Abstract

The aim of the current study was to examine whether parental mental health, the parent-infant relationship, infant characteristics and couple's relationship factors were directly or indirectly associated with the infant's cognitive, language or motor development. Forty-two families took part at three time-points. The first, at three months postpartum, involved a video recorded observation (CARE-index) of mother-infant and father-infant interaction. At five months postpartum, each parent participated in an in-depth clinical interview (The Birmingham Interview of Maternal Mental Health; BIMMH) that assessed parental mental health as well as parental perceptions of their relationship with their infant, their partner and their infant's characteristics. Finally, the Bayley Scales of Infant Development (Bayley Scales III) was carried out approximately 17 months postpartum to assess the infants' cognitive, language, and motor development. A higher mother-infant relationship quality was significantly associated with more optimal infant language development, whilst a higher father-infant relationship quality was associated with more advanced motor development. In addition, maternal postnatal PTSD had a negative impact on the infant's cognitive development whilst maternal prenatal depression was associated with a less optimal infant's language development. The largest prediction, however, was afforded by parental perceptions of their infant's characteristics. The findings indicate that such perceptions may be crucial for language, cognitive, and motor development and imply that negative internal parental perceptions should be considered when assessing risk factors or designing interventions to prevent negative child outcomes.

Introduction

Pregnancy and the first year of an infant's life is a critical time for laying the foundations for the child's future development. Research suggests that prevalence rates of early developmental problems range between 11 and 13 % (e.g., Skoovgard et al., 2007; Tough et al., 2008). The identification of children at risk for developmental problems is important, as untreated developmental problems may have significant negative impact on the individuals and have economic and social impacts on society as a whole (Tough et al., 2008). Research suggests a range of interrelated risk factors for negative child developmental outcomes, such as poor mental health of the mother (e.g., Lung, Chiang, Lin & Shu, 2009; Murray, 2009; Brouwers, Van Baar & Pop, 2001), low levels of maternal social support (Tough, Siever, Benzies, Leew & Johnston, 2010) and poor quality of the couple's relationship (Hanington, Heron, Stein & Ramchandani, 2012). Other major risk factors include an impaired parent-infant relationship and attachment problems (Murray & Cooper, 1996; Tomlinson, Cooper & Murray, 2005; Wan & Green, 2009) and also infant factors, such as prematurity (Forcada-Guex, Pierrehumbert, Borghini, Moessinger & Muller-Nix, 2006), male gender (Hay et al., 2001; Tough et al., 2008) and difficult infant temperament (Black et al., 2007).

The current study adds to this literature by including both mothers and fathers in the analysis of the associations between their mental health, relationships with infant and partner, infant characteristics, and their infant's development, using Belsky's model of determinants of parenting (1984) as a general framework. This model suggests that the parent-infant relationship (parenting) and the infant's characteristics have a direct effect on the child's development, and that parental mental health and the couple's relationship are related to infant outcomes by the effect they have on parenting. However, more recent evidence has

also suggested direct links between parental mental health, the couple's relationship and infant developmental outcomes.

Parental mental health and infant development

There is ample evidence of adverse effects of maternal postnatal depression on the infant's cognitive, emotional and language development, behaviour and mental health (Lung et al., 2009; Murray & Cooper, 1996; Murray, 2009; Quevedo et al., 2012). Links between paternal depression and less optimal language development (Paulson, Keefe & Leiferman, 2009) and adverse emotional and behavioural outcomes in children have also been found (Ramchandani et al., 2005).

Mental health in pregnancy may be especially important for later child outcomes. Accumulating evidence suggests exposure to maternal prenatal anxiety and stress in the womb, may have long term negative developmental consequences for the baby (e.g., Glover, 2011; Punamaki et al., 2006; Van Batenburg-Eddes et al., 2009). For example, the results of a large longitudinal study (Evans et al., 2011) suggested that prenatal exposure to depression may be more predictive of less optimal child cognitive development than postnatal depression. It has been suggested that this can be explained by abnormal physiological pathways within biological systems (e.g. neuroendocrine, immune and cardiovascular systems) involved in pregnancy and stress physiology, through which maternal prenatal mental health exerts a risk on child development by affecting the fetal development (Federenko & Wadhwa, 2004; Field, Diego & Hernandez-Reif, 2006).

The majority of research regarding the association between postnatal parental mental health and the infant's development has focused on depression. Less is known about the effect of other aspects of parental mental health, such as anxiety and posttraumatic stress disorder (PTSD), on the infant's subsequent development. A systematic review of the effects of postnatal maternal anxiety on children (Glasheen, Richardson & Fabio, 2010) found that

the strongest adverse effect were on somatic, behavioural and emotional problems in the child, but with inconclusive evidence regarding the effect on children's cognitive and general development. Also, Bosquet et al. (2011) found that maternal PTSD symptoms six months postpartum were associated with measures of emotional regulation when the child was 13 months old. Similarly, Pierrehumbert et al. (2003) found that the severity of PTSD symptoms amongst parents of premature babies was a significant predictor of their children's subsequent regulatory (e.g. sleeping and eating) problems. However, no known studies have assessed infant developmental outcomes in relation to postnatal PTSD.

Infant characteristics and infant development

Early difficult infant temperament has been associated with elevated rates of parental mental health (e.g., Bang, 2011; Melchior et al., 2011), a less optimal parent-infant relationship (Hofacker & Papousek, 1998; Zhu et al., 2007), child behavioural problems (Bosquet et al., 2011; Dale et al., 2011; Jessee, Mangelsdorf, Shigeto & Wong, 2012) and also identified as a predictor of later difficult child temperament (Canals, Hernandez-Maranez & Fernandez-Ballart, 2011). However, generally it should be noted that the associations between different variables, such as parental mental health and the infant' temperament, are reciprocal, not just one way. One aspect of infant temperament is infant sleep disturbance, which has been associated with worse parental pre and postnatal mental health and child behavioural problems (Baird, Hill, Kendrick & Inskip, 2009; Britton, 2011; Field et al., 2007; Lam, Hiscock & Wake, 2003). There is however a lack of studies looking at the link between infant's early temperament and children's subsequent cognitive, language and motor developmental outcomes.

The parent-infant relationship and infant development

Apart from the physiological pathways between women's prenatal mental health and child outcomes as mentioned above, the parent-infant relationship itself may serve as an

important behavioural pathway between parental mental health and child outcomes (e.g., Grace, Evindar & Stewart, 2003; Westbrook & Harden, 2010). The parent-infant relationship has a central position in Belsky's process model (1984), as having a direct effect on the child's development, but also as a mediator of other parental and child predictors).However, although several studies (e.g., Grace, Evindar & Stewart, 2003; Murray, FioriCowley, Hooper & Cooper, 1996; Westbrook & Harden, 2010) have suggested the existence of mediation effects between parental mental health and child outcomes through the parent-infant relationship , these findings are not universal (e.g., McManus & Poehlman, 2012).

Research shows that the quality of the mother-infant interaction may be affected by maternal depression (for a review, see Field, 2010; Leinonen, Solantaus & Punamaki, 2003; for a meta-analysis see Lovejoy, Graczyk, O'Hare & Neuman, 2000), with evidence of deficiencies in the mother's responsiveness and emotional involvement (Black et al., 2007; Murray et al., 1996) or hostile and intrusive interactions (Mantymaa, Puura, Luoma, Salmelin & Tamminen, 2004). It has been suggested that deficient maternal interactions and caregiving consequently affect the infant's responsivity (Field, 2010) and attention (Steadman et al., 2007) therein contributing to less optimal cognitive (Slater, 1995) and language (Stein et al. 2008) child developmental outcomes. Some studies have specifically linked negative parental perceptions and representations of their infant to a less optimal parent-infant relationship and subsequent child developmental or behavioural outcome (Dollberg, Feldman & Keren, 2010; Hernández- Martinez, Canals Sans et al., 2011).

Although most studies have focused on the mother-infant relationship, recent research on the influence of fathers' parenting and child development is also emerging. For example, the extent of fathers' positive involvement in parenting has been shown to reduce the likelihood of cognitive delays in their children, especially for boys (Bronte-Tinkew, Carrano, Horowitz & Kinukawa, 2008). Conversely, Ramchandani et al. (2012) found that paternal

disengagement and remote interaction with their babies at three months predicted child externalising behavioural problems at one year of age.

The couple's relationship and infant development

The above research shows that the family should be viewed as a system (e.g., Bell et al., 2007; Cowan & Cowen, 2002) with an awareness of both parents' contribution to their child's outcomes and also acknowledgement of possible spill over effects between the couple's relationship and parent-infant relationship subsystems (Erel & Burman, 1995). For example, the couple's relationship problems may negatively affect the parent-infant interactions (e.g., Mantymaa et al., 2006), and thereby indirectly contribute to the child's outcomes (Carlson, Pilkauskas, McLanahan & Brooks-Gunn, 2011; Leinonen et al., 2003; Westbrook & Harden, 2010) through parenting. Conflicts within the couple's relationship may also negatively indirectly influence the child's mental health, through having an effect on the child's emotional security (e.g., Davies, Harold, Goeke-Morey & Cummings, 2002; Koss et al., 2011, Kouros, Cummings & Davies, 2010). Recently, the couple's relationship has also been found to serve as an independent risk factor for adverse child outcomes (Hanington et al., 2012).

The present study

In summary, research suggests that poor parental mental health is a risk factor for negative infant developmental outcomes, but has mainly focused on the effects of maternal postnatal depression on the infant's development. Research also suggests that family relationship dynamics, primarily the parent-infant relationship itself may be an important mechanism by which parental mental health, infant characteristics and the couple's relationship affect the infant's development, but there is limited research including all of these factors and fathers. In addition studies looking at risk factors for negative child

developmental outcomes need to be extended to also include other mental health issues, such as PTSD and anxiety amongst both mothers and fathers.

The main aim of this study was to examine whether parental mental health, parent-infant relationship, infant characteristics and couple's relationship variables were directly or indirectly associated with the infant's cognitive, language or motor development. On the basis of previous research findings and Belsky's model, it was predicted that a less optimal parent -infant relationship, poor parental mental health, low quality of the couple's relationship and difficult infant temperament would be associated with less optimal infant developmental scores. Whilst parental mental health, the parent-infant relationship and infant characteristics would be directly associated with the infant's development, it was also predicted that the parent-infant relationship would act as a mediator between parental mental health, the couple's relationship, the infant temperament and the infant's development.

Method

Participants

Participants were 42 families recruited from The Sussex Journey to Parenthood Study (UK), a longitudinal study of the transition to parenthood from pregnancy to the postpartum. Inclusion criteria for the Journey to Parenthood study were that the women were nulliparous, cohabiting with their partner, fluent in English, and over 18 years old. The majority of the participants of the present study were Caucasian (86%) and 85 % had undergone higher education (diploma and beyond). The babies were born healthy and full term. At the time of the child development assessment, the infants; 23 girls and 19 boys, were between 16 and 20 months old (M= 17.17 months, SD = 0.73). At the time of recruitment, the length of the couple's relationship ranged from 1 to 25 years (M = 6.36 years, SD =4.04) with the women aged between 26 and 46 years (M = 33.41 years, SD = 5.08) and the men aged between 26 and 44 years (M = 34.20, SD = 4.75).

Procedure

Ethical approval was obtained from the NHS Research Ethics Committee and the University Research Governance Committee. A subsample of participants of the Sussex Journey to Parenthood questionnaire study took part in an observational study of their interaction with their baby approximately three months after the birth of their baby. Forty five families agreed to take part in a short parent-infant play interaction, conducted separately with the mother and father and their baby at home and videotaped for later coding. Next, the parents who took part in the observational study were also invited for a clinical interview (Birmingham Interview for Maternal Mental Health; BIMMH), which took place approximately 5 months after the birth of their first baby. The interviews were conducted separately with mothers (n = 46) and fathers (n = 40) in their homes, and took between 75 and 120 minutes to complete. Finally, 17 months after birth, the same families were invited to have a developmental assessment of their baby. Three families had moved away, and were not available and one of the families declined to take part, resulting in the final sample of 42 families.

The infant developmental assessment was carried out in the participants' homes by a researcher who was qualified and trained in the use of the Bayley Scales of Infant Development III, following the usual procedures (Bayley, 2006). One or both parents were present throughout the assessment, which lasted between 45 minutes and 1 ½ hours. Written informed consent was obtained before the start of each assessments, and confidentiality, anonymity and the right to withdraw at any time was assured. Participants were debriefed and were also offered a brief summary of their baby's development after the assessment.

Measures

Infant Development. The infant's cognitive, language and motor development was assessed using the Bayley Scales of Infant Development III (Bayley, 2006). It is composed

of rating scales and qualitative observations. It is an individually administered examination that assesses the current developmental functioning of the infant. The Bayley Scale is a widely used tool for assessing children's development (e.g., Black et al., 2007; Huhtala et al., 2011). It has been standardised and extensively reviewed for its psychometric quality and tested for reliability (*r*, ranging from .86 to .93) and validity using large samples of children with and without developmental delay (Bayley, 2006). Raw scores from each scale were converted to three composite scores ($M = 100$, $SD = 15$), one for cognition, one for language and one for motor development.

Mental health, relationship and infant factors. The Birmingham Interview of Maternal Mental Health (BIMMH; 5th edition, Brockington et al., 2006), a semi-structured clinical interview was used to assess parental mental health. This interview has previously been used in a number of international reliability studies (e.g., Brockington, Aucamp & Fraser, 2006; Chandra, Bhargavaraman, Raghunandan & Shaligram, 2006) and used to validate the Postpartum Bonding Questionnaire (Brockington, Fraser & Wilson, 2006). Anxiety and depression were rated on a 0 – 3 point scale (none, mild, moderate and severe; rated 0-3), PTSD, on a 0 – 2 point scale (none, some evidence and severe). Ratings related to the other key variables under investigation were also derived from the Birmingham Interview. Principal component analysis was performed on groups of these interview items, to create summary scores for the inter-correlated items, in order to reduce the number of predictor variables and in the same time retain as much information as possible. Items in the parent-infant relationship section of the Birmingham interview were reduced to two factors of parental perceptions of their relationship with their infant, one for mothers (explaining 53%) and one for fathers (explaining 62%). Items included in these factors were; angry response, onset of positive feelings, nature and strength of feelings and rough treatment towards baby. The infant characteristics factor included both maternal and paternal reports of their infant's

temperament and the infant's sleeping difficulties, explaining 62% of the variance. The couple's relationship factor was derived from a combination of items for both parents' postpartum support and relationship with the partner, explaining 61% of its variance. In all cases, relevant items were summed using unit weights to form scale scores.

Parent-infant interaction. The CARE-index procedure (Crittenden, 2004) was utilized to analyse and code short (3 – 5 minute) video recordings of the parent-infant interactions on different aspects of the parent and infant's dyadic interactional behaviour. For the current study, the global dyadic synchrony score was used. This score combines the judgments of parental sensitivity and infant cooperation (Crittenden, 2004) and ranges from 0 -14, with a high score, indicating a more optimal interactive relationship. Reliability was tested for 12 % of the video-interactions. The intra class correlation coefficient (ICC; two-way random, absolute agreement, single measure) for this score was .86, which indicates an excellent agreement between the main rater and first author (YP).

Statistical analysis

Correlational analyses and multiple regression analyses were conducted to examine the associations between variables and impact of the predictor variables on the children's development. Thereafter, mediation effects were examined in accordance with Baron and Kenny's criteria (1986), to explore whether the association between the infant's characteristics, parental mental health and the couple's relationship with cognitive, language and motor development were mediated by the quality of mother-infant and father-infant perceptions of their relationship or observed mother-infant and father-infant dyadic interaction. For each developmental outcome, mediation was tested through three regression models, separately for each predictor, mediator and outcome. The assumptions of multiple regression were met regarding multicollinearity, homoscedasticity, independent and normally distributed errors. Additionally, the developmental outcomes were normally distributed.

Results

Preliminary analysis and descriptives

Missing data analysis revealed that 84% of parents had completed all of the measures included in the present study. Parents with missing data (n = 14, 4 women and 10 men) did not differ from parents with complete data on ethnicity (χ^2 (1) =0.86 , p = .35), marital status (χ^2 (1) = 0.70 , p = .40) , gender (χ^2 (1) = 3.08 , p = .08) or education(χ^2 (1) = 0.10 , p = .75). The little MCAR test was not significant (χ^2= 18.90, p = ns). This indicates that the data was missing completely at random (MCAR), which suggests that the EM method for imputation of data is suitable (Tabachnick & Fidell, 2007). Missing data for the predictor variables were therefore replaced using the EM method, which concurs with the way similar studies have dealt with missing data (e.g., Flykt, Kanninen, Sinkkonen & Punamaki, 2010).

Mean scores for infant's developmental ages are reported in Table 1. It shows that on average the infants' developmental age is within normal age limits with slightly higher means than their actual age on most of the scales, and just below their actual age on the gross motor scale. However, when looking at the range of developmental outcomes, it should be noted that there was variability amongst the children, with some being considerably less developed than others, at the time of the assessment. Similarly, Table 1 also indicates that all the composite scores of the infants' performance on the Bayley Scales III are within normal limits. Descriptive statistics (means and standard deviations) for parental mental health and parent-infant interaction variables are also given in Table 1.

Univariate predictors of infant development

To examine the prediction that a less optimal parent-infant relationship, parental mental health problems, a low quality of the couple's relationship and negative infant characteristics were associated with less optimal infant developmental scores, correlation analyses were conducted on the main variables of interest. Correlations between these are

presented in Table 2. As shown, the infant's negative characteristics were substantially associated with less optimal cognitive, language and motor developmental outcomes. Also, maternal perceptions of a less optimal mother-infant relationship was moderately associated with a poorer language development for the infant and paternal perceptions of a less optimal father-infant relationship was moderately associated with a poorer motor development. For mental health issues, maternal postnatal PTSD was moderately associated with poorer cognitive outcomes, whilst there was a moderate correlation between maternal prenatal depression and less optimal language development. All of these significant correlations were in the predicted direction, with the higher developmental scores, the less difficult infant characteristics, a more optimal parent-infant relationship and better parental mental health.

Multivariate predictors of infant development

To further examine the impact of the above predictor variables on the infant's development, three multiple regression analyses were conducted. A data driven approach was used, where predictors that yielded medium sized correlations ≥.2 (Cohen, 1992) with the infant developmental outcomes were entered into the regressions in one step to test the independent contribution by each of these on the infant's cognitive, language and motor developmental outcomes.

The results of the first regression analysis regarding the infant's cognitive development are shown in Table 3. This model included maternal prenatal depression, maternal postnatal PTSD, maternal perceptions of the mother-infant relationship and the infant's characteristics factors. Overall the predictors explained 27.5% of the variance of the cognitive composite score, F (4, 37) = 3.50, p= .016, with a unique significant contribution of maternal postnatal PTSD (β = -.34, t = -2.20, p = .03). Regression results for the infant's language development are detailed in Table 4. The model included maternal and paternal prenatal depression, parental perceptions of the mother-infant, the father-infant relationship

and the infant's characteristics factors as well as the mother-infant and father-infant dyadic interaction synchrony scores. The overall regression model for language development was significant, F (7, 34) = 3.15, p = .01, with 39% of the variance accounted for by the predictors. The only predictor adding a unique significant contribution to infant language development was the infant's characteristics (β = -.35, t = -2.13, p = .04). The total regression model for motor development included the infant's characteristics, the father-infant relationship factor as well as the mother-infant and father-infant dyadic interaction synchrony scores (Table 5). However, the total model failed to reach significance with only 18 % of the variance being accounted for by the predictors, F (4, 36) = 1.91, p = .13 and none of the individual predictors contributed significantly to motor development.

Mediation analysis

Finally, mediation was tested through three regression models, separately for each predictor, mediator and developmental outcome.

For the cognitive developmental outcome, the first regression models showed that both maternal PTSD, F (1, 40) = 5.62, p = .02, and the infant's characteristics, F (1, 40) = 7.56, p = .01, each significantly predicted the cognitive outcome. In the second regression models, only the infant's characteristics was significantly associated with one of the mediators, the perceived father-infant relationship, F (1, 40) = 5.55, p = .02. However, in the third regression model, the mediator (the father's perception of the father-infant relationship) failed to significantly predict the outcome (cognitive development), whilst the infant's characteristics remained significantly associated with the outcome (β = -.42, t = -2.71, p = .01). For the language developmental outcome, a similar pattern of associations was found, where maternal prenatal depression [F (1, 40) = 6.84, p = .01] and the infant's characteristics, F (1, 40) = 17.21, p = .001, fulfilled the first criteria of significantly predicting the language developmental outcome, with only the infant's characteristics factor

being significantly associated with one of the mediators, the father-infant relationship factor, F (1, 40) = 5.55, p = .02. As above, the perceived father-infant relationship was not a significant predictor of the language outcome in the third regression analysis, whilst the infant's characteristics factor remained significant (β = -.53, t = -3.69, p = .001)

For the motor developmental outcome, the infant's characteristics factor was the sole predictor that reached significance in the first regression analysis, F (1, 39) = 4.50, p = .04. Also, as above, the infant's characteristics was only significantly associated with one of the mediators, the perceived father-infant relationship factor. However, in the third regression analysis, neither the infant's characteristics nor the father-infant relationship factor reached significance in predicting the motor developmental outcome. These results indicate that none of the parent-infant relationship variables mediated the relationship between parental mental health, the infant's characteristics or the couple's relationship and the developmental outcomes.

Discussion

This study examined the association between parental mental health, the infant's characteristics, the couple's relationship, parental perceptions of the parent-infant relationship, parent-infant interaction and infant's cognitive, language and motor development, using interviews and observations. The results showed that parent's perceptions of their infant's characteristics were an important predictor of children's cognitive, language and motor development, whilst the mother's perceptions of the mother-infant relationship was mainly associated with the child's language development and the father's perception of the father-infant relationship with the child's motor development. However, no associations were found between observed parent-infant interactions and the infant's development. Amongst the parental mental health variables, maternal postnatal PTSD was predictive of children's cognitive development and maternal prenatal depression was significantly

associated with the children's language development. The hypotheses were thus partially supported. Contrary to predictions, none of the parent-infant relationship variables acted as mediators between the other predictors and infant's developmental outcomes. The following discussion further explores these findings in relation to previous research, Belsky's model of parenting (1984) and methodological issues and implications.

Parental mental health and infant development

It was hypothesised that pre and postnatal mental health (depression, anxiety and PTSD) would be associated with children's development. Contrary to evidence from several previous studies (e.g., Murray, 2009; Paulson et al., 2009; Ramchandani et al., 2005; Quevedo et al., 2012), no significant associations between maternal or paternal postnatal depression and child developmental outcomes were found. These inconsistent results may be partly due to measurement issues as previous research has predominantly used self-report questionnaires to measure mental health. A recent study (Keim et al., 2011) that used interviews to measure maternal psychological health (anxiety, depression and stress) and infant cognitive development also found no evidence of negative effects on the child's development from poor psychological health, but on the contrary found that moderate psychosocial stress was associated with accelerated motor and language development. Another explanation for the lack of association between parental depression and infant development at 17 months postpartum in the present study could be that such effects are not apparent until later on in the child's development. For example, a large Taiwanese birth cohort study (Lung et al., 2009) did not find any significant effects of parental mental health on the infant's language and social development at 18 months postpartum, but at 36 months this effect became significant. Fletcher, Feeman, Garfield and Vimpani (2011) similarly found that early paternal depression predicted child outcomes 4 years later. This highlights

the importance of long-term follow ups of children's developmental outcomes in relation to parental mental health.

In contrast, significant associations were uncovered between maternal prenatal depression and language development. This finding corresponds to previous research suggesting that prenatal exposure to depression may be even more detrimental and predictive of child developmental outcomes than parental postnatal mental health (e.g., Evans et al., 2011; Talge, Neal & Glover, 2007). Importantly, the current study also found that maternal postnatal PTSD was a significant predictor of a less optimal cognitive development for the infant. As a novel finding this requires replication and further examination of the underlying mechanisms. Although, no previous studies have examined this, Bosquet Enlow et al. (2011) found that maternal postpartum PTSD symptoms were associated with difficulties for the infant to regulate emotions at 13 months postpartum. It could be speculated that this may reduce the infant's capacity to attend to cognitive learning activities and result in a less optimal cognitive development. Another speculative mechanism could be the mother's insecure attachment style which may have increased her vulnerability to develop PTSD (e.g., Iles, Slade & Spiby, 2011), also resulted in harmful effects on the infant's cognitive development. Other possible reasons may be that mothers with PTSD, similarly to mothers with postnatal depression may lack contingent responses which in turn limit their baby's exposure to inferential learning (e.g., Hay et al., 2001).

The couple's relationship and infant development

Contrary to predictions and recent research (e.g., Hanington et al., 2012), the couple's relationship was not associated with any of the infant developmental outcomes in the present study. However, the results of the present study demonstrated a significant association between the father's perception of the couple's relationship and the father-infant relationship. This is in line with Erel and Burman's "spill over hypothesis" (1995) and other evidence of

the couple's relationship being predictive of a better parent-infant relationship (Carlson et al., 2011), especially for the paternal parenting behaviour (Florsheim & Smith, 2005). Contrary to Belsky's model and previous research (e.g., Leinonen et al., 2003; Westbrook & Harden, 2010) and as discussed below, no mediation effects occurred through the perceived parent-infant relationship or observed parent-infant interaction between the couple's relationship and infant development.

Infant characteristics and infant development

A key finding of this study was that the infant's characteristics factor, which included both parents' perceptions of their infant's temperament and sleep disturbances, was an important predictor of all three infant developmental outcomes. This finding supported the hypothesis and Belsky's model (1984) which suggests a direct effect of infant characteristics on the infant's development. Empirical evidence also agrees that early infant characteristics are an important factor to consider when predicting the child's developmental (Hernández-Martinez et al. , 2011) and behavioural outcomes, especially when combined with parental mental health problems (e.g., Black et al., 2007; Jessee et al., 2012).

Apart from Hernández- Martinez et al., 2011, there is very limited research regarding parental perceptions of their infant's characteristics in relation to their mental health, their relationship with their infant and infant developmental outcomes. It would also be necessary to follow the trajectories of the child's development across the first years of development in order to analyse whether different factors play a role over time. For example, Feldman and Eidelman (2009) suggested that although biological infant characteristics, such as the infant's neonatal vagal tone at birth was initially linked to the baby's cognitive and social emotional development across the first year, environmental factors such as parental mental health, interfered with the child's development at a later stage. In the current study, the infant's development assessed at one time point only. This meant that the infant's earlier development

could not be controlled for. However, it may be possible, that the parental perceptions of their infant's characteristics included aspects of the infant's development. For example, a parent with a developmentally more able child, may also perceive their child as more temperamentally "easy". One other aspect of the baby's characteristics that has been linked to less optimal child developmental outcomes is male gender (e.g. Tough et al., 2008). Infant gender was therefore initially included in the analysis, but no significant associations were found with the infant's gender and any of the other variables, so was therefore excluded.

The parent –infant relationship and infant development

The role of the parental perceptions of the parent-infant relationship and parent-infant interactions for the infant's developmental outcome were of central importance to this study. The results are partly in line with the prediction of a significant association between these and child development. It was found that the perceived mother-infant relationship was significantly associated with the language development, and also that the perceived father-infant relationship was significantly correlated with the motor development. However, neither the mother-infant nor father-infant global dyadic interaction scores reached significance in their association with developmental outcomes, although the correlations were in the predicted direction. Furthermore, none of the relationship variables made a unique contribution to the variance of any of the developmental outcomes. The link between the mother-infant relationship and language development concurs with other studies. For example, Leigh, Nievar and Nathans (2011) found that sensitive mother-infant interactions positively influenced the child's later expressive language and Stein et al., (2008), found that a poorer quality of maternal caregiving at 10 months predicted a lower language outcome at 36 months.

There is sparse research with which to compare the finding of a link between the father-infant relationship and children's motor development. However, one speculative

explanation for this comes from a study (Liu, Liu & Lin, 2001) which concluded that physical touch was beneficial to the baby's psychomotor development. As the father's play with their baby is characterised by being more physically stimulating than the mother's play (e.g., Kobayashi, 2008; Lewis and Lamb, 2003), the baby who has a more optimal relationship with their father, may get extra stimulation through touch and affection from the father (Combs-Orme & Renkert, 2009), which consequently aids their motor development. These results indicate that mothers' and fathers' relationships with their infant may influence different areas of their development. Further studies of child developmental outcomes may therefore benefit from comparing the types of play and care activities that mothers and fathers engage in with their infant and later child developmental outcomes.

Finally, it was predicted that the parent-infant relationship would have a mediating role between the other variables and the infant's developmental outcomes, but no such mediation effect were found. The lack of significant mediation effects of the parent-baby relationship may be due to methodological issues, such as the small sample size (see below). Another methodological limitation and potential explanation for the lack of mediation effects could be that the observational measure of the parent-infant interaction was collected a few weeks before the parental mental health interview measure. However, similarly to the current study, McManus and Poehlmann (2012) found no mediation effects of the quality of parent-infant interaction between maternal depression and children's cognitive development. On the contrary, the mediation analysis in the present study tentatively suggested that the infant's characteristics acted as a mediator for the father-infant relationship rather than the other way around.

Methodological issues and future directions

This study benefitted from "gold standard" methods with direct observations, in-depth interviews and assessments of the infant's development. The benefit of using face-to-face

interview measures rather than self-report measures for predicting children's outcomes has previously been acknowledged by Pawlby, Sharp, Hay and O'Keane (2008). As previously discussed, different measurement approaches are likely to influence results of studies. In the current study, the interview measure and observational measure for the parent-infant relationship differed in their links with child development, and were not significantly correlated with each other. These measures thus reflect different aspects of the parent-infant relationship. Interestingly, the interview measure appeared to be a better predictor of the infant's development than the observational measure of the parent-infant interaction. One reason for this could be that the observational measure was collected at a slightly earlier time point than the interview measure. However, the predictive power of self-reported parental mental representations and parental beliefs about their relationship with their baby has been found in other studies of child behaviour outcomes (e.g., Barnett, Shanahan, Deng, Haskett & Cox, 2010). Flykt et al. (2010) suggested that interview measures of the parent-infant relationship reflect parents 'attachment-related internal working models (e.g., Fonagy & Target, 2002) to a greater extent than direct parent-infant interactions, which are only snap-shots of the relationship, whereas parents' reflections represent many hundreds of hours of experience.

Similarly research suggests that specific facets of parenting , such as the capacity for a parent to mentalize (Slade, Grienenberger, Bernbach, Levy & Locker, 2005) and to be mind-minded (Meins et al., 2003) in their relationship with their infant may be especially important for positive child outcomes, such as the child's eventual attachment security (Slade et al., 2005), language acquisition and ultimately more optimal scholastic, emotional, social and behavioural adjustments (Berlin, Cassidy & Appleyard, 2008). Mind mindedness has also been linked to parental prenatal predictions of their infants' characteristics (e.g., Arnott & Meins, 2008) and may thus help to explain the mechanisms by which parental perceptions of

their infant's characteristics was significantly linked to the infant's later developmental outcome in the present study. These findings highlight the need to consider parent's verbal reports of their internal perceptions of their baby and their relationship when designing interventions to prevent poor child outcomes and to include measures accounting for parental internal representations of their baby in future research of risk factors for negative child outcomes. Prenatal interventions may be especially useful in helping both parents to form a positive representation and interpretation of their unborn baby from the very outset. Future studies would also benefit from including measures of parental mind-mindedness and reflective functioning, as another parental mediator between mental health and child outcomes.

This study's inclusion of both mothers and fathers enabled comparisons within couples of each parent's relative contribution to their infant's developmental outcome. However, a major limitation of the study was the small sample size, which limited the statistical power and increased the risk for Type II errors. Also, the small sample size restricted the types of analysis possible. Structural Equation Modelling (SEM) would have allowed for analysis of more complex interactional effects. The socially low risk sample of well-educated and co-habiting parents in the current sample may have protected the children from negative outcomes and may therefore have restricted the differences in developmental outcomes to be detected (e.g. Bronte-Tinkew et al.,2008). However, it could be argued that the homogenous sample controlled for socio-economical risk factors (e.g., Mensah and Kiernan, 2009) and therefore allowed for these factors to be excluded in the analyses, allowing the focus to be on the predictor variables of interest.

The small sample size also limited the number of predictor variables that could be included in the regressions. To minimize the number of predictors in the models whilst retaining maximal information, principal component analysis was used to provide a summary

of groups of inter-correlated variables using unit weights. To reduce the predictor variables further, the current study also used a combined dyadic synchrony measure for the mother-infant interaction and one for the father-infant interaction, despite rating these interactions on seven separate dimensions. It would have been beneficial to have examined whether these would have differential effects on the child developmental outcomes. This would be recommended in future larger scale studies.

Other methodological limitations include the retrospective measures of mental health variables in pregnancy, which could be subjected to recall biases. The study would also benefit from a long-term follow up of child developmental outcome, as earlier studies (Lung et al., 2009) have suggested that the impact of factors such as parental mental health may take time to emerge fully.

Moderating effects of combinations of predictor variables on infant developmental outcomes may also benefit further investigations.

Conclusions and implications

In conclusion, the results of this study showed that parental perceptions of early characteristics of their infants may have an important role in predicting infant's cognitive, language and motor development. The negative impact of maternal postnatal PTSD on the infant's cognitive development is a new and important finding, which should be addressed in future research. Maternal prenatal depression was also significantly related to the infant's language development, whilst paternal mental health was mainly linked to the couple's relationship and father-baby relationship. Despite the parent-infant relationship being widely viewed as providing a mechanism by which poor parental mental health, child characteristics and the couple's relationship affect child development, no such mediation effect was found. However, the maternal perceptions of the mother-infant relationship showed a significant association with the infant's language development and paternal perceptions of the father-

infant relationship with the infant's cognitive development. Importantly it needs to be emphasised that the results of the current study should be considered as preliminary due to the small sample size. It would therefore be valuable for future research, with larger sample sizes, to use more sophisticated modelling techniques to more fully examine the complex interplay among these variables within family systems, over longer periods and in different socio demographic groups.

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Table 1. *Means and standard deviations for Bayley Scales developmental ages and composite Scores, parental mental health and parent-infant interactions variables.*

Scores	Range	Mean (SD)
Cognitive development (months) [a]	12 - 21	18. 00 (2.06)
Receptive development (months)[a]	10 - 26	19.70 (3.40)
Expressive development (months)[a]	8 - 22	17.95 (3.17)
Fine motor development (months)[a]	11 – 23	19.51 (2.44)
Gross motor development (months)[a]	7 – 20	16.40 (3.19)
Cognitive composite [b]	75 – 125	101.90 (10.99)
Language composite [b]	68 - 129	106.98 (14.58)
Motor composite [b]	64 – 121	100.83 (12.07)
Maternal prenatal depression	0 – 3	0.48 (0.77)
Maternal postnatal depression	0 – 2	0.52 (0.70)
Maternal prenatal anxiety	0 – 3	0.91 (1.00)
Maternal postnatal anxiety	0 – 3	0.86 (0.98)
Maternal PTSD	0 – 2	0.21 (0.51)
Paternal prenatal depression	0 – 3	0.32 (0.67)
Paternal postnatal depression	0 – 2	0.24 (0.60)
Paternal prenatal anxiety	0 – 3	0.98 (0.88)
Paternal postnatal anxiety	0 - 2	0.46 (0.64)
Mother-infant global synchrony	2 - 13	7.83 (2.64)
Father-infant global synchrony	2 - 12	7.69 (2.42)

Note. N = 42. [a] The mean age of the infants at the time of the Developmental Assessment was 17.2 months. [b]A score of 100 on any of the composites defines the average performance of a given age group. Scores of 85 and 115 are 1 SD below and above the mean. About 68 % of all infants obtain composite scores between 85 – 115, about 98 % score in the 70 -130 range. Nearly all infants obtain scores between 55 and 145.

Table 2. *Correlations between infant developmental scores and predictor variables.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
1.Cognitive composite	1																		
2. Language composite	.63*	1																	
3. Motor composite	.67*	63**	1																
4. Prenatal Anxiety Mother	-.02	-.10	-.02	1															
5. Prenatal Depression Mother	-.21	-.38*	-.08	.59**	1														
6. Postnat Anxiety Mother	-.07	-.11	-.13	.58**	.29*	1													
7. Postnat Depression Mother	-.16	-.09	-.05	.04	.25	.36**	1												
8. PTSD postnatal Mother	-.35*	.06	-.12	.09	-.14	.21	.15	1											
9. Prenatal Anxiety Father	-.07	.01	-.06	.38**	.30*	.21	.23	.17	1										
10. Prenat Depression Father	-.19	-.20	-.11	.36**	.34*	-.04	.01	-.12	.66**	1									
11.Postnatal Anxiety Father	.15	-.02	.03	.27*	.15	.12	-.06	-.05	.41**	.42**	1								
12. Postnat Depression Father	-.03	-.19	-.12	.31*	.24	.22	.02	-.17	.43**	.61**	.72**	1							
13. PTSD postnatal Father	.02	.01	.11	-.13	-.16	-.35*	-.07	-.01	.02	.03	-.27*	-.28*	1						
14. Couple relationship	-.06	-.12	-.13	.12	.18	.15	.14	-.03	.34*	.22	.11	.31*	.15	1					
15. Infant characteristics	-.40**	-.55**	-.32*	.25	.38**	.39**	.17	.25	.34*	.14	.11	.20	-.08	.37**	1				
16. MotherInfant Relationship	-.24	-.30*	-.05	.21	.21	.20	.33*	-.10	.20	.44**	.23	.44**	-.17	.18	.28*	1			
17. FatherInfant Relationship	-.08	-.25	-.26*	-.09	-.10	.03	.04	-.01	-.02	.02	.34*	.42**	-.13	.33*	.35*	.32*	1		
18. Dyadic Synchrony Mother	.06	.21	.24	-.19	-.19	-.24	-.03	-.05	-.47**	-.12	-.16	.04	.11	.10	-.22	.11	.06	1	
19. Dyadic Synchrony Father	.03	.22	.20	-.18	.05	-.23	.01	-.22	-.02	.14	-.13	.19	-.21	.02	-.17	.16	-.08	.41**	1

Note: *$p < .05$. **$p < .01$. ***$p < .001$. Spearman's, one tailed

Table 3. *Multiple regression analyses regarding the parental mental health status, the couple's relationship, infant's characteristics and parent-infant relationship in predicting the infant's cognitive development.*

	Cognitive development		
Predictor	*B*	*SE B*	β
Prenatal depression (women)	-1.98	2.23	-.14
Postnatal PTSD (women)	-7.08	3.21	-.34*
Mother-infant relationship	-.71	.57	-.19
Infant's characteristics	-.74	.59	-.21
Total R^2	.28*		
F	3.50		

Note. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 4. *Multiple regression analyses regarding the parents' mental health status, infant's characteristics and parent- infant relationship in predicting the infant's language development*.

	Language Development		
Predictor	*B*	*SE B*	β
Prenatal depression (women)	-4.14	3.01	-.22
Prenatal depression (men)	-0.82	3.45	-.04
Mother-infant relationship	-0.70	0.84	-.14
Father-infant relationship	-0.43	0.71	-.09
Dyadic Synchrony: mother-infant	0.18	0.86	.03
Dyadic Synchrony: father-infant	1.05	0.93	.17
Infant's characteristics	-1.66	0.78	-.35*
Total R^2	.39**		
F	3.15		

Note. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 5. *Multiple regression analyses regarding the infant's characteristics and parent- infant relationship in predicting the infant's motor development*.

	Motor Development		
Predictor	*B*	*SE B*	β
Father-baby relationship	-0.73	0.61	-.20
Dyadic Synchrony: mother-infant	0.76	0.77	.17
Dyadic Synchrony: father-infant	0.45	0.83	.09
Infant's characteristics	-0.80	0.65	-.21
Total R^2	.18		
F	1.91		

Note. *$p < .05$. **$p < .01$. ***$p < .001$.