ARTICLE

INFANT–MOTHER AND INFANT–FATHER SYNCHRONY: THE COREGULATION OF POSITIVE AROUSAL

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ABSTRACT: To examine the coregulation of positive affect during mother–infant and father–infant interactions, 100 couples and their first-born child were videotaped in face-to-face interactions. Parents' and infant's affective states were coded in one-second frames, and synchrony was measured with time-series analysis. The orientation, intensity, and temporal pattern of infant positive arousal were assessed. Synchrony between same-gender parent–infant dyads was more optimal in terms of stronger lagged associations between parent and infant affect, more frequent mutual synchrony, and shorter lags to responsiveness. Infants' arousal during mother–infant interaction cycled between medium and low levels, and high positive affect appeared gradually and was embedded within a social episode. During father–child play, positive arousal was high, sudden, and organized in multiple peaks that appeared more frequently as play progressed. Mother–infant synchrony was linked to the partners' social orientation and was inversely related to maternal depression and infant negative emotionality. Father–child synchrony was related to the intensity of positive arousal and to father attachment security. Results contribute to research on the regulation of positive emotions and describe the unique modes of affective sharing that infants coconstruct with mother and father.

RESUMEN: Para examinar la co-regulación del afecto positivo durante las interacciones entre la madre y su hijo y el padre y su hijo, cien parejas y sus hijos primerizos fueron grabadas en vídeo en sesiones de interacciones cara a cara. Los estados afectivos de los padres y de los infantes fueron codificados en marcos de un segundo, y la sincronía se midió por medio de un análisis de tiempo en serie. Se evaluaron la orientación, la intensidad, y el patrón temporal del despertar positivo del infante. La sincronía entre las díadas del mismo sexo (madre-hija o padre-hijo) fue más óptima en términos de más fuertes asociaciones espaciadas del afecto entre padre/madre e infante, la más frecuente mutua sincronía, y más cortos espacios de sensibilidad.. El despertar de los niños durante la interacción entre la madre y su infante osciló entre los niveles medio y bajo, y el afecto positivo alto apareció gradualmente y se encontraba metido dentro de una situación social. Durante el juego entre el padre y su infante, el despertar positivo fue alto, rápido y organizado en múltiples puntos máximos que aparecieron con mayor frecuencia a medida que el juego progresaba. La sincronía entre la madre y su infante fue asociada con la orientación social de los participantes y fue inversamente relacionada con la depresión maternal y la negativa emocionalidad del infante. La sincronía entre el padre y su infante fue relacionada con la intensidad del despertar positivo y con la seguridad de la afectividad paterna. Los resultados contribuyen a la investigación sobre la regulación de las emociones positivas y describen los modelos únicos de la afectividad compartida que los infantes co-construyen con la madre y el padre.

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RÉSUMÉ: Pour examiner la co-régulation de l'affect positif durant les interactions mère-nourrisson et père-nourrison, cent couples et leur premier né ont été filmés à la vidéo durant des interactions face-à-face. Les états affectifs des parents et des bébés ont été codés en prises de vue d'une seconde, et la synchronie a été mesurée en analyse de temps-séries. L'orientation, l'intensité et le pattern temporel d'état de stimulation ("arousal," en anglais) positive du bébé ont été évalués. La synchronie entre des dyades parent-bébé de même sexe était plus optimale du point de vue d'associations décalées plus fortes entre l'affect du parent et du bébé, une synchronie mutuelle plus fréquente et des retards de réceptivité plus courts. L'état de stimulation des bébés pendant l'interaction mère-bébé a oscillé entre des niveaux moyens et bas, et un important affect positif est apparu graduellement, encastré dans un épisode social. Durant la séance de jeu père-enfant, l'état de stimulation positif était élevé, soudain, et organisé en pics multiples qui semblaient apparaître plus fréquemment au fur et à mesure que le jeu progressait. La synchronie mère-bébé était liée à l'orientation sociale des partenaires et était inversement liée à la dépression maternelle et à l'émotionalité négative du bébé. La synchronie père-bébé était liée à l'intensité de la stimulation positive et à la sécurité d'attachement paternelle. Les résultats contribuent à la recherche sur la régulation d'émotion positives et décrivent des modes uniques de partage affectif que les bébés construisent avec la mère et le père.

ZUSAMMENFASSUNG: Um die Regulation positiver Gefühle während Mutter – Kleinkind- und Vater – Kleinkindinteraktionen zu untersuchen wurden 100 Paare und ihr erstgeborenes Kind in Angesichts – zu Angesichtsituationen mittels Video aufgezeichnet. Der elterliche und der Gefühlszustand des Kleinkinds wurden jede Sekunde kodiert und die Synchronizität wurde in Zeitablaufsanalysen gemessen. Die Orientierung, Intensität und die zeitlichen Muster der positiven Erregung des Kleinkinds wurden festgestellt. Synchronizität zwischen den gleichgeschlechtlichen Elternteil – Kleinkindpaaren war besser im Bezug auf gleichzeitige Gefühle, häufigere gemeinsame Synchronizität und kürzere Aussetzer in der Beantwortung. Die Erregungen des Kleinkinds während Mutter – Kind Interaktionen hatten ein mittleres und niedriges Ausmaß, hoher positiver Affekt zeigte sich langsam und fand in einer sozialen Situation statt. Während Vater – Kind Spiel war die positive Erregung hoch, plötzlich und in mehreren Spitzen organisiert, die sich häufiger zeigten, wenn das Spiel anhielt. Mutter – Kind Synchronizität korrelierte mit der sozialen Offenheit der Mutter und korrelierte negativ zur mütterlichen Depression und der Mißstimmung des Kleinkinds. Die Vater – Kind Synchronizität korrelierte mit der Intensität der positiven Erregung und der Sicherheit der Beziehung. Die Ergebnisse fügen sich in die Forschung zur Regulation positiver Emotionen ein und beschreiben die Einzigartigkeit des Gefühlsaustauschs des Kleinkinds mit seiner Mutter und seinem Vater.

抄録：母親と乳児の、そして父親と乳児の相互作用の間の、陽性感情の共調節 **co-regulation** を検証するために、**100** 組の夫婦とその第１子が、対面での相互作用をビデオ録画された。親と乳児の感情状態は、１秒毎の枠でコード化され、時系列分析で共時性が測定された。乳児の陽性の覚醒 **arousal** における方向性、強さ、および経過パターンが評価された。同性の親と乳児の間の共時性は、親の感情と乳児の感情の間のより強い遅延した関係性 **lagged associations**、より頻繁な相互の共時性、そしてより短い遅れで応答しやすい、という意味で、より至適であった。母親と乳児の相互作用の間、乳児の覚醒は、中レベルと低レベルの間で循環し、高い陽性感情は、徐々に現れ、社会的なエピソードの中に埋め込まれた。父親と子どもの遊びの間、陽性の覚醒は、高く、突然で、遊びが進むにつれてより頻繁に現れる複数の頂点に組織化された。母親と乳児の共時性は、親の社会的志向性と関連し、母親の抑うつおよび乳児の陰性の感情性と逆方向に関係していた。父親と子どもの共時性は、陽性の覚醒の強さおよび父親の愛着の安定性と関係していた。結果は、陽性感情の調節についての研究に貢献し、乳児が母親と父親とともに構成するユニークな感情共有モードを記述する。

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Of the current topics in developmental research, the study of emotion regulation is among the most central. Infants' and young children's ability to moderate the experience and expression of affect is considered a cornerstone construct in theories of temperament (Rothbart & Posner, 1985), socialization (Eisenberg & Fabes, 1992), attachment (Cassidy, 1994), brain–behavior relations (Schore, 1994; Tucker, 1992), self- and intersubjectivity (Trevarthen, 1993), and psychopathology (Cole, Michel, & Teti, 1994).

Although emotion regulation is defined as the "extrinsic and intrinsic processes for monitoring, facilitating, and inhibiting heightened levels of positive and negative affect" (Buss & Goldsmith, 1998, p. 359), most research to date has focused on the regulation of negative emotions: high negative arousal, anger, fear, or shame. Studies addressing patterns, processes, and individual differences in the regulation of positive affect are rare.

Notwithstanding the different mechanisms involved in the regulation of negative and positive emotions, the two processes share several basic features (Garber & Dodge, 1991; Heller, 1993). All regulatory processes are defined by the interplay between the expression of arousal and the behaviors used for its modulation as they unfold in time. The study of regulatory processes can thus be directed toward the behavioral aspect—the specific behaviors employed in the regulatory effort—or toward the temporal aspect, comprising the organizing parameters that form the process of regulation. To date, most research on affect regulation has examined the specific behaviors infants use in reaction to stress or anger, and less attention has been paid to processes of regulation. Studying the process of affect regulation requires methodology that considers the level of the individual, quantified on the basis of large time series of behaviors, in combination with group trends, based on large samples.

Different neurologic processes, however, are implicated in the regulation of negative and positive emotions, and these are expressed in affect-specific processes and behaviors. The regulation of positive emotions is dominated by left hemispheric activity, whereas the regulation of negative emotions is dominated by the right hemisphere (Davidson & Fox, 1988; Heller, 1993). These two patterns of hemispheric asymmetry form the "approach" and "withdrawal" configurations (Hofer, 1990, 1995). Approach sequences involve motor and expressive behaviors that maintain consistent orientation to the environment and preserve the level of positive arousal to an optimal state. The goal of withdrawal sequences, on the other hand, is to interrupt ongoing behavior, turn away from environmental stimuli, and decrease the level of arousal (Dawson, 1994). Young infants reach high levels of positive arousal mainly during social interactions, and their ability to maintain positive affect requires the assistance of a social partner (Hofer, 1990; Stern, 1990). The regulation of positive affect, therefore, involves a continuous interplay between the partners' building of the infant's positive arousal and their joint moderation of this heightened affect to an optimal state (Feldman, Greenbaum, Yirmiya, & Mayes, 1996). Caretaker and child enter into a coregulatory exchange that integrates and extends the infant's natural cycles of engagement and disengagement (Tronick, 1989). Coregulation is defined as the process through which adult and infant coconstruct, maintain, and organize positive affective states in the context of social interactions (Fogel, 1993). Examining the process of coregulation as manifested in the first social interactions between mothers and fathers and their sons and daughters constitutes the major goal of the present study.

Synchrony has been described as the mechanism mothers use for building and maintaining infants' positive affect during face-to-face interactions. Synchrony refers to the process through which mother and infant match each other's affective states within lags of seconds, jointly moderating the level of positive arousal (Cohn & Tronick, 1988; Feldman & Greenbaum, 1997; Lester, Hoffman, & Brazelton, 1985). The terms coregulation (Fogel, 1993) or mutual regulation (Tronick, 1989), used to define synchrony, indicate that partners coconstruct both the infant's positive arousal and the regulatory framework as play proceeds. Mothers use synchrony to moderate infants' excitement, augment their tolerance for high positive states, and assist infants in processing the high amounts of cognitive and affective information afforded by face-to-face settings (Stern & Gibbon, 1978; Trevarthen, 1993).

Synchrony in dynamic systems, which coordinate sequential functioning in several subsystems, must include time as an indispensable parameter of the synchronizing process (Rosenfeld, 1981). In early social systems, synchrony describes the partners' moving in a coordinated fashion toward increased or decreased interactive involvement and positive arousal. Synchrony in early face-to-face interaction has been defined along three parameters (Feldman, Greenbaum, & Yirmiya, 1999). The first parameter involves the degree of synchrony—the strength of the lagged associations between the partners' behavior. In synchronous social interactions, partners maintain a degree of matched dialogue despite momentary states of miscoordination or external perturbations (Tronick & Cohn, 1989). The second parameter—lead-lag relations—addresses the question of who is driving change in the partners' interactive involvement. The mother may follow the infant's lead and change her behavior accordingly, or the infant may follow the mother's cues and behavior. As infants mature and gain social sophistication, synchronous interactions typically appear in the form of mutual synchrony—a mutual dependence between the partners' behavior. The shift toward mutual synchrony occurs during the second half-year and corresponds with a developmental shift in infants' social initiation and the emergence of intersubjectivity (Rochat & Striano, 1999; Stern, 1985). The third parameter considers the time-lag-to-synchrony—the lag between change in one partner's behavior and a parallel change in the other's. In the first months of life, shorter responsivity lags have been shown as more optimal (Bettes, 1988; Zlachower & Cohn, 1996) and as a better predictor of later self-regulatory capacities in children (Feldman et al., 1999).

To date, time-lag synchrony has been studied mainly in infants' interaction with mothers. The cyclic organization of early social interaction resembles physiologic rhythms of the neonate, observed in patterns of sucking, nursing, crying, or kicking (Burke, 1977; Thelen, 1979; Winfree, 1980; Wolff, 1967). Such rhythms are intimately familiar to mothers, who were thus considered biologically equipped to match microlevel shifts in infant affect (Lester et al., 1985; Stern, 1977). The question of whether fathers or other caretakers are capable of entering this face-to-face "dance" with the infant has remained unanswered, despite the implications of this issue for theories of social development. Although differences were not found between mothers and fathers on global measures of sensitivity (Lamb, 1981), mothers may be unique in their ability to establish microregulatory experiences, which are important inputs for the development of self-regulation (Feldman et al., 1999; Kopp, 1982). On the other hand, if fathers and infants are capable of creating second-by-second synchrony, it is possible that infants experience unique forms of coregulation with mother and father, each of which promotes different developmental outcomes. Understanding the distinct forms of arousal regulation that infants coconstruct with mother and with father may broaden our view on the ways different attachment relationships contribute to the formation of the self (Schore, 1994) or mediate the impact of context on the development of psychopathology (Steinberg & Avenevoli, 2000) by shaping the child's ability to regulate affect.

As coregulation requires the joint maintenance of infant interactive engagement, it involves ongoing relations between infant arousal and its joint moderation. Coregulation, therefore, is influenced by the expression of infant arousal as well as by the parameters of synchrony. Infant positive arousal during face-to-face interaction may similarly be described along three parameters: orientation, intensity, and temporal pattern. Bornstein and Tamis-LaMonda (1990) described the social and object orientations during play (i.e., the child's orientation toward the partner or the external environment, respectively) as two stable orientations that precede different outcomes. The intensity of arousal plays an important role in theories on emotion regulation; it represents a stable, biologically based trait, and is considered a central component of infant temperament (Rothbart, 1989; Schore, 1996). The temporal pattern of arousal refers to the distribution of arousal over time: whether positive arousal is organized in a specific structure (e.g., cyclical pattern), how often do high-intensity peaks of positive emotionality occur, and whether there are sequential relations (e.g., buildup) organizing the occurrence of positive emotional episodes.

Studies comparing the interactive styles of mothers and fathers have pinpointed differences in the expression of positive arousal, especially in the distribution of arousal over time. Father–infant interactions were shown as more arousing, indicating that fathers and infants coconstruct higher levels of positive arousal during play. Father–child interactions often focus on physical, "rough-and-tumble" play rather than on a face-to-face "social" exchange that centers on mutual gaze or covocalization. Father–infant interactions are characterized by frequent, intense bursts of positive arousal and contain quick buildups and declines from peaks of emotional excitement. Father–child play has also been described as less predictable, possibly as these exciting peaks do not follow the same regulated cyclic pattern typical of mother–child interactions. Infants demonstrate higher degrees of joy during father–child sessions and prefer interactions with father, possibly due to the higher overall excitement and the less regulated, perhaps more interesting pattern of positive states (Clarke-Stewart, 1978; Earls, 1976; Henderson, 1980; Kotelchuck, 1976; Lamb, 1977, 1981; Parke & Tinsley, 1981; Yogman, 1981). Although no data is available on father–infant synchrony, these differences in the patterns of arousal are likely to be expressed in distinct processes of coregulation during infant–mother and infant–father interaction.

Because coregulation is highly dependent on the contributions of both partners, it may be sensitive not only to the parent's or infant's gender but also to the gender-matching or mismatching status of the interacting partners. Male and female infants demonstrate different expression and organization of arousal immediately after birth, pointing to endogenous gender differences in modes of arousal regulation. Female newborns are more socially oriented and maintain longer periods of eye contact, while male infants show frequent peaks of excitement, quicker rapidity of buildup, and more labile state control (Osofsky & O'Connell, 1977). During the sleep states of neonates, Korner (1969) found more reflex smiles and rhythmical mouthing in females and more startles in males, defined as quick bursts of energy. Physiologic rhythmic patterns of the neonate lay the foundation for interaction rhythms and synchrony (Hofer, 1987), and these gender differences possibly shape distinct forms of arousal regulation in male and female infants, which in turn, promote different modes of coregulation in same- and cross-gender dyads.

Findings on gender differences in patterns of parent–infant interaction lend support to the hypothesis that the establishment of coregulation may be easier for same-gender dyads, as such processes capitalize on the partners' similar inborn modes of arousal regulation. Mothers tend to vocalize more than fathers (Brundin, Rodholm, & Larsson, 1988), and girls respond better to maternal vocalizations than do boys (Gunnar & Donahue, 1980). Mothers are also quicker to respond to the girl's facial expressions (Haviland, 1977). These tendencies may shape the mother–daughter exchange as a socially oriented form of coregulation, expressed in mutual gaze, shared facial expressions, and covocalization. On the other hand, synchrony with the father's more arousing, quick-peak pattern may be easier for boys, as this pattern mirrors the boy's endogenous expression of arousal. The father's focus on physical rather than social play may similarly accord with the boy's lower inborn tendency for social contact (Osofsky & O'Connell, 1977). Weinraub and Frankel (1977) found that parents and infants in same-gender dyads showed more emotional sharing and physical proximity during play, and the infants reacted with more distress to the departure of a same-gender parent. These findings suggest that same-gender dyads possibly achieve a higher degree of affective matching and that a same-gender parent may provide a closer regulatory framework, whose removal may evoke a higher degree of distress.

In sum, the focus of this study was on the regulation of positive affect, and its goal was to examine the process of regulation as it unfolds in time. Because infants reach and maintain high positive states mainly during social interactions, parent–infant face-to-face interactions were examined as the infant's first experience in the regulation of positive emotions. The two complementary aspects of coregulation were addressed—synchrony and arousal. With regard to arousal, based on research showing father–child interactions to be more arousing and less predictable (Lamb, 1981), the intensity of positive arousal during father–infant interaction was expected to be higher and to contain quick peaks of positive display. The gender-matching status of the partners was of particular interest. It was hypothesized that coregulation among same-gender dyads would be optimal, in terms of closer associations between the partners' behavior, more frequent expressions of mutual synchrony, and shorter lags to responsiveness.

In addition, parental depression, infant negative emotionality, and parent attachment security were examined as potential correlates of parent–infant synchrony. Maternal depression has been associated with diminished maternal ability to coordinate face-to-face settings (Field, 1992; Murray & Cooper, 1997). Field, Healy, Goldstein, and Guthertz (1990) found lower coherence between maternal and infant affective states among depressed mothers as measured by time series analysis. Maternal depression affects the mother's approach orientation, social planning, and timing of communicative behaviors and may thus disrupt the mother's response to microshifts in infant affect (Bettes, 1988; Murray & Cooper, 1997). Infant negative emotionality has similarly been shown to interfere with the development of mother–child synchrony. The infant's reduced capacity to self-regulate was thought to diminish the dyadic ability to settle into a mutually regulated interaction (Feldman et al., 1999). Finally, the parent's attachment security is an additional factor that may be associated with the parent's ability to engage in synchronous interactions. The link between parental sensitivity and infant attachment security is a central component of attachment theory (Ainswoth, Blehar, Waters, & Wall, 1978) and the crossgeneration relationship between the parent's and the infant's attachment security has been demonstrated (Fonagy, Steele, & Steele, 1991). Attachment security in adults has been associated with the capacity to regulate negative affect (Mikulincer, Florian, & Tolmacz, 1990) and may be related to the regulation of positive emotions. It was hypothesized that maternal depression and infant negative emotionality would be associated with lower degrees of parent–infant synchrony, and that the parent's attachment security would predict higher levels of dyadic synchrony.

METHOD

Participants

One-hundred Israeli couples and their first-born children (52 boys and 48 girls) participated in the study. All families were of dual-earner households, and parents reported sharing childcare responsibilities. Mothers were, on average, 27.7 years old ($SD = 3.93$) and had completed a mean of 15.25 years of education ($SD = 1.69$). Fathers were 30.37 years old ($SD = 4.99$), with an average education of 14.54 years ($SD = 1.64$). All parents had completed high school, were currently married and employed, and were considered middle-class by Israeli standards (Harlap, Davis, Grower, & Prywes, 1977).

Couples were recruited through well-baby stations in the Jerusalem and Tel-Aviv areas. Nurses in stations located in the family's immediate neighborhood introduced the study to 110 families who fit the study criteria, after screening the clinic's records for maternal and paternal serious physical illness or psychopathology and infant health complications. A total of 100 mothers agreed to participate. Ten mothers declined after consenting, citing father's refusal or scheduling difficulties as reasons. These families did not differ on demographic and infant variables from the participating families. Infants were five months old ($M = 20.51$ weeks, $SD = 3.14$). They were all born at full term in a singleton birth, with a birth weight of at least 2,700 grams.

Procedure

Parents who indicated their willingness to participate were contacted by phone, and a time for a home visit was scheduled when both parents were home and the infant was expected to be fed and awake. Visits included three videotaped interactions: mother–infant, father–infant, and a family session. The two parent–infant sessions were conducted one after the other in a counterbalanced order (counterbalancing for parent gender), and the triadic family interaction followed the two parent–child sessions. Because this study focused on parent–infant synchrony, the triadic interaction was not included in the present study. Parents were also interviewed in separate rooms and each parent completed a battery of self-report measures. For the parent–infant interaction, the infant sat in an infant seat and the parent sat in a face-to-face position in front of the infant on a chair. A camera was placed in front of the infant to capture the infant's face. A mirror was placed behind the infant and reflected the parent's full face. The final picture showed both the infant's face and the parent's face as reflected in the mirror, which enabled the coding of both partners' facial expression. Parents were instructed to play with the infant as they normally do, and five minutes of each interaction was filmed. Parents were not given any toys, but a few parents used their own toys and were not interrupted. We found no differences on any parental or infant measures between parents who did or did not use toys. Visits were conducted by two graduate students in psychology who were trained in the filming of face-to-face interaction.

Measures

Parent perception of infant difficult temperament. The Infant Characteristics Questionnaire (ICQ) (Bates, Freeland, & Lounsbury, 1979) was utilized to measure infant temperament as perceived by mothers and fathers. The instrument consists of 24 items rated on a nine-point scale, and yields four factors: Fussy–Difficult, Unadaptable, Dull, and Unpredictable. The fussy–difficult factor, used in this study, is the most stable factor, and is theoretically and empirically related to the negative emotionality dimension in other self-report instruments (Bates, 1980; Goldsmith & Alansky, 1987). Mean (and *SD*) fussy–difficult scores were 18.62 (5.97) in mother reports and 20.38 (5.73) in father reports, and higher scores reflected more fussiness. The difference between parents was significant: $F(1, 199) = 4.50$, $p < .05$. Internal consistency for this sample was, alpha = .82 in mother report and .83 in father report.

Parent attachment style. The Hebrew adaptation of Hazan and Shaver's (1987) Attachment Style Prototypes was used to measure parents' attachment style. This self-report instrument conceptualizes adult romantic relations as derivatives and indicative of early attachment relationships and assesses the attachment classifications of security, avoidance, and ambivalence on the basis of the adult's current intimate relationships. The instrument includes three paragraphs, each consisting of five statements, and participants mark the description that best fits their intimate relationships. In the Hebrew version (Mikulincer et al., 1990), each of the five statements is also presented separately in a mixed order and rated on a seven-point scale, which enables the assessment of the three attachment prototypes as continuous variables. Of the three prototypes, only the parent's security score was used in the present study. Mean (and *SD*) security scores were 4.77 (1.10) for mothers and 4.53 (1.02), for fathers with no significant difference between parents (higher score implies more security). Internal consistency for this sample was, alpha = .78 in the mother report and .75 in the father report.

Depressive symptoms. The Beck Depression Inventory (BDI) (Beck, 1978) was employed to measure parental level of depressive symptoms. The BDI includes 21 items on a three-point scale and is the most widely used self-report instrument for the assessment of depressive symptoms, with well-established reliability and validity (Bumberry, Oliver, & McClure, 1978). Mean (and *SD*) BDI scores were 6.20 (4.29) for mothers and 3.91 (3.17) for fathers, indicating higher levels of depressive symptoms for mothers. The difference between mothers' and fathers' depressive symptoms was significant, $F(1,199) = 18.36$, $p < .001$. Internal consistency was, alpha = .88 in the mother report and .81 in the father report.

Coding System for Analyzing Synchrony and Arousal

To provide affective data that could be analyzed for synchrony and arousal measures, the affective states of the parent and infant during the interaction were coded separately in one-second frames using the Monadic Phases Manual (Tronick, Als, & Brazelton, 1980). In this coding system, the stream of affective behavior of each partner is coded using five codes ("phases") for the parent and six codes for the infant. Each code is determined on the basis of facial expressions, vocalizations, direction of gaze, body orientation, and the level of observed positive or negative arousal, which cohere into a distinct affective configuration (Beebe & Gerstman, 1980; Weinberg & Tronick, 1994).

The following codes were used:

1. Protest (infant only)—fuss-cry vocalizations, negative facial expression, gaze and body aversion, and observed negative affect. Infant demonstrates clearly a refusal to participate in the interaction.
2. Avert—gaze aversion, low state of arousal, relaxed facial expression, and no observed affect, indicating a period of "off" or disengagement.
3. Object Attend—a period of engagement, gaze, and body are directed toward an object, affect is generally positive with an occasional smile, arousal is at a medium level, with no signs of high positive arousal.
4. Social Attend—same as object attend but gaze and orientation is toward the partner's face.
5. Object Play—orientation is toward an object and positive arousal is at a high level. High positive arousal is detected by clear signs of positive energy, such as laughing, giggling, sing-song vocalizations, high-pitched motherese, excited movements, or other signs of joy and exuberance.
6. Social Play—same as object play but orientation is directed toward the partner. Social

play is often indicated by covocalizations, joint laughing, mutual gaze, and sharing of facial expressions.

The Monadic Phases are organized on a continuum from negative to positive engagement in the interaction and the coding along a continuum enables the use of time-series analysis. To create the three patterns of arousal (see below) we divided the continuum (from Avert to Social Play) into three levels of arousal.

1. *Low arousal*: was represented by the "Avert" code. In the present study, the Avert code was defined as a period of disengagement or "off" time, and was coded only when the infant was in a low state of arousal. When gaze aversion was accompanied by an increase in negative arousal, such as fussy vocalizations, it was coded as Protest. We also found very few occasions ($<1\%$) for a "Positive Away" state (Cohn & Tronick, 1987). A clear indication of infant positive affect was mostly accompanied by either looking at an object (Object Attend) or at a person (Social Attend).
2. *Medium arousal* was indicated by the Social Attend and Object Attend phases, which implied engagement and focused attention with neutral expressions and medium-level arousal.
3. *High arousal* was indicated by the Social Play and Object Play phases, which marked clear signs of positive arousal, exuberance, and energy.

The Monadic Phases coding systems has been used extensively in the study of mother–infant synchrony (Cohn & Tronick, 1988; Feldman et al., 1999; Field et al., 1990; Lester et al., 1985; Weinberg, Tronick, Cohn, & Olson, 1999). Synchrony, according to this view, occurs when one partner shifts toward more or less involvement in the interaction, and the other partner responds with a shift in the same direction, escalating or diminishing the level of arousal. For instance, such synchrony occurs when the infant moves from gaze aversion to social or object attention, indicating a shift in involvement and an increase in positive arousal, and the parent responds by shifting from neutral attention to high positive arousal, stimulation, and social play.

Coding of the videotapes was conducted in a university laboratory by four graduate students in psychology, who did not participate in the home visits, following extensive training in the use of the Monadic Phases coding system. Coding was conducted in one-second frames for three minutes of the interaction: the second, third, and fourth minutes. In previous work (Feldman et al., 1996, 1999; Feldman & Greenbaum, 1997), we found that these minutes are the most pronounced period of play at this age, occurring once the infant's gaze is focused on the parent's face and before the infant shows signs of fatigue. To ensure unbiased assessment, coding of the parent's and the infant's affective states was not done successively. Coders watched the videotape in real time, noted the approximate time of phase change in minutes and seconds, and then returned and assessed the exact time of phase change while the videotape was running in slow motion. Because time-series analysis requires at least 100 observations with no missing data for valid analysis (Gottman, 1981), in the few cases when missing data occurred because of filming difficulties, we found a sequence of at least 100 seconds from the five-minute interaction with no episodes of missing data.

Coding resulted in 400 time series (100 infants $\times$ 2 and 200 parents), each containing 180 observations. Interrater reliability was performed for 20 mothers and their infants and for 20 fathers and their infants. Reliability kappas were conducted in one-second time window and were .84 for mothers' time series (range .75–.89), .86 (range .74–.90) for infants' time series with mother, .84 (range .71–.88) for fathers' time series, and .85 (range .71–.88) for infants' time series with father.

Data Analysis: Computing Synchrony

Synchrony was computed separately for each dyad using a time-domain time-series analysis. This data analysis method involved several steps. Prior to the assessment of synchrony, the autocorrelated component in each time series needed to be partialed out. The autocorrelated component in the time series refers to the infant's natural tendency to cycle between states of engagement and disengagement, regardless of the parent's behavior. Synchrony between the partners' affective states can only be inferred when the autocorrelated contribution in each time series is controlled.

The autocorrelated component in the time series was estimated using separate Autoregressive Integrated Moving Average (ARIMA) models for each series. ARIMA is a univariate time domain technique that estimates the internal structure of a series and involves three steps. First, the autoregressive component in a time series (AR) was estimated on the basis of the autocorrelation (ACF) and the partial autocorrelation (PACF) plots. These plots are visual representations of the time series and its autocorrelation matrix at different lags. Second, a best-fitted model for the time series was estimated. Finally, the series of residuals from the best-fitted model was diagnosed for lack of autocorrelation in the residuals, using the Box-Ljung Q statistic, to ensure that the series of residuals was randomly distributed (Gottman, 1981; Gottman & Ringland, 1981). Once the autocorrelated components in the parents' and infants' time series were partialed out, crosscorrelation functions (CCFs) for each dyad were computed with the two series of residuals. The CCF assesses the lagged correlations between the parent's and the infant's behavior at various lags above and beyond the internal rhythms in each partner's affective states.

Parameters of Synchrony

Three variables were derived from the analysis of parent–infant synchrony. The degree of synchrony variable indexed the strength of the associations between the two time series. The mutual synchrony variable pinpointed the lead-lag relations between the interacting partners. The time-lag-to-synchrony variable referred to responsiveness lags (in seconds) between change in one partner's behavior and corresponding change in the other's.

Degree of synchrony. The continuous definition of synchrony was used to measure degree of synchrony—i.e., the degree to which the partners change their affective behavior in reference to one another. This allowed for greater variability than would a dichotomous definition (i.e., whether or not significant lagged relationships were found between the parent's and the infant's time series). Synchrony as a continuous variable is indexed by the size of the largest crosscorrelation coefficient on the CCF plot. Scores range from 0, implying no associations between the two time series, and 1, describing a perfect match between the two time series. For each dyad, synchrony was indexed by the size of the largest crosscorrelation coefficient on the CCF, whether it was significant or not and regardless of whether the peak was positive (implying an infant-leads-parent-follows relationship) or negative (implying a parent-leads-infant- follows relationship).

Mutual synchrony: The lead-lag relations. The lead-lag relationship pinpoints the direction of dominance in the interaction and considers the question of who is driving change in the partners' affective behavior. Lead-lag relationship variables are meaningful only when the interaction is synchronous and when significant relations are found between the partners' behaviors. Thus, the lead-lag relation variables took a value only when the crosscorrelation coefficient was significant and when at least one significant peak appeared on the CCF plot. Lead-lag variables were used as binary variables taking a value of 1 when applicable and a value of 0 otherwise. Three such binary variables were computed: parent synchrony with infant, infant synchrony with parent, and mutual synchrony. These variables were assessed according to the direction of the peaks on the CCF plot. A positive peak indicated parent synchrony with infant, implying that the parent responds to changes in the infant's affective behavior. A negative peak indicated infant synchrony with parent, suggesting that the parent was leading and the infant was following. Mutual synchrony was inferred when both positive and negative peaks appeared on the CCF, implying that both partners were responsive to changes in each other's affective behavior and that the interaction was mutually dependent.

Time-lag-to-synchrony. The time-lag-to-synchrony variable indicates the time in seconds between change in one partner's behavior and corresponding change in the other's. Similar to the lead-lag relation variables, the time-lag-to-synchrony variable assumed a positive value only when at least one significant peak appeared on the CCF. The time-lag to the first significant peak, whether positive or negative, was used to index time-lag-to-synchrony. This variable measured the time required for the dyadic system to settle into a coregulated exchange. The time-lag-to-synchrony variables were within the range of 1 (implying one second to the partner's responsiveness) and 7.

Parameters of Arousal

Three variables considered the infant's positive arousal during face-to-face interactions and were extracted from the infant's time series.

Social orientation. The degree to which the infant's positive arousal was socially directed and focused on the parent's face (as opposed to object orientation or gaze aversion) was computed as the summed proportions of the social attend and social play frames in the infant's time series.

Positive arousal. The relative proportion of time in which the infant showed high positive arousal was computed as the summed proportions of the social play and object play frames in the infant's time series. High positive arousal indicated periods in which the infant shows clear signs of positive energy, laugh, and exuberance directed toward the parent or toward an object of joint attention.

Pattern of positive arousal. To describe the distribution of positive arousal over time, in addition to its relative frequency that is measured by the positive arousal variable, three patterns of positive arousal were described. Patterns were defined according to the number of "peaks" the infant reached during play. Peaks were defined as episodes of high positive arousal, indexed by the codes of object play or social play. The assessment of the pattern of arousal variable and the evaluation of "peaks" did not consider the global amount of positive arousal during play. The purpose of using this is measure was to examine how often peaks of positive arousal were reached, how quickly episodes of emotional intensity decline, and what was the interpeak interval. This measure, therefore, relates to the organization of positive arousal across time.

Patterns were as follows:

1. No Peak: no episode of positive arousal was reached during play, and the infant's affect cycled between states of medium and low arousal (Attend and Avert).
2. Single Peak: infant arousal generally cycled between medium and low level, but one

episode of positive arousal was reached during play. This single episode of positive arousal was typically reached gradually, was preceded by a state of neutral arousal, and was embedded within the partners' mutual gaze. The most frequent phase preceding and following the positive peak in this pattern was Social Attend: $\chi^2(4) = 10.35$, $n = 43$, $p < .001$, and: $\chi^2(4) = 5.42$, $n = 43$, $p < .01$, for the phase succeeding the single peak.

3. Multiple Peak: the infant reached several peaks of positive arousal during play. These peaks were of short duration, lasting no longer than one or two seconds, and no systematic buildup or decline from the positive peak was found: $\chi^2(4) = 1.02$, $n = 93$, NS, for the preceding phase, and $\chi^2(4) = .98$, $n = 93$, NS, for the succeeding phase.

During mother–infant interaction, the number of multiple peaks ranged from 2 to 18, and during father–infant interaction, the number of peaks ranged from 2 to 23.

Infant negative emotionality composite. This variable was created to measure the infant's negative emotionality on the basis of both parent report and direct observation. For each parent–infant interaction, the infant's global negative emotional display during the session was rated on a five-point scale ranging from low negative emotionality to high expression of negative affect. Coding was conducted by two coders who were not involved in the microanalytic coding. Reliability kappa measured on a random sample of 15 infant–mother and 15 infant–father interactions was .89 (range = .82–.93). The negative emotionality composite was computed for each parent–infant session as the average of the standardized ICQ Fussy-Difficult score of the interacting parent and the standardized score of the rated negative emotionality score. The observed negative emotionality score and the self-reported ICQ score were related, $r = .58$, $p < .001$. The final negative emotionality composite was the average of the standardized coded negative emotionality score of the standard ICQ score (alpha = .73).

RESULTS

Data Analysis Plan

Results are reported in three sections. In the first, mean level differences are presented for synchrony and arousal. In the second section, the patterns of infant positive arousal are explored and relations between synchrony and patterns of arousal are examined. In the third section, regression models predicting the degree of synchrony in infant–mother and infant–father interaction by parameters of arousal and the background variables are presented for same-gender and cross-gender dyads.

Mean Level Differences

Descriptive statistics for the synchrony and arousal variables are presented in Table 1.

Synchrony. Multivariate analysis of variance (MANOVA) with parent gender and infant gender as the between-subject factors were conducted for the three parameters of synchrony (degree of synchrony, mutual synchrony, time-lag-to synchrony). No overall main effects for parent gender or infant gender were found. A significant overall interaction effect was found, Wilks' $F(3, 195) = 2.72$, $p < .05$. Univariate analyses are reported in Table 1. Analyses for the continuous variables (degree of synchrony, time-lag-to-synchrony) were computed with anal-

TABLE 1. *Descriptive Statistics for Synchrony and Arousal*

	A: Mother–Daughter		*B: Mother–Son*		*C: Father–Daughter*		*D: Father–Son*		
	M	SD	M	SD	M	SD	M	SD	*Interaction F*
A: Synchrony									
Degree of Synchrony[a]	.18	.06	.16	.05	.17	.06	.20	.07	3.85* D > C
Mutual Synchrony[b]	29%		24%		17%		26%		4.21* A > B, D > C
Time-Lag-to-Synchrony (seconds)	2.35	1.13	3.05	2.08	3.44	2.45	2.52	1.24	3.96* A > B, D > C
B: Arousal									
Social Orientation[c]	.27	.23	.26	.22	.26	.23	.23	.20	.68
Positive Arousal[c]	.16	.09	.17	.07	.19	.10	.20	.10	1.85
Pattern of Arousal[b]:									
No peak	44%		35%		14%		15%		1.65
One peak	25%		30%		29%		23%		
Multiple peak	31%		35%		57%		62%		

* < .05.
[a] Numbers represent the size of the crosscorrelation coefficients.
[b] Numbers represent the percentages of dyads showing Mutual Synchrony or specific patterns of arousal.
[c] Numbers represent the proportion of frames infants showed Social Orientation or Positive Arousal.

ysis of variance (ANOVA) and for the categorical variable (mutual synchrony) with log-linear analysis. ANOVA for the degree of synchrony was computed after coefficients were transformed into z scores.

As seen in Table 1, interaction effects were found for all three synchrony variables, suggesting a closer affective coordination between same-gender dyads. Post hoc comparisons with Duncan's tests followed the three significant interaction effects. Results showed that for the degree of synchrony, significant differences were found between father–daughter and father–son synchrony, $F(1, 99) = 3.98$, $p < .05$, but not between mother–daughter and mother–son synchrony. For mutual synchrony, post hoc comparisons indicated significant differences between mothers' interaction with sons and daughters, $F(1, 99) = 3.79$, $p < .05$, as well as between fathers' interaction with sons and daughters, $F(1, 99) = 3.83$, $p < .05$. Finally, post hoc comparisons showed that same-gender partners were quicker to respond to changes in each other's affective states. Significant differences emerged between mother–son and mother–daughter dyads; $F(1, 99) = 3.76$, $p < .05$, as well as between father–son and father–daughter dyads, $F(1, 99) = 3.98$, $p < .05$.

Arousal. A similar multivariate analyses of variance (MANOVA) with parent gender and infant gender as the between-subject factors conducted for the three arousal variables (social orientation, positive arousal, pattern of arousal) revealed no overall main or interaction effect.

Different patterns of arousal characterized infant–mother and infant–father interactions. The no-peak pattern and the single-peak pattern were more frequent during infant–mother interactions, whereas the multiple-peak pattern was more frequent during father–infant interaction: $\chi^2(2) = 6.08$, $N = 200$, $p < .05$. As seen in Table 1, during mother–infant interactions, most infants cycled between states of neutral and low arousal with or without a single positive peak, and when the single peak appeared it was typically embedded within a social episode.

During father–infant interactions, infants' arousal was typically organized in several bursts of emotional intensity that seemed to appear at random and could be reached from any state.

Patterns of Positive Arousal: Temporal Organization and Relations to Synchrony

To further understand the temporal organization of the multiple-peak pattern and to examine whether peaks occurred at random or were organized in a certain temporal order, the length of the interpeak interval was measured across the session for interactions that contained three or more positive peaks. For each interaction containing three or more peaks (infant–mother: $N = 30$, infant–father: $N = 55$), a regression function was fitted for the interpeak intervals. The slope of the regression function measuring the gap between peaks was used to assess whether peaks appeared more rapidly, more slowly, or were evenly distributed across play (see Benasich and Tallal, 1996, for a similar assessment of infants' visual habituation). The distribution of peaks across time was different in infant–mother and infant–father interaction. Slopes of the interpeak intervals were −4% in mother–infant interaction ($SD = 39.98$) and −39% ($SD = 49.16$) in infant–father interaction, and the difference was significant, $F(1, 84) = 8.36$, $p < .01$. During mother–infant interaction, when infants' arousal was organized in multiple peaks, peaks of positive arousal appeared in relatively regular intervals across the interaction. During father–infant interaction, on the other hand, the gaps between positive peaks became increasingly shorter with time, and bursts of emotional excitement seemed to appear more frequently as partners became involved in play.

To examine the relations between the parameters of synchrony and the three patterns of arousal, the latter were combined into two categories. The no-peak and single-peak patterns were combined, to describe interactions in which arousal generally cycled between low and medium levels, typifying infant arousal during interaction with the mother. The multiple-peak pattern described interactions in which the infant reached several episodes of high arousal levels, typifying infant arousal during interaction with the father. A 2 (patterns of arousal) × 2 (parent gender) ANOVA yielded a significant main effect of pattern for the degree of synchrony; $F(1, 199) = 3.85$, $p < .05$. The degree of synchrony was higher when the interaction contained multiple peaks of positive arousal ($M = .19$, $SD = .05$) than when no peaks or a single episode of positive arousal was found ($M = .16$, $SD, = .07$). A similar 2 × 2 log-linear analysis computed for mutual synchrony showed an interaction effect: χ^2 (1) = 3.95, $N = 200$, $p < .05$. In mother–infant interactions, mutual synchrony was more likely to occur if the infant's arousal cycled between low and medium arousal; during father–infant interaction, mutual synchrony was more frequent if the infant's arousal showed multiple peaks. Mutual synchrony, therefore, seems to be associated with the pattern of arousal that is more typical of the interacting parent.

Predicting Synchrony

Tables 2 and 3 present hierarchical multiple regression models predicting infant–mother (Table 2) and infant–father (Table 3) synchrony. The dependent variable in each equation was the degree of synchrony—the continuous variable assessing the degree of lagged associations between the two time series. As this study focused on the relations between synchrony and arousal, the first set of predictors included the three arousal variables: social orientation, positive arousal, and pattern of arousal. To test the relations between parent–infant synchrony and parent and child characteristics, the infant negative emotionality composite, parent depression, and parent attachment security were entered following the arousal variables. The infant measure

TABLE 2. *Predicting Mother–Infant Synchrony*

	Total Sample			*Mother–Daughter*			*Mother–Son*		
	Beta	R^2	F *Change*	*Beta*	R^2	F *Change*	*Beta*	R^2	F *Change*
Criterion: Mother–Infant synchrony									
Predictors									
Social orientation	.30	.10	10.20**	.25	.11	5.30*	.55	.09	4.69*
Positive arousal	.11	.10	.40	.15	.12	.47	−.11	.09	.27
Pattern of arousal	−.09	.10	.07	−.01	.12	.00	−.15	.10	.35
BDI	−.19	.12	2.39	−.20	.17	2.32	−.50	.23	7.47**
Infant negative emotionality	.26	.20	6.99**	−.27	.26	4.93*	−.22	.26	1.90
Parent attachment security	−.10	.21	1.54	.11	.27	.13	.09	.27	.26

Total $R^2 = .21$; $F(6, 92) = 3.63$, $p < .01$; Total $R^2 = .27$; $F(6, 40) = 2.43$, $p < .05$; Total $R^2 = .27$; $F(6, 40) = 2.55$, $p < .05$; * <.05, ** $p < .01$.

(negative emotionality) preceded the parent measures, and depression preceded attachment in line of previous research linking decreased mother–infant synchrony and maternal depression (Field et al., 1990). In each table, three regression models are presented, for the entire sample and for the gender-matched and gender-mismatched dyads.

As reported in Table 2, mother–infant synchrony was independently related to the dyad's social orientation and to infant negative emotionality. Examination of the same- and crossgender dyads showed that mother–daughter synchrony was related to the partners' social orientation and to the daughter's negative emotionality. Mother–son synchrony was associated with the partners' social orientation and with maternal depression, highlighting the differential effects of maternal depression and infant negative emotionality on the mother–infant synchrony.

Table 3 presents similar models for father–infant synchrony. As can be seen, the degree of father–infant synchrony was related to the level of positive arousal that the infant displayed during play and to the father's attachment security. Father–son synchrony was uniquely related to the level of the son's positive arousal and to the organization of positive arousal in multiple

TABLE 3. *Predicting Father–Infant Synchrony*

	Total Sample			*Father–Daughter*			*Father–Son*		
	Beta	R^2	F *Change*	*Beta*	R^2	F *Change*	*Beta*	R^2	F *Change*
Criterion: Father–Infant synchrony									
Predictors									
Social orientation	−.17	.00	.00	−.14	.00	.25	−.14	.00	.11
Positive arousal	.33	.08	8.09**	.32	.14	.30**	.63	.33	20.03***
Pattern of arousal	.10	.09	.67	−.06	.15	.21	.28	.38	3.15*
BDI	.00	.09	.00	−.14	.17	.97	.08	.38	.04
Infant negative emotionality	−.10	.10	1.61	−.02	.18	.00	−.03	.38	.00
Parent attachment security	.25	.16	6.10**	.33	.28	6.02*	.11	.39	.58

Total $R^2 = .16$; $F(6, 92) = 2.78$, $p < .05$; Total $R^2 = .28$; $F(6, 44) = 2.65$, $p < .05$; Total $R^2 = .39$; $F(6, 44) = 3.85$, $p < .01$; * <.05, ** $p < .01$. *** $p < .001$.

positive peaks. Father–daughter synchrony was related to the daughter's level of positive arousal and to the father's attachment security.

In sum, results of this microanalytic assessment of parent–infant synchrony revealed three main findings. First, different patterns of parent–infant synchrony were found in same-gender dyads. Second, different forms of coregulation emerged during infants' interaction with mother and with father. Third, the background variables were differentially related to mothers' and fathers' synchrony with sons and daughters.

DISCUSSION

Although emotion regulation predominates among current topics of interest in the field of child development, little research has addressed the regulation of positive emotions. A central context for the regulation of positive affect in infancy is the face-to-face exchange, where the infant's positive affect is constructed and coregulated by means of parent–infant synchrony. Results of the present study demonstrate that fathers and mothers are equally capable of engaging in second-by-second synchrony with their infant, suggesting that mothers are not unique in their ability to match microshifts in infant affect. Each parent, however, seems to offer infants different experiences and practice in affective sharing and arousal regulation. Mothers offer the coordination of socially oriented affective signals, and fathers offer the management of high-intensity turns in positive arousal. In addition, the degree of interactive synchrony between parent and child was higher in same-gender parent–infant dyads, possibly as synchronous processes integrate and extend the partners' inborn modes of affect regulation (Hofer, 1987, 1990). These findings may suggest that the effects of parent–infant synchrony on the development of children's self-regulation, previously shown for mother–infant interaction (Feldman et al., 1999; Gianino & Tronick, 1986; Kopp, 1982), need be examined in relation to the parent's and the child's gender. In the same vein, developmental consequences of parental absence or emotional unavailability may also be related to the gender-matching or mismatching status of the parent and child.

Infants' arousal during mother–infant interaction was mostly organized in cyclic oscillations between states of low and medium states of arousal, with or without a single positive peak. Such rhythms are thought to provide continuity from the rhythms of intrauterine and early neonatal movements to the interaction rhythms of the first social dialogue (Stern, 1977). When peaks of positive emotionality appeared, they were mostly embedded within the partners' mutual visual regard, were preceded by a gradual buildup from medium arousal, and were followed by a gradual decline. Mother–infant synchrony was linked to the partners' social orientation, as manifested in patterns of mutual gaze, sharing of facial expressions, and covocalization. These outcomes are consistent with previous accounts on the microanalytic features of mother–infant face-to-face interaction (Beebe & Gerstman, 1980; Feldman & Greenbaum, 1997; Kaye & Fogel, 1980; Trevarthan, 1993). The mode of coregulation that the infant experiences with the mother appears to be characterized by stable, regulated turns in arousal and by mutual focus on the facial and vocal signals of the social partner.

As distinct from mother–infant cyclicity and social focus, the mode of arousal regulation during father–infant play was directed toward the building and organizing of high emotional intensity. Although the level of positive arousal infants reached during play with mother and father was similar, differences emerged in the organization of positive arousal across time in the two sessions. Positive arousal during father–child interaction was often organized in several peaks of high positive intensity. These peaks were not embedded within a social episode, were sudden rather than gradual, and tended to appear more frequently as play progressed. In contrast to the global observation that father–infant interactions are unpredictable (Lamb, 1981), the current microanalysis reveals that father–child play abides by complex temporal rules. These rules may be less regulated than those underlying the mother–child exchange, but the interaction is not a random display of positive emotionality. Furthermore, the degree of synchrony was found to increase when play included several quick peaks, possibly to protect against infant disorganization during father–child sessions when positive emotionality is high and sudden. Father and mother, therefore, may facilitate the development of different modes of affective sharing and co-regulation, different schemas of "being-with-other" (Stern, 1990). It is possible that these two modes of nonverbal communication may later emerge in relationships that incorporate more or less novelty, emotional intensity, or social focus.

The present study is among the first to examine father–infant microlevel synchrony in a large sample, thus providing data on the full parent gender by infant gender matrix. The interaction effects found for the three parameters of synchrony demonstrate that same-gender parent–infant dyads achieve a closer affective match during face-to-face interactions. This was evident in stronger lagged associations between the time series of fathers and sons, more frequent mutual synchrony between mothers and daughters as well as between fathers and sons, and shorter responsiveness lags between mother–daughter and father–son pairs. These variables accentuate a higher degree of attunement and more mature social dialogue between same-gender partners (Bettes, 1988; Feldman et al., 1999; Rochat & Striano, 1999). The similarity in biologic preparedness between parent and child in same-gender dyads may have facilitated the greater degree of affective matching between the interacting partners. Due to the fact that most large studies on the early social relationship (especially those using microanalytic codes) were conducted with mothers, the present results may extend our understanding of parent–infant attunement, particularly on the mother–son match. Weinberg and colleagues (1999) found more disruptions in the synchrony between mothers and sons, expressed in lower rates of matched states and longer latencies to reparation from mismatched to matched states. It is possible that such difficulties are related not only to the boy's general tendency toward emotion dysregulation, as the authors suggested, but also to the gender mismatching status of mother and son. In the present sample, father–son pairs showed the highest degree of synchrony a compared to all other groups, but such synchrony had a nonsocial interactive orientation and play containing quick, starlike episodes of high positive arousal. Thus, the higher degree of affective mismatching the infant son may encounter during interactions with his mother may be balanced by the experience of a natural coordination with the father. Such findings underscore the importance of attuned fathering during the first months of life to the male infant's social development and self-regulation.

It is possible that the closer synchrony observed between same-gender dyads may be related to children's preference to play with same-age peers from the toddler years through preadolescence (Maccoby & Jacklin, 1974). Perhaps at the early stages of socialization, same-gender friendships may facilitate the integration of the child's biologic modes of arousal regulation into the coregulated process of children's play, thereby assisting the development of imagination and creativity (e.g., Winnicott, 1971). The findings may also be related to the literature tracing the effects of father absence on the development of dysregulation in boys but not in girls (Cabrera, Tamis-LeMonda, Bradley, Hofferth, & Lamb, 2000). The coregulation formed between father and son during the first months of life may be essential environmental inputs that facilitate the formation of self-regulatory capacities. Under optimal conditions, infants should have the opportunity to experience affective coordination with a gender matching as well as mismatching parent. In these two types of early interactions, infants can engage in coregulatory processes that provide a good fit to their natural tendencies as well as in those that introduce different forms of affective sharing and arousal regulation.

Different maternal and infant characteristics were related to infant–father and infant–

mother synchrony. Infant negative emotionality was inversely related to mother–infant synchrony, whereas paternal attachment security was associated with father–infant synchrony in the entire sample. In the separate analyses of the gender-matching and mismatching groups, maternal depression had a unique contribution to the prediction of mother–son, but not mother–daughter synchrony; infant negative emotionality uniquely predicted mother–daughter synchrony, and attachment security was independently related to father–daughter synchrony. Mother–child synchrony seems to be more sensitive to the child's inborn capacity to self-regulate, as expressed in the child's negative emotionality, than is father–child synchrony. Possibly, as mother–child interaction is organized in a more regulated cyclic pattern, infant dysregulation may be more disruptive to the formation of cyclic rhythms. The relation between synchrony and negative emotionality was more pronounced in mother–daughter dyads. Mothers and daughters tend to vocalize more (Brundin et al., 1988) and pay closer attention to each other's affective states (Haviland, 1977). The daughter's fuss–cry vocalizations and negative facial expressions may interfere with the formation of synchrony when the mother is very attentive to the child's emotional display. The relations between maternal depression and the mother's ability to synchronize with microshifts in infant affect had been documented (Field et al., 1990; Murray & Cooper, 1997). The maternal mode of synchrony, which relies on patterns of mutual gazing and covocalization, may be more sensitive to the adult's depression and its resulting deficits in the encoding and expressing of facial and vocal signals (Murray, Kempton, Woolgar, & Hooper, 1993). The uniqueness of this effect to mother–son dyads may be related to the greater impact of maternal depression on the interaction with her son, where the process of synchrony is more fragile and there is a decreased dyadic ability to repair mismatched states (Weinberg et al., 1999).

The finding that the parent's attachment security was related to father–child but not to mother–child synchrony was somewhat surprising. Previous research on the predictors of parent–child relationship at the transition to parenthood show that the mother–child relationship is often linked to maternal personality factors, such as anxiety, depression, or adaptation, whereas the father–child relationship is related to the marital quality (Belsky, Youngblade, Rovine, & Volling, 1991; Feldman, 2000; Feldman, Nash, & Aschenbrenner, 1983; Heinicke, 1984). Belsky and Pensky (1988) observed that fathers in distressed relationships with their spouses tend to withdraw from their infants and are less involved and attuned during father–child interactions. Possibly, the measure of attachment used here, which defines attachment security on the basis of the parent's current intimate ties, is related to the marital quality as the two measures consider the spousal relationship. The special effect of paternal attachment security on father–daughter synchrony may be viewed from the crossgeneration perspective in attachment theory and the internalized link between the father's mother, wife, and daughter. The father's attachment to his mother is thought to shape his romantic relationship with his wife (Hazan & Shaver, 1987), and this line of positive attachments to women may facilitate an attuned relationship between the father and his infant daughter.

In sum, the maternal and paternal models of synchrony provide infants with varied opportunities to engage in interactions having a greater or a lesser focus on social orientation, positive energy, and regulated rhythms, thus affording practice in different modes of arousal regulation. Wright (1991) and Schore (1994) suggested that the emergence of the self as a cohesive and regulatory structure draws upon the infant's microregulatory experiences during face-to-face interactions—experiences that integrate visual, vocal, tactile, and rhythmic inputs into a coordinated social event. The contribution of father–child synchrony to the formation of the self requires much further research and is possibly related to the specific mode of coregulation during father–infant interaction.

Future research may examine the effects of parental unavailability in same-gender versus crossgender parent–child relationships, its specific cause (divorce, death, long working hours, or personality factors), and the extent of its influence on children's self-regulatory skills in the cognitive or social-emotional domains. Furthermore, the impact of parental synchrony or unavailability may be particularly salient at periods of reorganization, such as school entry or puberty, when earlier modes of self-regulation may give way to new and mature ones. Thus, the link between same- and crossgender relationships and child outcomes should be examined at different developmental nodes. Father and mother coconstruct with the infant unique experiences of sharing, intimacy, and coregulation. The impact of these modes of affect coregulation on the child's developing social skills, sense of security, creativity, and the ability to form intimate ties throughout life are exciting questions for future research.

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