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ABSTRACT

This study explored the relation between mother-infant coordinated interpersonal timing, an automated microanalytic measure of dyadic vocal coordination, and maternal sensitivity. Thirty-four mothers and their developmentally normal 4-month-old infants were audio recorded during a 20-minute laboratory vocal interaction session, which was later analyzed for coordinated interpersonal timing. Maternal sensitivity ratings were based on a videotaped 45-minute unstructured interaction period also obtained during the laboratory visit. The findings indicated a significant curvilinear relation between the degree to which mother coordinated her noninterruptive co-occurring speech to that of her infant (r=.381) and revealed that mothers highest in sensitivity were characterized by moderate levels of coordination. The finding supported the notion that examining mother-infant interaction at the specific behavioral level, while incorporating tests of nonlinear trends, may provide important information about the nature of sensitive parenting. (Contains 40 references.) (Author/AMC)

The Relation Between Coordinated Interpersonal Timing and Maternal Sensitivity in Four-Month-Old Infants[1]

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The relation between mother-infant coordinated interpersonal timing (CIT), an automated, microanalytic measure of dyadic vocal coordination, and maternal sensitivity (MS) was explored. Thirty-four mothers and their developmentally normal four-month-old infants were audio recorded during a 20-minute laboratory vocal interaction session, which was later analyzed for CIT. MS ratings (Ainsworth & Bell, 1969) were based on a video-taped 45 minute unstructured interaction period also obtained during the laboratory visit. A significant curvilinear relation between the degree to which mother coordinated her noninterruptive co-occuring speech to that of her infant was found (r=.381, p<.05), and revealed that mothers highest in sensitivity were characterized by moderate levels of coordination. This finding lends support for the notion that examining mother-infant interaction at the specific behavioral level, while incorporating tests of nonlinear trends, may provide important information about the nature of sensitive parenting.

maternal sensitivity	coordinated interpersonal timing	vocal contingency
mother-infant interaction	temporal coordination	microanalysis

The mother-infant attachment relationship evolves via dyadic reciprocal exchanges. These exchanges involve a strategy in which infants elicit cues that indicate their need for safety, comfort, and social interaction, and mothers accurately perceive and respond to these cues (Bowlby, 1969). Given that mothers and infants bring their own unique contributions to this relationship, the attachment relationship is dyad-specific (Stroufe & Waters, 1977). In addition, inherent to attachment theory is the notion that the early attachment relationship results in the formation of internal working models of

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behavior that serve to organize the infant's future social interactions (Main, Kaplan, & Cassidy, 1985). Thus, the early parent-child relationship is crucial to the long-term social outcomes of the child (Bowlby, 1969). Given the importance of the early mother-child attachment quality, Bowlby stated that the conditions in the early rearing environment, which contribute to the development of a secure attachment relationship, must be identified.

Ainsworth, Blehar, Waters, and Wall (1978) were the first to study the antecedents of mother-infant attachment. Through their home observations of 26 mother-infant dyads in Baltimore, early-occurring maternal behaviors (i.e., those occurring during the infant's first and fourth quarter of the first year) that predicted secure attachments at 12 months were identified. After 70 hours of home observation for each dyad, Ainsworth et al. discovered that ideal maternal behaviors reflected a high degree of maternal sensitivity (MS), or "sensitive responsiveness to infant signals and communications" (Ainsworth et al., 1978, p. 152). Such maternal sensitivity cultivates synchronous, reciprocal, and jointly satisfying mother-infant interactions. These interactions, in turn, foster the development of a secure attachment relationship. In contrast, maternal insensitivity--maternal failure to accurately perceive and respond to her infant's signals--results in poor timing, mutually unsatisfying interaction, and, thus, insecure attachment (Ainsworth et al., 1978). Specifically, results of their Baltimore study revealed that mothers of secure infants, in contrast to mothers of insecure infants, were more likely to respond promptly to infant distress; handle their infant carefully and tenderly; hold their infants longer; pace face-to-face interactions in accordance with the infants responses; and gear the feeding situation to the infant's signals of hunger and satisfaction.

Although Ainsworth and her colleagues provided the framework for more than 20 years of research concerned with measuring MS, the Baltimore study should be viewed as exploratory in nature. First, the study reported an unusually strong effect size for MS and the Strange Situation measure of attachment ($r = .78$). Indeed, a correlation of this magnitude may be indicative of shared method variance between the MS and attachment measures (De Wolff & van IJzendoorn, 1997). Lamb, Thompson, Gardner, Charnov, and Estes (1984) further note that this study should be viewed as hypothesis generating, rather than hypothesis testing. Because of the overlap between the Ainsworth rating scales of MS and the Strange Situation, failure to obtain satisfactory interrater reliability for measures of MS or Strange Situation, and data analysis that may have capitalized on chance (see Lamb et al., 1984 for review), it is cautioned that results of this study must be replicated before considered reliable (Lamb et al., 1984).

An abundance of research since Ainsworth's seminal findings has somewhat clarified the role of MS in the evolving attachment relationship. The effect size reported by Ainsworth et. al.(1978) has failed to replicate, and what has emerged instead is a weak-to-moderate relationship between MS and security of attachment (De Wolff & van IJzendoorn, 1997; Goldsmith & Alansky, 1987). In a meta-analysis of MS and attachment, Goldsmith and Alansky (1987) reported that the relationship between these two variables is weak at best. A more recent meta-analysis of MS and attachment reports the combined effect size of 66 studies to be moderate ($r[1,097] = .24$) based on Cohen's (1988) conventional criteria for effect-size (De Wolff & van IJzendoorn, 1997). In short, the original findings of Ainsworth and colleagues (1978) have not been replicated. Instead, researchers claim that their modest but significant effect sizes for MS

and attachment indicate partial replication of the original findings of Ainsworth et al.(1978).

Even given such partial replications, the previously held notion that MS is of primary importance to attachment, and thus long-term outcomes of the child, is losing support. An effect size of .24 suggests that there are likely other interaction variables of importance that contribute to the formation of the mother-infant attachment relationship. In their statement of conclusions, De Wolf and van IJzendoorn (1997) note that MS "cannot be considered to be the exclusive and most important factor in the development of attachment." (p. 585). Instead, researchers should consider other aspects of mother-infant interaction that contribute to attachment and social outcomes of the child. It is further suggested that specific interaction variables of particular importance are: mutuality and synchrony (which in their meta-analysis yielded larger effect sizes than MS, $r = .32$ and .26, respectively), maternal stimulation, positive attitude, and emotional support.

Another indication of the need to consider interaction variables beyond MS stems from the broad, inconsistent conceptualization of the construct itself. Indeed, as definitions of MS vary, so do approaches in assessment. Seifer, Schiller, Sameroff, Resnick, and Riordan (1996) argue that the inconsistency in measurement of MS explains, at least in part, the lack of agreement among published reports. The domains considered in the Ainsworth rating scales for MS encompass a vast number of parenting behaviors, including maternal responsiveness, affection, warmth, behavioral contingencies, and timing during feedings (Ainsworth, Blehar, Waters, & Walls, 1978). Maternal sensitivity, when not measured via Ainsworth's scales, is often measured globally on the basis of the Ainsworth conceptualization. For instance, variations in measurement of MS have included measures that have simplified the Ainsworth scales by using a small subset of the global ratings (Crockenberg, 1981; Rosen & Rothbaum, 1993), the use of Q-sort methodology (Pederson, Moran, Sitko, Campbell, Ghesquire, & Acton, 1990), and rating scales that focus on maternal behaviors in conjunction with dyadic contingencies, such as mutuality and reciprocity (Clark, Musick, Scott, & Klehr, 1985). These measures encompass so many aspects of maternal behavior that it is difficult to isolate the importance of any one specific maternal behavior.

Given the disparity among researchers in terms of the conceptualization and assessment of MS, it is evident that there is a need for measures that tap specific aspects of mother-infant interaction (Bakeman, Adamson, Brown, & Eldridge,1989; De Wolff & van IJzendoorn,1997). Bakeman and colleagues (1989) offer a perspective that is imperative to consider when studying mother-infant interaction. These authors suggest that efforts in prediction based on interaction are likely rewarded if "carefully constructed measures that closely reflect our understanding of critical aspects of interactions" (p. 240) are employed. Further, it is only when specific aspects of mother-infant interaction are isolated and measured that one can locate variables in the developmental context and thus explain developmental outcomes in terms of the mechanisms that link various aspects of interactions (Bakeman et al., 1989). For instance, an aspect of maternal sensitivity that is believed to be important to early interaction is contingent responsiveness. Without examining contingent responsiveness specifically, it would remain unclear whether such responsiveness is of particular importance, at what point in development it is important, whether it plays a role in facilitating sensitive parenting, and ultimately, whether it

is important to the social outcome of the child.

In addition, examining interaction within a narrow focus may aid account for more variation in attachment outcomes than when a multitude of variables are considered. Indeed, the meta-analysis of De Wolff and van IJzendoorn illustrates this point. When MS is measured by the global Ainsworth type scales, the meta-analytic effect-size was modest (r = .24) (De Wolff & IJzendoorn, 1995). However, examining one specific aspect of MS, for example, mutuality, elicited a meta-analytic effect size greater than MS (r=.32).

In summary, MS has been demonstrated to predict attachment security. However, the broad conceptualization of this construct has lead to global measures, which relate only modestly to subsequent attachment outcomes. In addition, reliance on global behavioral measures has made it difficult to isolate the importance of any one specific maternal behavior. Further, there is evidence that specific behaviors examined in-depth yield larger effect-sizes for attachment than do global measures. There is, then, a need for more detailed, specific measures of mother-infant interaction. It is suggested that one such specific interaction variable of importance is coordinated interpersonal timing (CIT). This study will examine the possibility that CIT, as measured by an automated, objective analysis of dyadic vocal interaction (Feldstein & Welkowitz, 1978; Jaffe & Feldstein, 1970) will relate to Ainsworth's global measure of MS.

CIT, as defined here, occurs when the temporal pattern of each person's vocal behavior is predictable from that of the other (Feldstein et al., 1993). Separate measures of coordination are obtained for each member of the dyad, each reflecting the degree to which the vocal behavior of one member is coordinated with, or predictable from, that of the other. In general terms, these separate aspects of CIT include: Coordination of vocalizations, or the degree to which each party's vocalizations are contingent upon the other; pause and switching pause coordination which gauge the extent to which each member of the dialogue regulates their turn-taking behavior to that of the other; and measures of coaction, which measure the degree to which each member of the dialogue balances their vocally interruptive behavior with that of the other. The coefficient of Maternal CIT (CIT-M) represents the degree to which the vocal behaviors of the mother are predictable from those of her infant; infant CIT (CIT-I) reflects the degree to which the infant's behaviors are predictable from those of the mother. An in-depth discussion of this measure is provided later in this text.

Research examining temporal aspects of mother-infant interaction lends support for the notion that the degree of coordinated timing in mother-infant interaction is related to the evolving attachment relationship between mother and infant (Ashley, Feldstein, Hoffhines, & White, 1997; Belsky, Rovine, & Taylor, 1984; Belsky, Taylor, & Rovine, 1984; Isabella, Belsky, & von Eye, 1989; Feldstein et al., 1993; Feldstein, Crown, Beebe, & Jaffe, 1994; Jaffe et al., 1991). In addition, research examining the role of synchronous timing in mother-infant interaction has provided the field with an important, emergent discovery. Past research exploring the antecedents of attachment has found that the most favorable child outcomes are associated with high levels of parental sensitivity. What has logically followed is the premise that "more is better." Or, the more attentive, stimulating, and involved a mother, the more secure the attachment. Provided below is a review of timing literature that finds secure attachments to be predicted by *moderate*, rather than *high*, levels of behavioral and vocal synchrony.

Temporal Aspects of Mother-Infant Interaction

The work of Belsky and colleagues (Belsky et al., 1984a; Belsky et al., 1984b; Isabella et al., 1989; Isabella & Belsky, 1991) in behavioral synchrony provides empirical support for the existence of a curvilinear relation between interactional timing and attachment outcomes. Isabella et al. (1989) used a time sampling observational system in operationalizing mother-infant interactions to test the hypothesis that attachment outcomes in infants differ depending upon the relative degree to which their interactional histories were characterized by synchronous or asynchronous exchange. It was found that secure dyads at 12 months were characterized by synchronous temporal co-occurrences at 1 and 3 months. In contrast, attachment insecurity at 12 months was predicted by asynchronous mother-infant interactions, that is, characterized by either under- or over-involvement. In a replication of this study, Isabella and Belsky (1991) again found that securely attached infants at 12 months engaged in well- timed, reciprocal interactions at 3 and 9 months. Insecure dyads were found to be characterized by unresponsive or intrusive maternal behaviors at 3 and 9 months.

Research examining the role of vocal temporal coordination in attachment has revealed a similar pattern. In a study of coordinated interpersonal timing and attachment, Jaffe et al. (1991) found a curvilinear relationship between interpersonal timing at 4 months and attachment security at 12 months. Specifically, vocal interactions characterized by high coordination (i.e., over-sensitivity or hypervigilance on the part of mother) as well as low coordination (i.e., under-sensitivity or unresponsiveness on the part of mother) predicted insecure attachment. Secure attachments at 12 months were predicted by intermediate levels of coordinated timing at 4 months. A similar study of CIT and mother-infant attachment also found a significant curvilinear relation between CIT and attachment, such that high and low levels of timing at 4 months were found again to predict insecure attachment at 12 months (Feldstein et al., 1993). Another study examining the role of CIT and attachment security, measured concurrently at 18 months, is suggestive of the same curvilinear component (Ashley et al., 1997). This research suggests that the optimal level of sensitive parenting involves a moderate degree of predictability in dyadic vocal exchanges. These results are consistent with those of Isabella et al. (1989; 1991), which suggests that secure attachment outcomes are predicted by moderately synchronous contingent behavioral timing.

In summary, previous research has demonstrated that, like MS, CIT predicts attachment security. However, the nature of this relation is different than the linear relation between global measures of MS and attachment. Instead, there exits a curvilinear relation between CIT and attachment, such that high and low levels of CIT predict subsequent and concurrent insecure attachment outcomes (Ashley et al., 1997; Feldstein et al., 1993). These results are consistent with the work of Isabella et al. (1989; 1991), that found behavioral synchrony to predict optimal outcomes when it occurs at intermediate levels. These findings suggest that temporal measures play an intricate role in sensitive parenting. As stated by Schaffer (1977), "What appears to matter most about 'successful' mother-infant interactions is above all the temporal integration of the two partners' responses, and when we talk about mothers' sensitivity it is often this temporal characteristic that we have in mind" (p. 214). Such research also challenges the previously dominant notion that "more is better" when considering maternal involvement. The purpose of

this study is to examine the role of CIT in MS. Because both have been demonstrated to be important antecedents to the mother-infant attachment relationship, it is expected that the coordination of various vocal parameters of CIT, as assessed by an automated, microanalytic measure at 4 months, is related to MS, as measured by the Ainsworth Scales for Rating Maternal-Care Behavior, also assessed at 4 months. Further, given that moderate levels of CIT predict the most favorable outcomes, it is expected that this relation is curvilinear, such that mothers highest in maternal sensitivity coordinate their vocal timing to that of their infant's in moderate levels, whereas mothers low in MS are characterized by either high or low degrees of CIT. Finally, because MS, by definition, focuses on maternal behavior, this relationship is expected to be most evident when examining the degree to which mother's vocal behaviors are coordinated with those of her infant, or CIT-M. However, because the mother-infant relationship is reciprocal in nature, such that the infant predicts mother's behaviors, and, in turn, mother influences the infant, it is expected that the degree to which the infant's vocal behaviors are coordinated with those of the mother, or CIT-I, is also related to MS, in the same curvilinear fashion. A curvilinear relation between CIT and MS will provide empirical evidence to challenge current conceptualizations of sensitive parenting, and thus, confirm the need to approach mother-infant interaction at the specific behavioral level.

Method

Participants

Thirty-four mothers and their 4-month-old developmentally normal infants were recruited from fliers and ads in local papers as part of a larger longitudinal study of mother-infant communication that assesses mothers and infants in various aspects of mother-infant interaction when the infants are 4-, 12-, and 24- months-old. Infants averaged 16.74 weeks (SD=1.32) and 19 were female. All infants were screened for developmental normalcy using the Yale Neuropsychoeducational Scales (1982). The infants were reported by their mothers to be free of congenital abnormalities, full-term at the time of delivery, and within the normal limits of birth weight. Seventy-six percent
(n = 26) were primiparous and the remainder were second born. Mothers averaged 30.05 years (SD = 5.66) and all were cohabitating with the infant's father. Eighty five percent of the sample was Caucasian (n = 29), 9% (n = 3) was African American, and the remaining 6 % (n = 2) was of other ethnicity. Mothers were predominatly middle class, with 63 % (n = 22) reporting an annual household income (AHI) greater than $51,000.00; 5.8% (n = 2) reporting an AHI between 41 to 50,000; 17.1 % (n = 6) reporting an AHI between 31- to 40,000; 8.6 (n = 3) reporting an AHI between 21- to 30,000; and 2.9 % (n = 1) reporting an AHI of less than $10,000. All mothers signed informed consent for themselves and their infants and participation was voluntary.

Measures

Coordinated Interpersonal Timing

The audio-taped vocal behaviors from a 20-minute mother-infant interaction session for

each mother-infant dyad were analyzed by the Automatic Vocal Transaction Analyzer (AVTA) System (Jaffe & Feldstein, 1970). The AVTA System is comprised of an analog-to-digital converter that determines whether the audio signal of each party is on or off, thus allowing for the measurement of the turn-taking "flow" of the conversation. This analysis does not take into account the frequency or intonational aspects of the speech. Once the signals have been measured, AVTA transforms and digitally stores them as a sequence of numbers that correspond to the following speech patterns:

0--The signal when neither party is speaking, or mutual silence
1--The signal when party A is speaking alone
2--The signal when party B is speaking alone
3--The signal when both parties vocalize simultaneously

The system converts these signals into a set of vocal parameters for each party (Feldstein & Welkowitz, 1978; Jaffe & Feldstein, 1970) and provides descriptive statistics for these parameters for a prespecified time unit for the purpose of calculating a time-series regression analysis. For this study, such descriptives were generated every 5 seconds, which has been previously determined to be long enough to obtain several occurrences of all the parameters (Feldstein et al., 1993). These parameters include: *vocalizations,* defined as vocal sounds from either party that are bounded by the pauses of the same speaker and remain uninterrupted by silence; *pauses,* the occurrence of mutual silence that is commenced and terminated by the vocalizations of the same participant; *switching pauses*, defined as the occurrence of simultaneous silences that have been initiated by one participant, but terminated by the other; *noninterruptive simultaneous speech*, which occurs when both parties speak at the same time, but the party who had the floor before the simultaneous speech segment occurred continues to have the floor after the other party terminates (thus, the speaking party was never really interrupted); and lastly, *interruptive simultaneous speech*, which occurs when the party who was speaking prior to the simultaneous speech loses the floor (turn) to the party who initiated the simultaneous speech (the speaker is interrupted by the co-occurring speech of the other party). In addition, a second, final set of descriptives is generated which summarizes the occurrence of each of these parameters for the entire interaction period.

To obtain the degree to which the two partners coordinate their vocal behaviors with each other, a time-series regression analysis (Ostrom, 1978) is computed for each of these five parameters. Such an analysis is based on the premise that when one is conversing with another, the timing of that speech is influenced not only by the other party in the conversation, but also by the self. Time-series regression allows for the partialling of each member's self-influence (i.e., autocorrelation) to determine the degree to which each member's contribution to the dialogue was coordinated with (predictable from) that of the other (i.e., cross-correlation). The time series regression yields partial cross-correlation coefficients and their squares, or coefficients of coordination, which represent the degree to which one party's speech was coordinated with that of the other. Five of these coefficients represent the mother's degree of coordination with the infant (CIT-M), and another five are generated to represent the degree of coordination of the

infant with the mother (CIT-I). These coefficients constitute the scores for CIT, such that the higher the coefficient, the more coordinated is the timing of one party with the other.

AVTA has achieved impressive reliability, with repeated analysis of the same data in the system achieving correlation coefficients ranging from .91 to .94 (Jaffe et al., 1970). In addition, because the computer completes all coding, this measure is entirely objective, requiring research assistants only to familiarize themselves with the computer procedures. For this study, all AVTA processing was set-up and monitored by a supervised undergraduate research assistant. This assistant achieved sound intra-rater reliability, as this student's repeated analysis of the same data across 10 dyads yielded correlation coefficients ranging from .90 to .95.

Maternal Sensitivity

To assess the degree of maternal sensitivity, a modified version of the Ainsworth System for Rating Maternal-Care Behavior (Ainsworth & Bell, 1969) was utilized to code videotapes obtained from a 45-minute feeding/unstructured interaction period. In its entirety, this measure consists of 22 9-point rating scales, which rate behavior across 7 domains. Scale points 1, 3, 5, 7, and 9 are anchored in detailed behavioral descriptions. The higher the composite score across all 22 ratings, the more sensitive are the mother's behaviors to her infant.

Because these scales are based on detailed observations of mother-infant interaction as they occur in the home, not all of the scales are relevant to laboratory assessments. Thus, of the original 22 rating scales, only 16 were used to code laboratory sessions. These 16 scales are sub-divided into six separate domains as follows: *General Attitude of Mother towards Baby and Her Role as A Mother*, which includes ratings for maternal perception of her baby, maternal delight in baby, and maternal acceptance of baby; *Feeding,* which is rated based on synchronization of mother's interventions with baby's rhythms, determination of amount of food at the end of feeding, and mother's synchronization of rate of feeding to baby's pace; *Availability and Interaction*, which rates total availability of caretaker, amount of interaction offered by mother, and appropriateness of mother's initiations or interactions; *Physical Contact*, which rates the amount of physical contact and the quality of contact in holding baby; *Response to Crying*, which rates the effectiveness of mother's responses to baby's crying; and, lastly, *Social Contact*, which rates amount of visual and auditory contact, and frequency and appropriateness of play interactions.

An MS score was obtained for each dyad by obtaining the mean rating across the 16 scales. It must be noted that because of the limited nature of the laboratory interaction session, the mean for every dyad did not include all scales. The scales which rated feeding were particularly likely to not be rated, as of the 34 dyads, 8 were not fed during the laboratory visit.

All MS coding was completed by the two graduate student co-investigators of the project. Both raters had an estimated 4 years of hands-on research experience in mother-infant research. In addition, both raters completed extensive reading in mother-infant interaction and attachment theory, including the manual provided by the author of the scales (Ainsworth & Bell, 1969), which offers detailed descriptions of both sensitive and insensitive parenting for each of the 22 original scales. These raters achieved strong inter-rater agreement, as determined by the intraclass reliability coefficient (Haggard, 1958) based on independent ratings of five dyads

chosen at random (r_i=.91). Both MS raters remained blind to the timing data until the coding was complete.

Previous research using this measure has yielded high intercorrelations across these domains, with correlation coefficients ranging from .83 to .93 (Ainsworth & Bell, 1969). However, the intercorrelations of the modified MS scale used in this study ranged from .081 to .866.

The lack of agreement between many of these scales was hypothesized to be a function of the lack of relation between the scales which rate frequency, or amount of interaction, versus those which rate quality, or appropriateness of interaction. As MS, by definition, reflects degree of the contingent, reciprocal behavioral exchanges between mother and infant (Ainsworth et al., 1978), it may not necessarily follow that more stimulation during interaction with the infant is more sensitive to the infant's needs. As such, those items that clearly rated the quality of mother-infant interaction were isolated from those that measured only frequency, or amount of interaction. Items which were not clearly placed in either category (e.g. those which measure feeding, as these require ratings of both quality and frequency) were eliminated from either category.

The newly created frequency domain consisted on the following scales: amount of interaction, amount of physical contact, amount of visual contact, amount of auditory contact, and frequency of play interactions. Those scales that were placed into the quality domain are as follows: maternal perception of the infant, delight in the infant, maternal acceptance, appropriateness of interactions, effectiveness of response to crying, quality of physical contact, and appropriateness of play interactions. Scales which rated feeding episodes and the scale which measured maternal availability were excluded from these domains. For the former, ratings for feeding required both qualitative judgements of appropriateness as well as quantitative judgements about amount fed, thus not falling directly into either of the two categories. The availability scale was excluded as it represents psychological availability, which the scale instructs is to be gauged primarily by actual physical availability. Two problems with this scale arose, the first of which was the inflated likelihood that all the mothers in the sample were physically available to their infant, as they were restricted to the same room for 45-minutes. The other difficulty, in terms of placement into either domain, is similar to that of the feeding scales--the scale required both qualitative and quantitative judgements.

Subsequent intercorrelations between these 2 new domains and the composite MS score (see Table 1) revealed that this newly created frequency domain shares only 29% of its variability with the quality domain, suggesting that mothers who engaged their infants in more frequent interactive behaviors were not necessarily characterized by engaging their infants in highly appropriate stimulation. As such, these newly created domains were examined individually in post-hoc exploratory analyses, as each was believed to describe unique information about mother-infant interaction.

Table 2

Intercorrelations Among Maternal Sensitivity Domains and Overall Sensitivity Rating

MS Domain	MS Frequency	MS Quality	Overall Rating
Frequency	---	.536*	.778**
Quality		---	.921**
Overall			---

Note. *p < .005 **p < .0001

Procedure

Prior to their participation in the project, all mothers received a phone call during which they were informed of the longitudinal nature of the project, and thus, the long-term commitment. Mothers were then screened to ensure they met the following eligibility criteria: English as their primary speaking language, married or cohabitating with the infant's father, and an infant who is developmentally normal to the best of their knowledge (i.e. no major birth complications or developmental delays). Mothers and infants who met the inclusion criteria were scheduled for a laboratory visit between their infant's 15th and 18th week. All laboratory visits took place early to midmorning, when the infants were most likely to be active and alert. Mothers were sent reminders of their appointment in the mail roughly 1 week before their visit. The evening prior to their laboratory visit, all mothers received a phone call to confirm the appointment.

During the laboratory visit, mothers first signed informed consent for themselves and their infants. Mother and infant were then each fitted with a wireless clip-on microphone in order to record their vocalizations. Next mothers were escorted into one of the two interaction sessions.

For the 20-minute vocal interaction session, mother and infant were escorted to a simulated living room environment, complete with a couch, comfortable chairs, and a seat for the infant placed atop a low, round table. Mothers were instructed to engage their baby vocally as they would at home, but asked to leave the child in the seat to ensure adequate distance between the microphones (and thus reduce the possibility of auditory feedback into each other's microphones). Under ideal circumstances this session lasted 20 minutes and was both video- and audio-recorded by wall-mounted cameras in the room, and through a one-way mirror. For eight dyads, the session was terminated early due to infant protest. However, ample timing data was generated from these prematurely terminated episodes (ranging in duration from 10.5 to 19.5 minutes,
M = 14.44, SD = 3.32) thus permitting their inclusion into the analyses. Audio-recordings from

this vocal interaction session were analyzed by the AVTA System and then time series regression was performed in order to obtain degree of coordinated interpersonal timing.

For the unstructured/feeding interaction session, mother and infant were escorted to a different room complete with comfortable chairs, numerous toys, a changing table, an infant seat, and magazines. Mothers were instructed to engage the child as they would at home, taking advantage of the surroundings whichever way they chose, and feeding or changing the child as they deemed necessary. This session lasted exactly 45 minutes and was both audio- and video-recorded through a one-way mirror. Videotapes obtained from this session were subsequently coded for maternal sensitivity.

Prior to the laboratory visit and in order to avoid carry-over effects of one session to the next, each dyad was assigned to one of two procedural protocols to determine in which interaction session they would begin. This counterbalancing scheme involved rotating the order of these session for every dyad and was employed so that, ideally, half of the dyads would have entered the vocal interaction session first, whereas the other half would have partaken in the unstructured/feeding session first. However, modifications to the counterbalancing system were employed when the order of the episodes had to be tailored to the infant's own schedule (e.g. when the infant came to the lab hungry, the dyad was directed first to the 45 minute unstructured session where feeding is encouraged, despite the pre-determined order). Both the mother's direction and the research assistant's judgments about the infant's affective state guided such decisions. Of the 34 dyads, 17 entered the unstructured interaction session, 11 entered the vocal interaction session first, and 7 were assigned to the vocal interaction session first, but were subsequently placed in the unstructured interaction session due to infant protest. For these cases, the order of episodes was mixed, as these dyads were re-directed into the vocal interaction to complete the remainder of the 20 minute session following the termination of the unstructured interaction period.

Following both the 20-minute vocal interaction session and the 45-minute unstructured interaction session, mothers were administered a battery of questionnaires. With the exception of a demographic sheet and the Yale Neuropsychoeducational Scales (Shaywitz, 1982) used for developmental screening, data generated from these questionnaires were not utilized for this study.

Results

Preliminary Analyses

A Fischer's r to z transformation was used to normalize all coefficients of timing prior to data analysis. Table 2 presents the descriptive statistics of the coefficients of timing, whereas table 3 presents a summary of the MS data.

Table 2

Means and Standard Deviations of the Coefficients of Timing

Vocal Parameter	N	M	SD
Mother			
Vocalizations	34	.485	.378
Pauses	34	.531	.576
Switching Pauses	34	.504	.685
Noninterruptive SS	33	.565	.249
Interruptive SS	34	.558	.132
Infant			
Vocalizations	34	.495	.271
Pauses	33	.514	.382
Switching Pauses	34	.531	.365
Noninteruptive SS	33	.557	.186
Interruptive SS	34	.565	.144

Note. The entries in the column labeled M are the average degrees of temporal coordination (r), which have been transformed from z^1-scores back into original form for ease of interpretation. SS = simultaneous speech.

Table 3

Means and Standard Deviations of the Maternal Sensitivity Scores

Score	N	M	SD
MS Overall	34	6.385	1.356
MS Quality	34	6.055	1.727
MS Frequency	34	6.775	1.322

Pearson product-moment correlations were calculated among overall MS ratings, MS frequency scores, and MS quality scores and the following demographic information: mother age, infant age, infant gender, and parity. A significant positive correlation between frequency of interaction and infant gender was found($r = .379$, $p < .05$) and reveals that the mothers of female infants were more likely to engage their infants in interaction than were mothers of males. A significant correlation between MS frequency and parity also emerged ($r = -.371$, $p < .05$), such that mothers of first born infants were found to interact more with their infants than mothers of second born infants.

Relation Between CIT and MS

Two hierarchical multiple regression analyses were employed to test the hypotheses. Although there were no specific hypotheses about these coefficients individually (except that each would relate to MS in a curvilinear fashion), a hierarchical model was applied for two reasons. First, previous research examining the CIT of mother-infant interaction has found that each parameter, when considered separately, reveals important distinctive information about the nature of mother-infant vocal exchange. Second, the procedure for the testing of a quadratic trend in multiple regression requires that scores on each predictor be squared and entered into the regression analysis immediately following the entry of the variable's linear component. Entering the variables in this fashion yields the unique contribution of the quadratic trend, as the variance associated with a given predictor's linear relation to the criterion has been removed (for a complete description of this procedure, see Pedhazur, 1997). Thus, a hierarchical model was used to ensure that each parameter's curvilinear component (i.e. its respective squared value) entered the model directly follwoing its linear counterpart. Order of entry was determined by the theoretical and empirical importance of each parameter (Jaffe & Feldstein, 1999) and is as follows (where each parameter is directly followed by its square): switching pauses, pauses, vocalizations, interruptive simultaneous speech, and noninteruptive simultaneous speech.

The first regression analysis was employed to examine the linear and curvilinear relation between CIT-M and overall sensitivity scores. The five maternal coefficients of coordination were entered individually, followed by their respective squares. Results of this analysis yielded a significant curvilinear relation between CIT-M and coordination of noninterruptive simultaneous speech [$r = .381$, $F(1, 22) = 4.628$, $p < .05$.] and reveals that mothers' who coordinated their noninterrputive simultaneous speech to that of their infants in moderate levels were characterized by high levels of overall sensitivity. In contrast, mothers who were characterized by high or low levels of coordination of noninterrputive simultaneous speech were more likely to be low in sensitivity. No significant linear trends were found.

A similar analysis was employed using the infants' five coefficients of coordination and their respective squares to test for a curvilinear relation between CIT-I and MS. No significant linear or curvilinear component emerged.

Exploratory Analyses

Two post-hoc regression analyses were performed in order to explore the relation between the maternal and infant coefficients of coordination and the MS Frequency and Quality

domains. In the first analysis, MS Frequency scores were regressed on each of the five maternal coefficients of timing and their respective squares. No significant linear or curvilinear relation was found. A similar analysis was then performed using the infants' coefficients of timing and their squares with the MS Frequency score as the criterion. No significant linear or curvilinear relation emerged.

Another set of regression analyses using the MS Quality ratings as the criterion were employed to explore the linear and curvilinear relation between quality of interaction and CIT (mother and infant). Results of the first regression analysis using the maternal coefficients of coordination as predictors were almost identical to those found when MS overall was employed as the criterion, with a significant curvilinear relation between maternal noninterruptive simultaneous speech and CIT-M emerging, $r = .381$, $F(1,22) = 4.63$, $p < .05$. Results of the regression analysis using the infants' coefficients of coordination as predictors yielded no significant linear or curvilinear relations.

Discussion

The findings of this study provide only partial support for the hypothesis that the degree to which mother coordinates her vocal behavior to that of her infant is related--in a curvilinear fashion--to maternal sensitivity. Indeed, the significant quadratic trend of maternal noninterruptive simultaneous speech coordination and MS conforms to the predicted form, such that those mothers who were highest in sensitivity were characterized by moderate levels of noninterruptive simultaneous speech coordination. The second hypothesis, that the infant's degree of vocal coordination to the mother would relate to MS, was not supported. The lack of support for this hypothesis may be a function of limited statistical power and/or the nature of the criterion variable employed, which focuses almost exclusively on maternal behavior. Results of the post-hoc analyses which explored the contributions of CIT to separate domains of maternal sensitivity generate some interesting questions regarding current conceptualizations of sensitive parenting.

The finding that moderate maternal NSS coordination is associated with higher degrees of maternal sensitivity, whereas no other aspects of CIT emerged significant, may be a function of the frequency with which such noninterruptive co-occurring speech occurs during vocal exchanges with pre-verbal infants. Previous research in CIT has found that frequent occurrences of noninterruptive simultaneous speech are characteristic of mother-infant vocal exchanges (Jaffe, Beebe, Feldstein, Crown, & Jasnow, 1999). Anyone bearing witness to mother-infant vocal behavior has likely observed occasions when baby vocalizes and mother pipes in with utterances of encouragement, such as *"Good!"*; *"What else?"*; and *"Tell Mommy more!"*. In those instances, mother's contributions to the dialogue tend to be brief interjections that are not intended to halt the infant's behavior, but instead to facilitate it. As such, the infant continues to have the speaking floor after mother terminates. Such coaction has been referred to by others as marking a high arousal moment of either positive or negative vocal behavior (Stern, Jaffe, Beebe, & Bennett, 1975). During the course of mother-infant vocal exchange, particularly exchanges during which the mother is directly instructed to engage the infant in vocalization (as in this

study), the positive reinforcement of any infant vocal behavior is especially likely. Additionally, this type of noninterruptive co-occuring speech on the part of the mother may also occur during times of infant protest, when the infant persistently cries and mother's turns tend to be brief soothing messages, such as "*It's all right.*"and "*Shh.*", which, despite mother's best efforts, do not serve in all instances to halt the infants' cries.

However, the degree of coordination of MNSS represents the degree to which mother's noninterruptive interjections are coordinated with the same noninterruptive interjections on the part of the infant. Thus, the coordination of MNSS necessarily involves the infant engaging in the same type of vocal behavior as the mother. But why should the infant interrupt the mother's vocal behavior in the same fashion?

Bloom (1993) forwarded the notion that early-occurring repetitive vocal behaviors serve as procedural representations for the timing of dialogues later in development. Under this premise, the timing of adult-infant vocal interactions throughout the first year serves to guide the infant into formulating his/her own schema of conversational timing at 12-months, when speech is emergent. However, further evidence suggests that procedural representations of timing may be manifest before the onset of formal speech in the pre-verbal infant. Previous research informs us that "the turn-taking capacities for the give-and-take interactions of conversation are in place at least by 3 months of age" (Bloom, 1998, p. 316). Thus, even before the end of the first quarter of the first year, infants have acquired some of the conventions of conversational dialogue. In their work, Jaffe and his colleagues (1991) found strong correlations between the CIT-M and CIT-I for each of the same five vocal parameters used in this study. This finding provides evidence that the infant has learned very early on to "match" his/her vocal behavior to mothers (Jaffe et al., 1999). Thus, very early in development the infant has acquired, and will continue to acquire, the procedural knowledge of conversational timing, which is shaped, at least in part, by the temporal pattern that the mother adopts when conversing with him/her.

Given that the infantized speech of the mother tends to be characterized by these noninterruptive interjections, so too do the infant's vocalizations involve brief interjections that do not interrupt the mother's speech. Further, the infant's interjections also tend to convey states of arousal, and these are perhaps equally likely to be positive messages of encouragement or negative messages of distress. For instance, when mother engages the infant by talking, singing, or rhyming, it is not uncommon for the infant to coo or babble with pleasure. This cooing or babbling serves to reinforce mother's behavior and she thus continues vocalizing. Or, when mother is vocally soothing the distressed infant, it is equally common for the infant's cries to interrupt mother's turn briefly, but for mother to persist in her soothing even after the crying or fussing terminates.

The findings of this study suggest that a moderate degree of synchronization in this style of mother-infant vocal exchange is associated with high levels of maternal sensitivity, whereas both low and high degrees of such vocal synchrony are associated with less sensitivity. This finding suggests that a finely-tuned balance in mother's synchronization to the infant's coactions is associated with optimal outcomes. Thus, a mother who fails to interrupt her infant with brief interjections (e.g. reinforcing praise or comforting vocal soothing) to the same degree that her infant does so to her (be it more or less) was more likely to be rated as insensitive. In contrast, a

moderate level of MNSS timing characterizes a vocal exchange where mother times her interjections to her infant's interjections, thereby engaging her infant in a smoothly paced, steady, rhythmic vocal interaction that is associated with high levels of sensitivity.

Theoretically, it seems logical that the coordination of the one vocal state which is perhaps most characteristic of mother-infant preverbal vocal exchanges should emerge as the only significant correlate of MS. In addition, the form of this curvilinear relation is consistent with research in CIT that has found moderate levels of vocal coordination is associated with positive social outcomes (Ashley et al., 1997; Feldstein et al., 1993; Jaffe et al, 1991; 1999).

While the significant curvilinear association between NSS and MS is both significant and theoretically plausible, it is essential to note that any interpretations drawn from this and any finding of this study must be considered with caution, as the findings of this study are limited by the small sample size and the comparatively large number of variables entered into each regression analysis. Indeed, such a small subjects-to-variables ratio, coupled with the use of multiple statistical tests, increases the likelihood that this result is a function of chance alone. In addition, the limited number of subjects compromised the statistical power of the tests, reducing the likelihood that moderate effect-sizes approached significance. However, even given the limited power of the statistical analyses, some important trends in the data warrant mention.

The fact that maternal NSS was the only vocal state to achieve significance may also be a function of limited power. Although early mother-infant vocal exchanges may be typified by noninterruptive co-occurring speech, previous research has demonstrated that there are other vocal behaviors characteristic of mother-infant pre-verbal exchanges which relate to subsequent infant social outcomes. For instance, switching pause coordination, or the degree to which each partner tends to "match" durations of silence to those of the other, is one vocal parameter that has consistently correlated with both subsequent and concurrent infant social outcomes (Ashley et al., 1997; Feldstein, 1993; Jaffe et al., 1999). Although in this study this vocal parameter was not significant, the moderately strong effect (based on Cohen's conventional criteria [Cohen, 1988]) for the curvilinear relation between maternal switching pause coordination and MS (r =.224) suggests that, with more subjects, this relation may have been significant.

Another important trend in the data is the relative size of the quadratic components of maternal CIT as compared to their linear counterparts. Inspection of the effect sizes for the curvilinear trends reveals some important preliminary evidence about the nature of the relation between CIT-M and MS. In all but one of the vocal states, the curvilinear component yielded larger effect-sizes than the linear trends, suggesting that the quadratic trend of CIT-M and sensitive parenting is greater than the linear trend. While this approach to inspection of effect size, despite the lack of statistical significance, permits little more than speculation as to what future data may reveal, the potential importance of such a pattern in the data should not be overlooked. As stated by Abelson (1995), "...Exploratory Data Analysis...sharply shifts emphasis away from statistical significance tests toward freewheeling search for coherent patterns in data..." (p. 11). A preliminary, explorative glance at the data from this study adds further support to the importance of examining both linear and quadratic trends in testing relations between measures of mother-infant temporal coordination and other mother-infant interaction variables. Previous research which examines temporal aspects of mother-infant interaction

supports this claim, as moderate levels of the coordination in both behavioral and vocal timing have been found to be associated with optimum mother-infant outcomes (Ashley et al., 1997; Belsky et al., 1984; Feldstein et al., 1994; Isabella & Belsky, 1991; Isabella et al., 1989). The findings of this and previous work in interactional synchrony informs the field that exploring curvilinear trends in studies of either behavioral or vocal contingency in mother-infant interaction may prove more beneficial than limiting one's scope to testing linear trends only.

The lack of support for the second hypothesis, that the infant's vocal coordination to the mother would also relate to MS in a curvilinear fashion, may also be a function of the limited power in this study. The quadratic component of both infant pause and switching pause coordination (.200 and .249, respectively) was moderate in magnitude, although nonsignificant. The size of these effects suggests that future replications with larger samples are warranted. Also, the infant CIT data provides further evidence that exploring the curvilinear relation between CIT (both mother and infant) and MS may be a fruitful area for further research, as effects for the quadratic components of CIT-I were larger than those of the linear trends.

The lack of significance for the association between the infant's degree of coordination and sensitivity may also be a function of the nature of the dependent variable employed in this study. Previous research has found that the infant's degree of vocal coordination to the mother predicted such variables as mother-infant attachment, infant temperament, and developmental status at 12 months (Jaffe et al., 1999). However, each of these outcomes is dependent on infant behaviors (e.g., exploration, fussiness, and cognitive ability). In contrast, maternal sensitivity, despite the presumed underlying role of the infant in the sensitivity rating, involves gauging primarily the behaviors of the mother. And, although MS, by its original definition, reflects the degree of contingency and reciprocity in the mother-infant behavioral exchange (Ainsworth et al., 1978), no rating scale in the Ainsworth measure addresses contingency explicitly. Instead, contingency is implied by watching the mother's responses to her infant. For instance, ratings are based on judgments such as: Does mom exhibit pride or delight in the infant?; Does mom engage the baby in frequent play behavior?; and How much does mom vocalize to the infant? Perhaps the better questions for measuring contingent responsiveness would be: "Does mom smile when baby smiles?; Does mom play with the baby when the baby wants to play?, or Does mom vocalize when baby vocalizes? Given that the MS ratings used in this study require judgments of maternal behavior, some of which require no explicit judgment of infant behavior, it seems appropriate that mother's degree of coordination to the infant emerges as a significant correlate whereas the infant's coordination to the mother does not.

However, this is not to say that the MS scale employed does not gauge sensitivity. As suggested by De Wolff and van Ijzendoorn (1997), sensitive parenting is multifaceted, and includes such other variables as maternal attitude, emotional support, and stimulation. Ainsworth's MS scales incorporate each of the many of the factors that presumably play a role in sensitive parenting.

The broad conceptualization of MS reflected in Ainsworth's scales served as the basis for the post-hoc analyses employed in this study. Included in Ainsworth's measure are items that tap the quality of mother-infant interaction as well as scales that rate the frequency, or amount, of interaction offered by mother. Intuitively, it does not seem to follow that more stimulation or

interaction indicates more sensitive parenting. However, Ainsworth's MS measure implies that this is the case. The investigator's initial suspicion was somewhat supported by the lack of strong agreement between the newly created frequency and quality domains. This lack of agreement among the MS scales led to the inclusion of the post-hoc analyses that examined the relations between CIT and quality of interaction versus frequency of interaction independently. Although issues of statistical power limit these findings, the fact that the relations between CIT and quality of interaction were quite similar to the findings of CIT and MS overall--while regression of the frequency domain on the coefficients of CIT yielded quite dissimilar findings, none of which were significant-- reveals the potential benefit of tapping MS at a more specific behavioral level. Indeed, this broad conceptualization of MS as reflected in Ainsworth's seminal work and many studies to follow, in conjunction with the disparity amongst the empirical findings in the literature, has sparked a great deal of debate about how best to define MS, both theoretically and empirically (Belsky, 1997; De Wolff & van Ijzendoorn, 1997; van den Boom, 1997; Thompson, 1997). Findings from this study inform this controversial issue in some important ways.

The findings of this study challenge the notion that "more is better" when considering sensitive parenting. Much of sensitive parenting involves careful maternal regulation, wherein interventions are evenly paced, that is, neither over- or under-stimulating. Also, the findings of this study suggest that optimal levels of vocal timing are associated with highly appropriate, high quality interactions--but not necessarily more frequent interactions. Thus, sensitive parenting may involve highly appropriate, but moderate maternal responsiveness. This finding is consistent with the notion of van den Boom (1997), who argues that the commonplace practice of presuming more of a good thing is always in the interest of the child has led to an abundance of research that investigates the linear relation between mother-infant interaction variables and infant social outcomes, therefore applying a nondevelopmental approach to a developmental issue. The same premise holds here, in so much as the findings of this study suggest that perhaps optimal sensitivity is reflected by moderate, comfortable levels of contingent responsiveness.

Finally, results of this study support the need to gauge MS at the specific behavioral level. The coordination of one very specific, but particularly prevalent, aspect of mother-infant pre-verbal vocal exchange is associated with maternal sensitivity. In addition, a more precise preliminary investigation of two separate aspects of MS revealed that more frequent interaction offered by a mother does not necessarily imply higher quality interaction. Finally, the curvilinear trends in the relation between CIT and MS, and the lack of findings for the relation between CIT and frequency of interaction provide suggestive evidence that maternal sensitivity is indeed a complex construct, requiring only modest levels of maternal involvement in some instances, but perhaps high levels of other types of involvement, in other instances (e.g., appropriateness during interactions and accurate interpretation of infant signals). What surfaces from this research is a further confirmation of the emergent notion that MS includes many facets, each of which predict infant social outcomes in different ways. Perhaps MS is best conceived as van den Boom (1997) states: "it would be more fruitful to think of sensitivity not as a parenting dimension that exists apart from other dimensions, but rather, as permeating all interactive behavior. The sensitive parent must package her social interactive behavior in such a way in the interaction flow that it

will promote rather than interrupt the exchange" (p. 593). Surely, further research that explores the role of CIT in sensitive parenting is warranted, as the findings from this study are preliminary and exploratory in nature. However, results of this study do reveal that future research endeavors that are more narrow in scope and open to investigation of both linear and curvilinear trends should aid the field in further defining the complexities of sensitive parenting.

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