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Maternal Sensory Sensitivity, Mother-Infant 9-Month Interaction, Infant Attachment Status: Predictors of Mother-Toddler Interaction at 24 Months

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Abstract

At 24-months of age, toddlers (*N* = 62) and their mothers were observed in a free-play session to determine the contribution of (a) maternal sensory sensitivity to positive and negative infant facial expressions as measured in a signal detection task at 6 months (b) maternal behavior and affect, infant behavior and affect, and dyadic interaction at 9 months, and (c) infant attachment status at 12 months in predicting maternal, toddler, and dyadic measures at 24 months. Hierarchical regression analyses revealed that over and above early maternal behavior, which was predictive of later maternal behavior at 24 months, sensory sensitivity to the positive infant expression at 6 months predicted maternal behavior at 24 months and sensory sensitivity to both the positive and negative expression was associated with later maternal affect. Infant attachment status emerged as the variable which predicted toddler behavior and dyadic interaction at 24 months.

Keywords

signal detection methodology; maternal sensory sensitivity; mother-infant interaction; infant attachment status; infant facial expressions

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The current study examined mother-toddler interaction patterns during play at 24 months by tracing their development longitudinally with respect to the potential influence of early maternal sensory sensitivity to infants' affective signaling at 6 months, maternal behavior and affect, infant behavior and affect, and dyadic interaction at 9 months, and infant attachment status at 12 months. Interaction between mothers and their infants provides opportunities for infants' socio-emotional learning and reflects the quality of dyadic interaction. Developing synchrony between a mother and her infant affords the infant reciprocal exchanges that facilitate social, emotional, and cognitive growth for the child (see Harrist & Waugh, 2002, for review). Early social play is frequently mentioned as an important relational context offering affective exchanges in the form of face-to-face play and attachment behaviors (Stern, 1995), exchanges which are thought to impact the child's development of self and others (Harel, Oppenheim, Tirosh, & Gini, 1999). Aspects of these earlier social play interactions change as the infant becomes more mobile to include exploration of the environment and manipulation of objects, with exploration of toys in the company of the mother being an important setting

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for the child's continuing development (Ruff & Lawson, 1991;Landry, Smith, Miller-Loncar, & Swank, 1998).

During interaction both infant and mother emit signals designed to capture the other's attention, offering an opportunity for the other to join or sustain the interactive process. For the young infant, affective signals are the primary means whereby he or she engages the mother, and with age, the infant's response repertoire expands. Mothers' differential sensitivity to their infants' signals during play has consequences for children's development. With play offering opportunities for learning, children of more responsive mothers were shown to display more mature play behavior (Bodle, Zhou, Shore, & Dixon, 1996) and were more adept at object exploration (Goldberg & Easterbrooks, 1984) compared with children of mothers who were less responsive to their needs. With mothers' positive affect sometimes conceived of as a component separate from responsiveness during dyadic interaction (Kirsh, Crnic, & Greenberg, 1995;Mahoney, Boyce, Fewell, Spiker, & Wheeden, 1998), mothers' affective state as seen in their mutually positive, enjoyable interactions or the lack thereof has been linked to favorable early developmental outcomes (Kochanska, 1997;Kochanska & Aksan, 1995), including symbolic competence during play (Feldman & Greenbaum, 1997). Thus, in the present study a free-play session was employed to assess the quality of interactive behavior and affective display between mothers and their infants. These behavioral and affective measures were first used at 9 months as predictor variables and again at 24 months as outcome variables.

Children of more sensitive mothers and those in synchronous dyadic interaction patterns have also been shown to be more securely attached, although some researchers have found that this relation is modest at best (e.g., Ainsworth, Blehar, Waters, & Wall, 1978;Crockenberg, 1981;Egeland & Farber, 1984;Fagot, 1997;Kochanska, 1998;Rosen & Rothbaum, 1993;van den Boom, 1994;Volling, McElwain, Notaro, & Herrera, 2002; also see Bakermans-Kranenburg, van IJzendoorn, & Juffer, 2003;De Wolff & van IJzendoorn, 1997 for meta-analytic reviews). Organization or quality of attachment is most frequently examined from the perspective originating with Bowlby (1969) and further standardized by Ainsworth and colleagues with the Strange Situation laboratory procedure (Ainsworth, et al., 1978). With attachment behavior viewed in terms of its balance with exploratory behavior, for the securely attached infant the mother is a source of comfort, generates feelings of security, and provides a secure base from which the infant explores the environment. Infant temperament has been hypothesized as a variable that may explain some of the variation in the organization of attachment, with the degree to which the two constructs over-lap having undergone considerable debate. Kagan (1982) has argued that variation in infants' behavior during the Strange Situation is due to differences in temperament. In contrast, Sroufe (1985) has argued that while temperament must be considered an important contributor to the mother-infant relationship, temperament per se is unimportant in explaining the construct of attachment itself. Others hold a more moderate position (e.g., Belsky & Rovine, 1987;Seifer, Schiller, Sameroff, Resnick, & Riordan, 1996;Stams, Juffer, & van IJzendoorn, 2002;Teti, Nakagawa, Das, & Wirth, 1991;Vaughn et al., 1992), and in a meta-analysis it was concluded that infant temperament variables are associated with attachment status to a similar degree as is maternal sensitivity (Goldsmith & Alansky, 1987). Together, these contentions suggest that temperament may be a confound in studies exploring relations between attachment status and variables of interest.

In addition to delineating the antecedents of infant-mother attachment, research has also focused on the sequelae of attachment security. Compared with insecurely attached infants, securely attached infants were later shown to exhibit greater visual self-recognition (Schneider-Rosen & Cicchetti, 1984), greater compliance to maternal requests (Londerville & Main, 1981;van der Mark, Bakermans-Kranenburg, & van IJzendoorn, 2002), and demonstrated a greater willingness to cooperate with the mother (Grusec & Goodnow, 1994;van IJzendoorn, 1997). In conjunction with an adaptive parenting style, secure attachment was shown to promote children's conscience development (Kochanska, Aksan, Knaack, & Rhines, 2004). During problem-solving, securely attached infants exhibited increased competence (Matas, Arend, & Sroufe, 1978) as well as more positive affect (Ainsworth et al., 1978) compared with insecurely attached infants. They were found to engage in more positive social encounters with peers at 18 months (Easterbrooks & Lamb, 1979), at 24 months (Fagot, 1997), and at 5 years (Youngblade & Belsky, 1992). They also displayed greater social competence in preschool years (Arend, Gove, & Sroufe, 1979), in forming close friendships at 10 years (Freitag, Belsky, Grossmann, Grossmann, & Scheuerer-Englisch (1996), and have been shown to be at reduced risk for later behavioral problems (Tizard & Hodges, 1978;Suess, Grossmann, & Sroufe, 1992). Given its significance in development theory, for the present study attachment status at 12 months was considered a potential predictor of quality of mother-infant interaction during play at 24 months and child temperament was measured as a potential confounding variable in this relation.

Responsive maternal behavior in the context of mothers' daily interactions with their infants, as well as its use in studies on maternal responsiveness, generally refers to a sensitivity that entails both appropriate, timely response and an accurate perception of cues (e.g., Bell & Ainsworth, 1972). In as much as maternal sensitivity during the infancy period holds a central position for emerging reciprocity and children's development, Donovan and colleagues (Donovan, Leavitt, & Walsh, 1997;1998;Donovan, Leavitt, & Taylor, 2005a;2005b) have argued the heuristic value of approaching the topic of maternal sensitivity by better understanding its component parts. We have argued that in those instances when a mother fails to respond or responds inappropriately to her infant's signals, failure may be due either to her inability to detect signal differences at the sensory level or to her decision to delay behavioral response. Facial signals of young infants are often fleeting, subtle, and mothers' ability to recognize facial expressions offers an important channel of communication when infants' behavior or utterances are absent, or unclear (Sullivan & Lewis, 2003). We have employed signal detection methodology to isolate the contribution of sensory sensitivity to infant signals in predicting maternal responsiveness during mother-infant interaction. Signal detection methodology allows an estimation of the degree to which variation in response may be due to differences in signal processing (sensitivity at the sensory level) independent of differences in the response (decision-making) system (Green & Swets, 1966;Macmillan & Creelman, 1991;McNicol, 2005). Sensory sensitivity reflects how well one is able to make correct judgments and avoid incorrect judgments independent of response bias which reflects the favoring of one response (e.g., Yes) over another (e.g., No).

Using signal detection methodology, the number of studies with data attesting to the relation between sensory sensitivity in infancy and maternal measures, including later behavior, is increasing and provides evidence that suggests measuring sensory sensitivity to infant affective stimuli offers a promising means whereby the contribution of sensory sensitivity to responsive parenting may be studied. Mothers with low self-efficacy have been shown to exhibit reduced sensory sensitivity to small changes in infant cries varying in fundamental frequency (Donovan et al., 1997), especially under conditions which manipulated frequency or soothability of a cry designed to mirror experience with a difficult infant (Donovan et al., 2005a). In another study, mothers with low self-efficacy were shown to be least sensitive at the sensory level to infant facial expressions of negative affect; furthermore, greater sensory sensitivity to the negative expression was associated with later behavioral sensitivity in a feeding session, with evidence that variation in infant temperament may be influential in this relation (Donovan et al., 2005b). Less negative maternal affect/behavior during feeding was also associated with greater sensory sensitivity to cries measured earlier (Donovan, Leavitt, & Walsh, 1999). With infant facial expressions depicting negative and positive affect as stimuli, signal detection methodology was again employed in this study to extend our recent focus on maternal sensory sensitivity as a component of responsive behavior that may be useful as a predictor of maternal and infant outcome measures. Hence, sensory sensitivity to infant affective signaling assessed at 6 months was a primary variable of interest in predicting quality of mother-infant interaction during play at 24 months.

In sum, we examined the role of maternal sensory sensitivity to infants' affective signaling at 6 months, behavior and affect of each partner as well as dyadic interaction at 9 months, and attachment status of the infant at 12 months in predicting both the behavior and affect of mothers and their infants as well as the quality of the dyad's interaction during a play session at 24-months. Three specific study goals guided the present investigation and the development of hypotheses. First, we examined the stability of mother, infant, and dyadic measures during play from 9 to 24 months. Given that maternal behavior (e.g., responsiveness, affect, directiveness) has been reported to be moderately stable in infancy and early childhood (e.g., Ainsworth et al., 1978;Bornstein & Tamis-LeMonda, 1990;Feldman, Greenbaum, Mayes, & Erlich, 1997;Rubin, Nelson, Hastings, & Asendorpf, 1999), it was predicted that maternal behavior and affect would be stable across the two time periods. In contrast, research suggests that for the infant, instability is as likely as stability (e.g., de Weerth & van Geert, 2002;Rutter, 1984) for measures such as the infant's early interactive (social responsivity, interest in toys, positive affect; Masur & Turner, 2001) and play (Tamis-LeMonda & Bornstein, 1991) behaviors. Therefore, infant behavior and affect were predicted to be unstable across the two time periods. For the dyad, with the structure and function of positive interaction (e.g., synchrony) changing throughout the course of early development, establishing its stability is more complex; and to date, no one has followed mother-child dyads across time to determine the stability of synchrony as its structure and function change (see Harrist, & Waugh, 2002 for a review). Thus, because one of the partner's measures was predicted to be unstable, dyadic interaction was also predicted to be unstable across the two time periods.

Second, we sought to determine the relative contribution of infant attachment status at 12 months in predicting toddler behavior and affect as well as dyadic interaction during play at 24 months over and above any contribution of the 9-month interaction measures. With toddlerhood being a pivotal period for various developmental milestones including the acquisition of social interaction skills, the present study attempted to expand the data that link infant attachment security to more advanced toddler development, assessed here by more positive behavior and affect during play. Associations between secure attachment and more positive social play interaction for the toddler (e.g., Fagot, 1997) and child (Stams et al., 2002) have been reported. Also, with secure attachment considered a good example of mutually responsive interaction (e.g., Ainsworth et al., 1978), we predicted that for both the toddler and the dyad more positive interaction during play at 24 months would be observed in those dyads with a history of secure attachment compared with those for whom secure attachment was not evident.

Lastly, we sought to determine the unique contribution of mothers' sensory sensitivity to infants' affective signaling at 6 months in the prediction of maternal, toddler, and dyadic measures during play at 24 months over and above any contribution of 9-month interaction measures and 12-month attachment status. Given the growing evidence that sensory sensitivity, particularly in response to negative affective signaling, has been linked to maternal parenting measures (Donovan et al., 1997;1999;Donovan et al., 2005a;2005b), we predicted that greater sensory sensitivity at 6 months would be linked to more positive maternal measures at 24 months. Examining its relation to infant and dyadic measures was exploratory.

Method

Participants

The mother-child dyads in this project were participants in a longitudinal study of maternal response to infant's affective signaling and child development with observations made within one week of infants being 6, 9, 12, and 24 months of age.[1] The initial sample consisted of 70 mothers (age range = 21 to 41 years, *M* = 32.1 years), each with a 6-month-old infant. Recruited through local public birth announcements, mothers were first sent a letter of introduction followed by a phone call requesting their participation in a study assessing mothers' responses to infant signals. All mothers were White, 32 were primiparous; 68 were married, and two were not married to but cohabitated with the infant's father. Sixty-eight were primary caregivers (the remaining two caregivers were the father). All mothers had completed high school, 69 had some college, 56 had completed an undergraduate degree, and 23 had completed a master's level or other advanced degree. Thirty-eight mothers worked outside the home an average of 30 hours per week; median family income was $65,000 (range = $10,000 to over $80,000). All infants were typically developing, none was diagnosed with a high-risk condition; 30 were male and 40 were female.

At the time of the final session at 24 months, eight families had moved away or were faced with unexpected circumstances that interfered with their ability to continue participation in the study; thus, 26 male and 36 female infants and their mothers comprised the final study sample. Since the first visit, seven mothers had given birth to another child and five were pregnant. At 24 months, four mothers were not the primary care giver; one mother had been separated from and no longer lived with the child's father. Forty-two mothers worked outside the home an average of 30 hours per week.

General Procedure

When their infants were 6 months of age, mothers completed demographic information and the Infant Temperament Questionnaire (ITQ) and then participated in a signal detection task that assessed their sensory sensitivity to positive and negative infant facial expressions. The signal detection task was conducted in a small sound-attenuated chamber with only the mother present. For the 9-, 12-, and 24-month sessions, observations were conducted in a large sound-attenuated chamber furnished in a naturalistic fashion with both mother and infant present. At 9 months, mothers returned with their infant to be observed in a free-play session from which quality of maternal, infant, and dyadic interaction was assessed. At 12 months, infant attachment status was assessed using the Strange Situation laboratory procedure. At 24 months, mothers returned with their toddlers for a second free-play session from which quality of maternal, toddler, and dyadic interaction measures was assessed as outcome variables. At this 24-month play session, the Early Childhood Behavior Questionnaire (ECBQ) was completed by each mother.

Demographic and Questionnaire Instruments

Demographic information—Demographic information included child sex, parity, mother's age, educational level, household income, marital and employment status, as well as the number of hours worked per week.

Infant Temperament Questionnaire (ITQ)—Mothers rated the frequency of specific infant behaviors on a 1 (*almost never*) to 6 (*almost always*) Likert-type scale, with higher scores indicating greater infant difficulty. A test-retest reliability of .84 over a 2-week period and a

[1]Additional data were collected during each of these sessions; however, none of the data reported here has been reported elsewhere.

validity correlation of .52 with mothers' general evaluations of their infants' difficulty has been reported (Carey & McDevitt, 1978). Scores on five of the sub-scales (i.e., rhythmicity, approachability, adaptability, mood, and intensity) comprised the ITQ difficulty score. In the present sample, Cronbach's alpha = .61.

Early Childhood Behavior Questionnaire (ECBQ)—The ECBQ includes 18 scales designed to capture temperament in toddlers between 18 and 36 months of age. Adequate alpha coefficients were reported on each of the ECBQ sub-scales, ranging from .60 - .89 for 24-month-old toddlers. From these scales, three factors (negative affectivity, surgency/extroversion, and effortful control) were derived (Putnam, Garstein, & Rothbart, in press). This questionnaire has been described by Putnam and colleagues as predominantly “downward extensions” of the dimensions contained in the Children's Behavior Questionnaire (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001) and “upward extensions” of the dimensions from the Infant Behavior Questionnaire (IBQ; Garstein & Rothbart, 2003). For the purposes of the present investigation, five sub-scales loading on the factor of *negative affectivity* were measured: discomfort, sadness, fear, shyness, and soothability, yielding a Chronbach's alpha of .50. Sub-scales were averaged to yield a composite ECBQ negative affectivity score for analyses.

Maternal Sensory Sensitivity at 6 Months

Mothers' sensory sensitivity to positive and negative infant facial expressions was measured in a signal detection task. Specifically, mothers' ability to differentiate between pairs of a given infant facial expression which differed slightly along a continuum of morphed pictures varying in expression intensity was assessed.

Stimulus construction—Stimulus construction of four stimulus sets (positive and negative expressions for a male and female infant) involved three steps. First, photo-quality digital pictures were taken of two 6-month old infants, one male and one female, displaying both positive and negative facial expressions. These expressions, broadly defined as positive and negative, incorporated features common to the universally recognized facial expressions of happiness/joy and sadness/anger/distress, respectively, which for the respective expressions are thought to commonly blend in the natural environment (Camras, 1992;Matias & Cohn, 1993;Sullivan & Lewis, 2003). Precautions were taken to ensure gender-neutrality by having infants wear white shirts with no accessories.

Second, for each stimulus set two images were selected which were similar in facial orientation but differed in intensity of expression. For the positive expression, cheek raising, eye constriction, and mouth opening varied, and for the negative expression, furrowed brow, lip stretching, and eye constriction varied. Adobe Photoshop 5.0 was then used to create two images which would vary slightly in intensity but be identical except for the defining features of a given facial expression (e.g., mouth, eyes, and cheeks). This was accomplished by the background (e.g., background cloth, ears, neck and torso) of one of two images serving as the common background for both. Thus, one image remained unaltered while its corresponding pair had its defining facial features (e.g., mouth, eyes, and cheeks) pasted onto the common background. Background flaws were removed and luminance adjusted to appear equivalent across images.

Third, WinMorph 2.0 was used to morph images (i.e., to produce a linear continuum of images between the two endpoints). Control points selected on each image identified for WinMorph those portions of the stimuli (area of pixels) that were to be morphed, the most important of which were the defining features of the facial expression. A critical aspect of this procedure is that precise features anchored by control points are morphed by an equal percentage of the total distance between their initial and final positions to create interpolated images on a continuum that are equidistant from one another. Seven equidistant images with changes appearing gradual, smooth, and natural-looking were used for each stimulus set (see Appendix I). The image with the least intense expression for each stimulus set served as the standard stimulus and the remaining six morphed images were the variants for that expression.

Equivalency of task difficulty between the four stimulus sets (positive and negative expressions for the male and female infant) was established through pilot work. With mothers of 6-month-old infants serving as participants and following signal detection methodology, seven equidistant images were selected for each stimulus set. The equidistant images selected for each set met the criterion that the final variant could be discriminated 100 % of the time, the variant at which the pair (standard and variant) could be discriminated 75% of the time was the same for all sets, and that level of difficulty in differentiating the first variant from the standard was at chance level. Pilot work also confirmed that the stimuli were gender-neutral; mothers' forced-choice responses of male or female were approximately evenly distributed for each set.

Procedure—Each mother viewed two of the four stimulus sets (positive and negative expression of a single infant) and on a given trial was asked to discriminate between two stimuli, the standard infant facial expression and one of its six variants, by responding whether the two were the same or different. Whether the mother viewed the male or female infant and the presentation order of the positive and negative expressions was determined by random assignment. Images were presented on a 21" color monitor with a pixel setting of 1280 × 1024 and were positioned at eye level in front of the mother. Diameter of the infant head measured 6 inches horizontally across the eyes for all stimuli. Stimulus control and presentation was implemented using the E-Prime 1.0 Suite with images programmed to appear in slightly different horizontal positions so that on a given trial the standard and variant were not in the same position. The response apparatus consisted of a small box with two spring-loaded buttons mounted across the top and labeled DIFFERENT or SAME. The same computer which controlled the stimulus presentation recorded the mothers' responses.

Instructions were presented on the monitor as well as read aloud by the experimenter. Each stimulus set consisted of 160 trials. For each trial, a blue screen was presented for 4 s, followed by the 3-s standard image, a 2-s black pause screen, and the 3-s test image. The test image for each trial was either the same as the standard image or a different expression variant. The variant selected for each trial's test image was determined at random with the restriction that all variants be presented an equal number of times; the standard image was presented with twice the frequency of any individual variant. Within each trial, presentation of the two images (standard and variant) was followed by an ITI of 4 s (i.e., the blue screen) during which the mother gave her response and prepared for the next presentation. The mother was instructed to indicate whether she thought the test image was the same or a different image from the standard by pressing the appropriate button. Mothers completed five practice trials per stimulus set to familiarize them with the task difficulty; only on these practice trials were they told whether they were correct.

Data reduction – sensory sensitivity—For each mother, a sensitivity score was calculated for each of the two stimulus sets observed. Following signal detection methodology, four conditional probabilities were generated from the *same* and *different* responses, two of which are necessary for calculating sensory sensitivity: (1) probability of responding with *different* given *stimulus variant* [P(D/d) or Hits], and (2) probability of responding with *different* given *same variant* [P(D/s) or False Alarms]. Because a higher hit rate can only be gained at the expense of a larger number of false alarms, sensitivity (hits relative to false alarms) remains constant and is measured independently of response bias. To calculate the sensitivity score for each set, a Receiver Operating Characteristic (ROC) curve with P(D/s) on the ordinate and P(D/d) on the abscissa was plotted for each stimulus variant. The proportion of the area beneath the ROC curve, P(A), defined sensitivity for that particular stimulus variant. To obtain the sensitivity threshold for a particular mother from these six P(A)s, the sensitivity P(A) for each variant was plotted against the change level, that is, the equidistant points of the morphed continuum (see Figure 1). A logistic psychometric function was then fitted to these data with the sensitivity threshold for a particular mother defined as the equidistant point where P(A) = 75% intercepted the fitted function (Allen & Wightman, 1994). Lower threshold values indicate greater sensitivity.

Mother-Infant Interaction at 9 Months

Mother-infant dyads were videotaped in a 10-minute free-play session. Mothers were instructed to sit on a large play mat and play with their infants as they would at home. A bin of standard toys appropriate for 9-month-old infants (e.g., ball, rattle, plastic rings, and car) was provided. Interactions were videotaped by means of a split-screen technique; two small, inconspicuous cameras were attached on adjacent walls and positioned to optimize viewing the interaction. A microphone was attached to the ceiling and an adjoining observational room held the recording equipment.

Using the Parent-Child Early Relational Assessment (ERA; Clark, 1985), the videotapes of the free-play session at 9 months were coded for quality of maternal, infant, and dyadic interaction exhibited over the entire 10-minute period. The ERA has been used in several studies examining the mother-child relationship (e.g., Burns, Chethik, Burns, & Clark, 1997;Harel & Scher, 2003;Hess, Teti, & Hussey-Gardner, 2004;Teti, et al., 1991). Clark devised the instrument to assess behavioral and affective characteristics of mothers and children in a variety of interaction settings including free-play. A free-play session allows for the assessment of the mother's capacity to be playful with and enjoy her child, to follow the child's interest, and to facilitate the child's capacity for exploratory play; additionally, the dyads capacity for social interaction, mutuality, and reciprocity can be observed (Clark, 1999). Items on the ERA reflect the quality and amount of behaviors present during interaction and were rated on a 1 to 5, Likert-type scale with anchor labels specific to each item; scores on the low end of the scale designate clinical concern and those on the high end designate a strong display of positive affect and behavior or denote the absence of negativity (e.g., 5 = no anger).

Item selection from the ERA for coding at 9 months was based upon the present study's conceptual focus and the criterion that items were expected to capture differences in mother-infant play behavior in infancy. Five variables for analyses were created from this subset of maternal, infant, and dyadic items. They were *maternal behavior, maternal affect, infant behavior, infant affect, and dyadic interaction*. Mothers' behavior was coded using seven items which reflected the quality of responsiveness (i.e., appropriate and sensitivity responding to infant cues, consistency/predictability, amount of verbalization, structures and mediates environment, connectedness/attunement, quality and amount of negative physical contact, and intrusiveness). Maternal consistency/predictability did not yield variability in the sample at 9 months and was therefore omitted from this 9-month measure. The remaining six items yielded a Chronbach's alpha of .61 and were averaged to yield a composite maternal behavior score. Both positive and negative maternal affect were coded; however, negative affect did not yield variability at 9 months. Thus, the single item of positive affect was used for the 9-month maternal affect measure. Infant behavior was scored using the exploratory play item which at 9 months reflects an infant's interest in manipulating the environment, mouthing objects, and finger play. Both positive and negative infant affect were coded, but like maternal negative affect, infant negative affect at 9 months did not yield variability. Therefore, the single item of positive affect was used for the 9-month infant affect measure. Quality of dyadic interaction was coded using three items (i.e., flat/empty, joint attention/activity, and reciprocity). The three dyadic items yielded a Cronbach's alpha of .50; items were averaged to yield a composite dyadic interaction score. Two trained coders, blind to participants' performance on other study measures, rated the tapes after establishing inter-rater reliability for the combined scales on a randomly selected 20 % of the sample. Agreement between the two raters was 99 % within one scale point and exact agreement was 86 %.

Infant Attachment Status at 12 Months

Infant attachment status was assessed using the standardized Strange Situation laboratory procedure (Ainsworth et al., 1978). This classic procedure assesses attachment status by observing the infant's tendency to explore when stress is minimal, the response when stress becomes greater as with a stranger's entrance and being left alone, and finally, the response as he or she is reunited with the mother after separation. On the basis of the infants' exploratory behavior, orientation to the stranger, and their behavior upon reunion with the mother, infant-mother relationships are classified into types of attachment, with the three secure-insecure types containing subcategories. Briefly, the securely attached infant (B) uses the mother as a secure base from which to explore, and if visibly upset when separated from the mother, greets her positively upon reunion. The insecure-avoidant infant (A) explores without sharing with the mother, may show more positive interactions with the stranger than with the mother, and ignores or fails to greet the mother early in the reunion episode. The insecure-resistant/ambivalent infant (C) is wary of the unfamiliar, shows little exploration, is very likely to cry during separation, and is unable to be comforted during reunion because of anger or resistance to contact. The disorganized infant (D) does not resort to a single, organized attachment pattern, and instead becomes disoriented in the face of threat or stress. The video-recording equipment was identical to that used in the free-play session at 9 months.

Two coders, blind to mother/child performance on other study measures, were trained by the senior author. Each tape was viewed by both coders to ensure that each coder would rate those tapes containing the relatively uncommon A1, A2, C1, C2, B4, and D subcategories. Agreement between the two coders was 91 % for the A, B, C categories, and was 83 % for the subcategories. For those cases in which disagreements occurred, a final classification was made in conference between the two coders and the first author. At 12 months, 70 % of the infants were classified as securely attached, 12 % as insecure- avoidant, and 18 % as insecure-resistant. Of the 62 infants who returned for the 24-month play session and comprised the data base for the current report, 68 % were classified as securely attached (B1, n = 8; B2, n = 13; B3, n = 20; B4, n = 1), 13 % were classified as insecure-avoidant (A1, n = 4, A2, n = 4) and 19 % were classified as insecure-resistant (C1, n = 9; C2, n = 3). None was classified as disorganized.

To gain statistical power for regression analyses, we employed a continuous variable of attachment status that has been recommended and used by others (see Main, Kaplan, & Cassidy, 1985;Stams, et al., 2002;van der Mark, et al., 2002;van IJzendoorn, Sagi, & Lambermon, 1992). Specifically, the B3 classification received the highest score of 5, followed by B1 and B2 that received a 4. The B4 classification received a 3, and the A2 and C1 classifications received a 2. The A1 and C2 classifications received the lowest score of 1.

Mother-Toddler Interaction at 24 Months

A second 10-minute free-play session was conducted at 24 months. The procedure for this session was identical to that reported for the 9-month session with two exceptions. First, the bin of toys provided for each dyad contained standard toys appropriate for 24-month-old infants (e.g., ball, doctor kit, and musical instruments). Second, the items selected from the ERA for coding were expanded from those measured at the 9-month play session to include behaviors expected to yield variation in 24-month-olds and, in doing so, measured the richer content of

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mother-child play behaviors possible at this stage of development. Maternal affect was expanded to five items by adding anger, criticism/disapproval, and enjoyment/pleasure (Chronbach's alpha = .70). Maternal behavior was expanded to 10 items by adding amount and quality of visual contact, quality of verbalization, and flexibility/rigidity (Chronbach's alpha = .87). Infant affect was expanded to four items by adding happy/pleasant mood and irritable/angry mood (Chronbach's alpha = .74). Infant behavior was expanded to four items by adding social behavior/child initiating, social behavior/child responding, and avoiding/averting (Chronbach's alpha = .82). Finally, dyadic interaction was expanded to four items by adding mutual enjoyment/enthusiasm (Chronbach's alpha = .89). Two trained coders, blind to participants' performance on other study measures, rated tapes after establishing inter-rater reliability for the combined scales on a random 20 % of the sample. Agreement between the two raters was 99 % within one scale point and exact agreement was 86 %.

Results

Overview of Analyses

First, descriptive statistics were calculated for the main study variables. Second, preliminary analyses were conducted to determine whether any demographic variables should be entered as covariates in the analyses testing the hypotheses. Then, correlations between all independent variables and maternal, toddler, and dyadic interaction measures during play at 24 months were determined. Finally, the main analyses included a series of hierarchical multiple regression analyses conducted to test the relative contribution of (a) maternal sensory sensitivity to positive and negative infant facial expressions at 6 months (b) maternal behavior and affect, infant behavior and affect, and dyadic interaction at 9 months and (c) infant attachment status at 12 months in predicting maternal behavior and affect, toddler behavior and affect, and dyadic interaction during play at 24 months.

Preliminary Analyses

Table 1 shows descriptive statistics for the main study variables at each session. Spearman's rho correlations and Univariate Analyses of Variance (ANOVAs) were conducted to determine whether maternal income, education, employment and marital status, number of hours worked, child sex and parity were related to any of the main study variables. Except for child sex, none of these variables related to the main study variables, *p*s > .10. Child sex was significantly related to dyadic interaction at both 9 months, $F(1, 66) = 7.97$, $p < .01$, $\eta_p^2 = .11$, and 24 months, $F(1, 60) = 5.14$, $p < .03$, $\eta_p^2 = .08$. At 9 months, mother-girl dyads ($M = 4.33$, $SD = .56$) showed more positive dyadic interaction than mother-boy dyads ($M = 3.96$, $SD = .45$) and similarly at 24 months, dyadic interaction was more positive for mother-girl dyads ($M = 4.70$, $SD = .22$) compared with mother-boy dyads ($M = 4.54$, $SD = .45$).

Also shown in Table 1 are the Spearman's rho correlations between the main predictor variables and the outcome measures at 24 months. More securely attached behavior at 12 months was associated with more positive toddler behavior at 24 months, more positive maternal play behavior at 9 months was associated with more positive maternal behavior and dyadic interaction at 24 months, and more positive dyadic interaction at 9 months was related to more positive infant affect at 24 months.

Predictors of Maternal, Toddler, and Dyadic Interaction during Play at 24 Months

A hierarchical multiple regression analysis was performed on each of the five outcome measures: maternal behavior, maternal affect, toddler behavior, toddler affect, and dyadic interaction. Because past research has shown that the infant temperament variable is associated with infant attachment status (Goldsmith & Alansky, 1987), dyadic synchrony (Vizziello, Ferrero, & Musicco, 2000), and with maternal behavioral sensitivity (e.g., Crockenberg &

McClusky, 1986;Mangelsdorf, Gunnar, Kestenbaum, Lang, & Andreas, 1990) and sensory sensitivity (Donovan et al., 2005a;2005b), the temperament measures, ITQ and ECBQ, were initially entered as control variables in Step 1 of each regression analysis. The entry of the ECBQ measure was found to improve the significance of all the predictor variables, including sensory sensitivity for which its entry was necessary to obtain significance. In contrast, all regression analyses were fundamentally identical with and without ITQ as a control variable; therefore, ITQ was not entered in the final regression analyses reported in Table 2. Nor was sex of infant reported in final regression analyses because findings were fundamentally identical when this variable was entered as a control variable in Step 1. With the expectation that the antecedent 9-month play measures would be the largest contributor and because our goal was to determine the contribution of attachment status above and beyond the interaction measures, the 9-month variables were entered in Step 2 and the 12-month infant attachment variable was entered in Step 3. Analyses remained unchanged when order of entry for the 9- and 12-month variables was reversed. Lastly, entry of maternal sensory sensitivity in Step 4 was based on our interest in isolating the unique contribution of sensory sensitivity in predicting variance in the mother, toddler, and dyadic measures at 24 months above and beyond that of the other predictor variables.

Predictors of maternal behavior and affect—The data presented in Table 2 indicated that antecedent maternal behavior in the play session at 9 months was a significant predictor of maternal behavior at 24 months, indicating stability in quality of maternal behavior observed during play from 9 to 24 months. Of particular interest, maternal sensory sensitivity to the positive infant expression at 6 added to the prediction of maternal behavior over and above the contribution of maternal behavior at 9 months, with greater sensory sensitivity to the positive expression being associated with more positive maternal behavior at 24 months. Sensory sensitivity accounted for an additional 10 % of the variance. In predicting maternal affect at 24 months, sensory sensitivity to both the positive and negative expressions at 6 months predicted maternal affect at 24 months, again with greater sensory sensitivity to infant affective signaling being associated with more positive maternal affect. Sensory sensitivity accounted for an additional 13 % of the variance. Mothers' earlier affect was not predictive of later affect.

Predictors of toddler behavior and affect and dyadic interaction—Also shown in Table 2, while early infant behavior and affect were not predictive of those later same measures, infant attachment status contributed in predicting toddler behavior, with more securely attached infants displaying more positive play behavior at 24 months. Attachment status accounted for an additional 11 % of the variance in predicting toddler behavior. Although attachment status predicted toddler behavior, it did not predict toddler affect at 24 months. Infant attachment status also contributed in the prediction of dyadic interaction, with more securely attached infants being associated with greater quality of dyadic interaction during play. The additional variance accounted for by attachment status was 6 %; that not more variance was accounted for is perhaps due to an apparent contribution of maternal behavior at 9 months in predicting later dyadic interaction (although Step 2 was not statistically significant). Dyadic interaction at 9 months was not predictive of later dyadic interaction. The 6-month measures of maternal sensory sensitivity did not predict any of the infant or dyadic measures at 24-months.

Discussion

By the end of the second year of life, primarily through reciprocal exchanges with the caregiver, a toddler has acquired to varying degrees the acquisition of skills and abilities requisite for the attainment of several developmental milestones including self-regulatory behavior (Sroufe, 1996), the establishment of a secure bond with the caregiver (e.g., Ainsworth, et al., 1978), the emergence of an independent identity (Cicchetti, Ganiban, & Barnett, 1991), and the development of behavioral control (Kopp, 1982) and compliance (e.g., Crockenberg & Litman, 1990). Thus, by 24 months, observation of mother-infant interactive behavior provides a means whereby we can assess the behavioral and affective maturity of the toddler as well as the quality of dyadic interaction. As such, the current study assessed the contributions of early maternal sensory sensitivity to infant affective signaling at 6 months, quality of mother, infant, and dyadic interaction at 9 months, and infant attachment status at 12 months in predicting quality of mother, toddler, and dyadic interaction during a free-play session when toddlers were 24 months of age.

Predictors of Maternal Behavior and Affect at 24 Months

In the prediction of maternal behavior and affect during play at 24 months, antecedent maternal behavior in a similar play session at 9 months emerged as a significant contributor, thus supporting the first hypothesis that quality of maternal behavior was stable across the two play sessions; contrary to prediction, maternal affect at 9 months was not predictive of affect at 24 months. Supporting the third hypothesis, maternal sensory sensitivity to infant affective signaling at 6 months predicted both the mothers' behavior and affect at 24 months beyond any contribution made by 9-month maternal behavior. More specifically, greater sensory sensitivity to the positive expression was associated with more positive maternal behavior at 24 months, whereas greater sensory sensitivity to both the positive and negative expression was associated with more positive maternal affect at 24 months.

The sensory sensitivity data demonstrated that mothers' early sensory sensitivity to infant affective signaling continues to exert its influence on both mothers' behavior and affective state as toddlers reach the second year of life. However, these data, together with data from earlier studies, offer evidence that lead us to speculate that maternal sensory sensitivity to positive versus negative affective signaling may be differentially useful in predicting later maternal outcomes. Studies have begun to establish a relation between early sensory sensitivity to negative infant signaling and later maternal affect and behavioral sensitivity during a feeding session at 9 months (Donovan et al., 1999), with some evidence that infant temperament plays a role in that relation (Donovan et al., 2005b). In contrast, in the present study, it was sensory sensitivity to the positive signal, not the negative, which predicted maternal behavior at 24 months. Thus, whereas sensory sensitivity to the negative signal again predicted maternal affect at 24 months, supporting its reliability as a predictor, sensory sensitivity to the positive signal emerged not only as predictive of affect but also as predictive of behavior. One interpretation of this shift in relative influence is that maternal sensory sensitivity to negative affective signaling (e.g., early infant crying) may have its greatest impact during early infancy with its influence on maternal behavior waning as the impact of sensitivity to expressions of positive affect increases. Sensory sensitivity to the positive affective signaling (even though measured at 6 months) may emerge as influencing maternal behavior at 24 months because responsiveness to positive signals in general, at least during social interactions in play-like contexts, may increase in importance as the child grows.

Together, these data inform our understanding of maternal responsiveness by demonstrating that early sensory sensitivity to infant affective signaling can be measured as a component of responsiveness independently of the decision-making system. Affective signaling is a compelling type of communication that infants use to engage their caregivers, with positive expressions communicating the pleasurable engagement necessary for normative infant development and negative expressions communicating unpleasant experiences and the need for help from the caregiver (Bolzani-Dinehart et al., 2005). If mothers are unable to recognize and interpret their infants' emotional signaling (e.g., lower sensory sensitivity) they may be less certain about their infant's needs and less able to share positive affect; consequently, they may become less expressive themselves, further degrading the quality of interaction (Dawson, Hill, Spencer, Galpert, & Watson, 1990). Moreover, with the demonstration that mothers exhibiting greater sensory sensitivity were, in fact, more behaviorally attuned at a later time to their infants' behavior and were more positive in their affective display during those interactions, we have elucidated the predictive validity, hence significance, of the signal processing component, sensory sensitivity, for general maternal responsiveness during interaction.

Predictors of Toddler Behavior and Dyadic Interaction at 24 Months

Compared to the prediction of maternal behavior and affect at 24 months, a different picture emerged from the models predicting the toddler and dyadic measures. Supporting the second hypothesis, both toddler behavior (but not affect) and dyadic interaction at 24 months were predicted by the 12-month attachment status of the infant. As predicted in the first hypothesis, neither of the 9-month infant measures contributed in the prediction of toddler behavior and affect at 24 months, which is in contrast to the stability of mothers' behavior across the two play sessions. This finding is consistent with those that report instability in infants' early interactive behaviors is as likely as stability (de Weerth & van Geert, 2002;Masur & Turner, 2001;Rutter, 1984;Tamis-LeMonda & Bornstein, 1991). Similarly, as predicted, 9-month dyadic interaction did not predict later dyadic interaction at 24 months.

The finding that 12-month infant attachment status predicted both toddler behavior and dyadic interaction at 24 months is consistent with data that link infant attachment security to more positive social play interaction for the toddler (e.g., Fagot, 1997) and child (Stams et al., 2002). In interpreting our finding, we turned to the seminal work of Bowlby (1969) and Ainsworth (Ainsworth et al., 1978) where organization of attachment in the mother-infant relationship is recognized as a critical indicator of the overall quality of the relationship. Confident of their caregiver's availability, the secure child is relaxed and shows enjoyment during interaction with the mother (e.g., Thompson, 1998). With attachment being a developmental task of the infancy period, the sequelae of different infant attachment patterns for later toddler behavior and dyadic interaction reflect not only the more or less successful resolution of this earlier task but also the toddler's maturity level and acquisition of wider adaptive goals. That attachment status emerged as the variable best predicting the 24-month toddler and dyadic measures rather than the 9-month infant or dyad measures agrees with the proposition that partners are not static as they interact. Because of the transactional nature of the mother-infant relationship (e.g., Sameroff, 1975) both the infant and the dyad undergo reorganization. It has been proposed that reciprocity reflects a reorganization in that it involves a step in which interactive positive behaviors require an interpretation of interactions with the mother (i.e., working model) by the child (Fagot, 1997). In the present study, for both the infant and the dyad, infant attachment status was a measure of that reorganization.

Implications, Limitations and Suggestions for Future Research

Findings from the present study have implications for research methodology. Signal detection methodology allowed us to measure sensory sensitivity (i.e., how well one is able to make correct judgments and avoid incorrect ones) independently of the decision-making process (i.e., response bias or the extent to which one favors one response choice over another). By providing a means whereby the unique contribution of maternal sensory sensitivity to maternal responsiveness can be studied, we were able to test our proposition that knowledge about mothers' signal processing ability (i.e., sensitivity at the sensory level) is a critical component in understanding and predicting maternal responsiveness. This may be particularly relevant for dyads with interaction patterns that place infants at risk for poor developmental outcome. Information about which component, sensory sensitivity or the response system, contributes to decreased maternal behavioral responsiveness is important as intervention strategies are implemented to facilitate maternal responsiveness. To the degree that mothers' signal processing is linked to reduced responsiveness, resources can then be directed toward interventions aimed at enhancing mothers' attention to nuances in infant signaling. In addition, having demonstrated that sensory sensitivity to infant affective signals (broadly defined as positive and negative) predicted later maternal behavior, further research is needed to determine whether differences in sensory sensitivity to specific signals (e.g., sadness versus anger) exist, and if so, whether these differences are important for maternal responsiveness and child outcomes.

The study is not without limitations. A larger sample size would have allowed for the use of additional, informative statistical approaches, such as path analysis, permitting an investigation of the complex inter-relations among the current study variables and allowing a best-fit model to be derived. As such, the present data can be viewed as a preliminary step toward this goal. Our sample consisted of married, White, middle class women who, on average, together with their infants displayed quite positive interaction during play at 24 months; hence generalizability to other populations is limited until verified. Caution must be also be exercised given the cultural specificity in individual maternal and infant behaviors during dyadic exchanges (e.g., Bornstein, Haynes, Pascual, Painter, & Galperin, 1999) and the range of cultural influences on the attachment process (e.g., Grossmann, Grossmann, Spangler, Suess, & Unzner, 1985;Kazui, Endo, Tanaka, Sakagami, & Suganuma, 2000). Furthermore, because observations in this study were made in only one context, mother-infant play, research is needed to determine the generalizability of these finding to contexts other than play. Missing also is information relative to the father-infant and father-mother dyad, and thus whether variation in either of these relationships might impact aspects of the mother-infant relationship reported here is not known.

Conclusions

Despite these limitations, two major contributions of the present study further our understanding of different patterns of interaction between mothers and toddlers. First, we demonstrated that early maternal sensory sensitivity to infant affective signaling contributed in the prediction of maternal behavior and affect at 24 months over and above the contribution of maternal behavior observed during play at 9 months. This finding informs our understanding of maternal responsiveness by demonstrating that early sensory sensitivity can be measured as a component of responsiveness independently of the decision-making system and that it has predictive validity for later maternal responsiveness – both behavior and affect. Second, our findings emphasize the importance of the quality of the mother-infant relationship, reflected here in infant attachment status, as being critical in shaping later toddler behavior and quality of dyadic interaction. With the mother-infant relationship being transactional in nature, infant attachment status, which reflects a reorganization of both infant and dyad, emerged as the variable which predicted the 24-month measures of toddler behavior and dyadic interaction.

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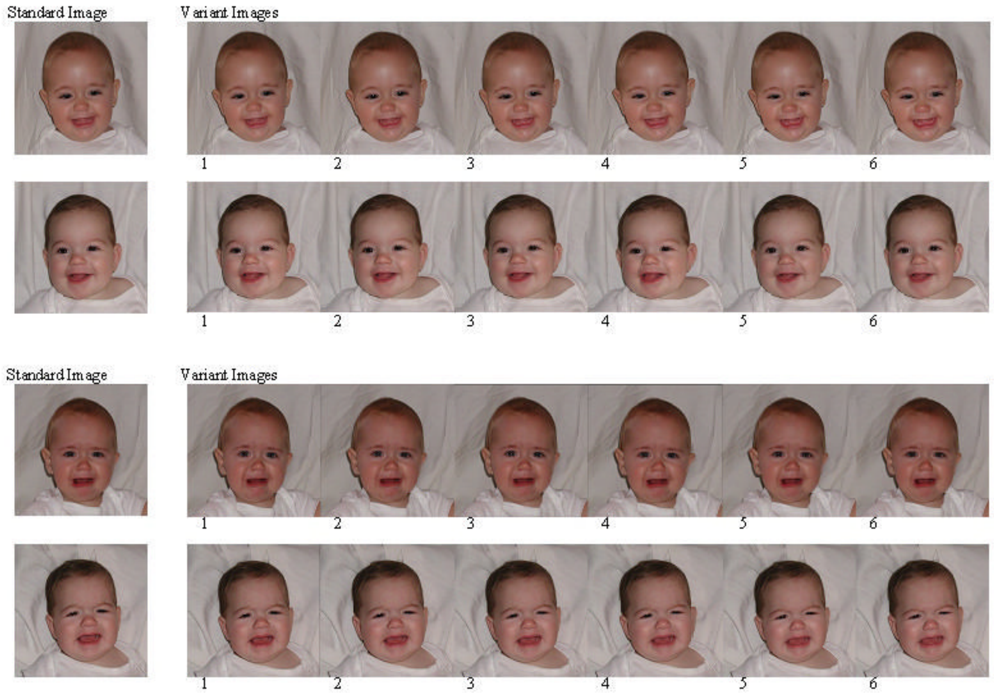
Appendix: Expression Stimuli for the Signal Detection Task



Positive and Negative Expression Stimuli for the Signal Detection Task

References

Ainsworth, MDS.; Blehar, MC.; Waters, E.; Wall, S. Patterns of attachment: A psychological study of the strange situation. Hillsdale, NJ: Erlbaum; 1978.

Allen P, Wightman F. Psychometric functions for children's detection of tones in noise. Journal of Speech and Hearing Research 1994;37:205–215. [PubMed: 8170124]

Arend R, Gove RL, Sroufe LA. Continuity of individual adaptation from infancy to kindergarten: A predictive study of ego-resiliency and curiosity in preschoolers. Child Development 1979;50:950–959. [PubMed: 535446]

Bakermans-Kranenburg MJ, van IJzendoorn MH, Juffer F. Less is more: Meta-analyses of sensitivity and attachment interventions in early childhood. Psychological Bulletin 2003;129:195–215. [PubMed: 12696839]

Bell SM, Ainsworth MD. Infant crying and maternal responsiveness. Child Development 1972;43:1171–1190. [PubMed: 4643768]

Belsky J, Rovine M. Temperament and attachment security in the Strange Situation: An empirical rapprochement. Child Development 1987;58:787–795. [PubMed: 3608649]

Bodle JH, Zhou LY, Shore CM, Dixon WE Jr. Transfer of responsibility in parent-child play during the second year. Early Development and Parenting 1996;5:185–194.

Bolzani-Dinehart LH, Messinger DS, Acosta SI, Cassel T, Ambadar Z, Cohn J. Adult perceptions of positive and negative infant emotional expressions. Infancy 2005;8:279–303.

Bornstein MH, Haynes OM, Pascual L, Painter KM, Galperin C. Play in two societies: Pervasiveness of process, specificity of structure. Child Development 1999;70:317–331. [PubMed: 10218257]

Bornstein MH, Tamis-LeMonda CS. Activities and interactions of mothers and their firstborn infants in the first six months of life: Covariation, stability, continuity, correspondence, and prediction. Child Development 1990;61:1206–1217. [PubMed: 2209190]

Bowlby, J. Attachment and loss: Vol 1. Attachment. New York: Basic Books; 1969.

Burns KA, Chethik L, Burns WJ, Clark R. The early relationship of drug abusing mothers and their infants: An assessment at eight to twelve months of age. Journal of Clinical Psychology 1997;53:279–287. [PubMed: 9075056]

Camras LA. Expressive development and basic emotions. Cognition and Emotion 1992;6:269–283.

Carey WB, McDevitt SC. Revision of the Infant Temperament Questionnaire. Journal of Pediatrics 1978;61:735–739.

Cicchetti, D.; Ganiban, J.; Barnett, D. Contributions from the study of high-risk populations to understanding the development of emotion regulation. In: Garber, J.; Dodge, KA., editors. The development of emotion regulation and dysregulation. Cambridge: Cambridge University Press; 1991. p. 15-48.

Clark, R. The Parent-Child Early Relational Assessment: Instrument and manual. Madison: University of Wisconsin Medical School, Department of Psychiatry; 1985.

Clark R. The Parent-Child Early Relational Assessment: A factorial validity study. Educational and Psychological Measurement 1999;59:821–846.

Crockenberg SB. Infant irritability, mother responsiveness, and social support influences on the security of infant-mother attachment. Child Development 1981;52:857–865. [PubMed: 7285658]

Crockenberg SB, Litman C. Autonomy as competence in 2-year-olds: Maternal correlates of child defiance, compliance, and self-assertion. Developmental Psychology 1990;26:961–971.

Crockenberg SB, McClusky K. Change in maternal behavior during the baby's first year of life. Child Development 1986;57:746–753.

de Weerth C, van Geert P. Changing patterns of infant behavior and mother-infant interaction: Intra- and interindividual variability. Infant Behavior and Development 2002;24:347–371.

De Wolff MS, van IJzendoorn MH. Sensitivity and attachment: A meta-analysis on parental antecedents of infant attachment. Child Development 1997;68:571–591. [PubMed: 9306636]

Dawson G, Hill D, Spencer A, Galpert L, Watson L. Affective exchanges between young autistic children and their mothers. Journal of Abnormal Child Psychology 1990;10:335–345. [PubMed: 2376657]

Donovan WL, Leavitt LA, Taylor N. Maternal self-efficacy and experimentally manipulated infant difficulty effects on maternal sensory sensitivity: A signal detection analysis. Developmental Psychology 2005a;41:784–798. [PubMed: 16173875]

Donovan, WL.; Leavitt, LA.; Taylor, NL. Maternal sensitivity to infant signals: A signal detection analysis; Paper presented at the meetings of the 12th European Conference on Developmental Psychology; Tenerife, Spain. 2005b Aug.

Donovan WL, Leavitt LA, Walsh RO. Cognitive set and coping strategy affect mothers' sensitivity to infant cries: A signal detection approach. Child Development 1997;68:760–772.

Donovan WL, Leavitt LA, Walsh RO. Conflict and depression predict maternal sensitivity to infant cries. Infant Behavior and Development 1998;21:505–517.

Donovan, WL.; Leavitt, LA.; Walsh, RO. Mothers' perceptual sensitivity to an infant cry predicts behavior; Poster presented at the biennial meeting of the Society for Research in Child Development; Albuquerque, New Mexico. 1999 Apr.

Easterbrooks MA, Lamb ME. The relationship between quality of infant-mother attachment and infant competence in initial encounters with peers. Child Development 1979;50:380–387. [PubMed: 487879]

Egeland B, Farber E. Infant-mother attachment: Factors related to its development and changes over time. Child Development 1984;55:753–771. [PubMed: 6734316]

Fagot BI. Attachment, parenting, and peer interactions of toddler children. Developmental Psychology 1997;33:489–499. [PubMed: 9149927]

Feldman R, Greenbaum CW. Affect regulation and synchrony in mother-infant play as precursors to the development of symbolic competence. Infant Mental Health Journal 1997;18:4–23.

Feldman R, Greenbaum CW, Mayes LC, Erlich SH. Change in mother-infant interactive behavior: Relations to change in the mother, the infant, and the social context. Infant Behavior and Development 1997;20:151–163.

Freitag MK, Belsky J, Grossmann K, Grossmann KE, Scheuerer-Englisch H. Continuity in parent-child relationships from infancy to middle childhood and relations with friendship competence. Child Development 1996;67:1437–1454. [PubMed: 8890493]

Gartstein MA, Rothbart MK. Studying infant temperament via the revised Infant Behavior Questionnaire. Infant Behavior and Development 2003;26:64–86.

Goldberg WA, Easterbrooks MA. Role of marital quality in toddler development. Developmental Psychology 1984;20:504–514.

Goldsmith HH, Alansky JA. Maternal and infant temperamental predictors of attachment: A meta-analytic review. Journal of Consulting and Clinical Psychology 1987;55:805–816. [PubMed: 3320116]

Green, DM.; Swets, JA. Signal detection theory and psychophysics. New York: Wiley; 1966.

Grossmann K, Grossmann KE, Spangler G, Suess G, Unzner L. Maternal sensitivity and newborns' orientation responses as related to quality of attachment in northern Germany. Monographs of the Society for Research in Child Development 1985;50:233–256. [PubMed: 4069129]

Grusec JE, Goodnow JJ. Impact of parental discipline methods on the child's internalization of values: A reconceptualization of the current points of view. Developmental Psychology 1994;30:4–19.

Harel J, Oppenheim D, Tirosh E, Gini M. Associations between mother-child interaction and children's later self and mother feature knowledge. Infant Mental Health Journal 1999;20:123–147.

Harel J, Scher A. Insufficient responsiveness in ambivalent mother-infant relationships: Contextual and affective aspects. Infant Behavior and Development 2003;26:371–383.

Harrist AW, Waugh RM. Dyadic synchrony: Its structure and function in children's development. Developmental Review 2002;22:555–592.

Hess CR, Teti DM, Hussey-Gardner B. Self-efficacy and parenting of high risk infants: The moderating role of parent knowledge of infant development. Applied Developmental Psychology 2004;25:423–437.

Kagan, J. Psychological research on the human infant: An evaluative summary. New York: W T Grant Foundation; 1982.

Kazui M, Endo T, Tanaka A, Sakagami H, Suganuma M. Intergenerational transmission of attachment: Japanese mother-child dyads. Japanese Journal of Educational Psychology 2000;48:323–332.

Kirsh SJ, Crnic KA, Greenberg MT. Relations between parent-child affect and synchrony and cognitive outcome at 5 years of age. Personal Relationships 1995;2:187–198.

Kochanska G. Mutually responsive orientation between mothers and their young children: Implications for early socialization. Child Development 1997;68:94–112. [PubMed: 9084128]

Kochanska G. Mother-child relationship, child fearfulness, and emerging attachment: A short-term longitudinal study. Developmental Psychology 1998;34:480–490. [PubMed: 9597358]

Kochanska G, Aksan N. Mother-child mutually positive affect, the quality of child compliance to requests and prohibitions, and maternal control as correlates of early internalization. Child Development 1995;66:236–254.

Kochanska G, Aksan N, Knaack A, Rhines HM. Maternal parenting and children's conscience: Early security as moderator. Child Development 2004;75:1229–1242. [PubMed: 15260874]

Kopp CB. Antecedents of self-regulation: A developmental perspective. Developmental Psychology 1982;18:199–214.

Landry SH, Smith KE, Miller-Loncar CL, Swank PR. The relation of change in maternal interactive styles to the developing social competence of full-term and preterm children. Child Development 1998;69:105–123. [PubMed: 9499561]

Londerville S, Main M. Security of attachment, compliance, and maternal training methods in the second year of life. Developmental Psychology 1981;17:289–299.

Macmillan, NA.; Creelman, CD. Detection theory: A user's guide. Cambridge: Cambridge University Press; 1991.

Mahoney G, Boyce G, Fewell RR, Spiker D, Wheeden CA. The relationship of parent-child interaction to the effectiveness of early intervention services for at-risk children and children with disabilities. Topics in Early Childhood Special Education 1998;18:5–17.

Main M, Kaplan N, Cassidy J. Security in infancy, childhood and adulthood: A move to the level of representation. Monographs of the Society for Research in Child Development 1985;50:66–104.

Mangelsdorf S, Gunnar M, Kestenbaum R, Lang S, Andreas D. Infant proneness-to-distress temperament, maternal personality, and mother-infant attachment: Associations and goodness of fit. Child Development 1990;61:820–831. [PubMed: 2364756]

Masur EF, Turner M. Stability and consistency in mothers' and infants' interactive styles. Merrill-Palmer Quarterly 2001;47:100–120.

Matas L, Arend RA, Sroufe LA. Continuity of adaptation in the second year: The relationship of quality of attachment and later competence. Child Development 1978;49:547–556.

Matias R, Cohn JF. Are max-specified infant facial expressions during face-to-face interaction consistent with differential emotions theory? Developmental Psychology 1993;29:524–531.

McNicol, D. A primer of signal detection theory. Mahwah, NJ: Erlbaum Associates; 2005.

Putnam, SP.; Gartstein, MA.; Rothbart, MK. Infant Behavior and Development. Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. in press

Rosen KS, Rothbaum F. Quality of parental caregiving and security of attachment. Developmental Psychology 1993;29:358–367.

Rothbart MK, Ahadi SA, Hershey KL, Fisher P. Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. Child Development 2001;72:1394–1408. [PubMed: 11699677]

Rubin KH, Nelson LJ, Hastings PD, Asendorpf J. The transaction between parents' perceptions of their children's shyness and their parenting styles. International Journal of Behavioral Development 1999;23:937–957.

Ruff, HA.; Lawson, KR. The assessment of infants' attention during play with objects. In: Shaefer, C.; Gitlin, K.; Sandgrund, A., editors. Play diagnosis and assessment. New York: Wiley; 1991. p. 115-129.

Rutter, M. Continuities and discontinuities in socioemotional development: Empirical and conceptual perspectives. In: Emde, RN.; Harmon, RJ., editors. Continuities and discontinuities in development. New York: Plenum Press; 1984. p. 41-68.

Sameroff A. Transactional models in early social relations. Human Development 1975;18:65–79.

Schneider-Rosen K, Cicchetti D. The relationship between affect and cognition in maltreated infants: Quality of attachment and the development of self-recognition. Child Development 1984;55:648–658. [PubMed: 6723453]

Seifer R, Schiller M, Sameroff AJ, Resnick S, Riordan K. Attachment, maternal sensitivity, and infant temperament during the first year of life. Developmental Psychology 1996;32:12–25.

Sroufe LA. Attachment classification from the perspective of infant-caregiver relationships and infant temperament. Child Development 1985;56:1–14. [PubMed: 3987395]

Sroufe, LA. Emotional development: The organization of emotional life in the early years. Cambridge: Cambridge University Press; 1996.

Stams GJ, Juffer F, van IJzendoorn MH. Maternal sensitivity, infant attachment, and temperament in early childhood predict adjustment in middle childhood: The case of adopted children and their biologically unrelated parents. Developmental Psychology 2002;38:806–821. [PubMed: 12220057]

Stern, DN. Self/other differentiation in the domain of intimate socio-affective interaction: Some considerations. In: Rochat, P., editor. The self in infancy: Theory and research. Amsterdam: Elsevier; 1995. p. 419-429.

Suess GJ, Grossmann KE, Sroufe LA. Effects of infant attachment to mother and father on quality of adaptation in preschool: From dyadic to individual organization of self. International Journal of Behavioral Development 1992;15:43–65.

Sullivan MW, Lewis M. Emotional expressions of young infants and children: A practitioner's primer. Infants and Young Children 2003;16:120–142.

Tamis-LeMonda CS, Bornstein MH. Individual variation, correspondence, stability, and change in mother and toddler play. Infant Behavior and Development 1991;14:143–162.

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Teti DM, Nakagawa M, Das R, Wirth O. Security of attachment between preschoolers and their mothers: Relations among social interaction, parenting stress, and mothers' sorts of the Attachment Q-Set. Developmental Psychology 1991;27:440–447.

Thompson, RA. Early sociopersonality development. In: Damon, W.; Eisenberg, N., editors. Handbook of child psychology: Vol 3. Social, emotional, and personality development. 5. New York: Wiley; 1998. p. 25-104.

Tizard B, Hodges J. The effect of early institutional rearing on the development of eight-year old children. Journal of Child Psychology and Psychiatry 1978;19:99–118. [PubMed: 670339]

van den Boom DC. The influence of temperament and mothering on attachment and exploration: An experimental manipulation of sensitive responsiveness among lower-class mothers with irritable infants. Child Development 1994;65:1457–1477. [PubMed: 7982362]

van der Mark IL, Bakermans-Kranenburg MJ, van IJzendoorn MH. The role of parenting, attachment, and temperamental fearfulness in the prediction of compliance in toddler girls. British Journal of Developmental Psychology 2002;20:361–378.

van IJzendoorn MH. Attachment, emergent morality, and aggression: Toward a developmental socioeconomical model of antisocial behavior. International Journal of Behavioral Development 1997;21:703–727.

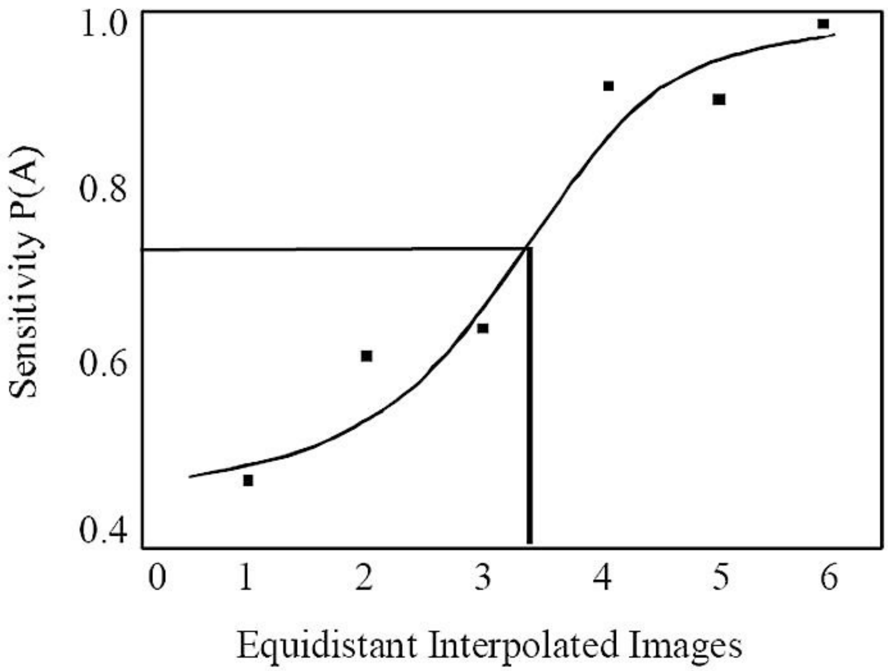
van IJzendoorn, MH.; Sagi, A.; Lambermon, MWE. The multiple caretaker paradox: Data from Holland and Israel. In: Pianta, RC., editor. New directions for child development: No 57. Beyond the parent: The role of other adults in children's lives. San Francisco: Jossey-Bass; 1992. p. 5-24.

Vaughn BE, Stevenson-Hinde J, Waters E, Kotsaftis A, Lefever GB, Shouldice A, Trudel M, Belsky J. Attachment security and temperament in infancy and early childhood: Some conceptual clarifications. Developmental Psychology 1992;28:463–473.

Vizziello, GMF.; Fererro, C.; Musicco, M. Parent–child synchrony of interaction. In: Crittenden, PM.; Claussen, AH., editors. The organization of attachment relationships: Maturation, culture, and context. Cambridge: Cambridge University Press; 2000. p. 38-60.

Volling BL, McElwain NL, Notaro PC, Herrera C. Parents' emotional availability and infant emotional competence: Predictors of parent-infant attachment and emerging self-regulation. Journal of Family Psychology 2002;16:447–465. [PubMed: 12561291]

Youngblade LM, Belsky J. Parent-child antecedents of 5-year-olds' close friendships: A longitudinal analysis. Developmental Psychology 1992;28:700–713.



1.
Logistic psychometric function of hypothetical data defining sensitivity threshold as the value on the axis representing the equidistant interpolated images where P(A) = 75% intercepts the fitted function.

Table 1

Means and Standard Deviations for Main Study Variables and Correlations with Variables at 24 Months

	***Mean* (*SD*)**	***N***	***Observed R***	**Maternal Behavior**	**Maternal Affect**	**Toddler Behavior**	**Toddler Affect**	**Dyadic Interaction**
6 Months								
Sensory Sensitivity – Positive Expression[a]	2.94 (1.17)	70	.89 − 5.37	−.06	−.03	.11	.01	.08
Sensory Sensitivity – Negative Expression[a]	3.23 (1.12)	70	.64 − 6.00	−.09	−.20	−.08	−.23†	−.14
ITQ	2.56 (.36)	70	1.70 − 3.65	−.01	.15	−.18	.02	−.12
9 Months								
Maternal Behavior	4.58 (.35)	68	3.83 − 5.00	.33*	.23†	.22†	.20	.30*
Maternal Affect	4.85 (.40)	68	3.00 − 5.00	−.10	−.10	−.09	−.04	−.01
Infant Behavior	3.97 (.75)	68	3.00 − 5.00	.05	.06	−.03	.18	.05
Infant Affect	4.38 (.49)	68	4.00 − 5.00	−.07	−.05	.05	.24†	.06
Dyadic Interaction	4.18 (.54)	68	3.33 − 5.00	.14	.18	.10	.26*	.21†
1 Year								
Infant Attachment	3.63 (1.40)	67	1.00 − 5.00	.13	−.13	.34**	.20	.24†
2 Years								
Maternal Behavior	4.61 (.42)	62	2.60 − 5.00	-				
Maternal Affect	4.63 (.34)	62	3.20 − 5.00	.68**	-			
Toddler Behavior	4.46 (.56)	62	2.75 − 5.00	.34*	.22†	-		
Toddler Affect	4.69 (.34)	62	3.71 − 5.00	.43**	.53**	.58**	-	
Dyadic Interaction	4.33 (.64)	62	2.50 − 5.00	.62**	.66**	.72**	.74**	-
ECBQ	2.78 (.50)	62	1.82 − 4.09	.14	.27*	.07	−.09	.14

[a] Lower values indicate greater sensory sensitivity.

† $p < .10$.

* $p < .05$.

** $p < .001$.

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Table 2

Results from five Hierarchical Multiple Regression Analyses Predicting Maternal, Toddler, and Dyadic Interaction During Play at 24 Months

Dependent variable, step, and predictor entered	R^2	*F* ch	*df*	*p* ch	*B*	*SEB*	*β*
Maternal Behavior							
1. ECBQ	.03	1.66	1, 60	.20	.16	.13	.16
2. Maternal Behavior	.23	2.95	5, 55	.02	.59	.16	.49**
Maternal Affect					−.19	.14	−.17
Infant Behavior					−.02	.08	−.03
Infant Affect					−.15	.13	−.17
Dyadic Interaction					−.06	.13	−.07
3. Infant Attachment Status	.24	.52	1, 54	.47	.03	.04	.09
4. Sensory Sensitivity – Positive Expression[a]	.34	3.77	2, 52	.03	−.10	.05	−.29*
Sensory Sensitivity – Negative Expression[a]					−.06	.05	−.16
Maternal Affect							
1. ECBQ	.04	2.49	1, 60	.12	.16	.10	.20
2. Maternal Behavior	.17	1.68	5, 55	.16	.37	.14	.37
Maternal Affect					−.12	.12	−.13
Infant Behavior					.02	.07	.04
Infant Affect					−.12	.11	−.17
Dyadic Interaction					−.00	.11	−.00
3. Infant Attachment Status	.17	.06	1, 54	.80	−.01	.03	−.03
4. Sensory Sensitivity – Positive Expression[a]	.30	5.02	2, 52	.01	−.08	.04	−.27*
Sensory Sensitivity – Negative Expression[a]					−.08	.04	−.26*
Toddler Behavior							
1. ECBQ	.01	.35	1, 60	.56	.10	.17	.08
2. Maternal Behavior	.09	.95	5, 55	.46	.35	.24	.22
Maternal Affect					−.26	.20	−.18
Infant Behavior					−.06	.12	−.08
Infant Affect					.10	.18	.09
Dyadic Interaction					−.02	.18	−.01
3. Infant Attachment Status	.20	7.58	1, 54	.01	.14	.05	.36**
4. Sensory Sensitivity – Positive Expression[a]	.22	.68	2, 52	.51	−.01	.07	−.01
Sensory Sensitivity – Negative Expression[a]					−.08	.07	−.15
Toddler Affect							
1 ECBQ	.00	.18	1, 60	.67	−.04	.10	−.06
2. Maternal Behavior	.11	1.32	5, 55	.27	.14	.14	.15
Maternal Affect					−.11	.12	−.12
Infant Behavior					−.02	.07	−.03
Infant Affect					.10	.11	.15
Dyadic Interaction					.09	.11	.13
3. Infant Attachment Status	.13	1.52	1, 54	.22	.04	.03	.17
4. Sensory Sensitivity – Positive Expression[a]	.17	1.08	2, 52	.35	−.01	.04	−.03
Sensory Sensitivity – Negative Expression[a]					−.06	.04	−.19
Dyadic Interaction							
1. ECBQ	.02	1.33	1, 60	.25	.22	.19	.15
2. Maternal Behavior	.13	1.31	5, 55	.27	.56	.27	.31
Maternal Affect					−.23	.23	−.14
Infant Behavior					−.01	.14	−.01
Infant Affect					−.04	.21	−.03
Dyadic Interaction					.05	.21	.04
3. Infant Attachment Status	.19	4.33	1, 54	.04	.12	.06	.27*
4. Sensory Sensitivity – Positive Expression[a]	.22	1.12	2, 52	.33	.01	.08	.01
Sensory Sensitivity – Negative Expression[a]					−.11	.08	−.19

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Note. The findings were fundamentally identical for each regression when Steps 2 and 3 were entered in reverse order and when ITQ and child sex were entered as control variables in Step 1.

[a] Lower values indicate greater sensory sensitivity.

* $p < .05$.

** $p < .01$.