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Comparing emotional coordination in early spontaneous mother–infant and father–infant interactions

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We compare matching of facial expressions and attunement of emotional intensity in spontaneous communication of mothers with infants and of fathers with infants, in families in Crete. Eleven infant–mother and 11 infant–father dyads were video-recorded at home in familiar interactions from the 2nd to the 6th month. Microanalysis of infant, maternal and paternal facial expressions of emotion provided evidence of quantitative differences that favour father–infant interaction as more playful, but the infants' behaviours with mothers and fathers show similar developmental curves. These results are discussed in the frame of the theory of innate intersubjectivity and of the emotional support parents give to developing motives of infants.

Keywords: Mother–infant interaction; Father–infant interaction; Emotional coordination; Emotional matching; Emotional attunement; Innate intersubjectivity.

By comparing emotional coordination in mother–infant and father–infant interactions at home, we examine emotional expressions exchanged between infants and parents in early months and we consider possible consequences for learning and the negotiation of interpersonal challenges.

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Theories of affective communication with infants

Different conceptions of how infants express their feelings and understanding in responses to an adult's emotional states relate to hypothetical mechanisms offered to explain human communication. In critical response to the "romanticized" notion that mothers and infants strive to synchronize in emotional harmony, Tronick, Reck and their colleagues present evidence that a more flexible process of match, mismatch and re-match, or "disruption and repair", characterizes mother–infant interaction more accurately (Reck et al., 2011; Tronick, 2005; Tronick & Reck, 2009). For these authors, "coordination" results not only from "matching", how mother and infant engage in the same behaviour at the same time, but also adjustment of the "rate of change" between matching and mismatching, and variations in "synchrony", the degree to which mothers and infants behave with the same rhythm. Beebe (2010) distinguishes "bi-directional" or "interactive" activities of "regulation" or "coordination". These constitute a "co-constructed" process in which each partner makes moment-by-moment adjustments to the other's shifts in behaviours, such as facial expressions, while sustaining self-regulation. But "coordination", the degree of matching of the *form* of expression, requires consideration as well of "affective attunement", sharing of the values of inner animation and *feelings* (Stern, Hofer, Haft, & Dore, 1985). Feldman (2003, 2007) defines "synchrony" as partners' strive towards increased or decreased mutual involvement and positive arousal. The psychobiological theory of "Intersubjectivity" attends to the whole process by which creative regulations in the mental activity of the integrated self, including conscious awareness, motives, intentions and emotions, are transferred between minds to generate shared human agency (Trevarthen, 1997, 1998, 2005). It draws on evidence that infants possess innate motives expressed with qualities of emotion and adapted to perceive, respond to, attract and influence how other persons feel and what they, in response, will perceive and do. This readiness for relationships is reflected back to affect the state of emotional equilibrium or "intra-subjective coherence" of the infant's self (Trevarthen, 1997). Based on previous behavioural evidence (Kokkinaki, 2009), we anticipate that parameters found to regulate mother–infant spontaneous interaction would also characterize engagements with fathers (Trevarthen, 1986, 1998).

A common element of the theories described is recognition, in various degrees of detail, that infants express their perception of feelings and interests to other persons, and seek responsive and selective attunement in emotionally regulated engagements which affect development of shared experience (Bråten & Trevarthen, 2007).

Previous studies of fathers' and mothers' communication with infants, and methods of this investigation. Comparisons of emotional coordination in the communications of mother–infant and father–infant dyads in early infancy

(Feldman, 2003; Kokkinaki, 2003; Yogman, 1982) confirm similarities in parents' synchrony with their infants' expressions and matching of affective states. Differences were found in the timing of expressions of positive arousal. During mother–infant play, peaks of positive arousal appeared at regular intervals. In father–infant interactions, gaps between positive peaks became shorter, and bursts of emotional excitement appeared more frequently as play progressed.

However, it is difficult to integrate evidence from the family studies with results obtained from separate investigations of the two kinds of parent–infant dyad. Differences in age and sex of subjects, method of analysis and theory also confuse comparisons.

This study aims to optimize the conditions of recording for natural intimate engagement in the family to favour comparing emotional coordination of infant-directed speech in dyadic interactions of both parents from the 2nd to the 6th month of the infant's life. Emotional coordination was evaluated with two measures: (a) *emotional matching*, where one partner expresses the facial expression of emotion of the other partner; and (b) *emotional attunement*, where one individual matches the shifts of emotional intensity or dynamics of the partner (see "Coding" section). We hypothesized that, first, there may be quantitative differences between mother–infant and father–infant interactions in *emotional coordination*, fathers matching and attuning to their infant's facial expressions of emotions more frequently than mothers, and second, there may be differences in *emotional consistency* for each partner, that is, within-infant and within-parent emotional expressions will be more consistent in father–infant compared to mother–infant interactions. We also anticipate that there will be similarities in effect of infant age on the development of emotional matching for father–infant and mother–infant engagements. Differences in the development of patterns of communication between infants and parents may have implications for their habits of relating to other persons, and their ability to regulate and negotiate interpersonal challenges and opportunities throughout their lives.

We recognize methodological issues. Continuous micro-analysis, to an accuracy of 1/25th of a second, was made of facial expressions of emotion in 11 infant–mother and 11 infant–father pairs, each of which was video-recorded for 8–10 min from the 2nd to the 6th month of infants' life at 15-day intervals. Microanalysis of behaviours in such detail is a time-consuming enterprise which "... yields a dense and rich population of events for each case study, such that the number of events in each category ... tends to be substantial, yielding *no difficulty in utilizing statistical procedures*" (Beebe, 1982, p. 174, *added italics*). It is difficult, however, to obtain data from comparable families with healthy infants for an extensive observational period (Keller & Zach, 2002). We also encountered a cultural factor. Notwithstanding modernization in the prefecture of Heraklion where recordings were made, there is a conventional distrust of outsiders (such as researchers) and reliance on the family for protection (Terkenli, Bella, & Jenkins, 2007).

Psychobiological processes in affective communication with infants

Support for the theory of innate intersubjectivity comes from the discovery of mirror neurons (MNs), which discharge both when a subject is performing an action and when they are observing the same action performed by another individual. MNs are located in certain cortical areas which also process emotional expressions (Ammaniti & Gallese, 2014; Rizzolatti & Craighero, 2004).

Organs of visceral motor control are adapted in the foetus for future regulation of respiration, heartbeat and feeding, and are also prepared to share these vitality states in communication (Porges & Furman, 2011; Trevarthen & Delafield-Butt, 2013). Response to another individual's facial expression relies on production of similar expressions in the observer (Blair, 2003). Energy adjustment may be evidenced by the matching of emotional shifts in both infant–mother and infant–father interactions (Kokkinaki, 2009). These mutual regulating patterns provide evidence that infants can experience both self-awareness and other-awareness, and purposeful sharing of emotional states (Reddy, 2008; Trevarthen, 2005).

Comparing emotional coordination of infants with mothers and fathers is important because the question of whether fathers are capable of entering an empathic "dance" of facial expressions with the infant remains unanswered (Feldman, 2003). Gender stereotypes (Brody, 1997) and evidence coming from neuroscience and cognitive research (Guntekin & Basar, 2007; Proverbio, Brignone, Matarazzo, Del Zotto, & Zani, 2006) appear to favour females over males in perception, experience, expression and responsiveness to facial expressions of emotions. Gender stereotypes shape our interpretations of and reactions to emotions expressed by others to ourselves (Brody, 1997), and perceiving another person's empathy for oneself is likely to strengthen the emotional bond with that person (De Vignemont & Singer, 2006). On the other hand, the finding that women have stronger awareness of and responsiveness to emotional expressions and the evidence that men have a tendency to be more physiologically reactive to emotional expressions of others indicate that there are constitutional differences between the sexes, which could affect communication with infants (Sonnby-Borgstrom, Johnsson, & Svensson, 2008). Male and female speakers may use different features to convey the same affective messages to their infants (Slaney & McRoberts, 2003).

The experience of emotional coordination generates affective states and causes effects in development of infants and children, which may last, particularly if strongly moving experiences occur during the early period of rapid brain maturation in infancy, with consequences for how the individual functions socially and approaches the world (Feldman, 2007; Tronick & Reck, 2009). Strong positive emotional coordination in infancy may provide a buffer against psychosocial maladjustment (Feldman, 2007).

METHOD

Participants

Eleven Cretan Greek mother–infant and 11 father–infant pairs of middle-class families took part in this study ($N = 33$). All parents were married. The mothers' mean age was 29.36 (SD = 5.12, range: 21–39) and the fathers' mean age was 33.63 years (SD = 5.69, range: 27–47 years). All the 11 infants (five males and six females) were full term and healthy. The infants' mean birth weight was 3568 g (SD = 487.479, range: 2800–4250 g), and the mean birth height was 52.22 cm (SD = 2.160, range: 48–55 cm).

Procedure

Video-recordings were made at 15-day intervals, from the beginning of the Primary Intersubjectivity Period (2–4.5 months) until about the middle of the Period of Games (4.5–6 months).

The order of video-recordings with the parents was counterbalanced, always beginning with the parent of the same sex as the infant. The only instruction given to the parents was: "Play as you normally do with your baby." Each recording lasted 8 min for the younger infants aged 2–4 months and 10 min for the older infants aged 4.5–6 months. All the dyads were subject to the same number of video-recordings and there were no data loss. The total duration of analysed interactions was 1760 min of video data, equally distributed between periods with mother and father (see Kokkinaki, 2009 for further details on the recruitment procedure and recording conditions).

Coding

Within well-defined units and sub-units of analysis, microanalysis of spontaneous infant, maternal and paternal facial expressions of emotions was carried out according to four types of facial expressions: (1) *happy*, which includes (a) pleasure directed to the partner or (b) pleasure directed to the external world; (2) *interest* (a) directed to the partner or (b) directed to the external world; (3) *neutral* expressions and (4) *sad or withdrawn* expressions (Figure 1; see Kokkinaki, 2009 for full description of these expressions and the theoretical background for distinguishing them).

Coding of the infant and parental facial expressions of emotions was continuous. The onset time in the expression of an emotion of one partner was also the offset time of the previous emotion of the same partner. In one sub-unit for analysis of the flow of parental speech, it was most likely for each partner to express more than one emotional state. In order to obtain a description of the

Figure 1. Facial expressions of a 2-month-old boy illustrating different emotions in spontaneous interactions with a parent. 1, expressions of *pleasure* shared with the parent; 2, expressions of *interest* in the parent; 3, *neutral* or non-social emotional expression; 4, a *negative* interpersonal expression of distress.

change of intensity of interpersonal engagement over time, the valence of facial expression within each category of emotion was represented by a symbol in the following scale: (a) *positive emotional valence* was graded as pleasure directed to the partner (+++), pleasure directed to the inanimate world, which could be shared (++), and interest directed to the partner (+); (b) *neutral emotional valence* (0) consisted of the neutral facial expression and interest directed to the external world, or to the self; (c) *negative emotional valence* (−) recorded any negative facial expression in engagement. The sequence of the aforementioned symbols of each partner in the course of each sub-unit of parental infant-directed speech determined four categories for intensity change in interpersonal engagement: *ascending, descending, stable* and *fluctuating* (for full definitions see Kokkinaki, 2009).

In this study, *emotional matching* was coded when partner 2 expressed the same valence (positive, neutral or negative) of facial expression of emotion as partner 1 before the latter had completed their expression, independently of the intensity. Thus, for example, emotional matching of pleasure was coded when the mother expressed laughter while the infant expressed a grin. *Emotional*

attunement was identified when one partner matched the shifts of emotional intensity of the other partner. In the case of *ascending attunement*, the intensity of both partners' emotional state at the end of parental speech was higher in the scale than the intensity of their emotional states in the beginning of the sub-unit of parental speech, e.g., when both partners changed from *interest* (+) to *pleasure* (+++) directed to the partner.

INTER-OBSERVER RELIABILITY

Inter-observer reliability for the type, valence and intensity of emotions ranged from .76 to .83, .80 to .87 and from .78 to .84, respectively. Inter-observer reliability for all categories ranged from .76 to .87, the mean value of κ (Cohen's κ) being .81. The increased task demands on the observer and the multiple messages of a complex interaction itself are recognized as two factors that contribute to the difficulty of establishing high inter-observer reliability (Bakeman & Gottman, 1986). Fleiss (1981) characterizes κ's over .75 as excellent. After the end of inter-observer reliability assessments, the two scorers discussed and corrected each assessment on which there was disagreement. The statistical analysis was carried out after all the corrections were made on the data-set.

STATISTICAL ANALYSIS

This experiment, by its nature, generated data with relatively strong dependencies between repeated observations in time obtained on a relatively small number of individuals. These longitudinal dependencies were not taken into account in the analysis because of their complexity. The Loglinear General Model was used to determine useful relationships between variables. The optimal Model was obtained using the likelihood ratio test (LRT) and the final Model retained a non-significant distance (in LRT terms) with the Saturated Model. The level of significance was set at 5%. In all cases, the Optimal Model consisted of only one two-way interaction between infant and parental emotional states, emotional intensity and infant–parental emotional states in the beginning and at the end of each sub-unit.

It has to be noted that the aim of this experiment is not to compare treatment groups but to provide information on the pattern of specific interactions appearing naturally between infants and parents. Therefore, we did not measure the variation between families with great accuracy. For our purpose, 11 infant–father and 11 infant–mother dyads provide a reasonable sample size for taking into account any variation (Christensen, 1998). Friedman test (with sliding windows) was used to explore possible age-related changes of emotional matching across the nine data points through four comparisons (one every three age points). Through Friedman analysis, we took into consideration the fact that we had different number of sub-units for each subject and at each age point. The

significance level for Friedman test was Bonferroni corrected and set at 5/4 (number of comparisons) = 1.25%.

RESULTS

Units and sub-units of analysis in mother–infant and father–infant interactions

The frequency of units of analysis was higher in father–infant interactions (943) than in mother–infant interactions (797) ($p = .001$, two-tailed Binomial test). Sub-units of analysis in father–infant interaction (4386) outnumbered insignificantly sub-units in mother–infant interaction (4265) ($p = .197$, two-tailed Binomial test).

Parent gender effect on infant and parental emotional expressions

Given that the investigation of the relationship between infant and paternal emotions was the main interest of the following analysis, any relationship would be of interest provided that it concerned the common predominant emotions of both partners; for example, maternal *pleasure* and *interest* addressed to the infant (83.9% and 49.4%, respectively), infant *pleasure* and *interest* addressed to the mother (28% and 64%, respectively), paternal *pleasure* and *interest* towards the infant (81% and 40%, respectively) and infant *pleasure* and *interest* addressed to the father (27.5% and 59.4%, respectively).[1]

A complex interaction between parental gender × parental emotional expressions × infant emotional expressions (LRT value = 6.2, df = 1, $p = .012$) was demonstrated with evidence that the sub-units in which both fathers and infants express the same facial expressions of emotions (*pleasure*: 25.3%, *interest*: 95%) predominated over sub-units in which mothers and infants express the same emotional states (*pleasure*: 18.3%, *interest*: 92.4%).

Parent gender effect on infant and parental emotional intensity

A complex interaction between parental gender × parental emotional intensity × infant emotional intensity (LRT value = 24.55, df = 9, $p = .004$) is indicated by the evidence that father–infant pairs *ascend* (36.0%), *descend* (27.8%), *fluctuate* in their emotional intensity (40.5%) or maintain it *stable*

[1]In each time-unit of analysis, coding of the infant and parental facial expressions of emotions was continuous; therefore, either the infant or the parent might be recorded to express an emotional state more than once in a sub-unit. Thus, the coding of categories of emotions was not mutually exclusive. This explains why the percentages for categories of emotion per unit of analysis may exceed 100%.

(55.7%) more often than mother–infant pairs (31.1%, 23.4%, 33.9% and 51.2%, respectively). Furthermore, when emotional states of mothers *ascend*, infants change their emotional states in a *fluctuating* way more often than when fathers ascend their emotional intensity (or vice versa). When mothers *fluctuate* in their emotions, infants *ascend* or *descend* their emotional expressions more than when fathers *fluctuate* their emotional states.

Parent gender effect on infant and parental emotional expressions in the beginning and at the end of sub-units

The interaction between parental gender × infant emotional expressions in the beginning of sub-unit of speech × infant emotional expressions at the end of the sub-unit (LRT value = 37.67, df = 4, $p < .001$) is shown to be complex by the evidence that this relationship occurs more often and is stronger for *pleasure* (66.1%), *interest* (67.5%) and *external interest* (74.5%) in father–infant compared to mother–infant interactions (48.9%, 61.0% and 72.9%, respectively).

Finally, a comparison of parental gender versus parental emotional expressions in the beginning of the sub-unit as compared to the parental emotional expressions at the end of the sub-unit (LRT value = 63.70, df = 4, $p < .001$) indicates a more *pleasure* (93.1%), *interest* (67.3%) and *external interest* (20.5%) in father–infant interactions compared to mother–infant interactions (88.3%, 59.2% and 9.5%, respectively).

Infant age effect on emotional matching

For the nonlinear developmental curves of incidence of matching for *pleasure* and *interest* in mother–infant and father–infant interactions (Figures 2 and 3), Friedman test analysis provided evidence of changes in the frequency of matching for *pleasure* and *interest* across the nine age points of this study, which, however, were non-significant. The changes in levels of emotional communication over the first 6 months correlate strongly with known developments in the body and brain of the infant and clearly marked changes in communication, self-awareness and engagement with objects (Trevarthen & Aitken, 2003), and the mothers and fathers responded differently to these changes.

As indicated in Figures 2 and 3, stages of development in months 2–3 (A), months 3–4 (B) and months 4–6 (C) may be summarized as follows (for detailed evidence and sources see Trevarthen & Aitken, 2003):

(A) The first weeks show large developments in the cerebral cortex as the infant adapts vital functions of the body, actions and awareness to a new environment within maternal care (Nagy, 2011). After 6 weeks, intimate proto-conversations with caregivers show the regulations of "primary intersubjectivity", with imitations of expressions of eyes, face, mouth and hands.

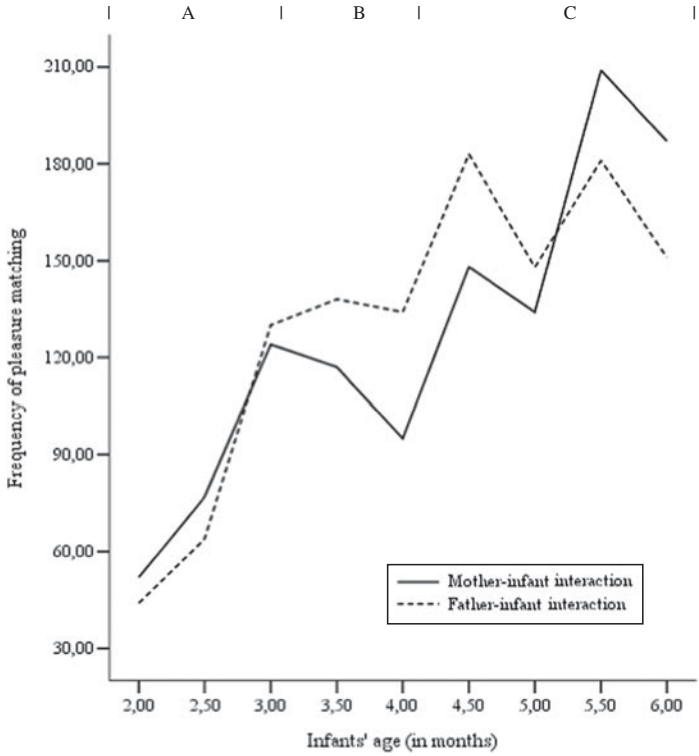

Figure 2. Developmental curves of pleasure matching in mother–infant and father–infant interactions.

(B) From 3 months, the infant becomes more playful, responding to rhythmic provocations of expressive movement in "person–person games" and body play. The infant shows self-conscious responses to a mirror (Reddy, 2008), as well as increased interest in objects to be manipulated with improved visual tracking. This expanding awareness of the outside world leads to "person–person–object play" as a parent takes up the infant's interests. Play rituals are learned (Trevarthen, 1986).
(C) After 4 months, infants imitate conventional mannerisms, such as pointing and waving, or making humorous expressions of sounds. There are clear expressions of an Other-aware Self, with "showing off" (Reddy, 2008). Signs of "stranger fear" are shown if an unknown person makes close advances.

Our evidence indicates that mothers and fathers tend to respond differently to these changes in the infants intelligence, self-awareness and social "vitality dynamics".

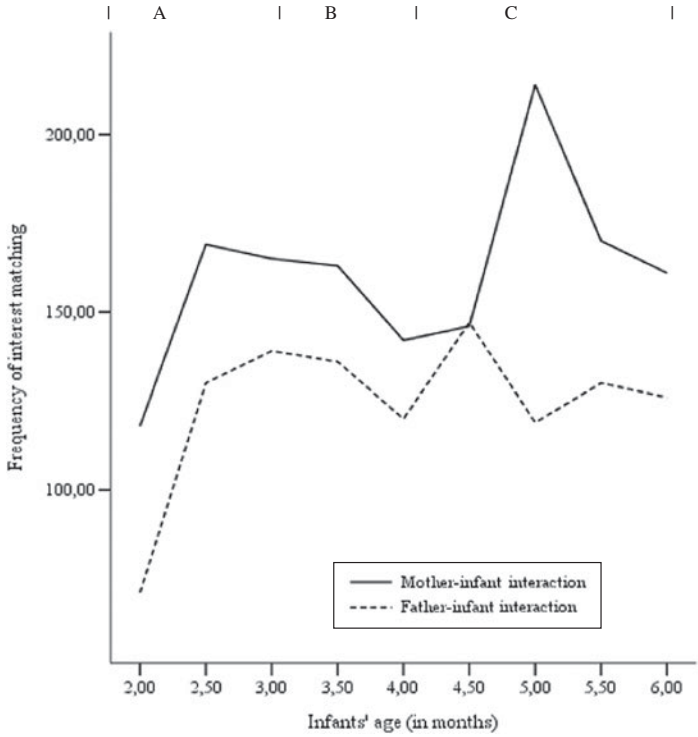

Figure 3. Developmental curves of interest matching in mother–infant and father–infant interactions.

DISCUSSION

This study compared emotional coordination in the course of spontaneous intimate and playful parent–infant interactions in families in Crete. Comparison between mother–infant and father–infant emotional matching and sequences provided evidence of quantitative differences that give a higher index for emotions of play in father–infant interaction, especially in months 3–5 (Figure 4 and 5). At the same time, expressions of pleasure and interest in playful communication show similar developmental curves for the two parents, with large changes in level at times when there are marked advances in the infant's attentiveness and playfulness. This evidence verified our initial hypotheses and confirmed most of the results of previous studies of this kind (Feldman, 2003; Kokkinaki, 2003; Yogman, 1982).

Extending previous empirical evidence on father–infant emotional coordination (Kokkinaki, 2009), this study presents new longitudinal and naturalistic data confirming that mother–infant emotional coordination supports adjustment of timing, form and energy of emotional expressions to obtain inter-subjective

synchrony and intra-subjective coherence within mutual interest (Trevarthen, 2005). At the same time, differences in timing, form and energy adjustment between mother–infant and father–infant emotional coordination are indicated by (a) a stronger *emotional matching* and *emotional attunement* in infant–father compared to infant–mother interaction, (b) differences in the relationship of infant–maternal and infant–paternal emotional states in the beginning and at the end of sub-units and (c) different patterns in the way infants attune to certain shifts of maternal and paternal emotional intensity. These variations correlate with evidence that units and sub-units of analysis were more frequent in father–infant interaction compared to mother–infant interaction. The fathers were more

40.02.11: Both sustain eye contact, and the mother starts talking to her infant with an expression of pleasure, nodding her head to emphasize her words. The infant looks at her intensely.

40.03.18: About 1 second later, the infant smiles and the mother has a more strong expression of pleasure.

40.14.00: Eleven seconds later, while keeping eye contact and "matching" an expression of pleasure, the infant starts vocalizing as he moves his head up while his mother nods downward.

40.14.08: The mother immediately interprets the infant's vocalizations, "agreeing" with him. They both have pleasure expressions, and both raise their heads.

Figure 4. Emotional matching of pleasure between a 3-month-old boy and his mother. The numbers represents the time in minutes, seconds and 25th of a second.

36.25.18: Keeping eye contact, the father, with unsmiling face, starts playing a verbal game, saying repeatedly: "*What's his name*?" while moving the infant's torso up towards him and back, in time with his chanting. The infant, looking at him intensely, starts smiling.

36.26.07: After the end of the third "round" of the game, both partners "match" pleasure expressions, keeping eye contact while the infant vocalizes.

36.32.19: In a short pause, both partners continue "matching" their expressions of pleasure while the infant focuses on his father's mouth, and the father looks at the infant with raised brows.

36.35.11: After seven "rounds", with sustained mutual eye contact, the father terminates the vocal game while both have matching expressions of pleasure. He then changed to a non-verbal vocal "song" with the same movements.

Figure 5. Emotional matching of pleasure between a 3-month-old boy and his father during 10 s of a rhythmic game with words or vocalizations accompanied by matching movements.

animated and reactive. They were more active and provocative in response to stages of development in the infant's movements, awareness and emotions, while the mothers responded with more attentive engagement in response to the infant's interest in intimacy. The differences affect fundamental dimensions of human intersubjective communication; the "kinematics", "physiognomics" and

"energetics" of their movements (Trevarthen, 1986) and the "vitality dynamics" with which their messages are composed (Stern, 2010).

With the segmentation procedure we employed, and given that the duration of the video-recording of the two dyads was the same, we conclude that father–infant pairs motivate their emotional coordination of positive expressions in shorter and more frequent temporal cycles than mother–infant pairs do. This may be attributed to gender differences in certain behaviours or awareness, such as the following: (a) the involvement of conscious or deliberate regulation of emotions in the experience of encounters (Sonnby-Borgstrom et al., 2008); (b) the distribution and attention and memory for perception of specific emotional cues (Wager & Ochsner, 2005); (c) differences in reaction time (Leppanen & Hietanen, 2001) and (d) in the maturation and the development of functions mediated by brain systems such as the temporal cortex which plays an important role in processing of facial emotional expressions (McClure, 2000). Interpretations such as these may gain support from data on the full parent gender by infant gender matrix. The patterns of variation may have implications for all partners' ability to regulate and negotiate interpersonal challenges in the present, and for the lifetime experience of learning participation in a society of different personalities, each with their culture of beliefs and practices (Bradley, 2005; Trevarthen, 1997).

We acknowledge the following limitations of this study. Our observations, informative as they have been, are based on short-time samples. How young infants experience family life by seeing and hearing their parent's actions at other times must be important. Finally, the focus on facial expressions as a powerful index of emotions, invites investigation of other expressive systems that convey affective information in interpersonal relationships and play (Weinberg & Tronick, 1994).

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