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Transition to Child Care: Associations With Infant–Mother Attachment, Infant Negative Emotion, and Cortisol Elevations

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Seventy 15-month-old infants were studied at home before starting child care, during adaptation (mothers present) and separation (first 9 days without mothers) phases, and 5 months later. Security of infant–mother attachment was assessed before and 3 months after child care began. In the separation phase, salivary cortisol rose over the first 60 min following the mothers' departures to levels that were 75% to 100% higher than at home. Compared with insecure infants, secure infants had markedly lower cortisol levels during the adaptation phase and higher fuss and cry levels during the separation phase, and their fuss and cry levels were significantly correlated with their cortisol levels. Attachments remained secure or became secure if mothers spent more days adapting their children to child care.

Parents have long been concerned and researchers fascinated by the emergence of separation protest near the end of the first year. Although separation protest was widely viewed as an index of reinforcement-based dependency (Gewirtz, 1961; Gewirtz & Pelaez-Nogueras, 1991), Bowlby (1969) theorized that such species-typical responses reflected the organization of emotional security around attachment figures. Belief in the propositions that attachment figures were sources of security and that separation was stressful was strengthened when researchers began to measure the activity of stress-sensitive systems such as the hypothalamic-pituitary-adrenocortical (HPA) system (see review by Gunnar & Brodersen, 1992). In monkeys, the presence of attachment figures prevents or buffers elevations of cortisol, the hormone produced by the HPA system in response to stress (Levine & Wiener, 1988), whereas cortisol levels rise following separations from the mothers (e.g., Gunnar, Gonzalez, Goodlin, & Levine, 1981). Likewise, the presence of human mothers appears to buffer or prevent cortisol elevations when securely attached infants encounter events that elicit fearful, wary behavior (Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996; Spangler & Grossmann, 1993).

Concern that separation from attachment figures was stressful for infants and toddlers intensified in the 1960s and 1970s as more families began seeking nonparental care for their infants and toddlers, and the attendant controversies fostered intense research on both stress in infancy and the association between child care and child outcomes. In both monkey and human children, the transformation of protest into despair following prolonged separation depends on characteristics of the separation environment, particularly the presence of responsive substitute caregivers (Bowlby, 1973; Gunnar & Brodersen, 1992; Reite & Field, 1985; Robertson & Robertson, 1971). Sensitive and responsive babysitters likewise prevent cortisol elevations during 30-min separations involving human infants (Gunnar, Larson, Hertsgaard, Harris, & Brodersen, 1992).

In monkeys, the relations between characteristics of the mother–infant relationship and responses to separation have been examined using separations that last for hours and even days (Suomi, 1997).

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Typically, larger cortisol responses to separation are observed in infants from well-functioning dyads (Gunnar et al., 1981) and in mother-reared rather than surrogate-reared infants (Hennessy & Kaplan, 1982). In humans, by contrast, stress reactions to separation have typically been studied using extremely brief separations lasting only a few minutes, such as in the Ainsworth and Wittig (1969) Strange Situation. Here, it is generally found that infants from secure dyads have lower cortisol levels 30 min after the last separation than do infants from insecure or disorganized dyads (Spangler & Grossmann, 1993; Spangler & Schieche, 1998). The contrast between the human and monkey results likely reflects the duration of the separations studied. We know nothing about the association between attachment security and cortisol responses to prolonged (several hours) or repeated (over many days) separations such as those experienced by children in child care that are more similar to those studied in nonhuman primates.

High-quality child care that provides children with rich and varied educational experiences enhances their linguistic and cognitive competence (Lamb, 1998; NICHD Early Child Care Network, 2000). Initial concerns that regular nonparental care increased the risk of insecure attachment (Belsky, 1986) have not been confirmed, although extended or poor quality care adversely affects the security of attachment when infant–mother relationships are already compromised (NICHD Early Child Care Network, 1997). Nonetheless, long periods of child care early in life are associated with more externalizing, aggressive, and oppositional behaviors in the preschool years (Belsky, 2001; NICHD Early Child Care Network, 2003), and young children exhibit increasing levels of cortisol over the course of the day in center-based child care settings (Dettling, Gunnar, & Donzella, 1999; Tout, de Haan, Campbell, & Gunnar, 1998). This pattern is most marked among toddlers (Watamura, Donzella, Alwin, & Gunnar, 2003), particularly those with more fearful (Watamura et al., 2003) or difficult temperaments (Gunnar & Donzella, 2002). No researchers have examined the association between the quality of child–parent attachment and the ability to maintain cortisol levels within basal ranges over the child care day. In addition, most of the relevant research has been conducted in the United States where mothers typically return to the work force before their infants are old enough to have organized their attachment behavior around specific attachment figures. Thus, there has been little opportunity to examine the effect of entry into child care on the quality of established attachment relationships.

The present study was conducted in Berlin, Germany, where most children spend at least a year at home with their parents before entering child care. Mothers are also encouraged to remain with their infants and toddlers in the child care settings during a transitional period to help them adapt before the first child care separation (Bundesministerium für Familie, Senioren, Frauen, und Jugend, 1994). As a result, we were able to ask in the present study whether: (a) the transition to child care causes stress that is reflected in both behavioral distress and activity of the HPA system; (b) the stress is attributable only to separation from parents, or whether the cortisol levels rise during the transition even if the mother is present to help the child adapt, (c) the security of infant–mother attachment affects the stressfulness of entry into child care, as indexed by both HPA activity and behavioral distress, beyond any influence of temperamental differences in responsivity to novelty; (d) the onset of child care alters the security of infant–mother relationships, and (e) if so, this is related to either the magnitude of the stress or the mothers' sensitivity during the transition period.

We anticipated elevated levels of cortisol following the onset of child care, although we expected smaller elevations, particularly for securely attached toddlers, when mothers accompanied their children to help them adapt. Secure patterns of attachment behavior are believed to reflect internal working models that serve as the basis for the child's felt security in the parent's presence (Ainsworth, Blehar, Waters, & Wall, 1978; Bowlby, 1969; Bretherton & Munholland, 1999; Sroufe & Waters, 1977). By the second year of life, therefore, securely attached toddlers should expect protection from threat in the presence of their attachment figures and this should be reflected in the toddlers' cortisol responses during exposure to novel and potentially threatening stimuli (Nachmias et al., 1996). The onset of nonparental child care can be viewed as a stressor capable of activating the HPA system (Hennessy & Levine, 1979), and a large center with many unfamiliar children and adults is likely to be a highly novel setting for children reared at home. We thus predicted that increases in cortisol would be observed when children entered child care but would be minimized or absent during the adaptation period—the period when the mother accompanied the child—for securely attached toddlers.

The associations between internal working models and responses to separation are more difficult to predict. Because securely attached toddlers should expect their mothers to be available and supportive, these toddlers might maintain strong expectations of their mothers' imminent return that help buffer them

from stress during brief separations (e.g., Spangler & Grossmann, 1993), but we do not know whether toddlers can sustain such expectations for many hours. Prolonged separations also violate expectations that mothers will respond to their toddlers' signals. Violations of expectancies, along with novelty, are potent activators of the HPA axis (Hennessy & Levine, 1979), and if such violations affect toddlers' responses to prolonged separations, securely attached toddlers should show strong behavioral and cortisol responses to extended separations. On the other hand, secure attachment relationships may help infants develop regulatory capacities that allow them to modulate stress reactions to separation more effectively (Hofer, 1995; Panksepp, Knutson, & Pruitt, 1998; Polan & Hofer, 1999; Schore, 2001; Siegel, 2001), just as responsive care in infancy leads juvenile and adult animals to have smaller and briefer HPA responses to stress (Caldji et al. 1998). If securely attached toddlers have already developed better regulated stress systems independently, they might control cortisol responses better, even in the absence of their mothers.

Behavioral distress and cortisol responses are often dissociated (Quas, Hong, Alkon, & Boyce, 2000); therefore, it is not clear that we should make the same predictions for cortisol and behavior. Panksepp et al. (1998) have argued that separation-distress vocalizations are jointly shaped by mother–infant interaction and biological predispositions, suggesting convergence between the direction and magnitude of cortisol increases and separation protest. By contrast, Cassidy (1994) has argued that insecure-avoidant infants inhibit displays of affect despite normal physiological responses, suggesting that their cortisol and behavioral responses to stress should be uncorrelated. Data obtained in studies of very brief separations are not consistent with either of these predictions. During separations in the Strange Situation, levels of fussing and crying and cortisol tend to be positively correlated among insecure but not secure infants (Spangler & Schieche, 1998). However, this may differ for longer separations (such as a day at child care); securely attached toddlers might appear more distressed or display levels of distress commensurate with their physiological reactions when separations are prolonged. Because securely attached infants reliably exhibit authentic emotions, especially negative emotions (see review by Magai, 1999), we predicted that the levels of distress manifested by securely attached toddlers would accurately reflect the degree of psychological distress experienced during prolonged separations during which their mothers failed to respond.

Finally, many researchers have shown that security of attachment often changes in the face of stressful life events (see reviews by Lamb, Thompson, Gardner, & Charnov, 1985; Thompson, 1998). If entry into child care for the toddler or return to work for the mother is stressful, little stability should be expected. This might be especially true for children whose behavior or physiology suggest they were stressed by entry into child care. Nonetheless, even in the context of daily child care experiences, maternal sensitivity and responsiveness remain the most reliable predictors of attachment security (NICHD Early Child Care Network, 1997). We thus used a measure of maternal behavior closely tied to child care entry, namely, the number of days the mothers spent adapting their toddlers to the setting before leaving the children there without them. We predicted that, in the face of a stressful transition period, the amount of time the mothers spent adapting their toddler to child care might reflect their concerns as well as their sensitivity to the children's needs during this transition. These should, in turn, help maintain secure relationships over this period and might even promote security in insecure relationships.

Method

Participants

Seventy healthy full-term toddlers (36 girls; 52 firstborns) with Bayley (1993) Mental Development Index (MDI) scores averaging 105.4 ($SD = 9.1$) participated in the study. Before enrollment in child care between 11 and 20 months of age ($M = 14.9$ months, $SD = 1.7$), all toddlers had been cared for at home, primarily by their mothers. A comparison with the sociological microcensus of Berlin (see Statistisches Landesamt Berlin, 1994) indicated that the toddlers' families were representative of middle-class families in Berlin with respect to parental age, education, occupation, and income. Because of generous maternal leave policies, German children rarely enter child care before 10 months of age. All child care centers in Berlin are licensed by the Senat, which provides curricula and conducts routine supervisory visits to ensure high quality care. Thirty-seven child care centers, each serving between 70 and 120 children between 6 a.m. and 6 p.m., were involved in the study.

Procedures and Measures

Overview. The families were visited twice during the week before child care started. The home visits

provided opportunities to obtain information about the family's socioeconomic background and to measure child temperament, developmental status (Bayley Scales of Infant Development; Bayley, 1993), and cortisol activity. When child care began, the toddlers attended part-time and were accompanied by their mothers for approximately 2 weeks ($M = 9$ days, $SD = 6.9$). Following this transitional period, all toddlers were enrolled for approximately 40 hr per week. The toddlers were videotaped and saliva was taken on the first and last of the days on which the mothers were present (adaption phase); on Days 1, 5, and 9 of the first 2 weeks without the mother (separation phase); and on one day during Month 5. Toddlers were also observed in Ainsworth and Wittig's (1969) Strange Situation with their mothers before child care entry and again 2 to 3 months later ($M = 2.37$ months, $SD = 1.15$).

Child temperament. Temperamental differences in responsiveness to novelty were evaluated using the German version of Fullard, McDevitt, and Carey's (1984) Toddler Temperament Scales (TTS). In this study, we focused on three of the original TTS scales that measure dimensions relevant to children's vulnerability to new care arrangements (Gunnar, 1994): approach-withdrawal (typical reactions to new persons or situations), adaptability (ease with which the child adapts to changes in the environment), and negative mood (amount of irritability, sadness, and negative mood typically displayed by the child). Because their internal consistency was inadequate, the original scales were revised and the internal consistency of the resulting scales (Cronbach's alphas) ranged between .60 and .84 (for details, see Weise & Ahnert, 1999).

Attachment assessments and classification. One week before child care began, the toddlers and mothers were videotaped in the Strange Situation. Two to 3 months later, after all toddlers had entered child care, 56 mother–infant dyads were again observed in the Strange Situation. These additional assessments in the Strange Situation were added to the research design after all the families had been recruited and we had established good relationships with the children, parents, and centers. By then, it was too late to assess the first 14 dyads, who did not differ from the others with respect to their families' socioeconomic backgrounds, Bayley MDI scores, or perceived temperament. All sessions took place in research settings outside the homes or centers.

Using Ainsworth's coding system (Ainsworth et al., 1978) the toddlers were classified as having secure (B), avoidant (A), or resistant-ambivalent (C) attachments, and their disorganized (D) behavior was rated using Main and Solomon's (1990) scales. One secure infant (first assessment) with a D score of 8 was reassigned to the insecure category along with one avoidant and one resistant infant (from the second assessment), who each had D scores ≥ 6. The patterns of attachment were rated by the first author and her assistant (Katrin Seltenheim), who were trained by and reliable with (classification agreement $\geq 90\%$) Karin Grossmann (University of Regensburg), who had previously established reliability of more than 90% with Main in 1976 and Sroufe in 1993. Interrater agreement for the major categories (i.e., A, B, C) was 89% (Cohen's kappa = .82) based on 30% of the tapes. Agreement on disorganized, or D classification, was 93% based on 60% of the tapes. Fabienne Becker-Stoll (University of Regensburg) was the reliability rater for D classification.

The 70 infant–mother attachments were classified as follows before the initiation of child care: B = 34, A = 32, C = 3, D = 1. This distribution is typical for Northern Germany (Ahnert & Lamb, 2001; Grossmann, Grossmann, Spangler, Suess, & Unzner, 1985). For purposes of analysis, 34 (49%) of the infants were labeled as secure (B) and 36 (51%) were labeled as insecure (A, C, and D). At the time of reassessment, the distribution of the 56 infants was similar, with 27 rated as B, 22 as A, 5 as C, and 2 as D (27 secure and 29 insecure). None of the results reported was different when the C and D pairs were removed from the analyses.

Saliva collection. Almost 2 weeks before child care began, saliva samples were collected three times, 30 min apart, during a home visit that was scheduled around the time when the mothers intended to take the children to the centers. After the first saliva sample was obtained, mothers introduced their toddlers to toys with which they played while the mothers answered questions or filled out questionnaires. A pilot study of toddlers visited at home two or more times before enrollment revealed no differences between cortisol levels in the first and second home assessments.

Saliva was also collected three times on each child care assessment day: After the toddlers arrived at the child care centers, as well as 30 and 60 min later. Saliva collection took 1 to 3 min. Toddlers were either allowed to suck directly on sterile cotton pads or cotton pads were inserted into a pacifier with several small holes that made it permeable. No oral stimulants were used (Schwartz, Granger, Susman, Gunnar, & Laird, 1998). All samples were immediately frozen to 0°F. Although we attempted to sample at home at the same time the mothers expected to take their children to child care, some mothers deviated

from their expected arrival times. Deviations on the first and last day of adaptation averaged $M = 17.3$ ($SD = 9.5$) and $M = 22.4$ ($SD = 8.6$) min, respectively. On separation days, deviations averaged $M = 12.2$ ($SD = 6.2$) on Separation Day 1, $M = 16.4$ ($SD = 6.6$) on Day 5, $M = 15.3$ ($SD = 7.0$) on Day 9, and $M = 17.5$ ($SD = 7.1$) in Month 5.

Cortisol quantification. The samples were analyzed by W. Rohde of the Institute of Experimental Endocrinology at Charité Hospital in Berlin using enzyme immuno assay (EIA) synelisa sensitive, which has a reported sensitivity of .02 μg/dl in concentrations of 0 to 10 μg/dl. Using 10 μl saliva samples, intra- and inter-assay variability ranged from 7% to 10% for concentrations of .4 to .7 μg/dl. Comparisons with a known ratio immuno assay (Kratzsch, Bier, Leistner, & Hubald, 1987) were extremely high, $r = .97$. Parallel assessments of saliva cortisol and serum cortisol from a sample of adult volunteers provided equivalent daily cortisol profiles when the synelisa sensitive assay was employed (Herden, Kratzsch, & Funk, 1991). In the present study, all samples from each toddler were analyzed in a single batch to minimize variability. To further ensure reliability, duplicate assays were performed whenever possible. Two children did not provide 10 μl saliva in 70% and 76% of their samples, respectively, and 1 child was excluded because her cortisol scores were outliers throughout the study. Thus, the analyses of saliva cortisol were based on data from 67 toddlers.

Negative emotions. Children were videotaped when they arrived at the centers, during entry into the groups, and for the first 30 min in the groups. Negative moods were only coded from the 30-min record in the group and were quantified by tabulating episodes of pronounced negative emotional expressions such as whines, cries, screams, anger, and aggression. These behaviors were marked on a second-by-second basis using a computer-linked program that preserved the temporal sequence and summed the total duration of negative emotions (Naumann, 1992). Six coders rated the tapes, and randomly chosen periods were independently rated by two or more coders on a second-by-second basis. High levels of intercoder agreement were maintained, with Cohen's kappas ranging from .89 to .99.

Results

Preliminary Analyses

Mothers spent between 0 and 30 days adapting their toddlers to child care. Toddlers were also brought to child care at different times in the morning (range = 8 a.m. to 11 a.m.). Univariate analyses of variance (ANOVAs) revealed that the number of days mothers spent in child care did not affect cortisol levels and was not associated with the security of prior child–mother attachment. Because secure toddlers were brought to child care a few minutes earlier in the day ($M = 9.40$ a.m., $SD = .6$) than insecurely attached children ($M = 9.80$ a.m., $SD = .6$), $t(65) = 2.9$, $p < .01$, however, normative circadian patterns of release might lead them to have higher cortisol levels (Kiess et al. 1995; Lifshitz, 1996). Temperament was uncorrelated with the time of arrival ($rs = -.06$ to .13, *ns*).

A one-factor (age: younger [9–14 months at onset] vs. older [14–19 months at onset]) ANOVA designed to determine whether age affected cortisol responses at the beginning and end of the study (first day of the adaptation phase vs. 5 months later) revealed no significant effects. This suggests that age itself did not significantly affect cortisol levels at different times, even though, by the end of the study, the younger children were the same age as the older children were at the beginning. Correlations among scores on the 3 temperament scales, the 6 emotion measures, and the 21 cortisol measures produced 9 (of 81) coefficients that were significant at the .05 level. There were also significant associations between temperament and attachment, with securely attached infants perceived by their mothers as more approachable, $F(1, 67) = 8.5$, $p < .01$, and adaptable, $F(1, 67) = 3.8$, $p < .05$, than insecurely attached children. When temperament scores were entered as covariates in all analyses, however, the results were unaffected, suggesting that temperament did not mediate or mask associations between cortisol levels and the infants' experiences upon enrollment in child care. To simplify the presentation, temperament is not considered further in the analyses reported.

Cortisol Responses to Child Care

We first examined changes in cortisol levels from home baseline to the adaptation, separation, and 5-month assessments. To reduce within- and between-subject variations due to the time of day, we selected home samples taken between 8 a.m. and noon and used the samples obtained at child care within 15 min of one of the home samples. In most cases (87%), the second sample taken on each child care day was matched with the second home sample, 9% of the second child care samples were matched with the first home sample, and 4% of the third home samples were matched with either the first or second child

care sample. A repeated-measures ANOVA (with Greenhouse-Geisser correction) was computed to examine the effects of attachment group (secure vs. insecure) and day of assessment (home; first and last adaptation days; Separation Days 1, 5, and 9; and Month 5). The results (see Figure 1) yielded a main effect of day, $F(4.4, 287.1) = 12.4$, $p < .001$, as well as an interaction between attachment and day, $F(4.4, 287.1) = 3.2$, $p < .01$. To examine the interaction, simple effects of day within attachment groups were tested and found to be significant for both the insecure, $F(4.4, 282.8) = 5.3$, $p < .001$, and secure groups, $F(9.4, 290.6) = 5.7$, $p < .001$. For securely attached toddlers, comparisons between adjacent time points revealed significant increases between home and the first adaptation day, $F(1, 32) = 6.6$, $p < .05$, and between the last adaptation day and the first separation day, $F(1, 32) = 19.2$, $p < .001$, as well as a significant decrease between Day 9 of separation and Month 5, $F(1, 32) = 14.8$, $p < .001$. For insecurely attached toddlers, there was a significant increase between home and the first adaptation day, $F(1, 33) = 19.6$, $p < .001$ and a significant decrease between Day 9 of separation and Month 5, $F(1, 33) = 15.3$, $p < .001$. None of the other differences was statistically significant. The differences between secure and insecure groups were different during the adaptation phase: first day, $F(1, 64) = 5.8$, $p < .05$; last day, $F(1, 64) = 9.0$, $p < .001$, but not significant on Separation Days 1, 5, and 9, and at Month 5, or at home; therefore, scores for the groups on these days of assessment were combined. Cortisol levels did not differ across attachment groups during the first separation days (from Day 1 to Day 9), but there was a significant decrease in cortisol levels from Day 9 to Month 5, $t(65) = 5.4$, $p < .001$, even though these levels remained significantly higher than at home, $t(65) = -3.1$, $p < .01$.

To examine changes across the three assessments for each of the days the children were unaccompanied by their mothers, a repeated-measures ANOVA (with Greenhouse-Geisser corrections) for Trial (drop off, 30 min, 60 min) × Separation (Days 1, 5, and 9, and Month 5) × Attachment Group (secure vs. insecure) was conducted. To avoid listwise deletion of cases, the 8% to 21% of scores that were missing were re-created by multiple imputation using an expectation maximization algorithm in PRELIS (see Graham & Schafer, 1999), and difference scores were used to control for home values. The results revealed no main effect of attachment, but significant main effects of separation, $F(2.7, 174.2) = 3.8$, $p < .05$, and trials $F(1.8, 115.4) = 13.4$, $p < .001$, as well as a significant Separation × Trial

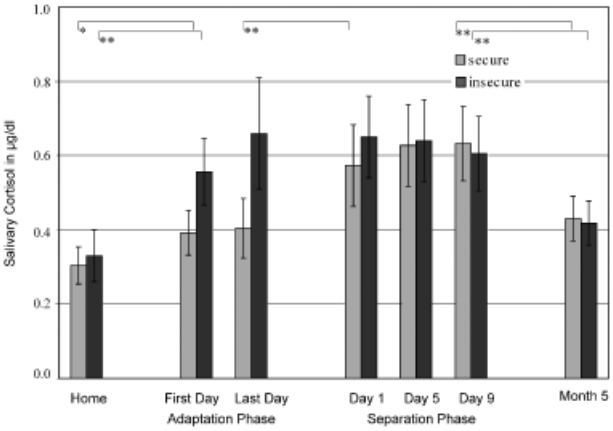

Figure 1. Cortisol levels in secure and insecure infants before and during the adaptation to child care. $^{*}p < .05$. $^{**}p < .001$.

interaction, $F(4.2, 266.8) = 4.2$, $p < .01$. Polynomial contrasts assessing within-group differences revealed significant differences between cortisol activity on Days 5 and 9 as compared with Month 5 ($ps < .05$). For trials, there were significant differences between all pairs of trials ($ps < .001$), suggesting general increases in cortisol. When we examined trials for each separation day separately, however, we found significant differences between all pairs of trials on Days 5 and 9 ($ps < .001$), but only a single significant difference—between Trials 2 and 3—on Day 1 ($ps < .01$), and no differences in Month 5 (see Figure 2).

We also conducted a repeated-measure ANOVA (with Greenhouse-Geisser corrections) for Trial (arrival, 30 min, and 60 min) × Day of Assessment in Adaptation Phase (first vs. last day) × Attachment Group (secure vs. insecure) for the three trials on each day the infants were accompanied by their mothers. Consistent with the results reported earlier, we found a main effect for days in the adaptation

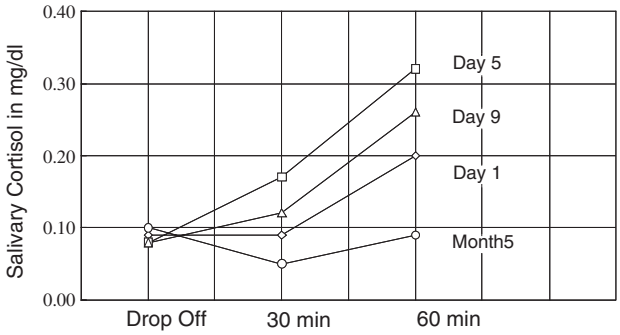

Figure 2. Changes in cortisol levels on separation days. Scores are expressed as deviations from data collected at home during the baseline phase.

phase, $F(1, 64) = 7.2$, $p < .01$, but no effect for trial. Thus, cortisol did not systematically differ across assessments when the mothers remained in the group with their children, in contrast to the striking differences in the children's responses to separation.

Fussing and Crying in Child Care

A similar analysis of fussing and crying on each of the six sample days revealed significant effects for attachment group, $F(1, 63) = 5.1$, $p < .05$, and trials, $F(2.1, 134.3) = 10.5$, $p < .001$. As shown in Figure 3, secure toddlers fussed and cried more than did insecure toddlers. Although the figure suggests that this was particularly true during the separation phase, the interaction was not significant, $F(2.1, 134.3) = 1.8$, *ns*.

To examine whether cortisol responses were correlated with distress vocalizations, the cortisol levels in the three samples taken each day were averaged to control for the possibility that different toddlers achieved peak cortisol levels at different times. These averages were then correlated with the fuss and cry scores within attachment groups to take account of the different amounts of fussing and crying by secure and insecure toddlers. The scores were not significantly associated among insecure toddlers, but securely attached toddlers who cried more had higher cortisol levels. Correlations ranged from $r = .41$, $p < .05$, on Separation Day 1 to $r = .35$, $p < .05$, on Separation Day 9.

Changes in Infant–Mother Attachment Security Following Child Care Entry

As shown in Table 1, attachment security changed quite commonly, Cohen's kappa = .18, *ns*, following enrollment in child care. An Attachment Group (secure vs. insecure before entry) × Change (no change vs. change) multivariate analysis of variance (MANOVA) with the number of days mothers accompanied the toddlers to child care and levels of fussing and crying and cortisol on Separation Days 1, 5, and 9 as dependent measures, revealed a significant interaction between attachment and change, $F(3, 47) = 3.1$, $p < .05$. Follow-up univariate analyses yielded effects only for the number of days mothers spent adapting their toddlers to child care, $F(1, 49) = 9.8$, $p < .01$. As shown in Figure 4, relationships remained secure or shifted from insecure to secure when the mothers spent more days helping their children become familiar with the child care setting. Furthermore, security of attachment after child care was unrelated to maternal age (19–24, 25–28, 29–40 years) and education (three levels). A Kruskal-Wallis test followed by chi-square test revealed an effect of work schedule (three levels: half-time, standard full-time, full-time shift work) on later attachment, suggesting that secure relationships were maintained or emerged after child care entry when mothers worked fewer hours on a regular schedule, $\chi^2(2, N = 56) = 5.6$, $p < .05$.

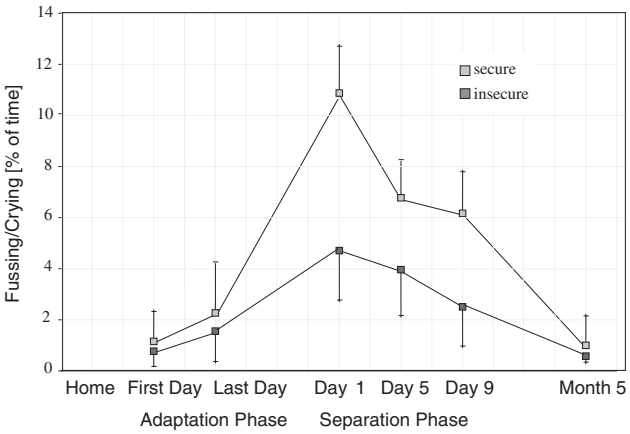

Figure 3. Fussing and crying in the course of adjustment to child care.

Discussion

This study yields important information about normative patterns of adjustment to child care and about the role played by child–mother attachment security in shaping individual differences in these patterns. Analyses of both behavioral distress and HPA system activity levels clearly demonstrated that entry into child care was stressful for these toddlers. Negative mood was more common during the separation phase than during the adaptation phase or 5 months after enrollment. In addition, higher levels of cortisol were evident in the child care setting, even with the mothers present, than at home, and levels were even higher (75% to 100% above home baseline levels) throughout the first 2 weeks that the toddlers

Table 1
Number of Infant–Mother Attachments Before and After Child Care Entry

	After		
Before	Secure	Insecure	Total
Secure	16 (29)	12 (21)	28 (50)
Insecure	11 (20)	17 (30)	28 (50)
Total	27 (49)	29 (51)	56 (100)

Note. Percentages are in parentheses.

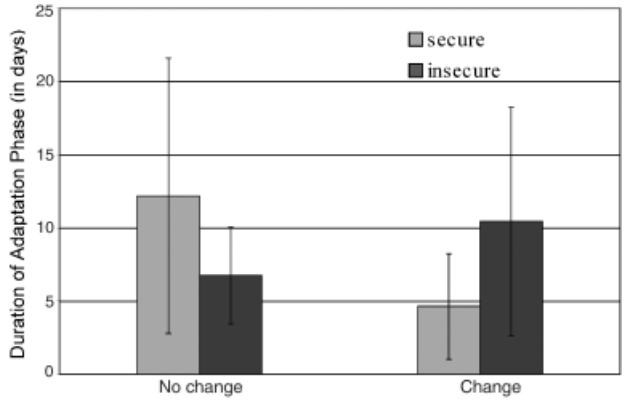

Figure 4. Changes in infant–mother attachment security after child care entry in relation to duration of the adaptation phase.

were left at child care without their mothers. Indeed, significant increases from drop off to 60 min after drop off were observed on separation days but not on the preceding days when mothers remained in the group. This suggests that the mothers served as a buffer against cortisol elevations while their children initially became familiar with the new care environment.

It was surprising that cortisol levels only increased slowly following drop off on the first separation day. Negative mood was marked on this first day of separation, suggesting that this was the most challenging day for the children. When nonhuman primates' expectation of reunion are maintained by continued visual access to their mothers, vocal distress is markedly elevated whereas cortisol levels are held in check (Bayart, Hayashi, Faull, Barchas, & Levine, 1990; Levine, Johnson, & Gonzalez, 1985). Our data may indicate that infants held higher expectations of immediate reunion with mother on the first separation day than on later separation days. Some researchers have argued that expressions of negative mood may release tension and thus reduce the activity of stress-sensitive physiological systems (Lewis, Ramsay, & Kawakami, 1993); this, too, would explain the pattern of findings observed on the first separation day. Care providers may also be more sensitive, responsive, and attentive to toddlers on the first day they are left without their mothers in child care, and this may buffer cortisol responses (Gunnar et al., 1992). The design of the study did not allow us to determine whether cortisol levels continued to rise each day during the separation phase or reached an asymptote around 60 min and then declined, but these toddlers' cortisol responses to separation were still marked 9 days after child care began. Even though the children appeared to adapt over the ensuing months, cortisol levels were still significantly higher than home baseline levels 5 months after child care began.

Because cortisol was not sampled at home on non-child-care days at the 5-month point, it is possible that the elevated cortisol levels in child care reflect a maturational or developmental increase. This seems unlikely for two reasons. First, the children in this study ranged from 9 to 19 months at the beginning of the study and 14 to 24 months at the end. If maturation produced increased cortisol levels over the course of the second year, toddlers over 14 months of age should have had higher baseline levels than the younger toddlers, which was not the case. Second, Watamura et al. (2003) reported comparable differences between cortisol levels in home and out-of-home care settings, and thus the 5-month values we recorded were likely persistent responses to a chronic mild stress. It is interesting, however, that separation was not the only influential stressor associated with the transition to child care. Even when mothers were present, cortisol levels were elevated over home baselines in both securely and insecurely attached toddlers, suggesting that the novelty of the setting and the numerous new social partners may have stimulated increased activity of the HPA axis (see also van Bakel & Riksen-Walraven, 2002).

As expected, attachment security affected the patterns of adaptation to child care, with cortisol increases during the adaptation phase predictably lower in securely attached than in insecurely attached toddlers. These findings suggest that the mothers' presence served a stress-protective function for securely attached children and are consistent with the prediction that internal working models lead securely attached toddlers to anticipate protection from threat whereas insecurely attached children feel more uncertain in their mothers' presence. Of course, these internal working models were not directly assessed, and the mothers' behavior, rather than the hypothetical working models, may have affected the toddlers' cortisol responses. It is possible, for example, that the mothers of securely attached toddlers stayed nearer their toddlers during the adaptation period and were more responsive than the mothers of insecurely attached toddlers.

Most of the insecurely attached children in this study (as in other studies conducted in this region; see Ahnert & Lamb, 2001) were insecure-avoidant, not insecure-resistant or disorganized, but the results were not affected when the few resistant or disorganized children were removed from the analyses. Kagan (1989) has argued that insecure-resistant attachment indicates fearfulness or behavioral inhibition that reflects a lower threshold for the activation

of stress-sensitive neurobiological systems, including the HPA system. If most of the insecure children had been insecure-resistant, the differences between securely and insecurely attached children might have reflected such differences in temperamental vulnerability to stress. But because most of the insecure toddlers were insecure-avoidant, this alternative explanation appears irrelevant. In addition, the results were unchanged when we entered the temperament measures as covariates.

Our analyses of individual differences in both behavioral and cortisol responses in the separation phase yielded results in line with a violation of expectations prediction from attachment theory. Specifically, negative mood was more intense in securely attached than in insecurely attached toddlers as they made the transition from the adaptation to separation phases, and parallel cortisol increases were noted only in the securely attached toddlers. Cortisol and negative mood were more closely associated among securely attached than among insecurely attached toddlers. The reverse is true when responses to brief separations are studied, but the present data are consistent with Cassidy's (1994) hypotheses that avoidant infants are characterized by affective inhibition and that the behavioral composure of avoidant infants should not be misinterpreted as physiological calmness. Our results are specific to insecure-avoidant children, however, although there were few insecure-resistant and disorganized children in this sample.

None of the data reported here suggests that securely attached toddlers regulate stress more effectively than insecurely attached toddlers in the absence of their mothers. If limbic-hypothalamic stress circuits are shaped by individual differences in early patterns of care, it seems that either (a) the differences between the types of care that yield secure and insecure patterns of attachment are not sufficient to produce neurobiological differences in stress regulatory physiology, or (b) the onset of nonparental care is so challenging that it overwhelms any differences attributable to differences in earlier patterns of care. Thus, any advantages in stress regulation conferred by secure attachment histories were not evident in the first hour following the daily separations experienced by these toddlers.

As further predicted on the basis of prior research (NICHD Early Child Care Network, 1997), the transition to child care did not promote insecure attachment: Both before and after enrollment, approximately half of the toddlers were securely attached. As expected, however, the security of toddler–mother attachment was remarkably unstable over the transition to child care, presumably because the toddlers continued to adjust their internal working models in response to changes in the patterns of care received (Bowlby, 1969; Bretherton & Munholland, 1999; Lamb et al., 1985; Sroufe & Sampson, 2000). Although the absence of a comparison group of toddlers who did not enter child care precludes any definitive conclusion, it is noteworthy that attachment security is typically stable across the second year of life among middle-class toddlers except when care patterns change (Thompson, Lamb, & Estes, 1982; Waters, 1978). Furthermore, other researchers have clearly demonstrated changes in maternal care patterns after the onset of child care (Ahnert, Rickert, & Lamb, 2000). It thus seems reasonable to conclude that the instability observed here was attributable to the onset of nonparental care.

Maternal sensitivity and responsiveness remain significant predictors of attachment security among children in child care (Lamb, 1998; NICHD Early Child Care Network, 1997). We have suggested here that the number of days mothers spent adapting their toddlers to child care reflected, at least in part, their sensitivity to the magnitude of the challenge this transition posed for their children. Secure attachment relationships were maintained or promoted when mothers allowed the children more time to adapt to child care with their mothers present. We also explored whether maternal age, education, or work parameters influenced attachment security over this transition. Although only exploratory in nature, the results suggest that relationships were more likely to remain or become insecure when mothers worked long hours or on unpredictable schedules. Because this was not predicted a priori, replication is necessary, along with analyses that might help us understand the proximal mechanisms mediating this effect.

Several other limitations should be noted. First, as we have noted, there was no comparison group of toddlers who did not enter child care; therefore, we do not know whether baseline cortisol levels or attachment relationships, or both, would have changed over this age period in the absence of child care. The appropriate comparison group would be pairs where the mother and child were randomly assigned to wait longer before child care entry. Naturally, such comparison groups are nearly impossible to construct. Second, maternal sensitivity was not measured directly; therefore, we can only speculate that the number of days spent adapting the toddlers to child care reflected the mothers' sensitivity to their children's needs during this transition. Third, we do not know whether the behavioral and

physiological stress we observed had enduring effects on the children. Particularly when it involves increases in stress hormones, stress is typically considered harmful (Sapolsky, 1996). Elevated cortisol levels have been shown to cause memory deficits, immune-system impairments, lowered thresholds for activation of fear and anxiety neural circuits, and sometimes irreversible damage to neurons in both animals and humans (Borysenko, 1984; Cacioppo, 1994; Lupien & McEwen, 1997; McEwen, Gould, & Sakai, 1992), but there is no evidence, as yet, that small elevations within the ranges observed here have adverse consequences (de Kloet, Oitzl, & Joels, 1999). As a result, we cannot conclude that the stress associated with the transition to child care has either positive or negative effects. Instead, the present data simply indicate that the onset of nonparental care poses a stressful challenge for toddlers, that the security of their attachment relationships before entry does not buffer them from elevated levels of cortisol in response to child care separations, and that levels of behavioral distress constitute a reasonable index of the extent to which securely (but not insecurely) attached toddlers are physiologically stressed.

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