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## Abstract

3 Objectives: To determine the influence of maternal sensitivity on infant feeding problems in  
4 very preterm/very low birth weight (VP/VLBW) and full-term (FT) infants.

5 Methods: Longitudinal study of 178 infants (73 VP/VLBW and 105 FT). Feeding problems  
6 and maternal sensitivity were assessed at term, 3 and 18 months. A cross-lagged path model  
7 was tested to assess the longitudinal associations.

8 Results: The direction of the association between maternal sensitivity and feeding problems  
9 differed among VP/VLBW and FT infants. In VP/VLBW infants, higher feeding problems at  
10 term and 3 months were associated with less maternal sensitivity at 3 months ( $\beta = -0.27, p <$   
11 0.05) and at 18 months ( $\beta = -0.36, p < 0.05$ ), respectively. In FT infants, a reciprocal  
12 relationship of feeding problems and maternal sensitivity over time was found. Feeding  
13 problems at 3 months were associated with decreased maternal sensitivity at 18 months ( $\beta = -$   
14 0.32,  $p < 0.05$ ) while decreased maternal sensitivity at 3 months was related to increased  
15 feeding problems at 18 months ( $\beta = -0.25, p < 0.05$ ).

16 Conclusions: Feeding problems are frequent in VP/VLBW infants and subsequently are  
17 associated with maternal sensitivity. In FT infants, decreased maternal sensitivity both  
18 resulted from feeding problems but also increased them over time.

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20 Keywords: feeding, maternal sensitivity, preterm birth, infancy.

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## INTRODUCTION

Feeding problems are a major concern during infancy and toddlerhood with a prevalence rate of approximately 20% to 30%. <sup>1</sup> The earlier the onset of these problems, the more severe and persistent the consequent eating problems tend to be. <sup>2</sup> Picky eating or food refusal and oral-motor difficulties such as difficulties in sucking, chewing and/or choking are the most frequent symptoms of feeding problems in infancy. <sup>3,4</sup> Infant feeding problems are distressing for parents<sup>5</sup> and observed in the relational context of parent-infant interaction around feeding. <sup>6</sup> If relational context matters in the development of feeding problems, both parenting behavior and infant characteristics should be involved. <sup>7</sup> Specifically, maternal sensitivity, indicating awareness of the cues by the infant and appropriate responses to the infant,<sup>8</sup> have been suggested to either predispose to the development of feeding problems or maintain them. <sup>9,10</sup>

Parent-infant relationships have most often been studied in those referred for feeding problems.<sup>11</sup> The observed maladaptive interactions in such dyads may be the result of the feeding problems<sup>12,13</sup> and do not allow any conclusions that these have been their precursors. Longitudinal studies identified family factors<sup>2,14</sup> or maternal negative emotionality<sup>15</sup> as precursors of persisting feeding problems, however, these were all based on parent self-reports rather than direct observations of mother-infant interaction. We are aware of two prospective studies that observed maternal sensitivity and feeding problems over time, one of which revealed no longitudinal influence of maternal sensitivity on feeding problems at 10 months and 2 years of age; <sup>16</sup> the other study showed that maternal mind-mindedness at 6 months, which may predict maternal sensitivity, was related to positive feeding behaviors at 1 year of age.<sup>9</sup> There is thus a surprising lack of prospective cross-lagged designs to disentangle the currently unclear direction of associations between infant feeding problems and maternal sensitivity over time.

1 Apart from parenting characteristics, individual child characteristics are important for  
2 the development of feeding problems.<sup>12,14</sup> Preterm birth has been identified as increasing the  
3 risk of feeding difficulties throughout the preschool years.<sup>14</sup> Feeding difficulties in preterm  
4 infants have been linked to neonatal medical complications, which could result in failure of  
5 achieving the essential skills, needed for successful oral feeding such as rhythmical sucking  
6 or motor organization.<sup>17</sup> These problems can further lead to delays in initiation and  
7 advancement of full oral feeds,<sup>18</sup> and result in stress for caretakers and increasing problems  
8 in mother-infant relationship.<sup>19</sup> Thus maternal parenting may be driven by initial feeding  
9 problems in preterm infants and not vice versa.

10 This study investigated, firstly, whether VP/VLBW infants have more feeding  
11 problems in infancy compared to FT infants and whether there are any differences in between  
12 the groups in maternal sensitivity. Secondly, the direction of the association between  
13 maternal sensitivity and feeding problems across infancy in VP/VLBW and FT infants was  
14 investigated. We hypothesized that in VP/VLBW infants, the initial feeding problems would  
15 adversely affect subsequent maternal sensitivity rather than vice versa. On the other hand, in  
16 full-term infants we hypothesized that the association between feeding problems and  
17 maternal sensitivity would be reciprocal or driven by maternal sensitivity.

## 18 METHODS

### 19 Participants

20 Seventy three VP/VLBW infants and their caretakers were recruited from 3 neonatal  
21 units in South East of England during an 18 months period (Please see Appendix 1 for  
22 participant flow). The principal selection criterion for entry into the study was that the infants  
23 were born before 32 completed weeks of gestation, or weighing less than 1500 grams. There

1 were 41 male and 32 female participants with a mean of 29.4 weeks of gestation and 1285.8  
2 grams of birth weight (see Table 1 for further details).

3 One hundred and five FT infants (37- 42 weeks gestation) who did not have neonatal  
4 medical problems, stratified by socio-economic status, sex and multiple birth were recruited  
5 from the same hospitals. There were 60 male and 45 female FT infants in the study.

6 Ethical approval was given by the university and ethical review boards of the  
7 participating hospitals. Moreover, informed consents were received from parents.

## 8 **Measures**

9 **Maternal Sensitivity.** Maternal sensitivity was measured with observational measures at  
10 term, 3 months and 18 months corrected age for prematurity. At term, the Boston City  
11 Hospital Assessment of Parental Sensitivity (BCHAPS<sup>20</sup>) was used by neonatal care nurses to  
12 rate maternal sensitivity of mothers of VP/VLBW infants based on their observations in the  
13 last week. For FT infants, midwives completed the BCHAPS during repeated home visits in  
14 the first 10 days of infant's life. The BCHAPS measures how the mother cares for, interacts  
15 with and enjoys the relationship with her infant rated on thirteen items with 5-point Likert  
16 type scales (1=poor; 5=very competent). An example item was 'mother effectively soothes  
17 the baby'. Internal consistency of the scale in the total sample was high (Cronbach's Alpha=  
18 .95).

19 At 3 months, maternal sensitivity was measured with a structured play observation:  
20 the Mother-Infant Structured Play Assessment (MISPA). The play observation consisted of 2  
21 minutes of play with a toy and 2 minutes of free play. Maternal sensitivity was coded using a  
22 5-point scale of maternal positive emotion expression, sensitivity and stimulation adapted  
23 from three interaction coding schemes: The Emotional Availability Scales (EAS)<sup>21</sup>; The  
24 Infant and Caregiver Engagement Phases (ICEP)<sup>22</sup>; The Play Observation Scheme and

1 Emotion Ratings (POSER).<sup>23</sup> 20 videotapes were coded by two independent raters. The inter-  
2 rater reliability scores for each item were moderate to high ( $\kappa_{\text{positive emotion}} = 0.76$ ,  $\kappa_{\text{sensitivity}} =$   
3  $0.76$ ,  $\kappa_{\text{stimulation level}} = 0.78$ ) and the overall reliability of the maternal sensitivity factor was  
4 moderate ( $\alpha_{\text{maternal sensitivity}} = .73$ ).

5 At 18 months, the Play Observation Scheme and Emotion Rating (POSER) was used  
6 to observe maternal behaviors. POSER includes two play sessions, play with a toy and free  
7 play each lasting 2.5 minutes. The maternal sensitivity factor consisted of maternal positive  
8 emotion expression, sensitivity and appropriateness of play each rated on a 9-point Likert  
9 scale (1: highly insensitive; 9: highly sensitive). 20 videotapes were coded by two trained  
10 independent researchers. Both, inter-rater reliability of each item ( $\kappa_{\text{positive emotion}} = .93$ ,  
11  $\kappa_{\text{sensitivity}} = .90$ ,  $\kappa_{\text{appropriateness of play}} = .91$ ) and overall reliability of the maternal sensitivity factor  
12 were high ( $\alpha_{\text{maternal sensitivity}} = .90$ ).

13 **Infant Feeding Problems.** Infant feeding problems were assessed via a standard structured  
14 interview (Appendix 2) about feeding problems at term, 3 and 18 months corrected age for  
15 prematurity. Problems in oral-motor functioning were measured with the following three  
16 items: a) stopping after a few sucks, b) excessive dribbling/difficulty swallowing, c)  
17 gagging/choking during the feed. Participants were dichotomized into two groups: no oral-  
18 motor functioning problems (0 or 1 problem present) and oral-motor functioning problems (2  
19 or 3 problems present). Faddy eating/ food refusal was measured with one item (fighting  
20 against the bottle/breast) at term and 3 months. At 18 months, a faddy eating/food refusal  
21 scale was created including the following variables: Eats too little, leaves most of the food  
22 offered, poor appetite, picky eater, slow eater, refuses to eat lumpy food, refuses to eat  
23 puree.<sup>24</sup> Internal consistency of this scale was high; Cronbach's Alpha: .80. Participants were  
24 categorized as having faddy eating/food refusal problems if they had 5 or more problems (i.e.  
25 a score > 75<sup>th</sup> percentile at 18 months).

1     **Control Variable.** Medical risk was a control variable which was the composite of  
2     neurosensory deficits, rehospitalization, surgical procedures, and oxygen dependency  
3     assessed from medical notes and interviews at 3 months. Neurosensory deficits were defined  
4     as clinically significant deficits in hearing, vision, muscle tone or presence of hydrocephalus.  
5     Re-hospitalization was defined as whether the infant was readmitted to a hospital after final  
6     discharge from the neonatal unit. Surgical procedures were defined as whether the infant had  
7     any major surgery (e.g. for Patent Ductus Arteriosus, Necrotizing Enterocolitis). Lastly,  
8     oxygen dependency was defined as oxygen use of more than 21% (1: never, 2: oxygen  
9     dependency still at term, 3: oxygen dependency still at 3 months).<sup>25</sup> Moreover, family income  
10    level (low: £0- £25k, middle: £25k- £40k, high: >£40k) was a control variable.

## 11    **Statistical Analysis**

12           Preliminary analyses were conducted with SPSS (version 21.0; IBM, Armonk, NY).  
13           One-way ANOVA was used to compare maternal sensitivity scores between VP/VLBW and  
14    FT samples, and Chi-square test was used to compare the feeding problems between  
15    VP/VLBW and FT samples.

16           A cross-lagged panel model<sup>26</sup> was used to assess the magnitude and significance of  
17    the associations of infant feeding problems on subsequent maternal sensitivity, and the  
18    associations of maternal sensitivity on subsequent infant feeding problems. Longitudinal  
19    cross-lagged model is a widely used method to assess the reciprocal relationship between two  
20    variables, in which the bidirectional associations between the two can be examined while  
21    controlling for effects at earlier points in time.

22           Cross-lagged panel analysis was conducted with MPlus (Version 7, Los Angeles,  
23    CA)<sup>27</sup> using full information maximum likelihood estimation to account for non-normality of  
24    the data. Four models (Figure 1) were assessed: 1) an autoregressive model with only

1 autoregressive effects and concurrent correlations between maternal sensitivity and feeding  
2 problems but no prospective associations from one construct to the other at a later time point;  
3 2) maternal sensitivity unidirectional model which proposes that early differences in maternal  
4 sensitivity predict subsequent feeding problems; 3) feeding problems unidirectional model  
5 which proposes that difference in early feeding problems predict later maternal sensitivity; 4)  
6 reciprocal model which suggests that feeding problems and maternal sensitivity have  
7 bidirectional associations with early feeding problems predicting later maternal sensitivity  
8 and early maternal sensitivity predicting later feeding problems. Analysis was adjusted for  
9 medical risk and income.

10 In order to evaluate the goodness-of-fit,  $\chi^2$  tests and the goodness-of-fit indices were  
11 considered. Among the various fit indices, incremental fit indices such as Comparative Fit  
12 Index (CFI), Tucker Lewis Index (TLI) and Root Mean Square Error of Approximation  
13 (RMSEA)<sup>28</sup> were used as they are less sensitive to the impact of sample size. For the CFI  
14 and TLI, values greater than .90 show an acceptable fit and values greater than .95 indicate a  
15 good fit.<sup>29</sup> For the RMSEA, values less than .05 indicate a good fit and values less than .08 an  
16 acceptable fit. Moreover, chi-square difference test between the constrained and  
17 unconstrained models were conducted in order to test for difference between VP/VLBW and  
18 FT models.

## 19 RESULTS

### 20 Group Differences in Feeding Problems and Maternal Sensitivity

21 VP/VLBW and FT infants significantly differed from each other on some components  
22 of feeding problems (Table 1). At term, VP/VLBW infants (40.3%) had significantly more  
23 oral-motor difficulties in comparison to FT infants (18.1%) ( $p < .01$ ), specifically more

1 excessive dribbling/difficulty swallowing (40.3%,  $p <.05$ ), and gagging/choking during feeds  
2 (37.5%,  $p <.05$ ). VP/VLBW infants (60.5%) continued to have more gagging/choking during  
3 feeds in comparison to FT infants (49.5%) at 18 months ( $p <.05$ ). Additionally, VP/VLBW  
4 infants had more faddy eating/food refusal (34.2%,  $p <.05$ ), specifically picky eating (57.8%,  
5  $p <.05$ ), and refusing to eat lumpy food (28.1%,  $p <.05$ ) at 18 months. In contrast, there were  
6 no significant mean differences between VP/VLBW and FT infants in maternal sensitivity  
7 across the first 18 months.

8 **Differences in the Association between Feeding Problems and Maternal Sensitivity in  
9 VP/VLBW and FT Infants**

10 Model fit of the four models are shown in Table 2. The reciprocal model showed the  
11 best fit to the data in the FT sample (CFI=1.00, TLI=1.00, RMSEA=0.00). In VP/VLBW  
12 infants, both the unidirectional model from feeding problems to maternal sensitivity  
13 (CFI=1.00, TLI= 1.04, RMSEA=0.00) and reciprocal model (CFI=0.99, TLI= 0.96,  
14 RMSEA=0.05) showed good data fit. Chi-square difference tests indicated that the model fit  
15 did not differ between VP/VLBW and FT infants.

16 In the VP/VLBW sample, uni-directional cross-lagged path weights from infant  
17 feeding problems to maternal sensitivity were significant from term to 3 months ( $\beta = -.27$ ,  
18  $p <.05$ ); and from 3 months to 18 months ( $\beta = -.36$ ,  $p <.05$ ). No reciprocal significant  
19 associations from maternal sensitivity to subsequent feeding problems were found at any time  
20 point (Figure 2).

21 In contrast, in the FT sample, there was significant reciprocal relationship between  
22 maternal sensitivity and feeding problems from 3 months to 18 months of age. Lower  
23 maternal sensitivity at 3 months significantly increased infant feeding problems at 18 months

1      (β = -.25,  $p < .05$ ). Similar, higher infant feeding problems at 3 months significantly decreased  
2      maternal sensitivity at 18 months (β = -.32,  $p < .05$ ). Neither infant feeding problems nor  
3      maternal sensitivity had significant influences on each other in early infancy from birth to 3  
4      months of age (Figure 2).

## DISCUSSION

This study found that VP/VLBW infants had more feeding problems at term and at 18 months compared to FT infants. Nevertheless, there were no differences in observed mean maternal sensitivity between FT and VP/VLBW infants at any time. Although the overall models were similar in VP/VLBW and FT infants, the individual significant associations between maternal sensitivity and feeding problems over time varied between VP/VLBW and FT infants. The relationship was reciprocal from 3 months in FT infants; however it was unidirectional in VP/VLBW indicating that feeding problems adversely influenced maternal sensitivity over time.

14 The finding that VP/VLBW infants tend to have feeding problems more often during  
15 infancy, in particular oral-motor problems and fussy eating/food refusal, is consistent with  
16 previous reports. This might be partly due to early medical complications and adverse oral  
17 motor experiences.<sup>17,18</sup> Furthermore, the finding that mothers of VP/VLBW show, on  
18 average, no differences in their sensitivity in interaction compared to FT mothers is also  
19 consistent with findings of a recent meta-analysis of thirty-four studies.<sup>30</sup>

20 The investigation of the association between feeding problems and maternal  
21 sensitivity showed that in VP/VLBW infants, low maternal sensitivity was not a predisposing  
22 factor for feeding problems across infancy. Rather, when VP/VLBW infants had difficulties  
23 in feeding, there was a decline in subsequent maternal sensitivity at the next assessment  
24 point, i.e. at 3 months and 18 months, respectively. This finding suggests that mothers of

1 VP/VLBW infants change their parenting behavior since it is the infant characteristics which  
2 alter parenting behavior rather than the opposite.

3 In contrast, the relationship between feeding problems and maternal sensitivity was  
4 best explained by a reciprocal model in FT infants. Feeding problems at three months  
5 decreased subsequent maternal sensitivity at 18 months while lower maternal sensitivity at 3  
6 months increased feeding problems at 18 months. This finding supports the suggestion that  
7 non-organic feeding problems in healthy infants are manifested in mother-infant interaction  
8 problems.<sup>7</sup> Similar complex relationships have been shown between maternal behavior and  
9 infant sleep patterns during early infancy.<sup>31</sup> The reciprocal relationship between feeding  
10 problems and maternal sensitivity in FT infants was apparent between 3 months and 18  
11 months of age but not between term and 3 months. This finding is may be consistent with a  
12 model of bio-behavioral shift in development from birth to 3 months during which both  
13 infants go through substantial changes in biological, cognitive and behavioral domains.<sup>32</sup>  
14 During this time, parents are also in a process of adaptation and change<sup>33</sup> and individual  
15 differences such as in crying behavior are large.<sup>34</sup> Thus, the association between feeding  
16 problems and maternal sensitivity might be more apparent after the first 3 months in FT  
17 infants.

18 Consistent with our findings, it has been suggested that categories of feeding  
19 problems (limited appetite, selective intake and fear of feeding) and maternal feeding styles  
20 (responsive, controlling, indulgent and neglectful) should be incorporated for a diagnosis of a  
21 feeding problem.<sup>35</sup> This suggestion was mainly based on maternal behaviors during feeding.  
22 Our study extends it as we tested general maternal sensitivity during play rather than during  
23 mealtime. Observations of maternal sensitivity during mealtimes are strongly dependent on  
24 the infant's feeding behavior while our observations during play provide an independent  
25 measure of maternal behavior.<sup>12</sup>

1 There are some strengths and limitations of the study. The main strength of this study  
2 is that it assessed maternal sensitivity and feeding problems longitudinally at the same time  
3 points which allowed us to use a cross-lagged design. Furthermore, this study measured  
4 general maternal sensitivity with observation tasks at each time point rather than focusing on  
5 the behaviors during meal time. One limitation of this study is that maternal sensitivity at  
6 term was assessed at hospital for VP/VLBW infants while it was assessed at home for FT  
7 infants. The nurses knew the VP/VLBW parents for a longer period in the special care unit  
8 whereas midwives visited the families of FT infants several times during the first 10 days.  
9 Therefore, nurses may be more familiar with parenting of VP/VLBW infants in comparison  
10 to FT infants. However, similar significant association between maternal sensitivity at term  
11 and 3 months in FT sample as in the VP/VLBW supports the validity of the term assessment  
12 in FT sample. Moreover, feeding problems were assessed with a parental report which may  
13 be less objective than direct observation or diary recordings.<sup>36</sup>

14 To conclude, in FT infants without medical complications feeding problems appear to  
15 have a reciprocal relationship with maternal sensitivity over time. In VP/VLBW infants, who  
16 more often experience feeding problems, the feeding problems tend to decrease maternal  
17 sensitivity although mothers of VP/VLBW infants are, on average, not less sensitive. Thus,  
18 clinicians should be aware in their diagnosis that the association between feeding problems  
19 and maternal sensitivity may differ in dyads of VP/VLBW infants and mothers compared to  
20 those of full term healthy dyads. Mothers of VP/VLBW infants with feeding problems at  
21 term and mothers of FT infants from 3 months onwards might need more support in dealing  
22 with feeding problems to avoid deterioration of mother-infant interaction with potential long  
23 term consequences.<sup>37</sup>

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Figure Legends

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