Heart Rate Correlates of Attachment Status in Young Mothers and Their Infants

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ABSTRACT

Objective: To explore heart rate (HR) correlates of attachment behavior in young mothers and their infants to generate specific hypotheses and to provide pilot data on which studies to test those hypotheses might be based. Method: Using the strange situation procedure, patterns of attachment were assessed in 41 low-income adolescent mothers and their infants. During the procedure, the HRs of the infants and mothers were recorded. The HR changes were analyzed and infant attachment group differences were examined. Results: Infants in all attachment groups demonstrated a similar HR response. There were, however, notably different behavioral reactions in the insecure groups: relatively increased behavioral distress in the insecure/resistant infants and relatively decreased behavioral distress in insecure-avoidant infants. Mothers of insecure-resistant infants demonstrated elevated HRs during reunions and the insecure/resistant dyads demonstrated lower consistency between HR changes in infant and mother than the secure dyads. Conclusions: The results suggest the discrepancy between attachment-related behavioral reactions and HR response in insecurely attached infants. Maternal and dyadic HR changes vary between the attachment groups. J. Am. Acad. Child Adolesc. Psychiatry, 2005;44(5):470–476.

Key Words: attachment, heart rate.

Attachment research has shown the extraordinary importance of the quality of infant–mother attachment for infant social-emotional and overall developmental outcome (Main et al., 1985; Suess et al., 1992). For example, children in high social-risk environments who had early insecure attachments are significantly more likely to show symptoms of depression and aggression and poor peer relations than securely attached children (Sroufe, 1990; Urban et al., 1991). On the other hand, securely attached children have been shown to be less dependent, more ego resilient, more socially competent, and more likely to develop friendships (Elicker et al., 1992). Studies also demonstrated links between particular patterns of infant insecure attachment and later psychopathology. Children with early insecure-resistant attachment have been shown to be at higher risk of developing anxiety disorders (Warren et al., 1997). Children with early insecure-avoidant attachment have been shown to be at higher risk of developing aggressive behaviors (Shaw et al., 2001).

Therefore, exploration of different aspects of infant–mother attachment is clinically relevant because it may bring information regarding the vulnerability of the insecurely attached infants to later psychopathology. In particular, the links between attachment and emotional and physiologic regulation may prove to be informative in this regard (Schore, 2001; Sroufe, 1997).

There have been just a few published reports exploring the physiology of infant attachment (Spangler et al., 2002). Most of them involved assessments of infant physiologic reactions during the strange situation (Ainsworth et al., 1978), a well-known attachment assessment procedure, which includes a series of brief infant–mother separations and reunions. The procedure allows classifying infant attachment into secure or insecure; the latter includes insecure-avoidant and insecure-resistant strategies.
Sroufe and Waters (1977) first recorded heart rate (HR) changes in infants during the strange situation. The authors reported that all infants showed increased HRs during separations and that HR recovery during reunions was faster in securely attached infants than in their insecurely attached counterparts. Later, Donovan and Leavitt (1985) reported that securely attached infants in their sample displayed a HR deceleration response to the entrance and approach of the stranger, whereas insecurely attached infants did not.

To date, that study (Donovan and Leavitt, 1985) is the only attachment study that explored simultaneous physiologic reactions in both the infant and the mother. The researchers reported HR changes in 29 infant-mother dyads. The small sample size in the study necessitated merging avoidant and resistant dyads together into the “insecure” group and thus did not allow examination of the utility of HR measurements indistinguishable from the behaviors of avoidant and resistant infants. The authors found that some HR reactions in securely attached infants were consistent with those of their mothers, whereas this pattern was lacking in insecurely attached dyads. Along with the authors’ previous work (Donovan et al., 1978; Donovan and Leavitt, 1978), this study supported their pioneering idea that both maternal physiologic regulation and behavioral responsiveness are important for infant behavioral and physiologic functioning. This notion is in agreement with the psychobiological theory of attachment that emphasizes the roles of the attachment figure’s regulatory input and the dyadic biobehavioral attunement in the development of the offspring’s self-regulatory abilities (Field, 1985; Hofer, 1984; Kramer, 1992).

We proposed to explore further this biobehavioral attunement, i.e., both physiologic and behavioral dimensions of infant–parent attachment interactions. If attachment contributes to the child’s later adjustment via mechanisms of the child’s regulation, which in turn is influenced by maternal regulation, then exploration of infant, maternal, and dyadic physiologic regulation in the attachment context may provide meaningful information relevant in the study of child development and mental health. Specifically, we were interested in infant and maternal HR changes and in the synchrony of the dyadic HR responses during attachment assessment. We chose to use HR responses in our study because HR measurements are noninvasive, they could be recorded synchronously with behavioral observations and could be obtained using portable equipment, and, importantly, HR responses have been shown to relate to childhood psychopathology (Calkins and Dedmon, 2000; Yeragani et al., 2002).

**METHOD**

**Sample**

Low-income adolescent families recruited for the University Teenage Pregnancy and Parenthood Project participated in the study. We chose poor young families because insecure infant–parent attachment has been shown to be more prevalent in this population, possibly due to maternal social and developmental factors (Lyons-Ruth et al., 1990; Ragozin et al., 1982).

The study was conducted at the University in collaboration with community pediatric clinics and agencies working with adolescent mothers. All procedures were approved by the University’s institutional review board. The following inclusion criteria were employed: (1) parental age 20 or younger, (2) low socioeconomic status as defined by public medical insurance or no insurance, (3) no current prescription cardiovascular medications or illicit drug use, (4) children’s age 12–14 months.

The recruitment was conducted from April 1999 to August 2000. Public nurses and social and community workers facilitated recruitment by presenting the study flyers to potential participants. Parents older than 18 years signed the informed consent. For younger parents, guardian’s consent was obtained along with the young parent’s affirmative consent. The meetings were conducted at the University clinic. If necessary, the research team provided transportation to the clinic. As a compensation for the time spent, each family received $30.

Of 48 families approached, 45 agreed to participate. Data on 4 families were excluded due to technical reasons. Demographic characteristics of the families who declined to participate and were excluded were similar to those in the final sample.

Average maternal age in the final sample (N = 41) was 17.8 ± 1.5 years, average maternal education was 10.8 ± 1.5 years, average household income per person per month was $405 ± 237, 27 (65.9%) young women were Hispanic, 13 (31.7%) were African American, and one mother was white (2.4%). Average infant age was 12.5 ± 0.8 months. There were 21 boys and 20 girls.

**Measures**

**Patterns of Attachment.** The quality of infant–parent attachment was assessed by the strange situation (Ainsworth et al., 1978). The procedure includes seven 3-minute episodes in chronological order: (1) the mother and the infant are alone in the room; (2) a stranger enters and interacts with the mother and the infant; (3) the mother exits and the infants stays with the stranger, the first separation; (4) the mother returns and the stranger exits, the first reunion; (5) the mother exits, the infant is alone, the second separation; (6) the stranger returns and stays with the infant; and (7) the mother returns and the stranger exits, the second reunion.

The assessments were videotaped and then scored by two trained coders. Interrater reliability for the patterns of attachment was 92.8% (κ = 0.87). The infants were assigned to three main categories (secure, insecure-avoidant, and insecure-resistant, per Ainsworth et al., 1978). Attachment categories were used as a grouping factor in the analyses.
HR Measures. HR may be influenced by multiple factors (Fox and Card, 1999), including the person’s emotional state (Duffy, 1962), general arousal (Schachter and Singer, 1962), attention/orientation response (Lewis et al., 1970), level of physical activity (Obrist et al., 1970), and initial HR level (Wilder, 1967). In addition to assessing attachment pattern and dyadic HR, we examined three other factors that might potentially affect the participants’ HR change: the initial HR, physical activity, and infant crying. Following suggestions of Fox and Card (1999), we recorded infant and mother HR and physical activity simultaneously to allow for the coding of synchronous portions of behavior and HR. Considering that HR has fast response times, we recorded HR in multiple epochs to allow averaging across epochs and obtaining more stable estimate (Rushton et al., 1983). The participants’ HRs during the strange situation were recorded using the Mini-Logger monitors. Mini-Logger is a portable (120 × 65 × 22 mm) lightweight (125 g) device that stores HR signals every 10 seconds. In the mothers, a waist Polar belt was used to transmit the HR signals to the logger, which the women carried in their pockets. For the use in infants, the logger was modified to allow direct transmission of HR signals from the infant chest to the logger, which was placed into a back packet of an infant vest designed for the study. The loggers were synchronized with a videocamera that allowed assessing HR changes in correspondence with the videotaped behaviors.

Each videotape was reviewed to determine the exact time when separate episodes of the strange situation started and finished. The complete HR record of the dyad was then broken into the HR records of separate episodes. The following five episodes were considered: initial free play with the mother, two separations, and two reunions. For all participants, the following HR measures were derived: (1) mean HR during the first episode (baseline), (2) mean HRs during two separations and two reunions (separation 1, reunion 1, separation 2, reunion 2), and (3) HR changes during separations and reunions compared with baseline (separation 1 minus baseline; reunion 1 minus baseline; separation 2 minus baseline; and reunion 2 minus baseline). Because the initial HR may affect the direction and magnitude of HR response (Wilder, 1967), we used HR changes rather than absolute HR values in the analyses.

Infant Crying. Infant crying during the strange situation was assessed using a slightly modified scoring system (Ainsworth et al., 1978) that allowed assigning a score on a 6-point scale based on the frequency and intensity of crying. An isolated unhappy noise without accompanying crying face was assigned a score of 1; repeated unhappy noises with or without accompanying crying face was 2; an isolated cry or fuss was 3; continuous fuss or a sequence of separate fusses was 4; definite crying when the infant is still responsive to the environment was 5; hard crying or screaming, when the infant is unable to respond to the environment due to severe distress was 6.

Two independent coders (interrater reliability 98.3%) reviewed the videotapes and assigned a score to every 10-second epoch. This allowed the calculation of the mean crying scores for each infant.

Physical Activity. Along with HR measurements, the Mini-Logger device recorded physical activity of the participants. The device, which is sensitive to the body movements, provided a numeric expression of the activity level every 10 seconds. This allowed calculation of the mean physical activity levels for each participant.

Data Analysis

All statistical analyses were done using SPSS version 11.5, with emphasis on descriptive statistics as appropriate to an exploratory or hypothesis-generating study.

RESULTS

Attachment Classification

Of 41 infants, 23 were classified as securely attached, six infants were classified as insecure-avoidant, and 12 infants were classified as insecure-resistant.

Infant and Maternal HR

Individual and dyadic HR changes in the three groups are presented in Figure 1.

We found no major group differences in the infants’ baseline HRs. Likewise, maternal baseline HR did not
differ between the groups. Further, there were no major differences in infant HR changes during separations and reunions in the three groups. Maternal HR changes during separations and reunions, however, showed notable differences in insecure-resistant dyads. In mothers of secure and insecure-avoidant infants, HR change followed separation-reunion cycles: acceleration during separations and deceleration during reunions. HR in mothers of insecure-resistant infants, however, during reunion 1 continued to accelerate (rather than decelerate). During reunion 2, HR in mothers of insecure-resistant infants decreased compared with that during separation 2 but remained substantially higher than in mothers of secure and insecure-avoidant infants and did not return to the baseline.

Consistency of HR Change in the Dyads

For each dyad, we calculated a consistency index. The consistency index of 1 reflects perfect parallelism between infant and maternal HR changes, –1 reflects negative correlation, and 0 means that the association between the HR changes in the dyad is random. The index was calculated using Spearman correlation coefficients of infant and maternal HR changes in each dyad at the five points (baseline, separation 1, reunion 1, separation 2, and reunion 2). Due to the sample size considerations, we included in the analysis only secure \( n = 23 \) and insecure-resistant \( n = 12 \) dyads. The consistency index was higher in secure dyads than in insecure-resistant dyads.

Infant Crying

Figure 2 illustrates the intensity of crying in the three groups. The purpose of presenting this information is to document that, as expected, the insecure-resistant infants cried more than other infants during the entire procedure (including reunions), whereas insecure-avoidant infants demonstrated the least amount of crying.

Infant and Maternal Physical Activity

Figures 3 illustrates infant physical activity and documents that during the first separation, the insecure-avoidant infants exhibited a relatively higher level of physical activity. During the second separation-reunion cycle, infants in the three groups exhibited similar levels of physical activity.

Figure 4 illustrates maternal physical activity and documents that mothers in the three groups exhibited similar levels of physical activity during the procedure.

DISCUSSION

The results suggest that there might be a discrepancy between attachment-related behavioral reactions and HR response in insecure-resistant infants. Explorations of the maternal and dyadic HR changes suggest that the mothers of the insecure-resistant children might have slower HR recovery from stress and that the dyadic
consistency of HR changes in insecure-resistant dyads is lower than that in secure dyads.

Limitations

The purpose of this study was exploratory, i.e., to develop hypotheses and to provide pilot data necessary to the design of strong hypothesis-testing studies. The major impediment to testing hypotheses in this study is that the classification of the infants into groups was based on the same data that are later used to compare the groups. In a future study, the classification of the infants into groups should be done in a manner blind to any data on which the groups are to be compared.

The study’s small sample size is a further impediment to drawing definitive conclusions. To have 80% power to detect pairwise group differences of a moderate size (standardized mean difference of 0.5), one would need 32 subjects per group (70% power, 25 subjects per group). Thus, since the present results suggest that approximately 14% of the infants in this population are insecure-avoidant, researchers would have to screen a large number of infants to have adequate representation of the smallest group. Moreover, as appropriate in an exploratory investigation, in the current study, the groups were compared on many parameters. In future studies, if there were to be multiple nonindependent hypotheses, adjustment would have to be made to avoid proliferation of false-positive results, and, consequently, the sample sizes would have to be even larger.

The multidetermined nature of the HR response makes definite interpretations of HR changes difficult. Besides the initial HR, infant cry, and physical activity, there may be some other factors potentially affecting the HR, such as maternal hormonal status, which we did not assess. In addition, our design limited our ability to assess statistically the contribution of infant cry and dyadic physical activity to HR changes. Furthermore, compared with other HR measures such as interbeat interval and respiratory sinus arrhythmia, our HR recording in 10-second intervals may be not as sensitive. We thought, however, that for obtaining HR means, the precision of the measurements was adequate.

Finally, our sample consisted of only poor young mothers and replication in other demographic groups is necessary to assess whether the results are generalizable.

Clinical and Theoretical Implications

One would expect that insecure-resistant infants, who by definition display a lot of behavioral distress during reunions, would continue to have their HR accelerated during reunions. However, in our sample, we did not find that. In fact, although insecure-resistant infants cried more than other infants during separations and reunions, their HR did not differ from that of other infants and successfully returned to baseline during the second reunion.

This finding, if proved true in future studies, may describe the discrepancy between infant behavioral and physiologic reactions in the insecure-resistant group, i.e., relatively increased behavioral distress without a corresponding increase in physiologic arousal compared with other infants. This is consistent with the theoretical assumption that insecure-resistant infants habitually display excessive behavioral signs of distress as part of the learned relationship strategy (Ainsworth et al., 1978). Infant insecure-resistant attachment strategy supposedly results from unreliable maternal availability and inconsistent responsiveness (Ainsworth and Bell, 1974; DeWolff and van Ijzendoorn, 1997). If behavioral expression of distress, whether “real” or not, leads to maternal efforts to soothe and comfort, then continuous display of distress may be an effective strategy that allows infants to ensure consistent maternal attention.

The discrepancy between infant behavioral and physiologic reactions during the strange situation, although of the opposite pattern, was previously found in another insecurely attached group, insecure-avoidant (Spangler and Grossman, 1993). In that study, the authors showed that insecure-avoidant infants, in spite of minimal apparent behavioral distress during separations, demonstrated a significant increase in HR and cortisol level. Asserting that these physiologic changes indicated distress, the authors concluded that insecure-avoidant infants demonstrated physiologic signs of distress while not revealing the distress behaviorally. The discrepancy between behavioral and physiologic reactions in insecure-avoidant infants is also in agreement with the theoretical proposition regarding the development of the avoidant strategy in infants. This proposition holds that, through previously experiencing their mothers as rejecting and/or
unresponsive to their distress, some infants learned not to display their distress behaviorally and distract themselves with other activities to avoid eliciting potentially negative maternal attention (Ainsworth et al., 1978).

The findings also may have clinical relevance in the exploration of the vulnerability of insecurely attached infants to later psychopathology. For example, in insecure-resistant infants, habitual excessive expressions of behavioral distress, which are not alleviated by maternal comforting efforts, may eventually lead to deficits in infant emotional and physiologic regulation observed in childhood anxiety disorders associated with this pattern of insecure attachment (Warren et al., 1997).

In insecure-avoidant infants, on the other hand, the distress seems to be not “acknowledged” in the mental state and behavior, i.e., behavioral reactions of the distress seem to be habitually inhibited. This might not only lead to impulsive release of the “bottled up” unexpressed negative emotions but also can undermine the child’s ability to recognize distress in other people—the phenomenon seen frequently in childhood aggression that is associated with the development of insecure-resistant attachment in infants. At the same time, previous unsuccessful experience in comforting a difficult-to-soothe infant might render these mothers more anxious during the assessment procedure, which in turn could exacerbate maternal regulatory difficulties. Perhaps, the feeling of being ineffective in providing comfort to the children was itself a stress factor in these mothers.

Maternal regulatory difficulties may be transmitted to the children genetically and thus predispose to anxiety disorders (Rosenbaum et al., 1992; Warren et al., 1999). At the same time, the mothers’ own regulatory difficulties may interfere with the optimal development of the infant inborn regulatory abilities (Sroufe, 1997). Perhaps, at least in some cases, maternal deficient regulatory input may first negatively affect the development of infant self-soothing behaviors, whereas deficits in infant physiologic regulation may follow the learned behavioral patterns.

The study’s explorations of dyadic HR are in agreement with the earlier reports investigating dyadic behavioral and physiologic attunement (Field et al., 1989) and, thus, provide further impetus for the bidirectional approach in the study of infant development and psychopathology (Spinrad and Stifter, 2002). The finding that secure dyads demonstrated more consistency of dyadic HR changes than insecure-resistant dyads may be related to the fact that secure infants and their mothers were engaged in more effective and reciprocal interactions (more attuned) with each other at the times of the infant’s distress than their insecure-resistant counterparts. This attunement was evidenced on the behavioral level and assessed as secure attachment. Consistent with Donovan and Leavitt (1985), our data suggest that the attunement also might exist on the physiologic level.

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