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Predicting infant–father attachment: the role of pre- and postnatal triadic family alliance and paternal testosterone levels

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ABSTRACT
This longitudinal study examined whether prenatal family alliance and prenatal paternal testosterone levels predicted infant–mother and infant–father attachment security and whether this association was mediated by postnatal family alliance and postnatal paternal testosterone levels. In 105 couples expecting their first child, family alliance was assessed in the third trimester of pregnancy with the prenatal version of the Lausanne Trilogue Play (LTP). Family alliance was measured again 6 months postnatally, using the LTP. Fathers provided testosterone samples prenatally and at 6 months postnatally. Infant–parent attachment was assessed with the Attachment Q-Sort (AQS) at 24 months. Results indicated an increase in paternal testosterone levels from the pre- to the postnatal period. A more positive prenatal family alliance predicted higher infant–father attachment security at 24 months, but not infant–mother attachment security. The association between prenatal family alliance and attachment security was not mediated by postnatal family alliance or postnatal paternal testosterone levels. This study highlights the significance of prenatal family relations, and the need to consider in research and practice the divergent effects of prenatal family alliance patterns on the emerging infant–mother and infant–father attachment relationships. The underlying hormonal mechanisms during the transition to fatherhood are important targets for future research.

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Infant–father attachment; prenatal family relations; triadic family interactions; testosterone; Lausanne Trilogue Play

A core hypothesis in attachment theory is the important role of parental sensitivity in shaping the child's attachment relationships (De Wolff & Van IJzendoorn, 1997; Grossmann, Grossmann, & Kindler, 2005). However, meta-analytical evidence shows modest associations between parental sensitivity and attachment security, suggesting the involvement of additional factors in the development of the infant–parent attachment relationship (De Wolff & Van IJzendoorn, 1997; Lucassen et al., 2011; Verhage et al., 2016). Few studies have addressed the

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association between family relations, hormonal processes and the development of the infant–parent attachment relationship. The aim of this study is to examine for the first time how prenatal and early triadic family relations affect the infant attachment relationship to both parents and how these associations may be mediated by paternal testosterone levels.

Taking a family system perspective on attachment, family relations at the triadic level (mother–father–child) may influence the quality of the attachment relationship at the dyadic level (mother–child, father–child) (Brown, Schoppe-Sullivan, Mangelsdorf, & Neff, 2010). It is plausible that infants who witness cooperative, coordinated and supportive parental interactions perceive their parents as secure and trustworthy caregivers to whom they can return in times of distress, danger or illness. In contrast, infants who are exposed to discordant, conflicted and competitive parental interactions may experience feelings of insecurity and uncertainty towards each parent (Caldera & Lindsey, 2006). It has further been argued that hormonal processes are involved in the establishment of triadic family interaction patterns (Gordon, Zagoory-Sharon, Leckman, & Feldman, 2010).

The few existing studies on family relations and infant–parent attachment have mainly focused on the construct of co-parenting. Co-parenting is defined as the degree to which partners share leadership and provide mutual support when working together as parents (McHale, 1995). Co-parenting includes dimensions like mutual support, cooperation, hostility, and competitiveness, and often has a dyadic focus. Caldera and Lindsey (2006) reported that competitive co-parenting was associated with less secure infant–mother and infant–father attachment relationships, as measured with the self-reported Attachment Q-Sort (AQS; Waters & Deane, 1985). Another study reported a positive association between supportive co-parenting and infant–father attachment security, and this association remained significant after controlling for paternal sensitivity. However, non-significant associations were found between supportive co-parenting and infant–mother attachment security (Brown et al., 2010).

The different findings for mothers and fathers suggest that family relations may have divergent effects on the emerging of infant–mother and infant–father attachment relationships. This is in line with studies reporting that family relations have a greater effect on fathers than on mothers. For example, when mothers actively support paternal interactive efforts with their child, fathers spent more time displaying positive affect, gazed at their infants longer, and touched their infant more frequently than mothers (Gordon & Feldman, 2008). In addition, marital conflict predicted a less secure infant–father attachment relationship but was not associated with the quality of the infant–mother attachment relationship (Owen & Cox, 1997).

The effect of family relations on infant–parent attachment relationships may already be observed prenatally. During pregnancy parents' sense of identity is changed and adjusted to fit their new role as a parent (Cowan & Cowan, 1992). Also, during pregnancy parents begin to form an emotional bond with their unborn baby (Doan & Zimerman, 2003), and parents have ideas, fantasies, and expectations about their future life with their baby (Benoit, Parker, & Zeanah, 1997; Vreeswijk, Maas, Rijk, & van Bakel, 2014).

Family interaction patterns have been shown to be rather stable from pregnancy to the child's second birthday (Favez, Frascarolo, Carneiro, Montfort, Corboz-Warnery, & Fivaz-Depeursinge, 2006), possibly because they are partly rooted in relatively stable personality traits or relational mental models. This would be in line with research showing correspondence between expectant parents' internal working models of attachment and subsequent infant attachment classifications (Steele, Steele, & Fonagy, 1996). Moreover, expectant parents' ability to fantasize about their future relationship with their unborn child has shown to be predictive of the quality of the triadic family interaction at 4 months postpartum (Von Klitzing, Simoni, & Bürgin, 1999). Finally, parents' perception of their romantic relationship during pregnancy predicted the infant–mother and infant–father bond at 3 and 15 months postpartum (Parfitt, Ayers, Pike, Jessop, & Ford, 2014).

In sum, relational mental models may already be reflected in prenatal family interactions. This would not only suggest that prenatal observations of family interactions can predict the quality of the later infant–parent attachment relationships, but also that prenatal observations of family interactions may be a stronger predictor of later infant–parent attachment relationships than postnatal observations of family interactions.

In the present study, we focus on the construct of family alliance, which is defined as the family's degree of coordination when fulfilling a rather complicated task (Favez, Frascarolo, & Tissot, 2017). Family alliance can be examined with the Lausanne Trilogue Play (LTP; Fivaz-Depeursinge & Corboz-Warnery, 1999). The LTP incorporates the child as an active family member and assesses triadic family interactions in several predetermined interactive settings. In the prenatal version of the LTP (Carneiro, Corboz-Warnery, & Fivaz-Depeursinge, 2006), the infant in the triadic family system is simulated by a doll. By doing so, family alliance can be assessed prior to entering parenthood while controlling for the contribution of child characteristics (e.g. temperament, gender). Whereas most studies focus on expectant parents' representations and perceptions of family relations, the prenatal LTP allows for systematic behavioral observations of intuitive parenting behaviors. The prenatal LTP is validated in samples of Swiss (Carneiro et al., 2006), Italian (Simonelli, Bighin, & De Palo, 2012) and American expectant parents (Altenburger, Schoppe-Sullivan, Lang, Bower, & Kamp Dush, 2014). Moreover, as it has been shown that intuitive parenting behaviors can be activated during interactions with a doll (Favez et al., 2006; Voorthuis et al., 2013), it is reasonable to expect that the prenatal version of the LTP is able to elicit intuitive parenting behaviors in expectant parents.

Whether the association between family alliance and the infant–parent attachment is influenced by hormonal processes is currently unknown. In the present study, we focus on paternal testosterone levels. Testosterone is an androgenic steroid hormone and is generally considered to be unsupportive of sensitive parenting practices, as it is traditionally associated with mating rather than parenting efforts (Bakermans-Kranenburg & van IJzendoorn, 2018). In species where males engage in offspring care, testosterone levels decline during the transition to fatherhood (Gettler, McDade, Feranil, & Kuzawa, 2011; Storey, Walsh, Quinton, & Wynne-Edwards, 2000), even though recent meta-analyses reported unexpectedly small effect sizes for lower testosterone levels among human fathers compared to non-fathers (Grebe, Sarafin, Strenth, & Zilioli, 2019; Meijer, van IJzendoorn, & Bakermans-Kranenburg, 2019). Nevertheless, a central hypothesis in endocrine studies of parenting in general and fathering in particular implies that lower testosterone levels allow for more and better caregiving of offspring (Gettler et al., 2011).

Indeed, fathers with lower testosterone levels have been found to show a more optimal expression of the human parenting repertoire, including more affectionate touch, gaze and vocalization during father–child interaction (Weisman, Zagoory-Sharon, & Feldman, 2014), and feel more sympathy when hearing infant cry sounds (Fleming, Corter, Stallings, & Steiner, 2002). Moreover, fathers' decline in testosterone levels during pregnancy predicted fathers' postpartum investment, commitment, and satisfaction in the couple relationship (Saxbe et al., 2017). To our knowledge, no study to date has examined how testosterone levels are involved in the association between pre-and postnatal triadic family relations and infant–parent attachment.

In sum, the aim of the present longitudinal study is to examine the relation between triadic family alliance, testosterone and infant–parent attachment security. More specifically, it will be the first study examining whether prenatal family alliance and fathers' prenatal testosterone levels are predictive of infant–mother and infant–father attachment security at 24 months and whether this relationship is mediated by postnatal family alliance and fathers' postnatal testosterone levels at 6 months. We hypothesized that higher prenatal family alliance will predict secure infant–mother and infant–father attachment at 24 months, above and beyond prenatal testosterone levels. We also hypothesized that the relation between prenatal family alliance and secure infant–mother and infant–father attachment will be mediated by higher postnatal family alliance and lower paternal testosterone levels at 6 months. Based on the available literature, we expected that prenatal family alliance will be more strongly predictive of infant–father attachment than of infant–mother attachment.

Method

Participants

Participants were 105 co-living heterosexual couples, expecting their first child at the time of recruitment. Families were recruited through internet advertisements, flyers, and medical centers. All parents were fluent in writing and speaking Hebrew, middle to upper class, and living in central Israel. Mean educational level was 15.36 years ($SD = 2.41$) for fathers and 16.3 years ($SD = 2.10$) for mothers. All women were in their third trimester of pregnancy ($M = 29.7$ weeks, $SD = 2.55$ range = 22.27–37.08 weeks) at the time of recruitment. Parents were in good health, without known neurological or psychological disorders, and reported no substantial medication or substance use. None of the parents reported any significant pregnancy complications and all infants were single-born. Both parents provided written informed consent at the start of the study. The study was approved by the institutional review board of the Interdisciplinary Center Herzliya. Families received a financial reimbursement and a token of appreciation of their time and effort for their participation in each phase of the study.

Procedures

Participants took part in the RIPPLE study, a larger longitudinal study on early socio-emotional development. For the current analyses, we used data from three measurement points: prenatal (T1), 6-months postpartum (T2), and 24-months postpartum (T3). At T1, during the third semester of pregnancy, expectant parents were invited to the lab where they were videotaped during the prenatal Lausanne Trilogue Play (LTP; Carneiro et al., 2006), and provided saliva samples for hormonal measures. The prenatal LTP is a five-minute, semi-standardized task in which parents are asked to play out their first meeting with their newborn. The baby is represented by a neutral doll with the typical size and weight of a newborn. The face is undefined with no particular eye, skin, and hair color. The prenatal LTP is an adaptation of the postnatal LTP and measures family alliance, defined as the degree of coordination parents demonstrate when working together as a team in relation to their baby-to-be (Fivaz-Depeursinge, Frascarolo, & Corboz-Warnery, 2010). Beyond role-playing abilities, the task requires parents' mutual support and cooperation (Carneiro et al., 2006).

In order to enhance parents' ability to get into the parenting state of mind and engage in the role play involved in the prenatal LTP, and in accordance with the prenatal LTP protocol, a research assistant interviewed the parents regarding their present situation, respective family histories, and representations about their future child (Carneiro et al., 2006; Fivaz-Depeursinge et al., 2010). Parents were then invited to sit in a triangular configuration with a crib and were asked to imagine their first encounter with their newborn. The research assistant helped the parents get into their roles by role-playing the nurse bringing the baby to them for the first time. Parents were instructed to play out the four components of the task: (1) One parent plays with the newborn (2) the parents switch roles, (3) the parents play together with the newborn, (4) the parents talk about the experience they just went through, while they let the baby sleep (for a more detailed description, see Carneiro et al., 2006). After exactly 5 minutes, the research assistant entered the room and announced that the task was over.

At T2, when infants were 6 months old, families were invited to the lab where they were videotaped during the LTP and provided salivary samples for subsequent hormonal analyses. Families were instructed to sit on a mat in a triangular position. Families were positioned on a mat instead of chairs because a pilot study showed that six-month-old infants had difficulties sitting in a high chair for a sustained length of time. This adaptation was confirmed and approved by the LTP team in Lausanne (F. Frascarolo, personal communication, May, 2016). Parents were asked to play out the four possible relational situations of everyday triadic interactions: (1) One parent plays with the infant while the other parent is in a third-party position, as participant-observer, (2) the parents switch roles, (3) mother, father and child play together, (4) the parents have a discussion with each other, while the infant is in the third-party position (for a more detailed description, see Fivaz-Depeursinge et al., 1999). Parents could decide how much time they spent on each component of the play. The mean duration of the LTP was 9.89 min (*SD* = 1.44 min).

At T3, when infants were 24 months old, two home visits were conducted to assess infant attachment security using the Attachment Q-sort procedure (AQS; Vaughn & Waters, 1990) – once to assess infant–father attachment and once to assess infant–mother attachment. The length of each visit was approximately 90 minutes. Infant–mother and infant–father attachment security were rated separately by independent observers. Order of assessment was random. The AQS is an evaluation of the child's attachment to the parent through natural observation in the child's home. During the observation, the researcher asks the parent to behave as they are usually doing in a regular situation. During the observation, the researcher initiates some situations to elicit secure proximity seeking behavior of the infant. Examples include introducing a new and unfamiliar toy to the child and making a surprising sound. After the observation, the experimenter described the observed behavior by classifying 90 items describing various behaviors of the child, most of which represent behaviors with a secure base.

Measures

Prenatal family alliance

Prenatal family alliance was assessed using the prenatal LTP coding system (Carneiro et al., 2006). Coding prenatal family interactions using the postnatal LTP coding system was shown invalid (Carneiro et al., 2006). Therefore, a coding system to assess prenatal family interactions was developed and validated (Altenburger et al., 2014; Carneiro et al., 2006; Simonelli et al., 2012). The coding system consists of five scales: (1) Co-parental playfulness towards the task (ability of the parents to create a playful space and co-construct the game), (2) structure of the play (ability of the parents to structure the four play parts according to the instructions and to give each part an appropriate duration for the play to be established), (3) intuitive parenting behaviors (use of intuitive parenting behaviors such as motherese vocalizations), (4) couple's cooperation (degree of active cooperation between the parents during the play), and (5) family warmth (degree of affection and humor shared between partners during the play) (Carneiro et al., 2006). A 5-point Likert-type rating system was used for each scale ranging from 1 (inappropriate) to 5 (appropriate). An example of inappropriate co-parental playfulness is when one partner engages in the play but the other partner struggles and shows no positive engagement in the play; or when parents follow the instructions too literally and show no awareness that they are involved in a game. An example of appropriate co-parental playfulness is when both parents show positive and affective engagement during the play and show awareness that they are engaged in a game and interpret the instructions freely (see Carneiro et al., 2006, for a more detailed description of scores for each subscale of the prenatal LTP coding system). Consistent with other studies, a global score of prenatal family alliance was computed, ranging between 5 and 25, with higher scores reflecting a more positive prenatal family alliance. The Intraclass Correlation Coefficient (ICC) Interrater Reliability (IRR) using 25% of the sample was .84.

Postnatal family alliance

Postnatal family alliance was assessed using the Family Alliance Assessment Scale (FAAS; Favez, Scaiola, Tissot, Darwiche, & Frascarolo, 2011), which analyzes the play across the following scales: (1) *Participation*: refers to the way the family creates an interactional space. Two aspects are considered: (a) postures – positioning of the bodies, such that parents show physical engagement by orienting their pelvises and torsos towards the child, (b) gazes – each partner is visually involved and sees the other parent in his or her peripheral vision. (2) *Organization*: regards the way partners organize the play they have to accomplish. The two subscales are: (a) role implication – each parent fulfils his or her role within the different stages of the task and allows the other partner to fulfill his or hers, (b) task fulfillment – being able to complete all segments of the task in a clear way and to divide enough time to each segment in order to complete the entire task in a sufficient time period. (3) *Focalization*: this function refers to partners' aptitude to share a common focus of interest and/or to perform activities together. The two subscales considered are: (a) co-construction – the family's capacity to co-construct activities. We expect all active partners to show initiatives and to enrich the ongoing activity in order to create a common focus, while also exhibiting turn taking, (b) parental scaffolding – the way parents stimulate their child adapted to the child's state and development; the way parents set limits; and the way parents provide guidance about the play framework. (4) *Affect sharing*: regards the global affective climate and to the circulation of affects between the family members. (5) *Family warmth*: the ability of the family members to exhibit fun, enjoyment, and pleasure from the interactive engagement. (6) *Validation*: considers the extent to which parental behaviors are emotionally attuned to those of the child. (7) *Authenticity*: refers to the extent to which affect expression is congruent with the experienced situations, in which the emotional expressions seem to match the context. (8) *Interactional* *sequence*: regards the partners' ability of repairing interactive mistakes. These interactive mistakes can occur within the subsections, in activities or in the transition from one segment to the following segment: (a) repairs of interactive mistakes during activities, (b) repairs of interactive mistakes during transitions. (9) *Coparenting*: assesses the support and cooperation parents show to each other in order to strengthen their parental roles. The two subscales assessed are: (a) support – active and pronounced signs of support are measured here, for example: head nodding for agreement, mutual smiles, or positive verbal comments, (b) conflict and disruptive interferences – refers to parents engaging in overt or subtle forms of behaviors revealing forms of conflict. (10) *Child's contribution*: involves two aspects of the child's autonomy: (a) child's engagement – the child communicating with his/her parents using affective, motor, visual and vocal signals, (b) regulation – the infant's ability to regulate inner states and stay available for the interaction.

Each subscale was given a rating of 0 (*inappropriate*), 1 (*moderate*), or 2 (*appropriate*). An example of inappropriate participation is when partners' gazes and their body positions do not create an optimal context for interaction, such as when they show bodily signs of disengagement and are unavailable for interaction or show prolonged indifferent or neutral attitudes. Appropriate participation can be observed when partners' gazes and body orientation create an optimal context for emotional exchanges and sharing of affects (see Favez et al., 2011, for a more detailed description of inappropriate and appropriate scores for each subscale of the postnatal LTP coding system). The ratings were then summed to create a global score, ranging between 0 and 30, with higher scores reflecting a more positive family alliance. The Intraclass Correlation Coefficient (ICC) Interrater Reliability (IRR) using 25% of the sample was .92.

Attachment security

Infant–mother and infant–father attachment security were measured separately with the Attachment Q-Sort (AQS; Vaughn & Waters, 1990). The AQS assesses the attachment security of children between 1 and 5 years of age based on a home observation lasting 90 minutes. An observer rated the typical attachment behaviors of the infant by sorting 90 cards into nine piles, each containing 10 items. The cards were sorted from "most descriptive of the child" to "least descriptive of the child". The attachment score was calculated by correlating the observer's Q-description with the criterion sort of the prototypically secure child (Waters & Deane, 1985). The AQS has been shown to be a valid measure of attachment with satisfactory convergent, discriminant and predictive validity (Van IJzendoorn, Vereijken, Bakermans-Kranenburg, & Riksen-Walraven, 2004). Observers were trained by experts for the assessment of infant–parent attachment using the AQS. In the current study, the Intraclass Correlation Coefficient (ICC) Interrater Reliability (IRR) using 20% of the sample was .71.

Testosterone levels

Following Granger et al. (2012), whole **s**aliva was collected by passive drool. Samples were donated, placed on ice and transferred to the laboratory where they were stored frozen at 80°C until assay. Samples were assayed in duplicate for testosterone at the Institute for Interdisciplinary Salivary Bioscience Research using commercially available enzyme immunoassays without modifications to the manufacturer's recommended protocols (Salimetrics, Carlsbad, CA). The test volume was 50 uL, and range of sensitivity was from

1.0 to 600 pg/mL. Interassay and intraassay precision (coefficient of variation) were, on average, less than 15% and 10%, respectively.

Results

Preliminary analysis

Descriptive statistics and zero-order correlations are displayed in Table 1. There was a significant increase in fathers' testosterone levels from before birth to 6 months after birth [$t(76) = 2.96$, $p = .004$, $d = 0.36$]. Moreover, as expected, prenatal and postnatal family alliance were positively correlated, as well as fathers' prenatal and postnatal testosterone levels. Prenatal and postnatal family alliances were correlated with having a secure attachment relationship with the father at 24 months, but none of these variables were correlated with infant–mother attachment security at 24 months. Finally, there was a positive cross-parent correlation between AQS security scores.

Mediation analysis

The estimated mediation model is displayed in Figure 1. Parameter estimates and bootstrapped confidence intervals are displayed in Table 2. We examined whether prenatal family alliance and fathers' prenatal testosterone levels predict attachment security at 24 months via family alliance and fathers' testosterone levels at 6 months. When predicting six-month testosterone levels from prenatal testosterone levels, we controlled for the age of the father and the time of day when testosterone samples were taken. This model was estimated via Mplus 8 (Muthén & Muthén, 1998–2017) using Full Information Maximum Likelihood (FIML) estimation and bias-corrected bootstrap confidence intervals. The model fits the data very well [$\chi^2(6) = 0.92$, $p = .99$; CFI = 1.00; RMSEA = 0.00; SRMR = .017].

Higher prenatal family alliance directly predicted a more secure attachment relationship with the father at 24 months, but not with the mother. There was no mediation through the postnatal family alliance at 6 months. Although prenatal family alliance predicted postnatal family alliance at 6 months above and beyond prenatal testosterone levels, postnatal family alliance did not predict a secure attachment relationship with the father above and beyond prenatal family alliance and prenatal and postnatal testosterone levels. The 95% bias-corrected bootstrap confidence interval for the indirect effect from prenatal family alliance to attachment security with the father via postnatal family alliance included 0 ($\beta = .04$, CI[−.11, .24]), indicating a non-significant effect. However, the total

Table 1. Means, standard deviations, and zero-order correlations between study variables.

	Prenatal T	Postnatal T	Prenatal LTP	Postnatal LTP	Security (Mother)	Security (Father)
Prenatal T						
Postnatal T	.46***					
Prenatal LTP	.02	−.14				
Postnatal LTP	−.01	−.10	.43***			
Security (Mother)	.03	.01	.05	.09		
Security (Father)	−.01	.05	.31*	.26*	.46***	
Mean	97.61	106.59	17.42	19.52	0.26	0.27
SD	28.53	31.29	3.90	6.09	0.19	0.22

T = father's testosterone (pg/ml). LTP = global LTP score: family alliance. Security = Q-sort attachment security score.
* $p < .05$, *** $p < .001$.

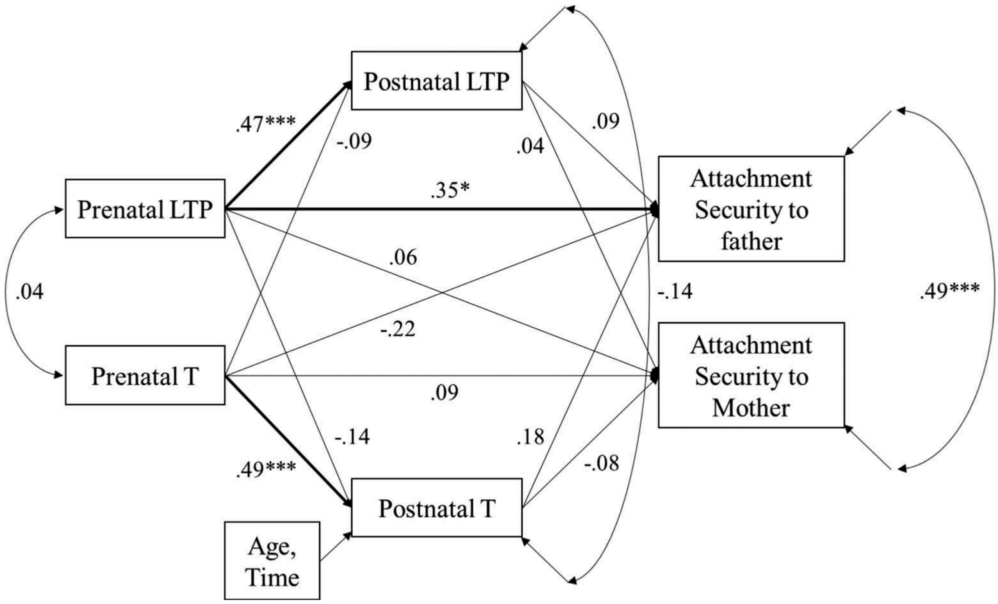

Figure 1. Mediation model. Bolded paths are statistically significant.

Table 2. Maximum likelihood standardized estimates and 95% bias-corrected bootstrap confidence intervals for mediation model predicting attachment security.

Regression Path			β	SE	p	CI_{Low}	CI_{High}
Prenatal T	→	Postnatal T (6M)	.49	0.13	< .001	.20	.71
Prenatal LTP	→	Postnatal T (6M)	−.14	0.12	.246	−.36	.11
Age	→	Postnatal T (6M)	.09	0.09	.317	−.08	.26
Time	→	Postnatal T (6M)	−.04	0.12	.725	−.27	.21
Prenatal T	→	Postnatal LTP (6M)	−.09	0.10	.376	−.28	.11
Prenatal LTP	→	Postnatal LTP (6M)	.47	0.11	<.001	.23	.65
Prenatal T	→	Security (Mother)	.09	0.14	.549	−.22	.35
Prenatal LTP	→	Security (Mother)	.06	0.14	.691	−.22	.34
Postnatal T (6M)	→	Security (Mother)	−.08	0.16	.638	−.36	.28
Postnatal LTP (6M)	→	Security (Mother)	.04	0.14	.791	−.25	.33
Prenatal T	→	Security (Father)	−.22	0.13	.080	−.46	.03
Prenatal LTP	→	Security (Father)	.35	0.14	.014	.05	.60
Postnatal T (6M)	→	Security (Father)	.18	0.14	.219	−.11	.47
Postnatal LTP (6M)	→	Security (Father)	.09	0.17	.620	−.25	.42

T = Father's Testosterone (pg/ml). LTP = Global LTP score: family alliance. Security = Q-sort attachment security score. Age = Father's age when postnatal Testosterone samples were taken. Time = Time of day when postnatal Testosterone samples were taken.

effect from prenatal family alliance to attachment security with the father, which is the sum of the direct and indirect effects, was significant (β = .39, CI[.12, .68]).

There was also a marginal but non-significant negative direct effect of prenatal testosterone levels on attachment security with the father at 24 months (p = .08, see Table 2), implying that lower prenatal testosterone levels might be associated with higher attachment security. Prenatal testosterone levels also predicted testosterone levels at 6 months, but testosterone levels at 6 months did not predict attachment to the father above and beyond prenatal testosterone levels and prenatal and postnatal family alliance. There were no effects on attachment security with the mother at 24 months.

Discussion

This longitudinal study showed that a more positive prenatal family alliance predicted higher infant–father attachment security at 24 months, but not infant–mother attachment security. There was no mediation through postnatal family alliance or paternal testosterone levels at 6 months. These findings highlight the significance of prenatal family relations, and the need to consider in research and practice the divergent effects of prenatal family alliance patterns on the emerging infant–mother and infant–father attachment relationships.

The predictive role of prenatal alliance in predicting infant–father attachment security suggests that the quality of the infant–father attachment relationship depends on the ability of the mother and father to cooperate and support each other when working together in their roles of parents. The present study found no link between prenatal family alliance and infant–mother attachment quality. This is in line with previous studies showing that the quality of the parental relationship seems to have a greater effect on the infant–father attachment relationship than on the infant–mother attachment relationship (Brown et al., 2010; Owen & Cox, 1997).

One possible explanation for the divergent effects on infant–mother and infant–father attachment may be that fathers are more susceptible to the quality of family relations. Research has shown that when mothers actively support paternal interactive efforts with their child, fathers express more positive parenting behaviors towards their child as compared to mothers (Gordon & Feldman, 2008). In contrast, in conditions of marital conflict, fathers are more likely to withdraw from their children (Cummings, & O'Reilly, 1997), and fathers' withdrawal during a co-parenting negotiation task was associated with greater disengagement and the expression of less warmth in a previous study with the Lausanne Trilogue Play task (Elliston, McHale, Talbot, Parmley, & Kuersten-Hogan, 2008). These findings suggest that the quality of family relations affects paternal behaviors that promote or repress infant–father attachment security.

Second, fathers may spend more time in a triadic family setting than in a dyadic family setting. Indeed, research has shown that mothers provide higher absolute amounts of childcare and spend more time in sole charge of their children as compared to fathers (Craig, 2006; Craig & Mullan, 2011). Consequently, fathers may be more dependent on the quality of triadic family interactions to establish themselves as secure and protective caregivers, while mothers may have more opportunities to do so in solitary interactions with their child. Future studies should investigate whether differences in time spent in dyadic and triadic family settings explain the divergent effects of prenatal family relations on the infant–mother and infant–father attachment relationship.

Third, maternal gatekeeping may be a mechanism accounting for the influence of triadic family relations on infant–father attachment security. Maternal gatekeeping refers to behaviors such as not sharing childcare responsibilities and criticizing the father's interactions with his child (Gaunt, 2008). Fathers who experienced greater maternal restrictions in their involvement with their child at 3-months postpartum showed lower parenting quality at 9-months postpartum. Intriguingly, maternal encouragement at 3-months postpartum was not associated with parenting quality at 9-months postpartum (Altenburger, Schoppe-Sullivan, & Dush, 2018). Nevertheless, it may be that father–child interactions in the triadic family setting are influenced by encouragements or restrictions of the mother. Future research is needed to examine how maternal gatekeeping behaviors in the triadic family setting affect the development of the infant–father attachment relationship.

Our results further show that specific family alliance patterns are observable before the birth of the baby. In addition, prenatal and postnatal family alliances were positively related to infant–father attachment security but the relation between prenatal family alliance and infant–father attachment was not mediated by postnatal family alliance. Postnatal family alliance might still contribute to infant–father attachment security, but it did not have a unique effect on infant–father attachment security in our mediation model, suggesting that the family dynamics that shape attachment relationships between infants and fathers may be better detectable prior to the baby's birth than after birth. An important next step for future research is to examine whether parents' generalized internal working model of attachment relationships is reflected in prenatal family relationships and affect later infant–parent attachments. This would be in line with research showing correspondence between expectant parents' internal working models of attachment and subsequent infant attachment classifications (Steele et al., 1996).

Postnatal testosterone levels did not mediate the association between the quality of prenatal family relations and infant–parent attachment security. It appears that alterations in paternal testosterone levels occur independently of the establishment of the infant–father attachment relationship. It may also be that paternal testosterone levels interact with other hormones and neuropeptides to mediate the quality of the infant–father attachment relationship. Unfortunately, the current study did not allow for testing the interplay of testosterone with other hormones and neuropeptides.

Contrary to our hypothesis, our results showed an increase in paternal testosterone levels from before to after the birth of the baby. These findings are in contrast with previous studies showing that testosterone levels decline during the transition to fatherhood (Gettler et al., 2011; Storey et al., 2000). However, it is important to note that these studies measured paternal testosterone levels at different age periods as compared to the ages included in our study – 6 months. For example, when assessing between-group changes, Gettler et al. (2011) stratified groups based on the age of the youngest child; fathers with newborns (younger than 1 month of age), fathers with infants (between 1 month and 1 year of age) and fathers with children (older than 1 year of age), and included men who were not fathers as the comparison group. Moreover, Storey et al. (2000) measured paternal testosterone levels in the early prenatal (between 16 and 35 weeks pregnancy) and late prenatal period (last 3 weeks before birth), and in the early postnatal (younger than 3 weeks of age) and late postnatal period (between four and 7-weeks old).

The downregulation of paternal testosterone levels has been hypothesized to allow for better caregiving of offspring (Bakermans-Kranenburg & van IJzendoorn, 2018; Gettler et al., 2011). Nevertheless, testosterone systems have shown to be flexibly dependent on context. For example, testosterone levels increase when fathers listen to infant cry sounds and are not able to provide a protective or caregiving response, but decrease when fathers can provide a nurturing response (van Anders, Tolman, & Volling, 2012). The flexibility of testosterone levels may suggest that paternal testosterone levels are also susceptible to fluctuations in the period from pregnancy to fatherhood. Indeed, research has shown that although fathers showed lower testosterone levels than non-fathers, fathers with newborn infants (younger than 1 month of age) showed greater declines in morning and evening testosterone levels than fathers with infants (between 1 month and 1 year of age) and fathers with older children (older than 1 year of age), and these findings were independent of reported psychosocial stress, sleep quality, and involvement in caregiving (Gettler et al., 2011).

Moreover, two recent meta-analyses reported rather small combined effect sizes for the association between fatherhood and testosterone levels ($r = .19$ in Grebe et al., 2019; $g = .27$

in Meijer et al., 2019). These findings suggest that additional factors may be associated with the downregulation of testosterone levels. Additionally, the effect sizes reported in these meta-analyses were predominantly based on studies incorporating a between subject-design. Much less is known about the magnitude and time window of changes in testosterone levels during the transition to fatherhood.

Fathers who are psychologically and hormonally prepared for fatherhood may be more likely to show reductions in testosterone levels during pregnancy. Especially fathers from intact families who are embracing their future role as fathers may show prenatal rather than postnatal reductions in testosterone levels. Relatedly, it has been shown that men who are more oriented toward their current partnership have lower testosterone levels than men who are less partnership-oriented (Grebe et al., 2019). Studies examining testosterone levels at various time points following the same sample in the period from pregnancy to the postpartum period are badly needed.

There was also a marginal but non-significant negative direct effect of prenatal testosterone levels on infant–father attachment security. Taking a hypothesis-generating approach, it may be suggested that lower prenatal testosterone levels are associated with higher attachment security. Lower paternal testosterone levels during pregnancy may prepare fathers to respond sensitively to the infant, which is particularly important in the early postnatal period when the infant is most vulnerable. However, this interpretation awaits further empirical verification, and it underscores the importance of future research measuring testosterone levels and parenting behavior at multiple time points when examining determinants of the infant–father attachment relationship.

This study has a number of strengths, including the longitudinal design, integration of a family system approach, use of pre- and postnatal measures of family relations, inclusion of observational measures of attachment security, and incorporation of hormonal measures. Moreover, the present study provides fruitful implications for the clinical field. Our results suggest the importance of prenatal examinations of family relations. This would allow for the identification of families at risk for developing insecure infant–father attachment relationships. Consequently, interventions can be implemented in the prenatal stage, and improvements in the quality of the triadic family system may be established before the birth of the baby.

Some limitations of the present study may be taken into account in future research. First, our sample predominantly consisted of highly educated parents from middle to upper-class origin. Future research should include samples with a larger variety of socioeconomic and cultural backgrounds. Second, we did not examine dyadic infant–father and dyadic infant–mother interactions. Incorporating both dyadic and triadic family interactions enables examining the direct and indirect associations among family interactions' patterns and infant–parent attachment security. Third, the setting of the prenatal LTP, in which expectant parents are asked to role play their first encounter with their newborn, may be experienced by expectant parents as a rather unusual situation. However, besides role-play abilities that might be controlled for, the task can activate intuitive parenting behaviors, and child characteristics can be made similar for all parents, which allows for a valid comparison of parenting behaviors between families (Bakermans-Kranenburg, Alink, Biro, Voorthuis, & Van IJzendoorn, 2015). As such, the prenatal LTP provides valuable information about the quality of the family relationship before the birth of the baby, which might be used for the purpose of screening and preventive intervention. Finally, the design of the present study does not allow for making inferences about causality, and our findings should not be interpreted in terms of causality.

In conclusion, the present study showed that infant–father attachment security but not infant–mother security was predicted from prenatal family alliance. In order to unravel the mechanisms underlying the development of the infant–father attachment relationship, an exclusive focus on paternal behavior is insufficient (Cabrera, Volling, & Barr, 2018). Instead, our research underscores the importance of including the triadic family system when examining precursors of the infant–father attachment relationship. Unraveling the role in this process of underlying hormonal mechanisms during the transition to fatherhood is an important target for future research.

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