STRESS AND COPING IN INFANCY AND CHILDHOOD

Edited By
Tiffany M. Field
Philip M. McCabe
Neil Schneiderman

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STRESS AND COPING

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Preface

This is the fourth volume based on the annual University of Miami symposia on stress and coping. These symposia focus on state-of-the-art research relating to developmental, physical, and mental health aspects of stress and coping. The first volume provided a general discussion of the concept of stress; an overview of psychophysiologic processes involved in stress and coping; and data relating behavioral stress to the immune response, sleep disorders, depression, and cardiovascular disease. The second volume focused on some representative stresses and coping mechanisms that occur during different stages of development including infancy, childhood, and adulthood. It included chapters on maternal deprivation stress during infancy; coronary-prone behavior in children; coping behaviors during medical stress, and diabetes management in childhood; and adulthood concerns including cancer stress, behavioral influences on the immune system, cardiovascular disease in depressed patients, and various forms of depression therapy. The second volume was a natural lead into the third volume, which was entitled *Stress, Coping, and Disease*. The third volume focused on the role of biopsychosocial factors in four of the most common health problems: cardiovascular disease, diabetes, cancer, and the AIDS epidemic.

This, the fourth volume, focuses on developmental stressors and clinical stressors during infancy and childhood. Developmental stressors are those that arise during normal development such as early separation stress, stranger anxiety, novelty stress, and personal distress in fear situations. The section on clinical stressors focuses on clinical conditions that are relatively common in infancy and early childhood. These include the stress of being born prematurely and undergoing invasive procedures, the stress of respiratory disease and the related anxiety parents experience surrounding apnea monitoring and near death experiences, and the stress of being a pediatric oncology patient as well as being a parent of one of these children. The section also discusses how various therapies such as relaxation therapy and massage can alleviate the stress associated with psychiatric conditions in childhood and adolescence, including depression and adjustment disorder.

In the first section on developmental stressors, Megan Gunnar compares maternal separation and activation of the adreno-cortical response in human infants with that of the primate species. She first presents data showing that the behavioral and hormonal responses to stress often do not mirror each other. For example, in the Old World rhesus monkey, the hormonal (adreno-cortical) response lasts less than 24 hours, while behavior agitation continues. In the New World squirrel monkeys, the opposite pattern occurs. Gunnar then relates data on repeated discharge examinations for newborns and swim classes for young infants, illustrating an attenuation of the physiological (cortisol) response to stress with repeated exposure. Several examples are given from her own work and the literature on the human infant's remarkable ability to physiologically cope with the stress of separation and novelty. Her chapter highlights the following three phenomena: (a) Differences might be expected in response systems because of differences in separation paradigms. (b) Differences can be expected across species and across cultures. For example, infants, unlike monkeys, spend much of their time separated from the primary caregiver, at least in Western cultures. (c) The human infant has a remarkable ability to acclimate or adapt to repeated separations as manifested by their attenuated responses to stress.

In the second chapter, data presented by Jacob Gewirtz and Martha Peláez-Nogueras suggest that infant separation distress is encouraged by mothers when they contingently respond to the stress. Gewirtz and Peláez-Nogueras illustrate with a rather impressive data set how the infant learns later in the first year to protest separations because their mothers encourage the very behavior that is stressful to all concerned (e.g., direct actions to block their departure, fretting and crying). In a series of laboratory paradigms, the authors demonstrate how infants who have not yet learned to protest can be taught to do so by their mothers' reactions to their behaviors. They then also illustrate how the separation protest can be minimized or eliminated by the mothers' use of noncontingent rather than contingent maternal responses to the protest (differential responding to behaviors other than protest). Too often, the infant's role in separation problems has been the primary focus without understanding the parent's role in this process. Mothers who are contingently responsive to their babies' smiles or vocalizations or who talk to their infants at play (instead of responding to their distress behaviors) tend to produce infants who do not show protest behavior. Importantly, understanding this process provides the basis for understanding not only early infant stress associated with separations but also how it can be applied to family, day care, and school settings where these separations occur.

In chapter 3 by Donovan and Leavitt, further attention is paid to the stress of the crying infant. For the parent, the greatest stressor during infancy is probably infant crying. Donovan and Leavitt propose and support a very interesting model that differing perceptions of control relate to effective versus ineffective coping styles in response to the demands of child care. Specifically, they found that high illusory control mothers, characterized by a depression-prone attributional style, are adversely affected by being paired with a difficult infant. "Depression-prone attributional style" (a term coined by Martin Seligman and his colleagues) refers to ascribing bad things to factors within oneself and good things to factors such as chance. This, they claim, is a maladaptive coping strategy that adversely affects infant developmental outcome, namely security of infant–mother attachment.

Brian Healy (chapter 4) reviews literature on sympathetic and parasympathetic system responses to stress. The thrust of his research is the relation between physiological response patterns and the development of individual differences in temperament as they relate to stress. Using twin studies in the search for heritability of autonomic reactivity, Healy points out that heart rate appears to be a genetic response but heart rate variability and vagal tone are significantly affected by environmental stresses. He points out that the effects of stress on parasympathetic activity or on the parasympathetic–sympathetic nervous system interaction have received very little attention. A specific stressor may cause an increase in heart rate and blood pressure, yet as Healy suggests, this response may be viewed not only as an indication of sympathetic activation but also as a parasympathetic inhibition. The purpose of his chapter is to provide data on the significance of vagal tone (parasympathetic activity) as it relates to behavioral responses to stress and to explore individual differences using a twin paradigm in the behavioral/physiological response to stress. Following a very comfortable session of viewing "Sesame Street," the behavior of each twin was observed during the presentation of a novel toy (a mechanical robot that moved on its own accord and presented itself as a potential stressor to the infants). Interestingly, the infants who were most attentive and reactive had higher vagal tone. Individual differences in vagal tone may reflect the infant's ability to attend to a new environmental event and to cope with mildly stressful situations. Those children who were more reluctant to approach the robot were rated by the mothers as being more difficult in temperament, more negative in mood, and more distractible. Those children with lower vagal tone were those who approached the toy immediately upon its presentation. These data are extremely interesting inasmuch as they are inconsistent with data reported by several others.

Nathan Fox (chapter 5) carries on this discussion with a review of the research he has conducted over the past decade on individual differences in temperament, responses to stress, and underlying EEG patterns. Being one of the first investigators to examine separation responses repeatedly over the first year, he has been able to show that there are consistent individual differences in infants' responses to separation with some always displaying distress and others only sporadically showing distress. Underlying this individual difference in behavior is a clear difference in EEG arousal. The infants predisposed to distress show greater relative right frontal arousal and those who do not cry exhibit left frontal arousal. Finally, Fox reviews data from other laboratories suggesting that children with greater left frontal arousal may also have strategies necessary to modulate negative arousal. That is, both sustained attention and distractibility, as well as verbal strategies, are left hemisphere competencies. Thus, as Fox concludes, language facility may help children cope with stress and novelty.

In a related chapter on slightly older children, Nancy Eisenberg (chapter 6) discusses the differences between sympathy, empathy, and personal distress as various forms of coping with others' distress. She provides examples of how children engage in emotion-focused versus problem-focused coping and, like adults, monitoring occurs in controllable situations and blunting occurs in uncontrollable situations. Children who are relatively reactive may be forced to develop effective coping strategies. Children with high levels of personal distress are not particularly helpful when they can escape from an anxiety-producing situation. Eisenberg also presents data suggesting that mothers' empathic dispositions are related to their children's empathic and prosocial behavior, suggesting a heritability aspect of this behavior.

The final chapter in this section, by Brooks-Gunn (chapter 7), reviews material and presents data suggesting that stress during the transition to adolescence is multidimensional. Although depression, aggressive affect, and eating problems increase during this period, large interindividual variation is noted, and these problems appear to derive more from social events than hormonal changes. Increases in estradiol levels, for example, accounted for less variance in depressive symptoms than negative life events. This was also true for aggressive behavior, although hormones did play a larger role in the aggressive behavior than in the depressive symptomatology. As Brooks-Gunn suggests, the interaction between negative events and hormonal change is further complicated by the timing and sequencing and the circumstances in which they occur, suggesting the need for new multidimensional models for describing the stresses associated with adolescent development.

Part II on clinical stressors begins with a chapter by Connie Morrow and Tiffany Field (chapter 8) on the stressful effects of invasive procedures and the nonstressful effects of noninvasive procedures on oxygen tension in preterm neonates treated in a neonatal intensive care unit. In their review of the literature, the authors note that medical procedures that involve handling have consistently been documented to cause declines in TcPO2 (oxygen tension). Consequently, a minimal touch policy for preterm infants has become standard protocol in many hospitals across the nation. Unfortunately, although the minimal handling protocols derive from research on medical and nursing procedures, the policy has been generalized to the social context. Unlike the full-term infant who receives considerable social stimulation and parental contact, the preterm infant's interactions occur primarily during necessary invasive medical or nursing procedures. Parental touching and holding is discouraged while the infant is in intensive care even though the effects of social stimulation have not been investigated. Morrow and Field reported data documenting the expected decreases in oxygen tension during invasive procedures such as heelsticks, but the data also showed negligible oxygen tension changes during neonatal assessments such as the Brazelton and during tactile stimulation procedures such as massage. Their results suggest that Brazelton assessments and massage stimulation are safe procedures at least for preterm infants who are being treated in intermediate care nurseries.

Chapter 9 by Debra Bendell-Estroff reviews the literature on the stress of Sudden Infant Death Syndrome (SIDS) and apnea monitoring on parents. Apneic infants (who are typically preterm infants with other medical complications) present a real stressor for parents, siblings, and extended family. Infants with interrupted Infantile Apnea are often discovered by their parents to be limp, pale, or cyanotic, and are revived only after vigorous manual or auditory stimulation and/or mouth-to-mouth resuscitation. The stress continues as the infant is hospitalized and placed on a monitor. Bendell-Estroff reports data suggesting that higher levels of distress are noted in parents who have previously lost a child to SIDS, mothers who are socially isolated, and those who have difficulty with monitor compliance. An additional stress is posed by the apneic infants typically being more demanding, wanting to be held more, and their more frequent crying and minor behavior problems, providing relatively little reinforcement for the mother's parenting the infant. Thus, apnea appears to be a significant stressor for both the infant and the infant's family.

In chapter 10, Danny Armstrong discusses the stress of childhood cancer and also presents ideas on how children and families can more effectively cope with cancer. Armstrong presents several examples of how most families of children with cancer are normal in their psychological functioning at the time of diagnosis, but their attempts to cope with the disease and treatment in a normal fashion often lead to ineffective or problematic behavior during and after the termination of treatment. For example, children with cancer often get extra attention, reassurance, and comfort. Their attempts to cope using accelerated distress behavior are responded to by increased comfort-giving and protection on the part of parents. This may in turn increase the stress by positively reinforcing and maintaining ineffective escape behaviors. The interventions Armstrong proposes are that the treatment be altered in some way to reduce its aversiveness, that strategies be taught to the patient to reduce the aversiveness of the treatment and its consequences, and that parents and children be taught to respond to this abnormal situation in ways that may seem abnormal to them but may be the most effective response for the situation.

Finally, Tiffany Field (chapter 11) reviews the literature on stress-reducing techniques for psychiatric patients. She then presents data from two studies on the use of relaxation therapy and massage with child and adolescent psychiatry patients. In the first study on relaxation therapy, decreases were noted in both self-reported anxiety and anxious behavior as well as increases in positive affect in child and adolescent patients diagnosed with adjustment disorder or depression. These patients also showed decreases in cortisol levels following relaxation therapy. Although both diagnostic groups appeared to benefit from the relaxation therapy, it was not clear what the effective treatment component was in that study because relaxation therapy consisted of yoga exercises, massage, progressive muscle relaxation, and visual imagery. In addition, although relaxation therapy clearly reduced stress and anxiety, at least in the short term, the study did not establish whether there were any longer term effects. Thus, the subsequent study was designed to examine the independent effects of massage as well as its short and longer term effects. Because child and adolescent psychiatric units in the United States have a no-touch policy, and these children and adolescents are typically hospitalized for as long as 2 to 3 months, they experience considerable touch deprivation. The data from this massage study showed that daily massage was beneficial in increasing positive affect and decreasing anxiety as well as cortisol levels. Over the longer term, nighttime sleep also increased. The consistency of the self-report, behavior observation, and physiological data support the use of this treatment for reducing stress in child and adolescent psychiatric patients.

Elsewhere, we have suggested that stress and coping begin at the moment of conception and continue across the life span. It is perhaps not surprising, then, that individual differences in responses to stress and individual styles of coping emerge early in infancy. For the same reason, it is not surprising that infants and children are able to cope with significant stressors such as invasive medical procedures and disease; they have had considerable experience with stress and practice with coping. Although this volume highlights individual differences and predispositions to stress responses and coping styles, it also reminds us of the role of the environment (most particularly parenting practices) in shaping these stress responses and facilitating coping.

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I DEVELOPMENTAL STRESSORS

1 Infant Stress Reactions to Brief Maternal Separations in Human and Nonhuman Primates

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Maternal separation is one of the two most commonly studied psychosocial stressors of infancy. The other one, interaction with strangers, is frequently a component of separation (e.g., Ainsworth & Wittag, 1969). Developmental psychologists have focused on the behavior infants display during separation (e.g., Ainsworth, Blehar, Waters, & Wall, 1978; Schaffer & Emerson, 1964; Weinraub & Lewis, 1977). In contrast, developmental psychobiologists and neuroscientists have focused on the physiological consequences of maternal separation (e.g., Coe, Wiener, Rosenberg, & Levine, 1985; Hofer, 1987; Levine & Wiener, 1988; Reite, Kaemingk, & Boccia, 1989), and on the physiological substrates of separation behavior (e.g., Kalin, Shelton, & Barksdale, 1988; Kehoe & Blass, 1986; Kraemer, Ebert, Lake, & McKinney, 1984).

One conclusion from all of the research is that there are at least two distinct phases in the infant's response to maternal loss (Bowlby, 1969; Hofer, 1984). The initial minutes and hours of separation are termed the *protest phase,* during which the infant actively seeks to reestablish maternal contact. This phase may be followed 1 to 2 days later by a *despair phase* similar to the depression often noted during bereavement in adults. Although Bowlby proposed that both phases were regulated by the emotional response to loss, the data do not support this conclusion. The two phases can be decoupled. In addition, reactions occurring during each phase have different regulators (e.g., Hofer, 1984, 1987).

In this review, we focus on the protest phase, the only phase involved when separations are brief. We have chosen to focus on this phase because (a) most of the behavioral and physiological data on human infants deal with separations of only a few minutes; and (b) reactions to brief separations are of import these days because of concerns about infant day care. Emphasizing the protest phase, we deal with the following questions: What are the physiological changes that occur during this phase of separation? How is the infant's affective behavior related to these physiological changes? What are the situational factors that make separations more and less stressful? And finally, what do we know about individual differences and developmental change?

PHYSIOLOGICAL CHANGES DURING BRIEF SEPARATIONS

Separations of a few minutes to a few hours produce a set of physiological changes indicative of stress in the young of many mammalian species. Dramatic increases in heart rate, cortisol, and catecholamines have been documented in a number of species (see review by Hofer, 1987). For example, in the rhesus monkey, whose endocrine system is similar to our own, 30 minutes of separation can elicit increases of 40 to 60 μg/dl in circulating levels of cortisol (Gunnar, Gonzales, Goodlin, & Levine, 1981; Smotherman, Hunt, McGinnis, & Levine, 1979). This corresponds to increases of 100 to 200%. In juvenile squirrel monkeys, separations of 1 and 6 hours produce significant increases in cerebral spinal fluid metabolites of dopamine, serotonin, and norepinephrine that indicates heightened anxiety (Coe et al., 1985). In both macaque and squirrel monkeys, changes in immune functioning have been documented in separations lasting only a few hours, including decreases in white blood cell counts, increases in complement proteins, and decreases in thymic hormone (Friedman, Coe, & Ershler, under review).

There have been very few studies of physiological changes during brief separations in human infants. Nonetheless, the work that has been done suggests that similar physiological changes are produced. Thus, increases in heart rate have been noted during maternal separation, including tachycardia associated with intense crying (Donovan & Leavitt, 1985). Changes in brain activity have also been noted: Fox and Davidson (1988) showed an increase in right frontal activity associated with negative affect during separation in 10-month-olds. Many of these changes have been less dramatic than those produced in monkeys, perhaps because of differences in the quality of the separation environments.

For example, neuroendocrine changes have been more difficult to document. In an early study, Tennes and her colleagues (Tennes, Downey, & Vernadakis, 1977) examined cortisol excretion rates in year-old infants subjected to a one-hour separation in the home. They found a 22% increase in cortisol that was not statistically significant. Recently, we (Gunnar, Mangelsdorf, Larson, & Hertsgaard, 1989) examined salivary cortisol concentrations before and after administration of the Louisville Temperament Assessment to 9-month-old infants. The Louisville assessment involves two separations lasting about 30 minutes each, during which the baby interacts with two different strangers who administer a series of predetermined tasks. Like Tennes et al., we observed a

22% increase in cortisol that was statistically significant in our sample (see Table 1.1). However, to complicate matters, postassessment cortisol levels were not significantly different from levels obtained at home under basal conditions. Furthermore, using the same infants at 13 months, we examined responses to the Strange Situation assessment involving only a few minutes of separation. Here we obtained only a 10% increase that was not statistically significant. However, this may have been because we sampled the adrenocortical response too early, before it had reached its peak.

None of these studies provided unambiguous evidence of a neuroendocrine response to separation in human infants. The only unambiguous evidence comes from a study we (Larson, Gunnar, & Hertsgaard, 1991) recently completed in which the cortisol response to a 30 minute laboratory separation in 9-month-olds was compared to the response to 30 minutes of play with mother present. These data (see Fig. 1.1) clearly indicate that maternal separation elevates cortisol at

TABLE 1.1
Salivary Cortisol in μg/dl Means and Standard Errors

	Parent Home	*Preseparation*	*Postseparation*
9 months	0.53 (0.03)	0.42 (0.03)	0.51 (.02)
13 months	0.57 (0.03)	0.50 (0.02)	0.55 (0.03)

Note. Ns ranged from 52 to 61. Values expressed as μg/dl. Numbers in parentheses are standard errors. Adapted from Gunnar et al. (1989).

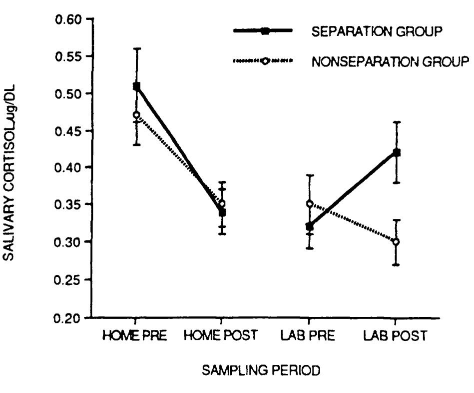

FIG. 1.1. Salivary cortisol at home and in the laboratory during either a 30 minute separation or a 30 minute play period with mother. (Difference between Home Pre and Lab Pre reflects the calming effect of riding in the car.) Reprinted from Larson et al. (1991) *Child Development.*

this age over the levels observed when the mother is present. However, they also point to the problem of concluding that the separated infants were in a state of physiological stress. The cortisol response was small, and postseparation concentrations were not that different from cortisol levels obtained at home at the same time of day.

RELATIONS BETWEEN PHYSIOLOGICAL AND BEHAVIORAL REACTIONS

Brief separations produce a variety of behavioral effects. As noted, all of these effects were once viewed as reflecting a unitary emotional response to maternal loss (Bowlby, 1973). However, the current evidence suggests that, at the very least, during the protest phase we need to distinguish emotional behavior triggered by the enforced separation from emotional behavior reflecting infant reactions to the separation environment (Hofer, 1987). Furthermore, we argue that the emotional arousal produced during the protest phase of separation reflects the interaction among at least four emotion-behavior systems. First there are the attachment behaviors organized around attempts to elicit retrieval and reestablish contact. These include signaling and search behavior. Next there are withdrawal behaviors reflecting fear. These include freezing, inhibition of play and exploration, and sometimes threat gestures to fear-eliciting elements of the environment. Third, there are vocal and gestural reflections of frustration and anger at being blocked from achieving maternal contact. Finally, there are the behaviors organized around affect regulation, including clinging to surrogate caregivers, self-stimulation, and distraction. Only the first two of these, attachment (signaling/calling) and fear-anxiety (behavioral agitation and freezing), have received much attention in the neuroscience literature.

The endogenous opiate system appears to be most intimately involved in regulating the attachment behaviors of searching and signaling. Panksepp (e.g., Herman & Panksepp, 1978) has argued that this system plays a central role in affiliation and attachment. Consistent with this argument, it has now been demonstrated in several species that morphine reduces the number and intensity of the infant's "calls for mother" during separation, and that naloxone, an opiate antagonist, increases these calls and blocks the morphine effect (Herman & Panksepp, 1978; Kalin et al., 1988). Morphine also reduces the physiological stress of separation, producing significant reductions in the adrenocortical response (Kalin et al., 1988). These reductions can be blocked by prior treatment with naloxone.

Stimulation that triggers endogenous opioid activity reduces separation calls. Endogenous opioids can be triggered by pleasant social interactions (Panksepp, Herman, Vilberg, Bishop, & De Eskinazi, 1978), the consumption of milk, sugars, and fats (Blass, Shide, & Weller, 1989), and by stress (Akil, Madden, Patrick, & Barchas, 1976). As later discussed, stimulation of endogenous opioid system may partly explain why companionship during separation so potently reduces the stress of separation (Panksepp et al., 1978; but see also Blass, Fillion, Weller, & Brunson, in press, for a counterargument). Increases in endogenous opioids also may be one factor influencing the time-course of separation calling. During separation, calling and search behavior decreases. In infants who have been calling from the onset, the decrease in calling typically begins 20 to 30 minutes into separation. This is about the point when increases in endorphins triggered as part of the activation of the hypothalamic-pituitary-adrenocortical responses would be at high or peak concentrations. Anecdotally, this is also the time when, in human infants, one begins to notice the baby rubbing its eyes and acting sleepy. It may be that in a supportive environment, the combined effects of tiredness from increased energy expenditure, and endorphin-related reductions in the acute sense of loss are what allow some babies to quiet down and fall asleep (see Tennes et al., 1977).

Fear and anxiety, the second major emotion-behavior component of the separation response, appear strongly affected by the nature of the separation environment (Kalin & Shelton, 1989). Not surprisingly, manipulations of the neurochemical substrates of fear and anxiety have potent effects on the infant's fearful and anxious behavior. For example, Kalin et al. (1988) have provided evidence that the endogenous benzodiazepine system plays a role in regulating behavioral inactivity and social withdrawal as well as signaling behavior during brief separations. The major neurotransmittors may also be involved; however, their role in regulating separation vocalizations is still under debate. Kalin and Shelton (1988) have presented evidence that both the alpha and beta adrenergic systems may play a role in regulating behavioral agitation during separation. But, they noted that in order to reduce separation calling, pharmacological manipulations of the norepinephrine system had to be dramatic enough to produce general sedation.

Fear behaviors during separation may be regulated in part by the hypothalamic-pituitary-adrenocortical (HPA) system. Kalin, Shelton, and Barksdale (1989) found that intraventricular injections of corticotrophin releasing hormone (CRH) increased freezing and inactivity during a one-hour separation in rhesus infants. Similarly, Levine and his colleagues (Coe et al., 1985) found that pretreatment with metyrapone, which blocks cortisol production and produces hypersecretion of CRH under stress conditions, resulted in extreme behavioral inhibition in separated infant squirrel monkeys. The levels of CRH required to produce behavioral inhibition, however, are quite high and may naturally occur only with extremely intense activation of the HPA axis. Cortisol (and consequently CRH) levels produced during separation using typical monkey separation paradigms are positively correlated with behavioral agitation, not freezing (Gunnar et al., 1981).

So far, little attention has been paid to anger as a component of the protest response. Nonetheless, anger may be especially important in understanding the human infant's response. In a recent analysis of discrete facial expressions, Izard and his colleagues (Shiller, Izard, & Hembree, 1986) noted that few infants displayed fear and only a few infants displayed sadness in response to the brief separations in Ainsworth's Strange Situation. In contrast, anger was frequently noted. Anger is the emotion associated with goal-blocking and loss of anticipated control over desired outcomes. In monkeys, separation situations that should elicit anger are associated with heightened vocalizations, cage shaking, and moderate rather than extreme elevations in cortisol and cerebral spinal fluid concentrations of norepinephrine metabolites (Bayart, Hayashi, Faull, Barchas, & Levine, 1990). Such conditions have been created by placing a plexiglas barrier between mother and infant during separation: the baby thus can see but not get to the mother. Levine (Levine, Johnson, & Gonzalez, 1985) has argued that these conditions reduce the HPA response to separation because seeing the mother helps sustain the infant's active attempts to cope with or control the situation.

For ethical reasons, the situations used to study separation in human infants all contain cues that should prevent the baby from feeling helpless. The mother leaves the baby of her own accord (as opposed to being captured and removed); she frequently says goodbye and indicates that she will return soon (a pattern that Western infants should have experienced enough to associate with separations of a finite period); and the infant is rarely left without an alternative caregiver or babysitter. It would make sense, then, that much of the distress observed during brief, laboratory studies of separations in human infants may reflect anger.

This conclusion is consistent with available physiological and neuroendocrine data. Fox and Stifter (1989; Stifter & Fox, in press) have recently described the results of a longitudinal investigation of vagal tone in human infants. Infants with high vagal tone were shown to respond with more intense behavioral distress to limb restraint at 5 months, a manipulation that should elicit anger. By 13 months, these infants showed more intense and immediate crying to maternal separation than did infants with low vagal tone. Similarly, Davidson and Fox (1989) found that infants who were more right lateralized in frontal lobe EEG activity under baseline conditions were more likely to cry to a 1 minute separation from mother than were infants who were more left lateralized. Fox and Aaron (in preparation) have recently replicated these results. Anger elicited by frustration and goal-blocking should be associated with intense right frontal activity.

In several separation studies, we (Gunnar et al., 1989; Larson et al., 1991), have examined the relations between cortisol, crying, and parent-reported measures of temperamental fear of novelty and anger at limitations. We have consistently found that the modest adrenocortical activation noted in our research is greater for babies who typically show more anger to limitations and is not strongly related to measures of fear in response to novelty. Of course, in separation paradigms containing more novel and strange elements, temperamental fear of novelty may be more predictive of the infant's response.

Relatively little attention has been paid to the biobehavioral substrates of affect-regulatory behaviors during separation. In human infants, many of these behaviors appear to have their roots in social stimulation. They include nonnutritive sucking, clinging to a favorite blanket or toy, and seeking contact with babysitters. Blass and his coworkers (Blass et al., in press) have argued that nonopioid mechanisms mediate the distress-modulating effects of nonnutritive sucking and physical contact. Panksepp's (Panksepp et al., 1978) data, of course, would suggest that the distress-reducing effects of affiliation are mediated by opioid pathways. Whether opioid mechanisms mediate the effects of social support during separation in primate infants remains to be examined. It is possible, of course, that nonopioid pathways mediate the effects of contact comfort, whereas opioid pathways mediate the impact of pleasant social relations. Distraction and attention-regulation form another major category of affect-modulatory behavior in infancy. Rothbart and Posner (1985) recently have speculated on the neural substrates of these behaviors and their relation to individual differences in temperament and to developmental changes in negative affectivity. Anecdotally, giving the baby attractive toys to play with does seem to help reduce distress during brief separations. Playing with toys, of course, may help the baby to "tune out" the parent's absence if the separation is brief enough.

STRESS AND THE ENVIRONMENT OF SEPARATION

The separation environment is a major determinant of the physiological stress of separation and it also affects behavioral reactions. However, the effects on behavior do not always mirror the physiological effects. As noted above, baby monkeys who can see their mothers during separation vocalize more and appear more agitated than infants who are completely isolated. Nonetheless, measures of cortisol and of brain monoamine metabolites indicate that the baby is less physically stressed when mother is visible (Bayart et al., 1990). Because crying and signaling are instrumental behaviors, they should be readily manipulated by altering environmental contingencies (Gewirtz & Pelaez-Nogueras, 1990). However, unless the manipulations increase the baby's control over stress-reducing elements of the separation environment, extinguishing crying and signaling by removing reinforcers should increase stress. This analysis is based on evidence that loss-of-control and helplessness are potent activators of physiological stress reactions (e.g., Hanson, Larson, & Snowdon, 1976).

Control is also a major determinant of fear in human infants by the last quarter of the first year. Babies who can self-activate a loud, mechanical toy cry less, smile more, and approach the toy more than yoked infants who have no control over activating the toy (Gunnar, 1980). Infants who can control the appearance of a stranger during peek-a-boo show more positive affect and less withdrawal than yoked, helpless babies (Levitt, 1980). Finally, 10-, 12-, and 18-month-old infants show less avoidance and more approach and positive affect when playing with controllable strangers who allow the baby to regulate the interaction as compared to controlling strangers who try to regulate the baby's actions (Mangelsdorf, Lehr, & Friedman, 1986; Mangelsdorf, Watkins, & Lehn, in preparation).

The behavioral and physiological effects of control over separation have not been experimentally examined in either human or nonhuman infants. However, perceived control over aversive stimulation is well known to reduce physical indices of stress in adult humans and animals (Seligman, 1975). Furthermore, sudden loss of control over a previously controllable event elicits even greater stress, as indexed by HPA activity, than never having control over the event (Hanson et al., 1976). A sense of sudden loss of control may characterize the infant's experience when forcibly separated from mother, and this loss of control may seem greater for infants from more rather than less responsive relationships. We (Gunnar et al., 1981) examined this prediction with rhesus infants who were observed in their social groups for several weeks prior to separation. We found that greater adrenocortical reactions to separation were produced in infants from more responsive mother-infant relationships, whereas separation produced a smaller HPA response in infants whose mothers were less responsive and more rejecting. Interestingly, upon reunion, the opposite pattern was noted, with infants from the most responsive relationships showing decreases in cortisol and those infants from unresponsive relationships actually showing a rise in cortisol to reunion (see Table 1.2).

Although control over separation has not been experimentally manipulated, there are a number of studies that have manipulated the controllability of the

TABLE 1.2
Relationship Quality and Plasma Cortisol Responses to Separation and Reunion in Rhesus Monkey Infants

Separated Pairs	*% Approach-Leave*[a]	*Separation Cortisol*[b]	*Reunion Cortisol*[c]
1	0.00	+29.8	- 0.7
2	0.19	+27.3	+ 1.0
3	0.29	+26.5	+20.5
4	0.31	+13.7	+12.7
5	0.46	+ 9.3	+27.1

Adapted from Gunnar et al., 1981.
[a]Higher scores indicate proximity of mother and infant regulated by infant approaching and mother leaving.
[b]Cortisol 3 hours after separation minus baseline.
[c]Cortisol 24 hours after reunion minus baseline. Separation period was 2 weeks.

separation environment. This manipulation of control, however, is typically produced through providing the infant with an alternative caregiver in the mother's absence. Thus the effects of control are confounded with the effects of social support.

The presence of familiar conspecifics is about the most potent situational factor determining the stress of separation. Levine and his colleagues (e.g., Levine & Wiener, 1988) have shown that the HPA response to separation can be reduced considerably, although not eliminated, in infant squirrel monkeys by leaving them in their social groups where they are often "aunted" by adult females during the separation. During prolonged separations, the presence of an "aunt" greatly reduces evidence of despair and moderates physiological reactions in macaque infants (e.g., Reite, Seiler, & Short, 1978). In human infants, even the presence of a strange adult female greatly reduces crying during brief separations in the Strange Situation (Ainsworth et al., 1978).

Physiologically, as noted, both opioid and nonopioid pathways may be involved in regulating the effects of companions on the infant's reactions to separation. Psychologically, there is growing evidence that the controllability of the social other is also important. For example, we (Gunnar et al., in preparation) recently manipulated babysitter responsiveness to 9-month-olds during separations lasting 30 minutes. In one condition the babysitter was moderately responsive and controllable: She responded warmly and sensitively to the baby if he became upset, but otherwise was preoccupied reading a magazine (caretaker condition). In the other condition, the babysitter was highly responsive and controllable. Throughout the separation period she interacted with the baby, playing with the baby if he was happy and comforting him if he became upset (playmate condition). Remarkably, this relatively small increase in the babysitter's controllability and responsiveness was enough to eliminate the HPA response to separation (see Fig. 1.2).

Because we believe that these data have important implications for discriminating low- from high-stress daycare environments, we decided to determine whether adding additional infants eliminated the buffering effect of high babysitter playfulness and responsiveness. Using the highly responsive/playful babysitter paradigm, we compared behavioral and adrenocortical responses of infants separated singly with the babysitter (1 : 1) to infants who shared the babysitter with two other infants of the same sex. As before, in the 1 : 1 condition, no evidence of a stress reaction was obtained. Furthermore, even when two "strange" babies were added to the separation environment, the availability of a playful and responsive babysitter still buffered the HPA response (see Fig. 1.3).

Control was probably not the only psychological variable affecting infant reactions to separation in our "playful/responsive" babysitter studies. The playful, responsive babysitter may have helped the baby use distraction as a coping strategy. In addition, her behavior may have been more predictable and under-

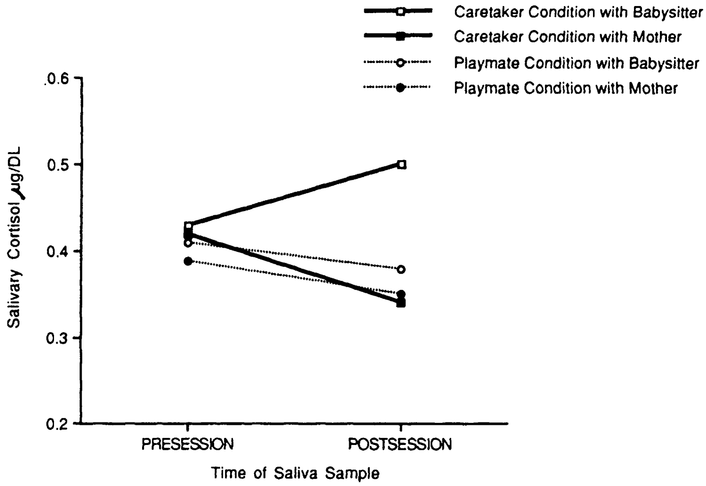

FIG. 1.2. Salivary cortisol under two care conditions, caretaker or playmate, with mother versus a babysitter as the caregiver. Gunnar et al., in preparation.

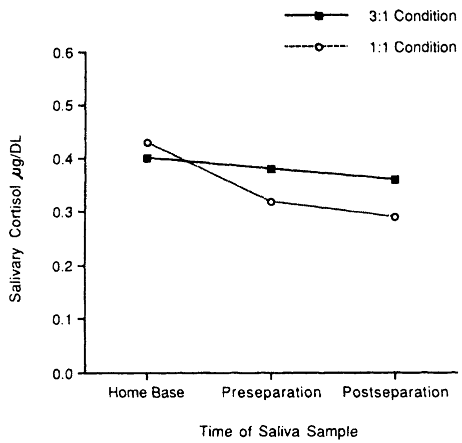

FIG. 1.3. Salivary cortisol during a 30 minute separation in either group care (3 babies: 1 caregiver) or singleton care (1 baby: 1 caregiver).

standable to the baby. In the stress literature, predictability has also been shown to reduce adverse reactions to noxious stimulation (Seligman & Binik, 1977). There are mixed data, however, on whether predictability increases or decreases the infant's negative reactions to separation. On the positive side, Kagan (1974) has demonstrated that infants cry and protest less when separated at home if the mother leaves by a familiar exit (the front door) than by an unfamiliar one (the