Parent-infant interaction: a growth model approach

Lars-Erik Malmberg[1], Alan Stein[2,3], Andrew West[4], Simon Lewis[5], Jacqueline Barnes[6], Penelope Leach[3,6], Kathy Sylva[1] and FCCC[7]

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[1] Department of Educational Studies, University of Oxford

[2] Section of Child and Adolescent Psychiatry, University of Oxford

[3] The Tavistock and Portman NHS Trust, London

[4] Berkshire Healthcare NHS Trust

[5] Department of Mental Health Sciences, University College London

[6] Institute for the Study of Children, Families and Social Issues, Birkbeck, University of London

[7] The Families, Children and Child Care (FCCC) project team is: Luc Altmann, Katherine Bethell, Beverley Davies, Katharina Ereky-Stevens, Jenny Godlieb, Lindsay Hague, Michelle Nichols, Bina Ram, Angela Triner, Jo Walker (see www.FamiliesChildrenChildCare.org)

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Address for correspondence:
Lars-Erik Malmberg, Dr., Senior Research Fellow
Families, Children and Child Care Project (FCCC),
Department of Educational Studies, University of Oxford,
15, Norham Gardens, Oxford OX2 6PY, UK
Phone: (+44) 01865 274047 Fax: (+44) 01865 274067
e-mail: lars-erik.malmberg@edstud.ox.ac.uk

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Abstract

The aim of this study is to compare the interaction of fathers and mothers with their 10-12 month old infants (n = 97; parental sensitivity and mood, and infant mood) during five structured contiguous play segments, and to examine the utility of individual growth modeling. Conventional comparison of means across play-segments showed that parents were equally responsive, but mothers were happier than fathers, and infants were equally happy during interaction with both parents. Sensitivity and mood were more strongly related for mothers than for fathers. Uni- and multivariate growth models revealed fine-grained patterns not seen in conventional analysis: (a) parental and infant mood decreased across play more for mothers than for fathers, (b) parental sensitivity in one play-segment predicted parental mood and infant mood in the next segment, (c) change in infants' mood was related to change in sensitivity in mothers, and to change in mood in fathers, and (d) mothers' sensitive interaction with the infant was predicted by family socio-demographic background.

[162 words]

Parent-infant interaction: a growth model approach

The recent literature suggests that the current generation of fathers participate more in childcare than their predecessors (Lamb & Lewis, 2004). Studies of the quality of interaction have shown a range of findings. Some recent studies indicate that fathers and mothers are equally sensitive in terms of interaction with their children (Tamis-LeMonda, Shannon, Cabrera & Lamb, 2004). Other studies have found that fathers and mothers exhibit gender-role specific behaviors with their children (Lundy, 2003), fathers and mothers differ in the way they respond to their infant's behaviors and emotional expressions (Kochanska, Freisenborg, Lange & Martel, 2004), and infants differ in their responses to fathers' and mothers' withdrawal of sensitive behavior (Braungart-Rieker, Garwood, Powers & Notaro, 1998). Even though studies in which differences and similarities in parental sensitivity, emotional expression and interaction with their infant have been conducted in both laboratory and naturalistic settings, there have been far fewer studies of fathers than mothers as caregivers (Lamb & Lewis, 2004). In the current study, we examine the utility of the uni- and multivariate individual growth models (IGM) for detecting fine-grained patterns of parent-infant interactions across structured play segments, by contrasting findings from (1) conventional correlational and mean-level analyses based on aggregated scores with findings from the IGM. In particular, we investigated similarities and differences between fathers and mothers across play segments with regard to (2) change in parent-infant interaction, (3) directionality of interaction, (4) relationships between change in parents' and change in infants' interactions, all controlling for infant and family characteristics.

Parental sensitivity and infant development

Sensitive parenting is a key predictor of infant secure attachment (Ainsworth, 1973, 1979), socio-emotional security (Skinner, 1986), secure exploration of the environment (Grossmann, Grossmann, Fremmer-Bombik, Kindler, Scheuerer-Englisch & Zimmermann, 2002), gradual increase in volitional and self-regulatory behavior (Posner & Rothbart, 1998; Tronick, 1989), effortful control (Kochanska, Murray & Harlan, 2000), regulation of emotional impulses and distress in the self and others (Derryberry & Rothbart, 1997), and overall social and cognitive adaptation (Saarni, Mumme & Campos, 1998). Sensitive parenting is a core component of parent-child synchrony (Lundy, 2002, 2003; Weinberg, Tronick, Cohn & Olson, 1999), shared parent-child ambience (Kochanska et al., 2004), and mutual parent-child engagement (Braungart-Rieker et al., 1998).

Ainsworth (1973) focused on four aspects of early care giving environment: sensitivity to the infants' signals, cooperation versus interference with ongoing behavior, psychological and physiological availability, acceptance versus rejection of the infant's needs. The parent of a securely attached child is able to both (a) perceive the infant's signals accurately, and to (b) respond to these signals promptly and appropriately (Lohaus, Keller, Ball, Elben & Voelker, 2001; Skinner, 1998). Accessibility is a necessary condition for maternal sensitive awareness. An accurate perception of the child can then lead to an appropriate response, for example picking up the infant if he or she seeks proximity, while an inaccurate perception, based on the mother's own wishes or ideals, can lead to under- or over-stimulation of the infant, for example feeding a child when he or she is not hungry (Ainsworth, 1973). During the first year of the child's life parents are usually cued toward responding to infant initiated signs and social communication. In the current study, as the infants were approaching the end of the first year, it was deemed to be a good time to investigate both father-infant and mother-infant play, and in particular the extent to which they supported their infant's exploration of toys, providing some guidance, which also at the same time took account of their infant's initiatives and intensions.

Fathers and mothers as parents

A number of empirical studies have found similarities in parental behavior. In their review, Tamis-LeMonda et al. (2004) concluded that mothers and fathers were similar in mean-levels of support, sensitivity, positive regard, stimulation, cognitive stimulation and use of age-appropriate language with the child. However, non-significant mean-level differences in parental sensitivity have usually been accompanied by weak to moderate correlations (r from .20 to .30; e.g., Braungart-Rieker et al., 1998) between maternal and paternal measures, suggesting that parents of the *same* child do differ in their interaction with that child. However, conducting mean-level tests and correlations separately, as the above studies have done, may mask important (co)variance information that is not modeled simultaneously.

Importantly, a range of other empirical studies have demonstrated that fathers and mothers differ in the way they respond to their infant's behaviors and emotional expressions (Kochanska et al., 2004), and infants differ in their responses to fathers' and mothers' withdrawal of sensitive behavior (Braungart-Rieker et al., 1998). Earlier studies, usually focusing on the transmission of male and female gender-roles, have found that fathers are more physically stimulating, unpredictable and engage the child in "rough and tumble games", whereby they elicit more positive responses from children than do mothers, and children prefer play with their father if they have a choice (for a review, see Lamb & Lewis, 2004). In more recent studies, fathers have been found to provide problem-solving comments, while mothers have been found to think and speak aloud for their child (Lundy, 2003).

The relationship between family contextual features and individual differences in both parents and children also plays a role in parent-child interaction. Overall studies agree that family sociodemographic background plays as crucial role in sensitive parenting (Hoff-Ginsberg & Tardif, 1995; Mistry, Bieasanz, Taylor, Burchinal & Cox, 2004; Raviv, Kessenich, Morrison, 2004). For example, disadvantaged parents tend to be less sensitive and more authoritarian in their child rearing approach, while advantaged parents tend to sustain verbal interaction, and respond to their children in a more contingent manner (Hoff-Ginsberg & Tardif, 1995). Studies focusing on fathers only have shown differences in paternal child involvement of resident and non-resident fathers, due to a range of sociodemographic circumstances, and father-mother conflict (Coley & Hernandez, 2006).

Measures and methods

The sensitivity measures included in previous studies have been either repeated time-sampled ratings, global ratings, or event counts (for a review, see Meins, Fernyhough, Fradley & Tuckey, 2001), expressed as ratios, averages or aggregated by more complex formulae (e.g., Kochanska et al., 2004; Weinberg et al., 1999) across situations and time. The classical measure of sensitivity has been assessed once across segments, on a 9-point (Ainsworth, Bell & Stayton, 1974) or 5-point scale (e.g., Grossmann et al., 2002), rated across a 20-minute period (Meins et al., 2001), or separately for different play situations (Tamis-LeMonda et al., 2004), or used in concert with other variables to categorize parental behavior into intrusive, withdrawn and positive interaction styles (Field, Hossain & Malphurs, 1999). Other observation intervals have ranged from one second (Weinberg et al, 1999) to 15 seconds (Grolnick, Bridges & Connell, 1996; Lundy, 2002, 2003). These studies have typically applied conventional mean-level (t-test or ANOVA) group comparisons (e.g., fathers versus mothers), within-individual differences across conditions (e.g., non-still face versus still face), and correlations of variables aggregated across the units of observation. The individual growth model (IGM), allows modeling of effects of time, and individual differences in change over time; and the multivariate growth model allows modeling of several variables simultaneously, within a multilevel framework (Bryk & Raudenbush, 1992; Goldstein, 2003; Singer & Willett, 2003). Applying the IGM enabled us to specify the following research questions:

Research questions

Are fathers and mothers of the same infant similar or different with regard to:

(1) parental sensitivity and mood, and infant mood on average, and in the relationship between these variables?

(2) change in parental sensitivity and mood, and infant mood across play segments?

(3) directionality in influence, i.e., whether parental sensitivity and mood predicts infant mood, or infant mood predicts parental sensitivity and mood across the play-segments?

(4) the relationships between change in parental sensitivity and mood, and change in infant mood across play segments?

(5) how parental sensitivity and mood, and infant mood, relate to infant and family characteristics?

In response to the first research question we use conventional methods (t-test and correlations), and for questions 2-5 we used IGM.

<u>Sample</u>

The fathers and mothers included in the present study were drawn from the Families, Children and Child Care study (FCCC; www.FamiliesChildrenChildCare.org). The FCCC follows up children from two fieldwork sites in England (Oxfordshire and North London), both catering for demographically diverse populations at pre- and post-natal clinics. Eligibility criteria for mothers were: aged 16 or over at the time of the child's birth, adequately fluent for interview in English, no specific plan to move in the next two years. Eligibility criteria for children were: singleton, birth weight 2500 grams or more, gestation of 37 weeks or more, no significant congenital abnormalities, no more that 48 hours in a Special Baby Care Unit. Researchers approached 1862 mothers at recruitment between 1998 and 2001, of whom 217 were found ineligible, and 444 chose not to participate. The final FCCC sample consisted of 1201 children and the mothers and infants were initially seen at three months and then followed up at 10, 18, 36 and 51 months. The social class distribution of the baseline sample reflected neighborhood poverty levels quite closely (Malmberg, Davies, Walker, Sylva, Stein, Leach & Barnes, 2005).

In addition to the 10-month mother interview (*N*=1077), the mother was video-taped during a semi-structured play session and a routine mealtime with their infant. At this interview, mothers reported the types and quantity of non-maternal child care used for their infant. Mothers were asked specifically about paternal involvement with child care, such as how many times a week the father bathed, fed, changed nappies and took sole responsibility for the infant. On the basis of the mothers and fathers reports, fathers who provided a substantial amount of care for their children were approached to participate in the present study. A cut-off of 20 waking hours a week of sole child-care was used as the definition of Primary Care Giving (PCG) fathers. Fathers were recruited to this study between May 1999 and July 2000. Consecutive PCG fathers were recruited over this period, and one in every six Non-Primary Care Giving (NPCG) fathers, were approached; 25 out of 30 PCG, and 75 out of 86 NPCG fathers consented to take part and were included in the sample. All but one of the NPCG fathers agreed to be interviewed and videotaped.

In 75 families, the infant was cared for primarily by the mother (n = 30), or the family had arranged non-parental care for the infant (n = 45). There was a high correlation (r_{xy} = .89) between maternal reports of paternal child care hours and father-reported hours as has been found previously (Manlove & Vernon-Feagans, 2002). Of these 100 families, there were videotapes of both parents for 97 of the infants, which formed the sample for this study. The mother-infant observations were conducted when the infant was on average 10.6 months old (*SD* = .47), and the father-infant observations when the infant was on average 11.9 months old (*SD* = .73).

The mothers were on average 32.8 years old (*SD* = 4.98), and the fathers 36.0 years (*SD* = 6.40). The mothers’ mean educational level was, on a six-point scale (1= no qualifications, 6

= higher degree), 4.51 (*SD* = 1.41) and the fathers' 4.33 (*SD* = 1.42). The distribution of mothers' socioeconomic class (Rose & O'Reilly, 1998) was: 26 working, 15 intermediate, and 55 managerial / professional class, while that of the fathers' was: 23 working, seven intermediate and 64 managerial / professional class (and two missing). A composite variable, concerning family socio-demographic background was created by averaging the standardized (z-) scores of both parents' educational level, socioeconomic class, and the family income (Sylva, Stein, Leach, Barnes, Malmberg & FCCC, in press), in order to reduce the number of covariates. With the exception of two families, all infants resided with both parents. Of the children, 46 were firstborn, 38 second born and 12 third or later born. The covariates included in the growth models were infant's age, gender and birth order, father's primary caregiver status, and an aggregate for parents' socio-demographic background (see Table 1).

<u>Procedure</u>

The play session consisted of five 2.5 minute consecutive segments with standardized sequential introduction of toys provided by the researcher: (1) free-play without toys (parents were invited to play a clapping game or to chat or sing with their infant); (2) exploration of a textured, age-appropriate book; (3) a stacking ring toy; (4) a wooden shape-sorting toy, and (5) a battery-operated musical toy (see also Stein, Woolley, Cooper & Fairburn, 1993; Stein, Woolley & McPherson, 1999). The toys were selected to be age-appropriate for exploratory play. The parents were asked to play with their children as they normally would, and considerable effort was made to help the parent feel relaxed in video-situation. For example, parents were reassured that this was not a test of ability on the part of the child. Two independent raters coded the videotaped father-infant and mother-infant interaction during each of the five 2.5 minute play segments. The following variables were coded for each segment. The average of each measure across the five play segments is presented in Table 1.

Measures

Parental Sensitivity was measured using two observation scales, the first was based on the original global sensitivity scale of Ainsworth (1973) and the second scale, facilitation (Stein et al., 1993, 1999). *Global sensitivity* was rated on a five-point scale (1 = highly insensitive, 2 = moderately insensitive, 3 = inconsistently sensitive, 4 = sensitive, 5 = highly sensitive). The average inter-rater agreement between the coder of the father tapes, the coder of the mother tapes, and an external coder for ten father and ten mother tapes, was $\underline{\kappa}$ = .84 for fathers and $\underline{\kappa}$ = .84 for mothers (weighted Kappa; Gwet, 2001).

Facilitation was defined as an action by the parent which assisted the child in an activity in which he/she was already engaged in or had signaled he/she wished to do (Stein et al., 1993, 1999), (1 = no facilitations at all, 2 = a few attempts at facilitation, 3 = moderate/some inappropriate facilitation, 4 = much facilitation, 5 = skilled and appropriate facilitation most of the time), identifying the second half of Ainsworth's (1973) original conceptualization of maternal sensitivity, as her ability to respond to the child's signals promptly and appropriately. The average inter-rater agreement was $\kappa = .78$ for fathers and $\kappa = .90$ for mothers.

Parental mood was rated on a five-point scale (1 = unhappy, angry, 2 = not unhappy/angry for whole time period, 3 = moderately positive/a mix of positive and negative or neutral, 4 = mostly happy and positive, 5 = very happy, animated). The inter-rater agreement was $\kappa = .86$ for fathers and $\kappa = .80$ for mothers.

Infant mood was similarly rated on a five-point scale (1 = very unhappy, 2 = not very happy, 3 = moderately happy, a mix of happy/unhappy or neutral, 4 = happy but not overjoyed, 5 = very happy, animated). The inter-rater agreement was $\kappa = .88$ for father, and $\kappa = .92$ for mother observations.

The global sensitivity and facilitation subscales were strongly intercorrelated (r = .72 for fathers and r = .75 for mothers), and merged together to form one sensitivity construct in line with Ainsworth's original definition (Ainsworth, 1973; Kochanska et al., 2004; Lohaus et al., 2001; Skinner, 1986). A three-factor multi-group Confirmatory Factor Analysis (CFA; parental global sensitivity and facilitation in the first factor, parental mood in the second, and child mood in the third), in which factor loadings and intercepts were equated across the five (time-points) groups, was conducted in AMOS 5. These models fitted data well for both fathers ($\chi^2_{[17]}$ = 25.210; p = .090; RMSEA = .032; CFI = .987) and mothers ($\chi^2_{[17]}$ = 29.376; p = .031; RMSEA = .039; CFI = .982)[1], using the following cut-offs for good model fit (Marsh, Balla & Hau, 1996): χ^2 >.05; Root Mean Square Error of Approximation (RMSEA) <.05; and Comparative Fit Index (CFI) > .95. The CFA confirmed the merging of global sensitivity and facilitation, and clearly distinguished between parental sensitivity and parental mood from each other, as corroborated in reviews (De Wolff & van IJzendoorn, 1997; Kochanska et al., 2004). Consequently, parental sensitivity, parental mood and child mood where used in the subsequent growth models.

Methods

Univariate individual growth models were specified with the data organized as time-points (play segments) within infants. The independent time-variable 'segment' was centered from, -2 to 2, in order to interpret the intercept as the grand mean of the dependent variable at the mid-segment (Biesanz, Deeb-Sossa, Papadakis, Bollen & Curran, 2004; Singer & Willett, 2003). One model per dependent variable (parental sensitivity and mood, and infant mood) was conducted in the pooled parent sample (see Equation 1 in the Appendix). Prior to analysis, the individual intercepts, slopes and quadratic slopes were found to be normally distributed for all three dependent variables (Carrig, Wirth & Curran, 2004). First, an unconditional growth model (model 1) was conducted in which the fixed intercept (i.e., the dependent variable at the zero point in time) and the random intercept (i.e., differences in the dependent variable at the zero point in time) effects were estimated (Muthén & Khoo, 1998; Singer, 1998). In model 2, the following effects were estimated: the fixed effects of linear play segment (i.e. change in the dependent variable across the play segments), squared play segment (i.e., U-shaped change in the dependent variable across the play segments), and parent (0 = father, 1 = mother; i.e., whether fathers and mothers differ at the time zero-point). In model 3, the following random effects were estimated: random segment (i.e., whether the rate of change in the dependent variable differs across infants), random parent (i.e., whether parents of the same child differ with regard to the dependent variable), and a series of fixed interaction effects: parent × segment (i.e., whether parents differ in change across the play segments) and parent × segment-squared (i.e., whether parents differ in U-shaped change across the play segments). In model 4, child, parent and family covariates were entered as fixed effects. In model 5, all parent × covariate interactions were included. All interaction effects were orthogonalized before entry. Only significant covariate and parent × covariate interaction effects were estimated, and interpreted only if the modeling step was significant. A significant χ^2-difference in -2 Log Likelihood (Δ-2*LL*), between nested models was used as an index of improved model fit (Goldstein, 2003).

Model 6 was set up as a baseline model for the analyses of reciprocal lagged effect. The four last play segments were used for this analysis. Each variable was lagged so that parent sensitivity at time T was predicted by parent mood and infant mood at the preceding time-point T - 1, parent mood at time T was predicted by parent sensitivity at time T - 1, and infant mood at time T was predicted by parent sensitivity and mood at time T - 1 (see Singer & Willett, 2003) in Model 7. In this reduced sample (four time-points), the fixed effects of the intercept, play-segment, segment-square and parent, and random effects of intercept and segment were included.

Multivariate individual growth models In order to investigate the relationships between changes in parental sensitivity and parental mood were related to change in infant mood, multivariate IGM were specified for fathers and mothers respectively (see Equation 2 in the Appendix). In the multivariate IGM, the data is organized in three levels: infant (Level 3), time-point (Level 2), and a response variable indicator at Level 1, albeit no variance is estimated at the lowest level (Snijders & Bosker, 1999; Rasbash, Steele, Browne & Posner, 2004; Plewis, 2005). Of particular interest are the covariances between the random linear segment effects (differences in change across the play segments) of the three dependent variables. These covariances represent the relationships between change in one variable and change in another variable, presented as correlations in Table 4. When conducting a multivariate multilevel model, care needs to be taken since covariance parameters may sometimes translate into correlations that are greater than one due to model misspecification or lack of information (Plewis, 2005; Rasbash et al., 2004; Snijders & Bosker, 1999). Each parameter was scrutinized and convergence criteria inspected to safeguard against non-negative matrices and model misspecifications (Gill & King, 2004). Consequently, the final models differed slightly for fathers and mothers. The multivariate IGMs were conducted according to the same logic as the univariate IGMs: First, a variance component model was estimated. Next, the fixed linear and squared segment effects were included, followed by random linear effects, and squared fixed effects. Finally, child covariates: child's age, gender and birth order, and family covariates: father as primary caregiver and family socio-demographic background, were included.

Results

Comparison of average scores In order to investigate differences in parent-infant interaction, paired t-tests were conducted, using the average of each dependent variable across the play segments (see Table 1). When the raw averages were compared between parents by paired t-tests, mothers were overall rated as happier than fathers during their respective play sessions with their infant (fathers: M = 3.54; mothers: M = 3.72; $t_{[96]}$ = 2.95; p<.01), but no differences were observed for parental sensitivity ($t_{[96]}$ = 1.51; p = .14) or child mood ($t_{[96]}$ = -

1.66; p = .10). Father's sensitivity and mood were correlated with infant mood in father-infant interaction, as were mother's sensitivity and mood with infant mood in mother-infant interaction. However, the correlation between average sensitivity and average mood was significantly stronger for mothers than fathers (r = .71 mothers and r = .51 for fathers; Δz = 2.22; p<.05). When the cross-correlations between parental sensitivity and mood, and infant mood where observed, father sensitivity and mood were unrelated to mother sensitivity and mood. The only significant cross-correlation was found between infant mood with the father and maternal mood (r = -.27). However, when the differences in change across play sessions for the two parents were observed, a different picture emerged.

Differences in change across play segments

Parental sensitivity. The intra-class correlation in the unconditional growth model showed that 26.5% of the variance was found between infants, and 73.5% of the variance was found within infants. It was thus justifiable to predict sources of the within-infant variability (Singer & Willett, 2003). The model fit was not improved by including the fixed linear segment and quadratic segment, and parent effects (model 2). The inclusion of the random segment ("are there individual differences in change over time?"), parent ("do parents of the same child differ?") and fixed interaction effects improved model fit (model 3).

When the random effects were observed, the random segment effect (σ^2 = .01), although small, suggested individual differences in change in sensitivity across play segments. The covariance between random parent and random segment (σ_{02} = -.25) showed that a larger difference between parents' sensitivity was related to less variability in average sensitivity. Importantly, the random parent effect (σ^2 = .53) showed that parents of the same child differed in sensitivity.

The significant parent × segment effect (β = -.05) showed that parents differed in the linear change across the play segments. Fathers became more sensitive and mothers less sensitive. When the family covariates were included (model 4), only a higher family socio-demographic background predicted a higher level of sensitivity (β = .23). The model step including interaction effects between family covariates and parent (model 5) was not significant.

Parental mood The unconditional growth model showed that 86.2% of the variance was found within infants. The negative linear segment effect (β = -.08) showed that parents became less happy across the play segments. The positive segment-square effect (β = .04) showed that the change in mood was slightly U-shaped, that is high in the first and last play segments and lower in the middle. The significant positive fixed parent effect (β = .18) showed that mothers at the mid-play segment were happier than fathers.

When the random effects for parental mood were similar to the random effects for sensitivity (see above), but were smaller in magnitude. The random intercept effect (σ^2 = .08) indicated variability in the intercepts, and the random segment effect (σ^2 = .005) variability in change across the play segments. The significant covariance between parent and intercept (σ_{02} = -.09) showed that a larger difference in parents' mood corresponded with less variability in average mood. The random parent effect (σ^2 = .26) showed that parents of the same child differed in mood.

The fixed parent × segment effect (β = -.09) showed that parents differed in change in mood across the play segments, mothers becoming more unhappy than the fathers. A higher socio-demographic background predicted happier parents (β = .12). The paternal primary caregiving × parent effect (b = -.45) showed that primary caregiving fathers were happier than non-primary caregiving fathers, while no differences in mood between the spouses of primary and non-primary care fathers were found.

Infant mood The unconditional growth model showed that 90.2% of the variance was found within infants. The negative fixed segment effect (β = -.08) showed that infants became less happy across the play segment. The positive segment-squared effect (β = .03) showed a slight U-shaped curvature.

The following random and interaction effects were found. The random segment (σ^2 = .01) suggested individual differences in change in infants' mood across the play segments. The random parent effect (σ^2 = .11) showed that infants varied in happiness with the two parents. The covariance between the random parent effect and the random intercept (σ_{02} = -.07), showed that a larger differences in infant mood with each respective parent was related to a smaller average difference.

The fixed parent × segment effect (β = -.08) showed that an infant differed in change in mood with his or her two parents. They became more unhappy with their mothers than with their fathers. A higher socio-demographic background predicted happier infants (β = .08).

Who influences whom?

Lagged variables were created and included as predictors in each model. As we can see in Table 2 lagged parent mood and infant mood did not predict parent responsiveness. Parental mood was predicted by parental sensitivity (β = .15), that is parents who were sensitive in a certain play segment were themselves happier in the immediately following play segment. Also infant mood was predicted by lagged parental sensitively (β = .13). No effects of lagged parental mood or infant mood were found. No parent × lagged variable effect was detected in a post-hoc model (not shown in Table 2), suggesting equal effects of lagged parental sensitivity on the infant's and their own mood.

Change in parental sensitivity and mood, and change in infant mood, during play

Father-infant play In the variance component model the intra-class correlations were .52 for sensitivity, .26 for parent mood and .22 for child mood (-2LL = 2126.43). Model fit was improved by including the following predictors: the fixed linear segment effects for parent mood and child mood (Δ-2LL = 16.91; p<.001); the random linear segment effects for parent mood and child mood (Δ-2LL = 19.99; p<.01); the fixed quadratic segment effects for all three variables (Δ-2LL = 45.33; p<.001). Including child or family covariate effects did not improve model fit (Δ-2LL = 7.49; p = .59 and Δ-2LL = 4.07; p = .67). Estimating the fixed linear segment effect for fathers' sensitivity distorted the model due to lack of sufficient variance (i.e., the change in father sensitivity across play segments was very small), and was set to zero (i.e., was not estimated). The form of the change in the dependent variables across the play segments replicated those of the univariate models, and is not shown.

When the average-to-average relationships were observed (Table 3), father sensitivity, mood, and child mood were inter-correlated: paternal sensitivity and mood (*r* = .56), paternal sensitivity and infant mood (*r* = .53), and paternal mood and infant mood (*r* = .45). Change in father mood across play segments was related to change in child mood (*r* = .41)[2].

<u>Mother-infant play</u>

In the variance component model for mothers the intra-class correlations were .56 for sensitivity, .46 for parent mood and .14 for child mood (-2LL = 2289.87). More variability was found in mothers' mood than in fathers', and less child mood variability with mothers than with fathers. Model fit was improved by including the following predictors: the fixed linear segment effects (Δ-2LL = 94.71; p<.001); the random linear segment effects (Δ-2LL = 18.48; p<.05); and the fixed quadratic segment effects (Δ-2LL = 42.72; p<.001). Including the child covariates did not improve model fit (Δ-2LL = 14.36; p=.11), but including family covariate effects on maternal sensitivity and maternal mood did (Δ-2LL = 17.68; p<.01). A higher family socio-demographic background predicted higher level of mothers' sensitivity and mood, clearly in line with the bivariate relationships (Table 1) and the univariate IGM (Table 2).

When the average-to-average relationships were observed (Table 3), mother sensitivity, mood, and child mood were correlated. The relationship between sensitivity and mood was stronger for mothers than for fathers (*r* = .82 vs. .56; Δz = 3.98; p<.001). Change in mother sensitivity was related to change in mood (*r* = .42), infant mood (*r* = .79), and change in mother mood was related to change in infant mood (*r* = .44 which was not significantly different from *r* = .41 of fathers).

Discussion

In the current study we investigated similarities and differences in fathers' and mothers' interaction with their 10-12 month old infants during five structured play segments. In particular we inspected differences and similarities in parental sensitivity and mood and infant mood, by observing (1) conventional mean-level comparisons and correlations, (2) effects of individual intercepts and slopes, (3) effects of lagged variables, (4) change-to-change covariances, all controlling for child and family characteristics. New findings emerged, suggesting subtle differences in interaction patterns between fathers and mothers of the same infant across five segments of exploratory play.

Father-infant and mother-infant play on average, and across play segments

First, when fathers' and mothers' sensitivity and mood, and infants' mood with their father and mother, were compared using the average values across the plays (t-tests), mothers were equally responsive to their infant, and infants equally happy. Mothers on average were happier than fathers on average, and were also happier than fathers at the mid-point during the play segments. These findings converged with the fixed parent effect on parent mood in the IGM. Overall these parental similarities agree with previous research showing that parents, on average, are generally similar in their interaction with the child (Tamis-LeMonda et al., 2004), and that emotional expressions may differ (Lundy, 2002).

The correlation between parents' sensitivity and mood was significantly stronger for mothers than fathers (*r* = .71 versus *r* = .51; Table 1), in line with the mid-point-to-mid-point correlations from the multivariate IGM (*r* = .82 versus *r* = .52; Table 3). This finding suggests that different aspects of mothering are fathering are salient for the communicative meaning in the exchange of behavior and affect between adult and infant (Cohn & Tronick, 1989). Interestingly, it seems as if maternal sensitivity during play is more closely related to facial expression, compared to that of fathers, where some dissociation between sensitivity and facial expression was observed. However, it is beyond the scope of the present study to attribute the found difference to cultural or ontogenetic antecedents (Ekman, 1999).

Braungart-Rieker and colleagues (1998) reported stronger associations between mothers' than between fathers' sensitivity and mutual parent-infant engagement (r = .62 for mothers and .45 for fathers), when their children were four months old. They speculated that it is possible to be mutually engaged, without being sensitive, while it would be difficult to be sensitive without being engaged (p. 1435). Another study (Kochanska et al., 2004) compared fathers and mothers during play, and found that if their children were happier both mothers and fathers were more likely to share a more positive ambience (initiate and maintain joint tasks). Mothers', but not fathers', sensitivity and consistent tracking were predicted by the child's joy. Furthermore mothers, but not fathers, were more likely to share a more positive ambience with their child if the child was fearful or less angry (Kochanska et al., 2004). Taken together, the findings regarding mutual engagement (Braungart-Rieker et al., 1998) and positive ambiance (Kochanska et al., 2004), and the findings in the current study clearly suggest that there are subtle differences in mother-infant and father-infant interaction processes.

Change across play segments and directionality

The parent × segment effects in the growth models clearly demonstrated differences in change in fathers' and mothers' sensitivity and mood across the play segments, and differences in change in infant mood with the father and mother across the play segments (Table 2; Figure 1). The random effects indicated interesting differences in the variability of parents and infants, more variability (i.e., a larger variance) found in mothers' than fathers' play mid-point sensitivity and mood, more variability in infant mood with the mother than with the father, and more variability in changes in mothers' mood than in fathers' mood. The fathers were a homogeneous group with regard to change in sensitivity across the plays, while mothers were not. This finding is important given the focus on mean-level differences in the ANOVA approach, while the IGM is able to model interaction terms between (co)variances. Next, we found that lagged parental sensitivity predicted parental mood and infant mood in the subsequent play segment, in line with studies illuminating the primacy of parental initiated tasks at this stage of infant development (Grolnick, Cosgrove & Bridges, 1996). This means that parents who were able to sensitively initiate play, appropriately respond to the infant's actions during that play, were also happier during the next play segment (Feldman, Greenbaum & Malphurs, 1999).

Change-to-change In the present study change infant mood was related to change in both fathers' and mothers' mood, but change in infants' mood was related to change in mothers', not fathers' sensitivity. Change in mothers' sensitivity was related to change in mothers' mood (Table 3). It is obvious that change in parental sensitivity and mood do not appear to relate in the same way to changes in infant mood in maternal and paternal dyads. Why would differences in changes in parental sensitivity and mood and infant mood emerge? We know from the literature that fathers and mothers respond differently to emotions expressed by their infant (Kochanska et al., 2004), that infants respond differently to expressed and inhibited emotions in their parents (Braungart-Rieker et al., 1998). Research in the still-face paradigm with infants between birth and six months, has shown that infants respond negatively to mothers' lack of expression (Grolnick, Cosgrove & Bridges, 1996; Tronick, 1989), and do so more negatively to their mothers' than to their fathers' still face (Braungart-Rieker et al., 1998). Depressed fathers have received higher ratings on a range of adaptive parent-child interaction behaviors than depressed mothers (Field et al, 1999). One plausible explanation for the patterns of change found in the present study could be that fathers rather focus on play, exploration and problem-solving (Grossmann et al., 2002) in a sequence where the U-shaped change in fathers' mood (but a drop in mood for mothers) can function as a buffer against reductions in child mood.

Family sociodemographic features

The mothers and fathers in the current sample were dissimilar in sensitivity and mood (e.g., lack of cross-correlations, and significant random parent effects), whereas other studies have found larger overlap between the parents (Braungart-Rieker et al., 2004; Tamis-LeMonda et al., 2004). Shared parenting characteristics may be due to joint learning how to handle fussy children, setting similar demands on the child, or engaging in events where the whole family is gathered. Although the current study was naturalistic and provided insight into parent-child interaction in a play context, it did not provide insight into the whole family functioning, either triadic – father-mother-child – or more complex interactions – including siblings.

Overall, our findings are in line with previous studies, which show that sociodemographic background predicts parental sensitivity (Hoff-Ginsberg & Tardif, 1995; Mistry et al., 2004; Raviv et al., 2004), and paternal involvement (Coley & Hernandez, 2006). Primary caregiving fathers were happier during play, but their spouses were less happy during play, and children were happier during play with primary than with non-primary caregiving fathers. A possible explanation could be that the primary caregiving fathers, who participate in both the running of day-to-day care, and take more decisions about the child, may develop play routines which the mother might not be attuned to. This would be an important theme to investigate in further studies. Finally, for mothers, but not for fathers, family socio-demographic background was associated with higher average levels of sensitivity and mood, in line with findings of Tamis-LeMonda et al. (2004), suggesting indirect effects of father characteristics on maternal functioning.

On methodology

The present study utilized multivariate and multilevel (IGM) models for investigating individual growth across play segments. IGM have a number of advantages above ANOVA approaches in that rich variance information can be explicitly modeled. Rather, scores that are not aggregated across time-points are seen as important sources of variance. As pointed out elsewhere (Cole, Martin & Dennis, 2004), there is an emerging trend for sophisticated analysis in the area of early child development. While time-series (Weinberg et al., 1999), and autoregressive models (Feldman et al., 1999) have been successfully incorporated in previous studies of parent-infant interaction, an additional method for the analyst's toolbox is the IGM.

Limitations of the study, and future perspectives

There are two features of the current study that make it different from a controlled laboratory experiment. First, in accordance with the recruitment strategy of the study, infants in the current sample were all first seen with the mother and later with the father, not in counterbalanced order as is typical in laboratory studies. This makes it difficult for us to completely rule out the possibility that the mother-infant findings (negative trajectories of sensitivity and mood) would not be due to the novelty effect of seeing the mothers first[3]. Second, the delay in seeing some fathers reflects practical issues that lead to some fathers to be less available for research than mothers. However, including infant's age at both visits as a covariate was a way in which we could technically control for the effect of maturation between the two visits.

The present study included one unipolar construct for measuring child mood (unhappy to happy). Theoretical advances suggest that the affect system includes both positivity and negativity (Cacioppa, Gardner & Berntson, 1999), whereby low levels of both positivity and negativity reflect indifference and high levels of both reflect ambivalence. Future studies need to incorporate a wider range of measures of child affect. Future studies employing the IGM approach could also control for individual differences in parents (e.g., marital satisfaction) and infants (e.g., temperament; Derryberry & Rothbart, 1997), and child outcomes (e.g., cognition, emotional regulation).

Conclusions

The aim of this study was to compare the interaction of fathers and mothers with their 10-12 month infant (n = 97) during a play session consisting of five structured segments. When conventional analyses and individual growth models were compared, subtle findings emerged demonstrating the utility of the IGM, going beyond findings arrived at using the ANOVA approach (De Wolff & van IJzendoorn, 1997; Lundy, 2003; Meins et al., 2001). The findings reported here contribute to the growing body of knowledge on parenting, and fathering in particular (e.g., Lamb, 2004; Lundy, 2002; Kochanska et al., 2004). Using just the average of behavioral ratings, parents were found to be equally sensitive, mothers happier than fathers, and infants equally happy during interaction with both parents. However, uni- and multivariate IGM found that (a) parental and infant mood decreased across play more for mothers than for fathers, (b) parental sensitivity on one play segment predicted subsequent parental mood and infant mood, (c) change in infants' mood was related to change in sensitivity in mothers, and to change in mood in fathers, and (d) the effects of family socio-demographic background on parental sensitivity and mood were more pronounced for mothers than for fathers.

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Table 1. Father- and mother-infant interaction, infant and parental characteristics (correlations, means and *SD*s).

	1	2	3	4	5	6	M / %[a]	SD
Father-infant								
1. Father sensitivity							3.63	0.53
2. Father mood	0.51***						3.54	0.34
3. Infant Mood	0.45***	0.45***					3.42	0.36
Mother-infant								
4. Mother sensitivity	0.07	-0.02	-0.18				3.75	0.63
5. Mother mood	-0.12	-0.09	-0.27**	0.75***			3.72	0.46
6. Infant Mood	0.18	-0.06	0.08	0.42***	0.32**		3.34	0.32
Infant characteristics								
Age w. father	0.10	0.04	0.13	-0.15	-0.14	0.08	11.91	0.73
Age w. mother	-0.05	0.10	0.01	-0.25*	-0.16	0.01	10.56	0.48
Gender (0=boy, 1=girl)	0.06	-0.06	-0.09	0.03	-0.04	-0.15	48.5%	
Birth-order	0.08	-0.04	0.10	-0.11	-0.20*	-0.05	1.71	0.84
Parent and family characteristics								
Father primary care giver (0=no, 1=yes)	0.01	0.21*	0.24*	-0.20*	-0.25*	-0.09	24.5%	
Mother's education	0.04	0.08	-0.12	0.25*	0.32**	0.18	4.51	1.41
Father's education	0.16	0.09	0.10	0.26*	0.15	0.24*	4.33	1.42
Mother's socioeconomic class	0.19	0.22*	0.03	0.39***	0.27**	0.17	2.29	0.88
Father's socioeconomic class	0.21*	0.08	0.01	0.39***	0.33**	0.28**	2.42	0.87
Family income	0.17	-0.06	-0.01	0.41***	0.25*	0.30**	£32,260	£19.044
Family sociodemographic background	0.19	0.09	-0.01	0.46***	0.37***	0.31**	0.22	0.75

Note: [a] = Means for continuous and proportions for categorical variables
[b] = Composite of z-scored parental education, socio-economic class and family income.
* = p<.05, ** = p<.01, *** = p<.001

Table 2. Univariate growth models in pooled parent sample, for parental sensitivity and mood, infant mood.

Fixed effects	Parent sensitivity			Parent mood			Infant mood		
Parameter	b	s.e.	p	b	s.e.	p	b	s.e.	p
Intercept	3.58	0.06	***	3.43	0.04	***	3.34	0.04	***
Segment	0.03	0.02		-0.08	0.01	***	-0.08	0.01	***
Segment-square	0.00	0.01		0.04	0.01	***	0.03	0.01	**
Parent	-0.11	0.12		0.18	0.06	**	-0.08	0.05	
Parent × segment	-0.05	0.02	*	-0.09	0.02	***	-0.08	0.02	***
Parent × segment-square	0.03	0.02		-0.02	0.02		0.03	0.02	
Family sociodemographic background	0.23	0.05	***	0.12	0.03	***	0.08	0.03	*
Parent × Father primary care giver	-	-		-0.45	0.13	**	-0.26	0.11	*
Fixed lagged effects (model P7)									
Lagged parent sensitivity	-	-		0.15	0.03	***	0.13	0.03	***
Lagged parent mood	0.02	0.04		-	-		-0.02	0.04	
Lagged infant mood	0.03	0.05		0.01	0.03		-	-	
Random effects									
Variances / covariances	σ^2	s.e.	p	σ^2	s.e.	p	σ^2	s.e.	p
(Intercept, intercept)	0.23	0.04	***	0.08	0.02	***	0.08	0.02	***
(Segment, intercept)	0.00	0.01		0.00	0.00		-0.01	0.01	
(Segment, segment)	0.01	0.00	**	0.00	0.00	*	0.01	0.00	**
(Parent, intercept)	-0.25	0.05	***	-0.09	0.02	***	-0.07	0.02	***
(Parent, segment)	0.01	0.01		-0.01	0.01		0.00	0.01	
(Parent, parent)	0.53	0.09	***	0.26	0.05	***	0.11	0.03	***
Residual	0.22	0.01	***	0.17	0.01	***	0.24	0.01	***
Model comparison	-2LL	Δ-2LL	p	-2LL	Δ-2LL	p	-2LL	Δ-2LL	p
P1 (variance componenets)	1999.22			1648.34			1683.53		
P2 (fixed segment, segment-square & parent)	2007.57	-8.35	---	1581.25	67.08	***	1652.49	31.05	***
P3 (random segment, parent, parent × segment, parent × segment-square)	1753.52	254.06	***	1397.47	183.79	***	1602.17	50.31	***
P4 (covariates)	1739.55	13.97	***	1392.30	5.17	*	1600.50	1.68	
P5 (covariates × parent)	1737.40	2.15		1382.42	9.88	**	1597.68	4.49	
P6 (baseline for lagged analyses)	1385.51			1112.73			1112.28		
P7 (lagged parent & infant variables)	1393.78	-8.27	---	1098.13	14.60	***	1083.79	28.49	***

Note: Estimates from the final model presented (SPSS 11.5). Only significant covariates were included in models 4 and 5. Dash (“-“) indicates a non-estimated parameter. * = p<.05, ** = p<.01, *** = p<.001

Table 3. Relationships between mid-point-to-mid-point, and change-to-change, of parental sensitivity, parental mood and infant mood.

	Mid-point-to-mid-point			*Change-to-change*		
Father-infant	Sensitivity	Parent Mood	Infant Mood	Sensitivity	Parent Mood	Infant Mood
Sensitivity						
Parent Mood	0.56 ***			-		
Infant Mood	0.53 **	0.45 *		-	0.41 ***	
Mother-infant						
Sensitivity						
Parent Mood	0.82 ***			0.42		
Infant Mood	0.53 **	0.35 *		0.79 *	0.44	

Note: The average-to-average estimates are the correlations between random intercepts of the three dependent variables, and the change-to-change estimates are the correlations between the random linear slopes. All parameter estimates are from MLWin. Only well-specified parameters were estimated. Dash (“-“) indicates a non-estimated parameter. Significance levels are from the Wald test in MLWin, and should be regarded indicative only: * = p<.05, ** = p<.01, *** = p<.001

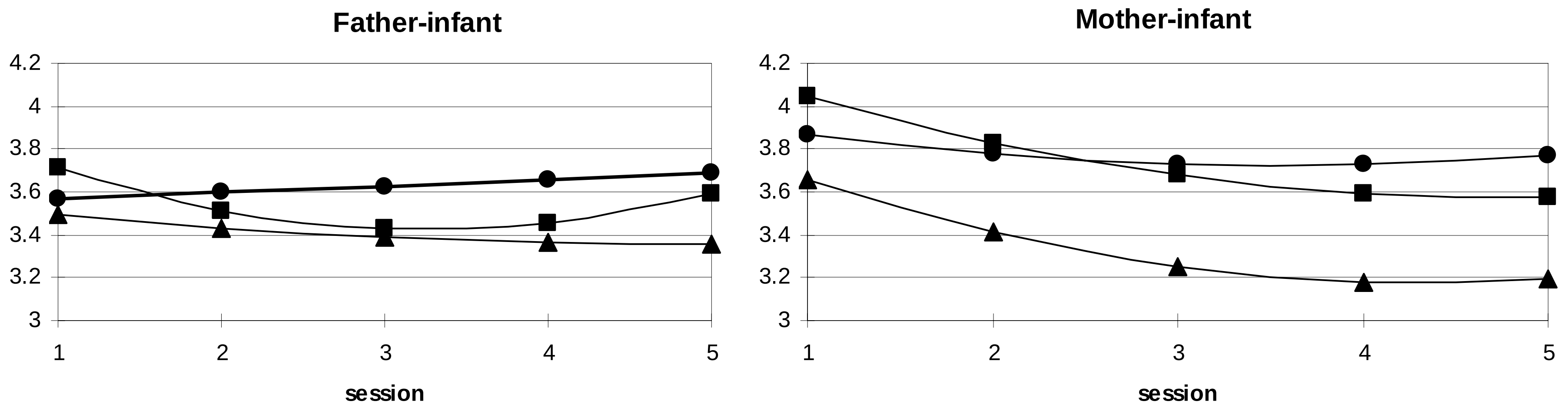

Figure 1. Parental sensitivity, parental mood, and infant mood across parents across play-segments for fathers and mothers (estimated values).
Note: ● = parent sensitivity, ■ parent mood, ▲ infant mood.

Appendix

Equation 1. Model for univariate multilevel models, in which the fixed effects (*β*) are:

$y_{ij} = \beta_{0j}\_INT_{ij} + \beta_{1j}\_SEGM_{ij} + \beta_{2j}\_SEGM\text{-}SQ_{ij} + \beta_{3j}\_PAR_j + \beta_{4j}\_PAR \times SEGM_j + \beta_{5j}\_PAR \times SEGM\text{-}SQ_j + \beta_{6\text{-}10j}\_COV_j + \beta_{11\text{-}15j}\_PAR \times COV_j + e_{ij}$

where time-points (i) are nested within infants (j), and e is the residual, INT is the intercept, SEGM the linear order of the play segments (-2, -1, 0, 1, 2), SEGM-SQ the quadratic order of the play segments (4, 1, 0, 1, 4), PAR is parent, COV infant covariates (age with father and mother, gender, birth order), and family covariate (family sociodemographic background). The random effects are:

$\beta_{0j} = \beta_{0j} + \upsilon_{0ij}$

$\beta_{1j} = \beta_{1j} + \upsilon_{1ij}$

$\beta_{3j} = \beta_{3j} + \upsilon_{3ij}$

The variances are assumed to have a mean of zero and a multivariate normal variance.

Equation 2. Multivariate multilevel model, specified at three levels (h) the dependent variable, (i) segment, and (j) infant, in which fixed effects on PARRESP (parental sensitivity), PARMOOD (parental mood) and INFMOOD (infant mood) are:

$$\begin{cases} PARRESP_{ij} = \beta_{0j}\_INT_{hij} + \beta_{3j}\_SEGM_{hij} + \beta_{6j}\_SEGM\text{-}SQ_{hij} + \varepsilon_{ij} \\ PARMOOD_{ij} = \beta_{1j}\_INT_{hij} + \beta_{4j}\_SEGM_{hij} + \beta_{7j}\_SEGM\text{-}SQ_{hij} + \varepsilon_{ij} \\ INFMOOD_{ij} = \beta_{2j}\_INT_{hij} + \beta_{5j}\_SEGM_{hij} + \beta_{8j}\_SEGM\text{-}SQ_{hij} + \varepsilon_{ij} \end{cases}$$

where INT is the intercept, SEGM the linear segment, and SEGM-SQ the segment-squared effect. The random effects are:

$\beta_{0j} = \beta_{0j} + \upsilon_{0j} + \varepsilon_{0ij}$

$\beta_{3j} = \beta_{3j} + \upsilon_{3j}$

$\beta_{1j} = \beta_{1j} + \upsilon_{1j} + \varepsilon_{1ij}$

$\beta_{4j} = \beta_{4j} + \upsilon_{4j}$

$\beta_{2j} = \beta_{2j} + \upsilon_{2j} + \varepsilon_{2ij}$

$\beta_{5j} = \beta_{5j} + \upsilon_{5j}$

$$\begin{pmatrix} \upsilon_{0j} \\ \upsilon_{1j} \\ \upsilon_{2j} \\ \upsilon_{3j} \\ \upsilon_{4j} \\ \upsilon_{5j} \end{pmatrix} \sim N\,(0, \Omega_\upsilon)\ ;\ \ \Omega_\upsilon = \begin{pmatrix} \sigma^2_{\upsilon 0} & & & & & \\ \sigma^2_{\upsilon 01} & \sigma^2_{\upsilon 1} & & & & \\ \sigma^2_{\upsilon 02} & \sigma^2_{\upsilon 12} & \sigma^2_{\upsilon 2} & & & \\ \sigma^2_{\upsilon 03} & \sigma^2_{\upsilon 13} & \sigma^2_{\upsilon 23} & \sigma^2_{\upsilon 3} & & \\ \sigma^2_{\upsilon 04} & \sigma^2_{\upsilon 14} & \sigma^2_{\upsilon 24} & \sigma^2_{\upsilon 34} & \sigma^2_{\upsilon 4} & \\ \sigma^2_{\upsilon 05} & \sigma^2_{\upsilon 15} & \sigma^2_{\upsilon 25} & \sigma^2_{\upsilon 35} & \sigma^2_{\upsilon 45} & \sigma^2_{\upsilon 5} \end{pmatrix}$$

where ν are the infant level covariances, and υ the residuals. $\sigma^2_{\upsilon 0}$ - $\sigma^2_{\upsilon 2}$ are the average-to-average variances, and $\sigma^2_{\upsilon 01,}$ $\sigma^2_{\upsilon 02,}$ $\sigma^2_{\upsilon 12}$ the average-to-average covariances, $\sigma^2_{\upsilon 03} - \sigma^2_{\upsilon 23,}$ $\sigma^2_{\upsilon 04} - \sigma^2_{\upsilon 24,}$ $\sigma^2_{\upsilon 05} - \sigma^2_{\upsilon 25}$ the average-to-change covariances, $\sigma^2_{\upsilon 3} - \sigma^2_{\upsilon 5}$ the change-to-change variances, and $\sigma^2_{\upsilon 34,}$ $\sigma^2_{\upsilon 35,}$ $\sigma^2_{\upsilon 45}$ the change-to-change covariances. The variances and covariances are assumed to have a mean of zero and a multivariate normal variance.

$$\begin{pmatrix} \varepsilon_{0ij} \\ \varepsilon_{0ij} \\ \varepsilon_{0ij} \end{pmatrix} \sim N\,(0, \Omega_{\varepsilon})\ ;\ \ \Omega_{\varepsilon} = \begin{pmatrix} \sigma^2{}_{\varepsilon 0} & & \\ \sigma^2{}_{\varepsilon 01} & \sigma^2{}_{\varepsilon 1} & \\ \sigma^2{}_{\varepsilon 02} & \sigma^2{}_{\varepsilon 12} & \sigma^2{}_{\varepsilon 2} \end{pmatrix}$$

where the variances are assumed to have a mean of zero and a multivariate normal variance.

[1] The three factor solution fitted data better than an alternative two-factor solution, in which all three parental variables loaded on the first factor, and infant mood on the second factor (fathers: $\chi^2_{[30]} = 100.113$; $p = .000$; RMSEA = .070; CFI = .897; mothers: $\chi^2_{[30]} = 119.168$; $p = .000$; RMSEA = .079; CFI = .848). A nested model comparison between the 3- and 2-factor models indicated that model fit was better for the 3-factor model ($\Delta\chi^2_{[13]} = 79.903$; $p<.001$, for fathers) and ($\Delta\chi^2_{[13]} = 89.793$; $p<.001$, for mothers).

[2] An alternative final model was fitted to the data. In this model the random quadratic play segment effect of fathers' responsiveness was included in the multivariate MLM. Quadratic change in sensitivity was related to linear change in fathers' mood ($\sigma^2 = -.51$) meaning that more fathers peaked in sensitivity at the mid play-segment the larger was the increase in mood, but change in quadratic sensitivity was unrelated to change in infant mood.

[3] We are thankful to an anonymous referee who highlighted this interpretation.