer-deprived settings) up to 22 months of age. Mother rearing after birth produced an increase in CSF NE in all infants by comparison to infants that did not have a mother. Peer-reared monkeys also consistently show lower CSF concentrations of 5-hydroxyindoleacetic acid (5-HIAA), the primary central serotonin metabolite (Champoux, Higley, & Suomi, 1997) than their mother-reared counterparts. Serotonin is a prominent inhibitory neurotransmitter implicated in ubiquitous aspects of metabolic, regulatory, and emotional functioning.

Taken together, the research reviewed above concurs with Hofer's contention that regulation should not be conceived of strictly in terms of affects but also in terms of discrete regulating mechanisms that act directly on developing physiological systems. The first function of the infant–caregiver system is that of the physiological regulation of both members of the dyad. At the most basic level, the infant's sense of security may result from adequate homeostatic regulation within the caregiving relationship, with the earliest form of secure attachment encoded physiologically in the experience of nondisruptive and need-satisfying regulation of early physiological systems. Attachment, then, is not an end in itself but rather a system adapted by evolution to fulfill key ontogenetic physiological and psychological tasks. Because of the obstacles to conducting controlled experiments with human infants, there is little information on how these physiological mechanisms related to body warmth, milk supply, tactile stimulation, and movement might impact the developing stress response system. However, given their importance in other primates, it is likely that similar mechanisms play a role in fostering the emergence of normal organization in the HPA system over the first year of life.

Intersubjective Processes as Hidden Regulators of Attachment and Fearful Arousal

Hofer (1994a, 1994b, 1995) confines his point concerning "hidden regulators" of attachment to the domain of direct physiological mechanisms. In addition, the elaborated human capacity for intersubjective sharing of affective signals is another likely regulator of early infant attachment and stress responsivity. However, at the time Bowlby (1969) was writing, the knowledge bases regarding both developmental neuroscience and the intersubjective capacities of the infant were limited. Therefore, in discussing the attachment behavioral system during the first year of life, Bowlby (1958) located the human attachment system within the context of primate evolution and identified the human attachment behaviors shared with other primates, such as clinging, following, sucking, smiling, and crying, as the critical mediators of the attachment relationship during the first year. Ainsworth et al. (1978) then emphasized much more clearly the role of the mother's sensitivity to infant cues over the first year in fostering open emotional communication and felt security in the infant. However, the standard attachment assessment focuses on infant behaviors that mature at the end of the first year, so that the attachment security or disorganization of the infant cannot currently be assessed at earlier ages.

Since Bowlby's early writing, however, numerous studies using diverse methodologies have demonstrated that human infants are equipped with much more elaborate capacities than other primates have for sharing both affective signals and intersubjective states with others (e.g., Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001; Tomasello, 1999). Tomasello has argued that only humans have an awareness of others' minds as being like their own and that this capacity is clearly seen by the end of the first year. Human infants then use this awareness to coordinate behavior with others and to learn from others.

Others have observed that a specifically human coordination of intersubjective information between the mother and the human infant begins much earlier than the end of the first year. Trevarthen (2001) has noted that from birth the infant organizes his or her behavior toward people and objects differently. In face-to-face interaction with people, 2- to 4-month-old infants display preadapted behavior patterns that appear to be organized around the intention to communicate, with focused attention on the face, rhythmic cycling of legs and arms, lip and tongue movements, cooing vocalizations, and responsiveness to the partner's expressions. In addition, young infants display turn taking in communicative acts and disruption in behavior to incomprehensible or mistimed partner behavior (Murray & Trevarthen, 1985). Murray and Trevarthen concluded that there is a preadapted intention toward cooperative communication and a preadapted capacity for coordination of subjectivities; in their words, "the forms and communicative values of human emotions are innately formulated" (1985, p. 194). This more developed intersubjective capacity of the human infant partially displaces the human attachment system from its primate base and recontextualizes attachment within particularly human forms of intersubjective relatedness from the beginning of life. Therefore, to understand the relations among the attachment system and the hidden traumas that produce dysregulation of the HPA axis during the first year, it is necessary to elucidate how attachment processes during the first year are embedded within a matrix of intersubjective communication. Little attention has been paid to delineating the pathways toward disorganized attachment strategies across the first year of life. Consequently, little is understood about how the caregiving deviations associated with disorganization by the end of the first year impact the infant's first year of development and, more specifically, how those same caregiving deviations affect the HPA system.

Primary Intersubjective Communication

As just reviewed, contemporary biologists have reconceptualized the capacity to regulate states of emotional security as a developmental process that begins with the dyadic regulation of the infant's earliest physiological homeostasis. The caregiver facilitates the infant's capacity to maintain internal homeostasis by adjusting the mode, amount, timing, and variability of her relational stimulation to the infant's signals.

A well-controlled study of caregiver contribution to very early physiological regulation was conducted by Sander, Julia, Stechler, and Burns (1972). Sander and colleagues randomly assigned newborn infants who were waiting to be given into foster care either to the regular hospital routine for the first 10 days or to a rooming-in relationship with a single nurse who cared for and fed the infant on demand. The regular hospital routine consisted of care in the newborn nursery by a rotating series of nurses who fed the infant on a preset schedule. The two intermediate conditions of demand feeding in the nursery and scheduled feedings by a rooming-in nurse were also evaluated. Regardless of rooming-in status, demand feeding during the first 10 days promoted earlier differentiation of day–night sleep cycles in the first days of life and greater individual stability in feeding behavior and sleep–wake cycles—stability that persisted over the first 2 months of life. Infants who had rooming-in caregivers during the first 10 days had longer awake periods and longer sleep periods by the second 10 days of life.

This careful study indicated that caregiving inputs that were timed to respond to cues from the infant had maximum regulatory impact, enhancing the infant's emergent self-organizing capacities, whereas caregiver inputs that were not contingent on infant cues were less effective in contributing to infant physiological regulation. The timing and fittedness of caregiver responses in relation to infant cues is likely to be fundamental to adequate early development.

The human infant also appears uniquely well equipped at birth to exchange affective signals with a caregiver. Ekman and Oster (1979) identified 24 distinct facial action patterns evident in early infancy, and emotions such as sadness, anger, disgust, fear, joy, and interest can be identified reliably from the facial displays of infants 1–9 months of age. The resulting subtlety of this capacity for exchanging affective signals in face-to-face communication by 2–3 months of age has been described in detail in time series analyses (e.g., Jaffe et al., 2001). In this earliest expression of intersubjective communication, the "topic" or referent of the shared affective "comment" is simply the hedonic quality of the relationship itself. There is a primary affective communication of "We make pleasure or displeasure together," with no reference to outside objects or events.

Very little research has examined as yet the relations among disorganized attachment strategies at 1 year of age, the characteristics of infant–mother affective communication, and infant stress responsiveness in the first 6 months of life. While it is clear that interaction is necessary for adequate development (Spitz, 1949), it is not known what aspects of early interaction are critical to the damping down of the HPA axis over the early months. In addition, it is likely that there are different developmental consequences to the HPA axis of parental withdrawal and of parental insensitive intrusiveness—or, in their most extreme form, of parental loss or neglect and of parental abuse. Jaffe and colleagues (2001) found that in a face-to-face interaction, "hypervigilant" tight vocal rhythm tracking by both the mother and the baby at 4 months of age, combined with the baby's postural and visual avoidance, was a predictor of disorganization of attachment strategies at 12 months of age. Jaffe et al. (2001) also found that babies who became disorganized showed more vocal and facial distress at age 4 months. A range of other early dysregulated interactive patterns are also likely to predict infant disorganization, but it is not clear where the tipping points are located along the spectrum of nonoptimal caregiving behaviors. It is also unclear what relative roles are played by such aspects of early interaction as physical touch, movement, soothing of distress, sharing of positive affects, quantity of interaction, or timing and fittedness of responses in the emergence of organized attachment strategies and normative HPA axis functioning. However, Thompson et al. (2003) have reported that cortisol response to a mildly stressful event occurs in the same direction for the mother and the baby by 6 months of age, and, as noted earlier, Ashman et al. (2002) have found cortisol elevations among infants of depressed mothers. Additional work is needed to elaborate our understanding of this critical early period in the formation of disorganized attachment relationships and dysregulated stress responses.

Secondary Intersubjective Communication

As infants approach 9 months of age, they increasingly look to their familiar social partners for affective cues to guide responses to objects and events outside the relationship itself, a process referred to as "social referencing." This capacity has been related to other indicators of a broad capacity for mutual sharing of subjective states, or affective comments toward other objects and events, that emerges during the last quarter of the first year and that Tomasello (1999) has described as uniquely human (for a review, see Lyons-Ruth & Zeanah, 1993). As an infant becomes more mobile, social referencing of the parent serves as an anticipatory affective guide to inform the infant about sources of danger or pleasure and serves to regulate the infant's affect and behavior from a distance. The sense of shared emotional states and mutually regulated affective displays underlying this behavior probably emerges from the earlier processes of affective communication in face-to-face play observed during the first 6 months of life.

However, little is known about what happens to subsequent intersubjective capacities if early affective communication with the caregiver is highly distorted. The literature on social referencing and secondary intersubjectivity has not yet been extended to infants at social risk, nor has it been related theoretically to attachment processes. However, we hypothesize that it is precisely this emergent capacity for using parental affective signals as cues to safety in the larger environment that promotes the shift from security mediation by close physical holding to the goal-corrected behavioral organization of attachment strategies at 12 months of age, in which security is partially mediated by maintaining proximity within visual/affective signaling distance. In a slightly different but related speculation, the developmental onset of 9-month-old infants' wariness with strangers may also stem from the increased intersubjective sharing capacity of 9- to 12-month-old infants, a capacity that makes the stranger's unknown affective communicative repertoire a source of uncertainty and potential lack of safety.

Clinical description of the absence of cautious behavior among children who have experienced early deprivation and neglect point to potential disruptions in the development of normal social referencing behavior among some groups of high-risk infants and toddlers. The indiscriminate friendliness evidenced by young children from severely depriving institutional settings also may rest on a disruption in normal social referencing capacities and suggests the fruitfulness of further explorations of the links between developing forms of intersubjective communication and risk-related deviations in attachment and HPA axis functioning (O'Connor, Rutter, & the English and Romanian Adoptees Study Team [ERA], 2000).

The emergence of elevated cortisol levels to stressful events among disorganized infants has not been studied over the first year, nor has disorganization been studied in relation to disrupted or hypervigilent social referencing behavior. There are also few data to relate particular profiles of atypical caregiver behavior to particular alterations in infant stress physiology, including hyper- or hyporesponsiveness or circadian rhythm disturbances, so it remains unclear whether there are tipping points in caregiver behavior that produce these shifts in infant functioning. However, given the diversity of atypical caregiver behaviors associated with infant disorganization, it is likely that helpless or withdrawing caregiving and hostile or intrusive caregiving produce different infant intersubjective regulatory strategies and different infant physiological correlates over time.

It is also unclear how circadian rhythm disturbances in infancy relate to hyper- or hyporesponsiveness of the HPA axis to stressors. Orphanage rearing is related to both elevated cortisol levels and shifts in circadian rhythms by the end of the first year of life (M. Carlson et al., 1995a, 1995b), but it is not clear whether the two forms of disturbance are related to one another or to the same aspects of caregiving. However, it is clear that disturbances in daily rhythm of cortisol release may occur under much more apparently benign conditions than orphanage rearing. For example, two recent studies have documented that circadian rhythm changes can occur under conditions of high-quality infant–toddler day care (Dettling, Gunnar, & Donzella, 1999; Dettling, Parker, Lane, Sebane, & Gunnar, 2000). Therefore, the tipping points for infant physiology may be much less extreme than the current emphasis on abuse or neglect would anticipate.

Collaborative Communication as Hypothalamic–Pituitary–Adrenocortical Axis Regulator

Multiple lines of evidence, then, indicate that a sensitive and responsive caregiving system can provide an HPA axis buffer for the human infant and toddler. When this system functions effectively, the young child appears to be able to experience conditions that elicit behavioral distress and that produce inhibition of approach or fearfulness without producing increases in glucocorticoids. The finding is consistent with Bowlby's (1973) assertion that securely attached infants need not rely on physiological adaptation within the "inner ring of life-maintaining systems" because regulation can be established through behavioral interaction with the caregiver in the "outer, or socially mediated ring" of homeostasis.

This socially mediated homeostasis is critically dependent on the shared intersubjectivities of the mother and the infant due to the prolonged helplessness and lack of mobility characteristic of human infancy and, we would propose, to the critical role of attuned and responsive social communication as a hidden regulator of HPA axis activity in human life. This proposal finds support in the work of Sethre-Hofstad, Stansbury, and Rice (2002), who examined attunement in adrenocortical response between the mother and the child as a function of maternal sensitivity. Sixty-four mother–child pairs with biological children age 24–51 months participated. Adrenocortical responsiveness was found to be highly correlated in sensitive mothers and their children, whereas responses in less sensitive mothers and their children were not significantly related. Because of the apparent role of the caregiver environment in fostering the adequate development of the infant's stress response system, primary trauma, or what we have referred to as hidden trauma, impacts the initial structuring of the system itself.

SUMMING UP

In this chapter, we have emphasized first the unique nature of trauma in infancy. Unlike many of the more observable discrete traumatic experiences that characterize later childhood, the traumas of infancy are woven into the moment-to-moment regulatory transactions experienced in the infant–caregiver system and are consequently nonevident. Frame-by-frame analysis (Beebe & Lachmann, 2002) has revealed a subtle dialogue involving synchronous rapid movements and fast changes in affective expressions. We suggest that trauma occurs within this "split second world of the mother and infant" (Stern, 1977) through varieties of caregiver unavailability and interactive dysregulation. These hidden traumas of early dysregulation appear to have the capacity to reset the infant's stress response system and therefore to influence the infant's and young child's responses to later stress or trauma. In one notable finding, infant disorganization and caregiver emotional unavailability in the first 2 years of life were shown to be stronger predictors than abuse experiences of dissociative symptoms in early adulthood (Ogawa, Sroufe, Weinfield, Carlson, & Egeland, 1997).

The interactive regulation provided in the context of the earliest caregiver–infant interactions appears critical to the development of adaptive psychobiological functioning. Indeed, contemporary thinkers have reconceptualized the capacity to regulate states of emotional arousal as a developmental process that begins with the regulation of the infant's physiological homeostasis or equilibrium in the earliest transactions between the caregiver and the infant (Sander, 1962; Sander et al., 1972; Sroufe, 1996; Trevarthen, 2001). The attuned caregiver, who is able to monitor her own internal signals and differentiate her own affective state, is able to facilitate the infant's capacity to maintain internal homeostasis by adjusting the

mode, amount, timing, and variability of the onset and offset of environmental stimulation. The mother and infant experience repeated state transitions, as they move together from low arousal to heightened arousal to restored equilibrium. The attuned caregiver matches her activity level to her infant's during periods of playful engagement, allows the infant to recover quietly when the child prefers disengagement, and sensitively responds to bids for reengagement after a period of decelerated arousal (Beebe, Jaffe, and Lachmann, 1994; Beebe & Lachmann, 2002; Shore, 2003). A dyadic regulatory system evolves where the infant's moment-to-moment state changes are understood and responded to by the caregiver, thereby achieving their regulation.

The caregiver who is unable to provide consistent affective attunement and containment of the infant's psychobiological responses during transitions from heightened arousal to homeostatic return contributes to heightened and enduring states of psychobiological arousal in the infant. The limited behavioral and cognitive resources of early infancy are insufficient to the task of regulation when the infant is aroused. Instead, psychobiological regulation during early infancy is dependent on external regulation by a caregiver to avoid overwhelming levels of physiological arousal that exceed available coping capacities. These uncontained and enduring states of overwhelming psychobiological arousal engender physiological consequences in the stress response system of the infant that are similar to the physiological consequences observed subsequent to the more salient traumatic events of childhood.

The considerable evidence across rodent, nonhuman primate, and human primate literatures presented above supports the contention that response to emotional arousal, as evidenced in the development of the stress physiology system, is regulated in part by nongenomic relational transactions with the caregiver from the earliest months of life. This conclusion perforce causes us to reconceptualize our model of attachment as not merely an end in and of itself but rather a system adapted by evolution to fulfill key ontogenetic physiological and psychological tasks. As Hofer asserts, a series of discrete regulatory mechanisms exist within the attachment relationship. We suggest that the development of an efficient stress response system in the infant results in part from adequate homeostatic regulation within the caregiving relationship, with the earliest form of secure attachment encoded physiologically in the experience of nondisruptive and need-satisfying regulation of early physiological systems, specifically the stress response system.

Bowlby suggests that inadequate attachment creates vulnerability to later stressors primarily through the development of maladaptive inner working models. Our revised view of attachment complements this perspective by suggesting that there are two mechanisms by which the hidden traumas of infancy can leave individuals vulnerable to adverse outcomes.