DOCTORATE IN CLINICAL PSYCHOLOGY

Major Research Project

The Association Between Early Maternal Responsiveness and Later Child Behaviour: A Longitudinal Study

Trainee name: Regine Anker

Supervisors: Dr Helen Bould and Dr Jonathan Evans, University of Bristol
Dr Nicholas Moberly, University of Exeter

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"I certify that all material in this manuscript which is not my own work has been identified and properly attributed. I have conducted the work in line with the BPS DCP Professional Practice Guidelines."

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Dissemination Strategy

The following dissemination strategy will be implemented to ensure that all relevant parties are informed of the findings of this research study.

The University of Exeter Doctorate in Clinical Psychology

This dissertation will be submitted as part of the requirements of the programme.

Sources of Recruitment

It is intended that the findings will be presented to local midwives who helped to recruit for this study, who can apply the findings in their clinical work with families, and potentially disseminate the findings to expectant mothers.

The wider academic and clinical community

The findings have already been presented to a group of ALSPAC researchers with an interest in this area and they will also be presented to trainee clinical psychologists, staff and other interested parties at Exeter University in June 2013. Furthermore the dissertation is written with a view of publishing it in the Infant Behavior and Development journal.

Abstract

A baby's early experiences have a crucial effect on their later development and adjustment. Early maternal sensitivity is a concept which has been associated with a crucial influence on these later child outcomes, including behavioural outcomes. Results from large longitudinal population based studies have provided conflicting evidence in relation to early maternal sensitivity, particularly sensitivity to non-distress, and later child behaviour and a need for further research in this area exists. The current study investigated early maternal sensitivity and its association with later child behaviour in a UK based population sample using data from the Avon Longitudinal Study of Parents and Children (ALSPAC). The study used a subsample of 766 mother-infant pairs who had data on observed maternal responsiveness at 12 months and on child behavioural difficulties derived from the Revised Rutter Parent Scale for Preschool Children at 42 months. Data for a number of potentially confounding variables, including maternal and child-based variables were also included in the analysis. Hypotheses were tested regarding an association between lower maternal responsiveness and higher child behavioural difficulties as well as regarding associations with further behavioural subscales of the Rutter scale, including a prosocial behaviour subscale. Results were analysed using a linear regression model with adjustments for groups of confounding variables. There was no evidence to support a relationship between lower maternal responsiveness and higher behavioural difficulties at 42 months although there was suggestion of a trend in the expected direction. Similar results were found for the subscales of the Rutter scale. The conclusion is that maternal sensitivity measured in this way does not have a strong relationship with child behaviour. One interpretation of these results is that there is a need to distinguish between maternal sensitivity to non-distress and to distress and ensure that the appropriate aspect of maternal sensitivity in relation to child behavioural outcomes is assessed. Limitations of the study are discussed and the effects of potential improvements are considered.

Keywords: Maternal Sensitivity, Maternal Responsiveness, Child Behaviour, ALSPAC

Introduction

The first years of life are thought to be a highly sensitive period for children's social and emotional development: "The human baby is the most socially influenced creature on earth...It is as babies...we start to organise our experience in a way that will later affect our behaviour and thinking capabilities." (Gerhardt, 2004 p.10). These early years are a period of substantial neural development and organisation which is shaped and influenced by the infant's interactions, experiences and environment (Weaver, 2009). Mothers, often the primary caregivers, therefore play a crucial part in influencing their child's development and the quality of the maternal responses has shown to be associated with the long term development in children (Weaver, 2009).

Maternal sensitivity is a concept which is used to describe the quality of a mother's responses and behaviours towards her infant and it is believed to be one of the important aspects in relation to the infant's early experiences. Maternal sensitivity has been researched extensively over the last decades and its influence on child development and adjustment is believed to be substantial (Shin, 2008). The term maternal sensitivity was first introduced in the 1970s by Mary Ainsworth as part of her theories of attachment (Ainsworth, Blehar, Waters & Wall, 1978) and describes a mother's ability to accurately perceive and interpret her infant's verbal and non-verbal communications and respond to the infant in an age and context appropriate way. Research into attachment styles and maternal sensitivity has revealed the importance of sensitive mothering on the attachment relationship (Belsky & Fearon, 2002) and has shown that children of sensitive mothers are expected to develop secure attachments shown by a confidence in the mother's emotional availability and responsiveness. High maternal sensitivity towards an infant is believed to support the development of a sense of predictability and thus security towards the mother, the infant themselves and the world. The opposite is achieved for children who receive insensitive care by their mothers and may thus develop an insecure attachment and struggle to develop a sense of predictability and security (Belsky & Fearon, 2002). Maternal sensitivity is therefore a crucial component of child attachment, which in turn has been shown to have an important influence on later developmental functioning (e.g. Thompson, 2000).

Whilst maternal sensitivity has been investigated in many studies, it is important to note that the concept is very broad and its content can vary between studies (Meins, Fernyhough, Fradley &

Tuckey, 2001). Some researchers will use the term maternal sensitivity as an overarching concept which includes a number of caregiving skills and maternal attributes such as appropriate affect, timing, flexibility, acceptance, conflict negotiation, maternal awareness and responsiveness (van Doesum, Hosman, Riksen-Walraven & Hoefnagels, 2007), whilst others will use the term to describe a specific maternal behaviour which represents sensitive mothering such as maternal verbal or non-verbal responses towards the child or similar (Shin, Park, Ryu & Seomun, 2008). Additionally the term maternal responsiveness is at times used interchangeably with maternal sensitivity (Drake, Humenick, Amankwaa, Younger & Roux, 2007). Furthermore, maternal sensitivity is measured in a variety of ways using observational methods, parental reports or specific coding approaches, all of which can lead to a variation in results. Whilst it is important to be aware of these discrepancies, general comparisons of the studies are possible due to the overlap between the concepts used and the fact that the underlying principle for the concepts used is Ainsworth's definition of an "appropriate perception and response to infant cues". In the current study the term maternal responsiveness is used to describe observed maternal non-verbal behaviour, which is felt to be a core aspect of maternal sensitivity.

Despite some of the difficulties in definition, research on the consequences of both high and low maternal sensitivity has been extensive and has found associations with children's cognitive, social and behavioural development (e.g. Landry, Smith & Swank, 2006; Bornstein & Tamis-LeMonda, 1989; Eshel, Daelman, de Mello & Martines, 2006). Lower early maternal sensitivity has been associated with children's developmental maladjustment such as behavioural difficulties, conduct difficulties and difficulties in social development (Kemppinen, 2007; NICHD, 1998). Higher levels of maternal sensitivity, on the other hand, have been associated with a number of positive consequences such as increased mother-child attachment security and positive infant development such as improved affective self regulation, increased social and cognitive development (Shin, Park, Ryu & Seomun, 2008).

In addition to the associations with attachment, cognitive and social development, previous research has found associations between maternal sensitivity and child behavioural development (e.g. Davidov & Grusec, 2006). The association between maternal sensitivity and child behavioural outcomes is a particular focus of developmental research due to the significant long-term implications. The pre-school years have been identified as a crucial period for

children's behavioural development and can determine whether children progress on an adaptive or maladaptive developmental path into adolescence (Campbell, 2002). Prospective evidence increasingly shows that behavioural difficulties developed in the pre-school years will often continue into adolescent years and frequently intensify (Moffitt, 1990; Campbell, 2002). Furthermore, behavioural difficulties in middle and later childhood have a significantly detrimental effect on other areas of development such as cognitive and social competence (McGee, Partridge, Williams & Silva, 1991; Olson 1992). Identifying and investigating potential predictors of behavioural difficulties in children, such as maternal sensitivity, is therefore an important task to support early intervention and improved outcomes.

A variety of studies have been carried out looking at the association between maternal sensitivity and child behavioural difficulties. A number of these used a cross-sectional design and found evidence for an association between maternal sensitivity and child behavioural and emotional difficulties (Page, Wilhelm, Gamble & Card, 2010; Denham, 1993; von Suchodoletz, Trommsdorff & Heikamp, 2011; Davidov & Grusec, 2006; Georgiou, 2008; Kaufmann, Gesten, Santa-Lucia, Salcedo, Rendina-Gobioff & Gadd, 2000; Deater-Deckard,2000). The sample sizes for some of these studies were limited, however Page et al. and Kaufmann et al., which had large sample sizes, found evidence for fewer behavioural and emotional difficulties in children with more sensitive mothers. A number of these studies focussed on maternal sensitivity to distress or distinguished between distress and non-distress and found that differences between groups with high and low maternal sensitivity were greater when studying sensitivity to distress (Page *et al,* 2010; von Suchodoletz *et al*, 2011; Davidov & Grusec, 2006). It is important to note that the cross sectional nature of these studies means that it is not possible to establish causal relationships.

A number of population based longitudinal studies have also been carried out in this area and found a range of positive outcomes for children with sensitive mothers, however these studies varied in sample sizes. Studies with small sample sizes found evidence for an association between lower maternal sensitivity and higher behavioural difficulties in the children (Mantymaa, Puura, Luoma, Salmelin & Tamminen, 2004; Rubin, Burgess, Dwyer & Hastings, 2003; Pettit & Bates; 1989), however sample sizes as low as 29 limit the generalisability of these results as well as the precision of the estimated strength of effects.

Large and very large longitudinal studies with population samples in this area are few and provide somewhat conflicting evidence. Leerkes, Blankson & O'Brien (2009) in a study of 376 mother-infant pairs found evidence for an association between maternal sensitivity to distress and decreased behavioural difficulties, no effect was found for maternal sensitivity to non-distress. Similarly, Bradley, Corwyn, Burchinal, McAdoo and Coll (2001), with a very large population sample, were unable to find a general association between parental responsiveness to non-distress and behavioural difficulties. Campbell and colleagues (Campbell, Spieker, Vandergrift, Belsky & Burchinal, 2010) found that lower maternal sensitivity to non-distress during early childhood was associated with higher aggression in the children later on, however these results were only found for girls and not for the whole sample. On the other hand, other studies focussing on maternal sensitivity to non-distress were able to find an association between maternal responsiveness and child behaviour, such as Degnan, Calkins, Keane and Hill-Sonderlund (2008), who found an association between high maternal control, seen as low maternal responsiveness, and increased behavioural difficulties in the children. Colman and colleagues (Colman, Hardy, Albert, Raffaelli & Crockett, 2006) in a sample of 549 mother-child pairs found higher levels of self-regulation in children with more sensitive mothers, however it is important to note that measures of maternal sensitivity were taken at 4/5 and behavioural difficulty measures were taken at 8/9 years of age. In line with these results Bradley and Corwyn (2007), with a sample of 1017 children, found an association between maternal sensitivity and later child behaviour which was the strongest in relation to the maternal sensitivity measured in middle childhood. Finally, a study which used a subsample from the NICHD early childcare study (NICHD, 1998), found that the children of sensitive mothers exhibited significantly less behaviour problems and were more compliant. It is important to note that the study focussed on children who attended childcare.

The results of these larger studies therefore provide a varied picture. Some studies were unable to find an association between maternal sensitivity to non-distress and child behaviour whilst others did find such an association. Furthermore whilst some studies were able to detect this association it appeared to be found in older children. A need for a large population based study focussing on early maternal sensitivity to non-distress and later child behaviour remains, to add to and possibly clarify the existing evidence.

In addition to the main exposure and outcome variables it is important to focus on variables which may be confounding the association between maternal sensitivity and child behaviour. Variables which are commonly controlled for in this area include socioeconomic status (SES), ethnicity, child temperament and gender. A number of studies also controlled for the effects of maternal depression, age at birth, education, employment status, household composition, paternal presence and child care; however there was no consistent approach across studies. In sum the current study aims to add to the literature by examining the association between a core aspect of maternal sensitivity (non-verbal maternal responsiveness) at twelve months and child behaviour at 42 months using a large population based sample and including a range of demographic, child-based and maternal mental health variables which may be confounding the association.

Based on the evidence described above one primary and four secondary hypotheses were developed for this study. The primary hypothesis proposed that (i) lower non-verbal maternal responsiveness at twelve months would be associated with higher child total behavioural difficulties scores at 42 months. The secondary hypotheses focussed on the subscales of the behavioural outcome scale, hypothesising that (ii) higher non-verbal maternal responsiveness at twelve months would be associated with higher child pro-social behaviour scores, (iii) lower non-verbal maternal responsiveness at twelve months would be associated with higher child emotional difficulties scores at 42 months, (iv) lower non-verbal maternal responsiveness at twelve months would be associated with higher child conduct difficulties scores at 42 months and (v) lower non-verbal maternal responsiveness at twelve months would be associated with higher child hyperactivity scores at 42 months. We hypothesised that these effects would remain after controlling for potential confounders.

Methods

Avon Longitudinal Study of Parents and Children (ALSPAC). ALSPAC is a longitudinal population-based study, which investigates the influence of a wide range of factors on the health and development of children. All pregnant women residing in the former Avon Health Authority, with an estimated date of delivery between 1st April 1991 and 31st December 1992, were invited to take part in this study. All women who completed at least one questionnaire or attended one focus group were included in the study, resulting in a core cohort

of 14,541 pregnancies and 13,988 children who were alive at 12 months. Participating mothers and their partners, as well as the children at later stages, completed questionnaires during pregnancy and at multiple time points afterwards and continue to do so. Ethical approval for this project was granted by the ALSPAC Law and Ethics Committee and the University Research Ethics Committee (Appendix A). Further information on ALSPAC can be found on the official web site http://www.alspac.bris.ac.uk.

Sample. The sample used for this project comprises a subsample of the complete ALSPAC cohort. A 10% sample of the ALSPAC cohort, known as the Children in Focus (CiF) group, attended clinics at the University of Bristol at various time intervals between four to 61 months of age. The CiF group were chosen at random from the last six months of ALSPAC births (1432 families attended at least one clinic). Excluded were those mothers who had moved out of the area or were lost to follow-up, and those partaking in another study of infant development in Avon. Clinics were held when the children were 4, 8, 12, 18, 25, 31, 37, 49, 55, and 61 months of age. Measures taken at these clinics included physical examinations and health checks as well as cognitive assessments and observations of behaviour.
The starting sample for this study comprised 1191 children who attended the 12 month CiF clinic and completed the observed and video-taped mother-infant interaction task from which the measure of Maternal Responsiveness (MR) was derived. Twins were excluded from the analysis as previous research has shown that maternal response to twin children may be qualitatively different (Thorpe, Greenwood & Rutter, 2003), which left 1107 singleton infants. Out of these 1107 mother-infant pairs 980 had available data from the Rutter Child Behaviour measure at 42 months (Elander & Rutter, 1996; see below). Including data on all the confounding variables reduced the sample size to 766 mother-infant pairs, hereafter referred to as the “complete case sample”. See Appendix B for a sample reduction clarification.

Measures.

Exposure Variable: Maternal Responsiveness. The working definition of maternal responsiveness for this study is that maternal responsiveness is the observed appropriate non-verbal interactional behaviour a mother shows towards her infant. The nonverbal communication subscale of the Thorpe Interaction Measure (TIM; Thorpe, Greenwood & Rutter, 2003) was used to derive a score for maternal responsiveness.

The TIM was carried out at the 12 months CiF clinic and involved mother and child sharing a picture book as they would at home, for around 5 minutes. During this interaction, the nature of the mother's behaviour towards her infant was rated on verbal and non-verbal communication, warmth, physical proximity and motivation. Inter-rater reliability of at least kappa=0.6 across four raters was established for all categories of behaviour (Thorpe et al., 2003). The interactions were rated live by a trained researcher.

This study focuses on the non-verbal aspects of the maternal responses, as non-verbal behaviours reflect more instinctive responses which are less consciously controlled and less likely to be influenced by social desirability (Fisher, 1993). There was also more variation in the ratings of nonverbal than verbal responses, with more than 70% of mothers rated as providing positive verbal responses and only 54% of mothers rated as providing positive nonverbal responses, indicating that the nonverbal measure may be more sensitive. Nonverbal responses were originally categorised as negative, neutral or positive (Table 1). However, due to the negative responses only comprising of twelve mother-infant pairs, these ratings were excluded from this analysis. It was decided not to collapse negative and neutral ratings as they may be qualitatively different.

Table 1: Non-verbal communication categories

1. Negative	Observation of pushing, distracting, non-response to positive initiation, gaze aversion.
2. Neutral	No clear examples of either negative or positive communication as in 1 or 3.
3. Positive	Observation of stroking, caressing, positive eye contact, smiling.

The TIM has been shown to have good predictive validity in areas such as child cognitive development (Pearson, Heron, Melotti, Joinson, Stein, Ramchandani, & Evans, 2011) and has shown to be associated with scores on the Mellow Parenting Scale (Puckering, 2004), a more in-depth and well validated measure of Maternal Responsiveness, demonstrating concurrent validity (Pearson et al., 2011). The TIM also has moderate inter-rater reliability of .73 between video raters, and .70 between a video rater and the original live rater (Pearson et al., 2011).

There was a high agreement between non-verbal responses and warmth ratings (Gamma = .9), and the ratings of warmth are thus explored as a secondary measure of maternal sensitivity. Global impressions of mother's warmth during the observations were rated on a scale from one to five (1=Very Warm, 2=Warm, 3=Moderate, 4=Cool, 5=Very Cool), however due to low numbers for the categories Very Cool and Cool the two categories were collapsed into one (1=Very Warm, 2=Warm, 3=Neutral, 4=Cool).

Outcome Variable: Child Behaviour. The working definition of child behaviour for this study is that child behaviour includes both the internalising and externalising behavioural difficulties which a child may display. Internalising behaviours include anxiety, sadness, social withdrawal and fearfulness, whilst externalising behaviours include overactivity, poor impulse control, noncompliance, aggression toward peers, and tantrums.

The Revised Rutter Parent Scale for Preschool Children (Rutter Scale; Elander & Rutter, 1996; Appendix C) was used to measure this variable. The Rutter Scale was completed by mothers at 42 months and is a 43-item questionnaire based on the Preschool Behaviour Questionnaire (Behar & Stringfield, 1974). The questionnaire yields frequency scores of reported behaviour difficulties on a Likert scale with possible answers being "Certainly true", "Sometimes true" and "Not true". The scale provides a total behaviour difficulties score as well as scores on three aspects of behaviour problems: emotional difficulties, conduct difficulties and hyperactivity difficulties. In addition to this there is a prosocial behaviour subscale which is not included in the total difficulties score. Although the differentiation of internalising and externalising problems is less clear in young children compared to older children, there is some support for concurrent and predictive validity for subscales of preschool behaviour problems (Sonuga-Barke, Thompson, Stevenson & Viney, 1997). High scores on the Rutter scale represent high behavioural difficulties, with a cut off score of 13 often being used to distinguish between non-clinical and clinical presentations. The original Rutter Parent Scale total behaviour difficulties score yielded a test-retest Pearson correlation of .87 (Rutter, Tizard & Whitmore, 1970). The primary outcome measure for this study is the total behaviour difficulties score; secondary outcomes of the four subscale scores will also be investigated.

Confounding Variables. A number of confounding variables, which have been shown to be associated with maternal sensitivity and child behaviour, were included. These variables were collected with questionnaires during the antenatal period and in the first few years of the study child's life. These variables included maternal age (in years), highest maternal education ("vocational or CSE", "A/O level", "university degree"), parity ("primiparous" or "multiparous"), marital status ("not married" or "married"), maternal depression at 32 weeks gestation, 8 months and 33 months (binary variable focussing on clinically depressed versus non-depressed mothers for clinical relevance, with a cut off of 12/13 on the Edinburgh Postnatal Depression Scale [EPDS; Cox, Holden & Sagovsky, 1987]), infant gender, infant temperament (score of 0-50 on the Intensity subscale of the Carey Temperament Scales [Carey & McDevitt, 1978], with a higher score reflecting a more difficult temperament; at six months) and infant development (score of 0-84 on the ALSPAC developmental scale, based on the Denver Developmental Screening Test [Frankenburg, Camp & Van Natta, 1971], with a higher score reflecting increased infant development; at six months).

Statistical Analysis.

As a first step in the analyses, descriptive statistics were produced for all variables.
For the statistical analyses, linear regression was conducted using maternal responsiveness as a dichotomous exposure variable and the total score of child behavioral difficulties from the Rutter scale as a continuous outcome variable. The analyses were initially carried out using all available data for the exposure and the outcome variable, and then repeated for the sample which had complete data on both the exposure and the outcome variables as well as all confounding variables (the complete sample).

Four further analyses were then conducted, including three analyses with adjustments for relevant groups of potentially confounding variables (demographics, child variables and maternal depression variables) and an adjusted analysis with all confounding variables. This procedure allowed for a clear examination of the separate effects of the three groups of confounders as well as an examination of the complete model. In the first of these analyses we adjusted for maternal age, maternal education, parity and marital status (demographics). The second analysis included adjustment for only child gender, temperament and development (child variables). A third analysis included adjustment for only maternal depression scores at the

above described three time points (maternal depression variables). Finally an analysis was run including all potential confounders in a complete model.

These analyses were then repeated using the warmth variable as a secondary exposure variable.

Finally, to explore the hypotheses regarding the Rutter subscales the association between maternal responsiveness and each of the four individual subscales (Prosocial behavior, Emotional difficulties, Conduct difficulties and Hyperactivity difficulties) was investigated by carrying out linear regression analyses for each subscale and both the primary and the secondary exposure variable within the complete case sample.

Results

Descriptive Analysis. As a first step the characteristics of mothers with complete data, some missing data and the whole ALSPAC sample, from which the CiF clinic sample was drawn, were compared (Table 2). The results showed that for the complete sample of 766 mother-infant pairs the mothers' mean age at the time of birth was 29.5, 87% were married and 17% had degree level education. With regard to maternal depression 11% of women scored above the threshold for clinical depression at 32 weeks gestation, 7% at eight months and 10% at 33 months after birth. Of the 766 infants 47% were girls and 47% were first born. The children scored on average 25 points on the Intensity subscale of the intensity subscale of the Carey temperament scale and 46 points of the Denver development scale.

Comparing these data with the data from the whole ALSPAC sample (12,404) shows that mothers in the whole ALSPAC sample were on average younger (27.85), less likely to be married (79%) and less likely to have degree level education (14%) than mothers in the complete sample. In addition, mothers in the whole ALSPAC sample were more likely to be depressed at 32 weeks gestation compared to the mothers in the complete sample but did not differ in relation to the two later time points. The children in the whole ALSPAC sample scored higher on the Denver development scale (47.72) but did not differ in relation to parity, gender and temperament scores. These results therefore show that the complete sample which was used for this study was slightly different from the whole ALSPAC sample in that they seemed to be to some extent socially advantaged and less likely to be depressed during pregnancy. Table

2 also outlines the data for mothers who attended the twelve months CiF clinic but had missing data on one or more of the other variables.

Table 2: Demographic data for the whole ALSPAC sample and CiF clinic attendees

	Mothers who did not attend the clinic but had a live infant at 12 months (n = 12,404)	**Mothers who attended the clinic but had missing data (n = 425)**	**Complete case sample (n= 766)**	**P Values**
Maternal age at delivery (years) mean (sd)	27.85 (5.01)	28.45 (5.12)	29.51 (4.12)	*p*<.001
Maternal Education				
% CSE or vocational	26%	24%	17%	*p*<.001
% with O Levels or A Levels	60%	64%	66%	
% with degree	14%	12%	17%	
% Primiparous	45%	47%	47%	*p*=.355
% Married at eight months	79%	75%	87%	*p*<.001
% Female baby	49%	44%	47%	*p*=.082
Child Temperament (Carey Scale, Intensity; 6m)	25.10 (5.59)	25.11 (5.58)	24.89 (5.89)	*p*=.595
Child Development (Denver Scale; 6m)	47.72 (8.10)	48.65 (9.14)	46.19 (8.18)	*p*<.001
% Maternal Depression (32 weeks gestation)	15%	16%	11%	*p*=.004

% Maternal Depression (8 months)	9%	9%	7%	*p*=.146
% Maternal Depression (33 months)	12%	16%	10%	*p*=.146

Data comparing mothers showing positive nonverbal communication with those showing neutral nonverbal communication (see Table 3) showed that mothers with positive maternal responsiveness were more likely to have degree level education (19% versus 14%) and more likely to be married (89% versus 84%). The children of mothers with positive nonverbal communication versus the children of mothers with neutral nonverbal communication did not differ notably.

Table 3: Demographic data for mothers showing positive and neutral non-verbal communication

	Mothers showing positive responses (n = 449)	**Mothers showing neutral responses (n = 317)**	**P value**
Maternal age at delivery (years) mean (sd)	29.36 (4.04)	29.72 (4.22)	*p*=.304
Maternal Education			
% CSE or vocational	13%	23%	*p*=.001
% with O Levels or A Levels	68%	63%	
% with degree	19%	14%	
% Primiparous	50%	42%	*p*=.117
% Married at eight months	89%	84%	*p*=.008
% Female baby	48%	45%	*p*=.080
Child Temperament (Carey Scale, Intensity; 6m)	24.88 (5.96)	24.90 (5.81)	*p*=.772
Child Development (Denver Scale; 6m)	46.64 (8.14)	45.56 (8.21)	*p*=.213

% Maternal Depression (32 weeks gestation)	11%	12%	*p*=.878
% Maternal Depression (8 months)	6%	8%	*p*=.201
% Maternal Depression (33 months)	11%	10%	*p*=.377

Statistical Analysis. Neutral maternal responsiveness was related to slightly higher scores (more behavioural difficulties) on the Rutter scale, compared with positive maternal responsiveness. The mean total score on the Rutter scale for children of mothers with neutral maternal responsiveness was 12.89 (Standard Deviation = 5.90), compared to a mean score of 12.09 (Standard Deviation = 5.50) for children of mothers with positive maternal responsiveness. A more varied pattern was found for the warmth variable, with “Cool” ratings achieving slightly lower scores than “Neutral” ratings. However, increasing maternal warmth did have slightly lower scores on the Rutter scale.

Linear regression analyses showed a small association between maternal non-verbal behaviour and total scores on the Rutter Scale, with children of mothers with neutral responses presenting with increased behavioural difficulties compared to the children of mothers with positive responses. The Rutter scale was treated as a continuous outcome variable due to its normal distribution within the complete sample (see Appendix D). The results were found for the sample of mothers who had scores for the maternal responsiveness ratings and the Rutter scale, but were missing data on potential confounding variables (“all data”) and were very similar for the complete sample (see Table 4). However, the association found was relatively small, particularly for the complete sample, with a difference of 14% of a Standard Deviation, which is equivalent to a difference of less than one point (0.8) on the Rutter scale between neutral and positive maternal responses.

Three separate adjustments were then carried out on the complete sample data, including adjustment for demographic confounding variables (“Adjusted 1”, Table 4), child confounding

variables (“Adjusted 2”, Table 4) and maternal mental health confounding variables (“Adjusted 3”, Table 4). All of the adjustments reduced the strength of the association to the point where there was no effect. In relation to the impact of the different adjustments on the findings, the child variables attenuated the association the most, whereas the maternal mental health variables had only a very small impact. However no association remained after any of the different adjustments. Finally all potential confounding variables were included in a complete model (“Adjusted 4”, Table 4), again causing the association to reduce to a point where there was no effect. See Table 5 for the standardised coefficients and confidence intervals of these analyses.

Table 4: Regression analyses of the association between Maternal Responsiveness at 12 months and Child Behavioural Difficulties at 42 months

		1. Crude Effect for all data (n=980)	**2. Crude Effect for Complete Sample** (n=766)	**3. Adjusted1** (Maternal age, Education, Parity, Marital status)(n=766)	**4. Adjusted2** (Child Variables) (n=766)	**5. Adjusted3** (Maternal Mental Health) (n=766)	**6. Adjusted4** (Complete Model, all variables) (n=766)
Effect of non-verbal maternal responses (Coefficient(95%CI))		-0.82 (-1.54 , -0.10) *p*=.026	-0.80 (-1.61 , 0.02) *p*=.056	-0.72 (-1.55 , 0.10) *p*=.086	-0.68 (-1.49 , 0.13) *p*=.100	-0.78 (-1.58 , 0.02) *p*=.057	-0.65 (-1.46 , 0.16) *p*=.114
Maternal Age		-	-	-0.07 (-0.17 , 0.04) *p*=.224	-	-	-0.08 (-0.18 , 0.03) *p*=.155
Maternal Education	1. Voc/ CSE	-	-	-	-	-	-
	2. O or A Level	-	-	-0.59 (-1.70 , 0.53) *p*=.302	-	-	-0.57 (-1.65 , 0.52) *p*=.304
	3. Degree	-	-	0.01 (-1.46 , 1.47) *p*=.993	-	-	0.26 (-1.17 , 1.68) *p*=.726
Parity		-	-	0.39 (-0.46 , 1.24) *p*=.368	-	-	-0.04 (-0.87 , 0.80) *p*=.930
Marital Status	1. Not Married	-	-	-	-	-	-
	2. Married	-	-	-0.80 (-2.01 , 0.41) *p*=.193	-	-	-0.46 (-1.66 , 0.73) *p*=.445
Child Gender		-	-	-	-0.42 (-1.22 , 0.38) *p*=.303	-	-0.40 (-1.18 , 0.39) *p*=.320
Temperament (Carey Scale, 6m)		-	-	-	0.08 (0.01 , 0.15) *p*=.021	-	0.07 (-0.003 , 0.14) *p*=.040
Child Development (Denver Scale, 6m)		-	-	-	-0.09 (-0.14 , -0.04) *p*<.001	-	-0.10 (-0.15 , -0.05) *p*<.001
Maternal Depression (32 weeks gestation)		-	-	-	-	1.39 (0.03 , 2.75) *p*=.045	1.46 (0.11 , 2.81) *p*=.034
Maternal Depression (8m)		-	-	-	-	0.78 (-0.90 , 2.47) *p*=.360	0.78 (-0.89 , 2.46) *p*=.359
Maternal Depression (33m)		-	-	-	-	2.84 (1.44 , 4.24) *p*<.001	2.78 (1.37 , 4.18) *p*<.001

Table 5: Standardised coefficients and confidence intervals for the association between Maternal Responsiveness at 12 months and Child Behavioural Difficulties at 42 months

	1. Crude Effect for all data (n=980)	**2. Crude Effect for Complete Sample** (n=766)	**3. Adjusted1** (Maternal age, Education, Parity, Marital status)(n=766)	**4. Adjusted2** (Child Variables) (n=766)	**5. Adjusted3** (Maternal Mental Health) (n=766)	**6. Adjusted4** (Complete Model, all variables) (n=766)
Effect of non-verbal maternal responses (Standardised Coefficient(95%CI))	-0.14 (-0.27 , -0.02) *p*=.026	-0.14 (-0.28 , 0.004) *p*=.056	-0.13 (-0.27 , 0.02) *p*=.086	-0.12 (-0.26 , 0.02) *p*=.100	-0.14 (-0.28 , 0.004) *p*=.057	-0.11 (-0.26 , 0.03) *p*=.114

The same regression analysis was carried out using maternal warmth as the secondary exposure variable. Warmth was analysed as a continuous variable due to the ordered structure of the variable implying linearity and due to a continuous analysis being a more sensitive approach to the available information. The results were again consistent with no effect both for the all data sample and the complete sample. See Appendix E for a table of the results of this analysis and all adjustments made.

As the prosocial subscale of the Rutter scale is not included in the total score, it was analysed separately as a next step. Whilst the descriptive results for the complete sample showed that children of mothers with positive maternal responsiveness scored on average a ninth of a standard deviation higher on the prosocial subscale, there was no effect after statistical analysis (coef = 0.40 (95% CI -0.13, 0.93), *p*=.137).

Finally analyses were carried out using the individual Rutter subscales Emotional Difficulties, Conduct Difficulties and Hyperactivity Difficulties. The regression analyses of the subscales did not show evidence of an association; however the descriptive results for the complete sample showed that mothers with neutral maternal responsiveness had children with slightly increased emotional, conduct and hyperactivity difficulties. Of the three subscales, conduct difficulties showed the most noteworthy findings, with children of mothers with neutral responsiveness scoring on average a tenth of a standard deviation higher on the conduct difficulties subscale. See Appendix F for the results for these subscales. Due to the lack of associations adjustments for confounding variables were not carried out for the subscales. Furthermore, Appendix G

outlines the results for the secondary exposure variable maternal warmth and the four individual subscales. Again no evidence for an association was found.

Discussion

We investigated the association between observed maternal responsiveness at twelve months and child behaviour at 42 months. The results of this study suggest that there is not enough evidence to support an independent relationship between early maternal responsiveness (to a non-distressed infant) and higher child behavioural difficulties later on; however the results which were obtained were in the hypothesised directions. These results cannot be seen to support the main hypothesis that lower non-verbal maternal responsiveness at twelve months would be associated with higher child behavioural difficulties scores at 42 months. The same results were found for the maternal warmth data. With regard to the secondary hypotheses concerning the subscales of the Rutter scale, the results were similar with no clear evidence for the hypotheses, both for the prosocial behaviour subscale and for the individual behavioural difficulties subscales.

The results are in line with some of the previous research using large population based samples which was unable to detect an overall effect for maternal sensitivity to non-distress and later child behavioural difficulties (Leerkes, Blankson & O'Brien, 2009; Bradley, Corwyn, Burchinal, McAdoo & Coll, 2001). Other studies, however, were able to find an association between early maternal sensitivity and later child behaviour (NICHD, 1998; Degnan, Calkins, Keane & Hill-Sonderlund, 2008), although direct comparisons are difficult due to the variability between studies. The results of this study therefore do not provide evidence for an association between maternal sensitivity to non-distress and child behavioural difficulties and it may be that maternal sensitivity is more strongly related to other aspects of child development such as cognitive or social development (Pearson et al, 2011; Page, Wilhelm, Gamble & Card, 2010). It is important to note that whilst there was no evidence for an association, the different adjusted analyses did have varying effects on the key association. The greatest effect on the association was noted by the child variables, and the child development variable in particular, indicating that the child's characteristics and in particular his/her developmental level may explain some of the relationship between a mother's sensitivity and their child's later behaviour. These results contribute to the literature around the question whether more sensitive mothers shape more

responsive children, whether more responsive children affect their mother's sensitivity or if there is a reciprocal relationship (Tamis-LeMonda, Briggs, McClowry & Snow, 2009). These findings may warrant further investigations to determine the exact relationships of these variables. In relation to the current study it is important to consider alternative explanations for the results found as well as the study limitations.

Firstly, a number of previous studies investigated maternal sensitivity to infant distress rather than non-distress and found maternal sensitivity to distress to be a stronger indicator for social, emotional and behavioural development than maternal sensitivity to non-distress (Leerkes, Blankson & O'Brien, 2009; Page, Wilhelm, Gamble & Card, 2010; von Suchodoletz, Trommsdorff & Heikamp, 2011; Davidov & Grusec, 2006). Recent research in this area has found that the two concepts are indeed distinctly different and that maternal sensitivity to distress is a unique and strong predictor of the infant's emotional development (Leerkes, Weaver & O'Brien, 2012). It is possible to assume that through the mother's sensitivity to their distress, infants are able to learn about and imitate behavioural self regulation skills and thus develop their behavioural adjustment skills. Maternal sensitivity to non-distress, as measured in the current study, may be providing the infant with a different learning opportunity, such as social skills, and thus has less of an effect on their later behaviour. It is therefore possible that this study measured an aspect of maternal sensitivity which is less related to behavioural outcomes than other aspects, which may provide an explanation as to why the current study did not find an association between maternal responsiveness and child behaviour.

Some limitations of the study need to be noted. Firstly, both the TIM, which measured maternal responsiveness, and the Rutter Scale, which measured child behaviour, include some measurement error. The maternal responsiveness scores were used as a dichotomised measure and as such only provided relatively crude measurements. The TIM was carried out in an artificial set up with an observer and pre-planned task and did not allow for more natural interaction which would occur during free play. The TIM thus has limited ecological validity and it may not be possible to generalise the maternal responsiveness data to other situations. As mentioned above the recordings also did not include maternal responses to infant distress which are considered valuable and highly relevant recordings. However it is important to note that the TIM recordings have been compared to other, similar measures such as the Mellow Parenting measures and have been found to be correlated with these (Pearson et al, 2011).

Furthermore, other studies within ALSPAC have used and are using the TIM outcomes with predictive validity (e.g. Pearson et al, 2011). Finally it is also important to note that the current study only investigated one component of maternal sensitivity, maternal responsiveness, rather than a construct with multiple components including other important aspects of maternal sensitivity such as the timing or appropriateness of the maternal response.

The Rutter Scale, whilst credited with reasonable validity and reliability (Rutter, Tizard & Whitmore, 1970), has been superseded by a number of different scales such as the Child Behaviour Checklist (Achenbach & Edelbrock, 1983), which have proven to have increased reliability and validity. In addition to this the fact that the behavioural recordings on the Rutter Scale were made by the mothers may indicate a number of potential biases such as social desirability bias or even a bias to overrate the behavioural difficulties a child is showing. Behavioural observations or additional scales filled in by other caregivers such as teachers may have resulted in more accurate recordings.

With regard to the sample the demographics described above the data showed that the complete case sample, used for this study, varied from the whole ALSPAC sample in the sense that the mothers in the complete case sample were more socially advantaged and less likely to be depressed. Maternal sensitivity is reduced in mothers living in social adversity (Murray, Hipwell, Hooper, Stein & Cooper, 1996). The CIF clinics also required increased time and motivation from the mothers and it could be assumed that the mothers who continued with the CIF clinics, and thus provided behavioural data at 42 months, also had different levels of motivation, increased disposable time and less pressure in other areas of their lives. Caution therefore needs to be taken when generalising the results to other, more deprived or pressured and less motivated groups. Whilst it is not assumed that the missing data in this study was of a systematic nature it is important to note that missing data can introduce biases and reduce power. These issues can be overcome by imputing missing data and thus reduce the possibility of a bias through missing data. However, the numbers of missing data in this study did not warrant such procedures. Previous research within ALSPAC has also shown that imputation had no noteworthy effect on the findings (Evans, Heron, Patel, & Wiles, 2007).

In addition to the above, more socially advantaged mothers would have brought more socially advantaged and possibly less behaviourally difficult children to the clinic. The ALSPAC sample in itself comprises of a non-clinical population and when considering the more advantaged study

sample, it is possible to assume that more marked differences in the results would have been found in a clinical and less advantaged population. Furthermore, due to very low numbers of mothers rated as responding negatively to their infant, only positive and neutral responses were included in this study, leaving to the characteristics of mothers rated as responding negatively, and of their children, unaccounted for. It is therefore possible that the data used for this study included a bias towards more responsive mothers and less behaviourally difficult children and if the study had captured more mothers with more negative responsiveness it is possible that the association found in this study might have been stronger.

The above described limitations will undoubtedly affect the association which was being measured in this study, it is therefore difficult to conclude that maternal responsiveness does not have an impact on child behaviour but only that maternal responsiveness measured in this way does not appear to have an impact on child behaviour.
Future research will need to include measurements of maternal responsiveness to distress and maternal responsiveness to non-distress to allow for a comparison of these concepts and their effect on child behaviour. It will be important that these recordings are as ecologically valid as possible and possibly include a variety of common mother-child activities so allow for an accurate and generalisable account of maternal sensitivity. Finally future research of maternal responsiveness and child behaviour may need to include some behavioural observations or teacher ratings to allow for the most accurate representation of the child's behaviour.

In conclusion, the results of the current study did not find clear evidence of an independent association of maternal sensitivity on child behaviour. Whilst this may be related to certain study limitations, it is possible that the effect is restricted to measures of maternal sensitivity to a distressed infant. Furthermore it is possible that maternal sensitivity to a non-distressed infant is important for other outcomes but not child behaviour. Further research is needed in this area to clarify the associations.

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Appendices

Appendix A: Ethical Approval (University of Exeter).

Psychology Research Ethics Committee

Psychology, College of Life & Environmental Sciences

Washington Singer Laboratories
Perry Road
Exeter
EX4 4QG

Telephone +44 (0)1392 724611
Fax +44 (0)1392 724623
Email Marilyn.evans@exeter.ac.uk

To: **Regine Anker**
From: **Cris Burgess**
CC: **Helen Bould, Raghu Lingam & Nick Moberly**
Re: **Application 2011/587 Ethics Committee**
Date: **April 23, 2012**

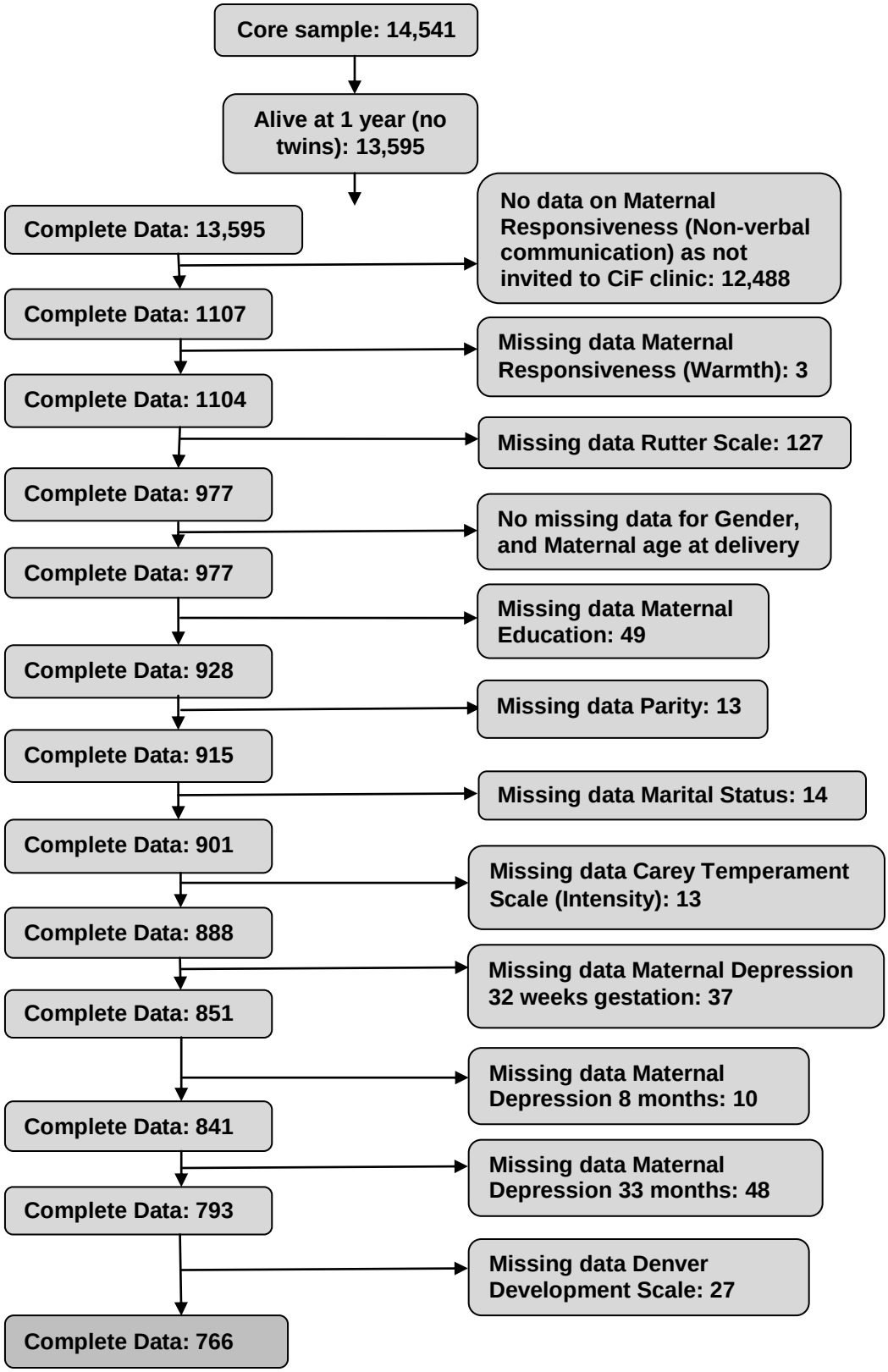
The School of Psychology Ethics Committee has now discussed your application, ***2011/587*** **– The association between maternal sensitivity and later child behaviour: A longitudinal study in the United Kingdom.** The project has been approved in principle for the duration of your study.

The agreement of the Committee is subject to your compliance with the British Psychological Society Code of Conduct and the University of Exeter procedures for data protection (http://www.ex.ac.uk/admin/academic/datapro/). In any correspondence with the Ethics Committee about this application, please quote the reference number above.

I wish you every success with your research.

Cris Burgess
Chair of Psychology Research Ethics Committee

Appendix B: Sample Reduction.



Appendix C: The Rutter Scale used within ALSPAC.

Here are some descriptions of children. Please tick the box that best describes your child nowadays.

Nowadays my child:	*Certainly true*	*Sometimes true*	*Not true*
1. Tries to be fair in games			
2. Is restless, runs about or jumps up & down. Doesn't keep still			
3. Is considerate of other people's feelings			
4. Is squirmy, fidgety			
5. Destroys own or others' belongings			
6. Is spontaneously affectionate to family members			
7. Fights with other children			
8. Is not much liked by other children			
9. Volunteers to help around the house or garden			
10. Is worried, worries about many things			
11. Tends to do things on his own, rather solitary			
12. Is irritable, quick to fly off the handle			
13. Will try to help someone who has been hurt			

14. Appears miserable, unhappy, tearful or distressed

15. Has twitches, mannerisms or tics of the face & body

16. Bites nails or fingers

17. Is disobedient

18. Is kind to younger children

19. Has poor concentration, or short attention span

20. Tends to be afraid of new things or new situations

21. Helps other children who are feeling ill

22. Is fussy, or over-particular

23. Tells lies

24. Has wet or soiled himself in the past 12 months

25. Comforts a child who is upset

26. Has a stutter or stammer

27. Has other speech difficulty

28. Plays imaginatively, enjoys 'pretend' games

29. Bullies other children

30. Is inattentive

31. Gets on well with other children

32. Doesn't share toys

33. Cries easily

34. Is a forceful, determined child

35. Blames others for things

36. Shares out treats with friends

37. Gives up easily

38. Is inconsiderate of others

39. Is an independent, confident child

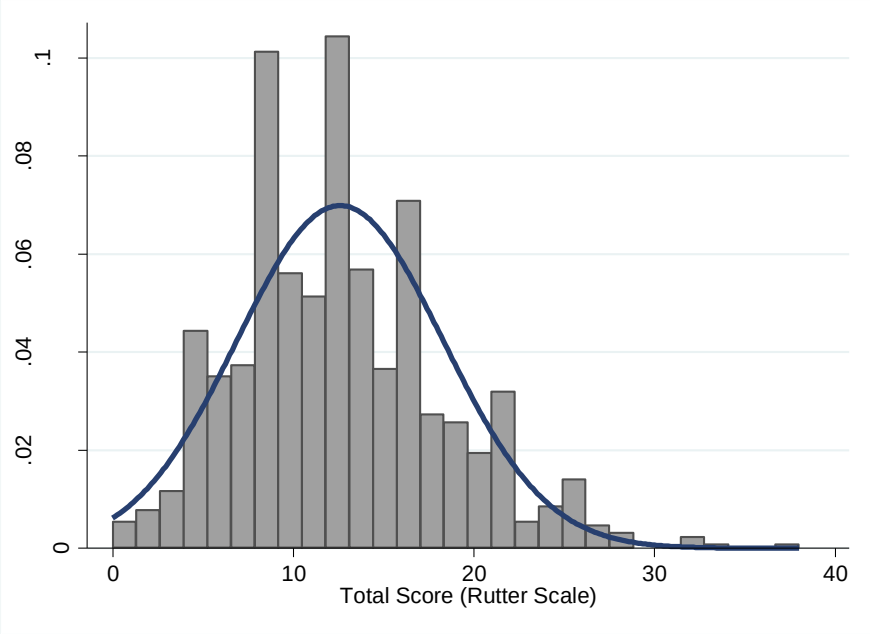
40. Kicks, bites other children

41. Is kind to animals

42. Stares into space (stares blankly)

43. Tries to stop quarrels or fights

Appendix D: Distribution of the Rutter Total Score.



Appendix E: Regression analyses Maternal Warmth and Total Score Rutter Scale.

		1. Crude Effect for all data (n=980)	**2. Crude Effect for Complete Sample** (n=766)	**3. Adjusted1** (Maternal age, Education, Parity and Marital status) (n=766)	**4. Adjusted2** (Child Variables) (n=766)	**5. Adjusted3** (Maternal Mental Health) (n=766)	**6. Adjusted4** (Complete Model, all variables) (n=766)
Effect of Maternal Warmth ratings (Coefficient(95% CI))		-0.43 (-1.09 , 0.24) *p*=.207	-0.33 (-1.07 , 0.42) *p*=.385	-0.26 (-1.01 , 0.50) *p*=.508	-0.16 (-0.90 , 0.59) *p*=.683	-0.26 (-0.99 , 0.47) *p*=.478	-0.04 (-0.79 , 0.70) *p*=.907
Maternal Age		-	-	-0.06 (-0.17 , 0.05) *p*=.260	-	-	-0.07 (-0.17 , 0.03) *p*=.183
Maternal Education	1. Vocational/ CSE	-	-	-	-	-	-
	2. O or A Level	-	-	-0.64 (-1.76 , 0.47) *p*=.257	-	-	-0.65 (-1.74 , 0.43) *p*=.239
	3. Degree	-	-	0.07 (-1.55 , 1.40) *p*=0.924	-	-	0.13 (-1.31 , 1.56) *p*=.861
Parity		-	-	0.41 (-0.44 , 1.26) *p*=.345	-	-	-0.01 (-0.85 , 0.83) *p*=.979
Marital Status	1. Not Married	-	-	-	-	-	-
	2. Married	-	-	-0.86 (-2.07 , 0.35) *p*=.165			-0.53 (-1.72 , 0.66) *p*=.385
Child Gender		-	-	-	-0.44 (-1.24 , 0.36) *p*=.283	-	-0.41 (-1.20 , 0.37) *p*=.304
Temperament (Carey Scale, 6m)		-	-	-	0.08 (0.01 , 0.15) *p*=.019	-	0.07 (-0.003 , 0.14) *p*=.038
Child Development (Denver Scale, 6m)		-	-	-	-0.09 (-0.14 , -0.04) *p*<.001	-	-0.11 (-0.16 , -0.06) *p*<.001
Maternal Depression (32 weeks gestation)		-	-	-	-	1.41 (0.05 , 2.77) *p*=.042	1.47 (0.12 , 2.83) *p*=.033
Maternal Depression (8 months)		-	-	-	-	0.80 (-0.89 , 2.48) *p*=.355	0.80 (-0.87 , 2.48) *p*=.347
Maternal Depression (33 months)		-	-	-	-	2.82 (1.41 , 4.22) *p*<.001	2.74 (1.33 , 4.14) *p*<.001

Appendix F: Regression analyses for the Emotional, Conduct and Hyperactivity difficulties subscales and maternal responsiveness.

Effect of non-verbal maternal responses (0=neutral, 1=positive (Coefficient(95% CI))	**1. Crude Effect for all data** (n=980)	**2. Crude Effect for Complete Case Sample** (n=766)
Rutter Scale (Emotional Difficulties, subscale)	-0.15 (-0.37 , 0.07) *p*=.183	-0.11 (-0.36 , 0.14) *p*=.382
Rutter Scale (Conduct Difficulties, subscale)	-0.19 (-0.48 , 0.10) *p*=.196	-0.22 (-0.54 , 0.11) *p*=.193
Rutter Scale (Hyperactivity Difficulties, subscale)	-0.14 (-0.37 , 0.10) *p*=.250	-0.14 (-0.41 , 0.13) *p*=.313

Appendix G: Regression analyses for all Rutter subscales and maternal warmth.

	1. Crude Effect for all data (n=980)	**2. Crude Effect for Complete Case Sample** (n=766)
Rutter Scale (Prosocial behaviour, subscale)	0.34 (-0.10 , 0.77) *p*=.127	0.38 (-0.10 , 0.86) *p*=.121
Rutter Scale (Emotional Difficulties, subscale)	-0.13 (-0.34 , 0.07) *p*=.191	-0.18 (-0.41 , 0.05) *p*=.120
Rutter Scale (Conduct Difficulties, subscale)	-0.15 (-0.42 , 0.11) *p*=.257	-0.09 (-0.39 , 0.21) *p*=.551
Rutter Scale (Hyperactivity Difficulties, subscale)	-0.09 (-0.30 , 0.13) *p*=.431	-0.04 (-0.29 , 0.21) *p*=.743

Appendix H: Infant Behavior and Development – Instructions for Authors.

PREPARATION OF AN ARTICLE

Use of wordprocessing software

It is important that the file be saved in the native format of the wordprocessor used. The text should be in single-column format. Keep the layout of the text as simple as possible. Most formatting codes will be removed and replaced on processing the article. In particular, do not use the wordprocessor's options to justify text or to hyphenate words. However, do use bold face, italics, subscripts, superscripts etc. When preparing tables, if you are using a table grid, use only one grid for each individual table and not a grid for each row. If no grid is used, use tabs, not spaces, to align columns.

The electronic text should be prepared in a way very similar to that of conventional manuscripts (see also the Guide to Publishing with Elsevier: http://www.elsevier.com/guidepublication). Note that source files of figures, tables and text graphics will be required whether or not you embed your figures in the text. See also the section on Electronic artwork.
To avoid unnecessary errors you are strongly advised to use the 'spell-check' and 'grammar-check' functions of your wordprocessor.

Article Structure

Submissions must conform in all respects to the format specified in the *Publication Manual of the American Psychological Association (5th Edition, 1994)*, or they will be returned without review. This requirement applies to the format for tables and figures. Copies of the *Manual* may be ordered from http://www.apa.org/books/4200061.html or APA Order Dept., P.O.B. 2710, Hyattsville, MD 20784, USA or APA, 3 Henrietta Street, London, WC3E 8LU, UK.

Subdivision - numbered sections

Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the text'. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

Introduction

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Material and methods

Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

Theory/calculation

A Theory section should extend, not repeat, the background to the article already dealt with in the Introduction and lay the foundation for further work. In contrast, a Calculation section represents a practical development from a theoretical basis.

Results
Results should be clear and concise.

Discussion
This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

Conclusions
The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

Appendices
If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Abstract
A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

Graphical abstract
A Graphical abstract is optional and should summarize the contents of the article in a concise, pictorial form designed to capture the attention of a wide readership online. Authors must provide images that clearly represent the work described in the article. Graphical abstracts should be submitted as a separate file in the online submission system. Image size: Please provide an image with a minimum of 531 × 1328 pixels (h × w) or proportionally more. The image should be readable at a size of 5 × 13 cm using a regular screen resolution of 96 dpi. Preferred file types: TIFF, EPS, PDF or MS Office files. See http://www.elsevier.com/graphicalabstracts for examples. Authors can make use of Elsevier's Illustration and Enhancement service to ensure the best presentation of their images also in accordance with all technical requirements: Illustration Service.

Highlights
Highlights are mandatory for this journal. They consist of a short collection of bullet points that convey the core findings of the article and should be submitted in a separate file in the online submission system. Please use 'Highlights' in the file name and include 3 to 5 bullet points (maximum 85 characters, including spaces, per bullet point). See http://www.elsevier.com/highlights for examples.

Keywords
Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes

Abbreviations

Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

Acknowledgements

Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

Math formulae

Present simple formulae in the line of normal text where possible and use the solidus (/) instead of a horizontal line for small fractional terms, e.g., X/Y. In principle, variables are to be presented in italics. Powers of e are often more conveniently denoted by exp. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text).

Footnotes

Footnotes should be used sparingly. Number them consecutively throughout the article, using superscript Arabic numbers. Many wordprocessors build footnotes into the text, and this feature may be used. Should this not be the case, indicate the position of footnotes in the text and present the footnotes themselves separately at the end of the article. Do not include footnotes in the Reference list.

Table footnotes

Indicate each footnote in a table with a superscript lowercase letter.

Artwork

Electronic artwork

General points

• Make sure you use uniform lettering and sizing of your original artwork.
• Embed the used fonts if the application provides that option.
• Aim to use the following fonts in your illustrations: Arial, Courier, Times New Roman, Symbol, or use fonts that look similar.
• Number the illustrations according to their sequence in the text.
• Use a logical naming convention for your artwork files.
• Provide captions to illustrations separately.
• Size the illustrations close to the desired dimensions of the printed version.
• Submit each illustration as a separate file.

A detailed guide on electronic artwork is available on our website:
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You are urged to visit this site; some excerpts from the detailed information are given here.

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Regardless of the application used other than Microsoft Office, when your electronic artwork is finalized, please 'Save as' or convert the images to one of the following formats (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below): EPS (or PDF): Vector drawings, embed all used fonts. TIFF (or JPEG): Color or grayscale photographs (halftones), keep to a minimum of 300 dpi. TIFF (or JPEG): Bitmapped (pure black & white pixels) line drawings, keep to a minimum of 1000 dpi. TIFF (or JPEG): Combinations bitmapped line/half-tone (color or grayscale), keep to a minimum of 500 dpi.

Please do not:
• Supply files that are optimized for screen use (e.g., GIF, BMP, PICT, WPG); these typically have a low number of pixels and limited set of colors;
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• Submit graphics that are disproportionately large for the content.
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Please make sure that artwork files are in an acceptable format (TIFF (or JPEG), EPS (or PDF), or MS Office files) and with the correct resolution. If, together with your accepted article, you submit usable color figures then Elsevier will ensure, at no additional charge, that these figures will appear in color on the Web (e.g., ScienceDirect and other sites) regardless of whether or not these illustrations are reproduced in color in the printed version. **For color reproduction in print, you will receive information regarding the costs from Elsevier after receipt of your accepted article.** Please indicate your preference for color: in print or on the Web only. For further information on the preparation of electronic artwork, please see http://www.elsevier.com/artworkinstructions.
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Figure captions
Ensure that each illustration has a caption. Supply captions separately, not attached to the figure. A caption should comprise a brief title (**not** on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Tables
Number tables consecutively in accordance with their appearance in the text. Place footnotes to tables below the table body and indicate them with superscript lowercase letters. Avoid vertical rules. Be sparing in the use of tables and ensure that the data presented in tables do not duplicate results described elsewhere in the article.

References
Citation in text
Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal

communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

Web references
As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list.

References in a special issue
Please ensure that the words 'this issue' are added to any references in the list (and any citations in the text) to other articles in the same Special Issue.

Reference management software
This journal has standard templates available in key reference management packages EndNote (http://www.endnote.com/support/enstyles.asp) and Reference Manager (http://refman.com/support/rmstyles.asp). Using plug-ins to wordprocessing packages, authors only need to select the appropriate journal template when preparing their article and the list of references and citations to these will be formatted according to the journal style which is described below.

Reference style
Text: Citations in the text should follow the referencing style used by the American Psychological Association. You are referred to the Publication Manual of the American Psychological Association, Sixth Edition, ISBN 978-1-4338-0561-5, copies of which may be ordered from http://books.apa.org/books.cfm?id=4200067 or APA Order Dept., P.O.B. 2710, Hyattsville, MD 20784, USA or APA, 3 Henrietta Street, London, WC3E 8LU, UK.

List: references should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication.

Examples:
Reference to a journal publication:
Van der Geer, J., Hanraads, J. A. J., & Lupton, R. A. (2010). The art of writing a scientific article. *Journal of Scientific Communications, 163*, 51–59.

Reference to a book:
Strunk, W., Jr., & White, E. B. (2000). *The elements of style.* (4th ed.). New York: Longman, (Chapter 4).

Reference to a chapter in an edited book:
Mettam, G. R., & Adams, L. B. (2009). How to prepare an electronic version of your article. In B. S. Jones, & R. Z. Smith (Eds.), *Introduction to the electronic age* (pp. 281–304). New York: E-Publishing Inc.

Journal abbreviations source
Journal names should be abbreviated according to:
List of title word abbreviations: http://www.issn.org/2-22661-LTWA-online.php; NLM Catalog (Journals referenced in the NCBI Databases): http://www.ncbi.nlm.nih.gov/nlmcatalog/journals; CAS (Chemical Abstracts Service): via http://www.cas.org/content/references/corejournals.

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One author has been designated as the corresponding author with contact details:
• E-mail address
• Full postal address
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All necessary files have been uploaded, and contain:
• Keywords
• All figure captions
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• References are in the correct format for this journal
• All references mentioned in the Reference list are cited in the text, and vice versa
• Permission has been obtained for use of copyrighted material from other sources (including the Web)
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