Mother-infant interaction at 3 months in very low birth weight premature infants.
The association of the infant's neurobiological risk and maternal anxiety

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Abstract
The birth of a very low birth weight premature (VLBW) infant is associated with anxiety for the mothers and higher neurobiological risk for the infant. How maternal anxiety experienced in the weeks after the premature birth and the neurobiological risk of the infant as assessed during the in-patient hospital stay may be reflected in the mother-infant interaction at 3 months corrected age is the focus of this study.
Comparing the VLBW premature sample (n=102) with a full-term control sample (n=35), showed mother-infant interactions of the premature sample to be more reactive in the vocal channel, however less reactive facially. Additionally compensatory strategies seem evident as mothers of premature infants show more sensitivity and stimulate their premature infants more than mothers of full-term infants do. However mothers of infants with higher neurobiological risk are less sensitive than if their infants are of lower neurobiological risk. Higher levels of anxiety were associated with less positive and reactive interactions. How these findings may inform therapeutic interventions will be discussed.

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Introduction

Great advances in medical technology have led to a continual decrease in the mortality rate of premature infants, however the emotional burden on parents is still considerable (Cobiella et al., 1990). A premature birth of a very low birth weight (VLBW) infant (weighing less than 1500g) has been seen as a time of crisis for parents, with many preterm births coming unexpected. Parents' anticipated joy is often replaced by impending catastrophe. The stresses experienced in the normal transitions to parenthood are compounded by being confronted with a situation in which parents relinquish the control over their baby, normal routines are disturbed as hospital dictates the care of the infant and uncertainty about their infant's survival for fear of loss, may lead to anxiety and difficulties in forming a relationship. As VLBW premature infants spend at least their first days in an incubator, spontaneous caressing can only be realised through the walls of the incubator. If mothers want close bodily contact, such as having their infant in their arms or their newborn on their chest (also known as kangarooing), medical staff are needed to assist in arranging tubes and cables with which the infant is connected to medical apparatus. The formation of the early relationship between a mother and her infant takes place in a highly technicalised environment, which may represent an obstacle as intimacy can only be created with great effort (Perehudoff, 1990).

Hence mothers have been found to react to a premature birth with anxiety, grief, feelings of loss and separation, helplessness, anguish, depression and stress (Caplan, 1960; Goldberg, 1979; Gloger-Tippelt, 1988; Gennaro et al., 1990). Anxiety in particular being an emotion brought into association with premature birth. Parents' level of anxiety seems to be dependent in part on the neurobiological risk status of the premature infant (Pederson et al., 1987, Blumberg, 1980; Silcock 1984). Also certain maternal characteristics may contribute to greater anxiety such as mothers being of younger age (Meyer at al., 1995). Young mothers may find the premature birth a more stressful situation than mothers with more life experience.

Maternal anxiety may in turn be manifest in the way mothers interact with their child (Whaley et al., 1999). Heightened maternal anxiety seems to have consequences on the way mothers interact with their children. Mothers show less warmth and positivity and have been shown to catastrophise and criticise more than control mothers do. This interactive style has been shown to contribute considerably to the children's own development of anxiety and is therefore relevant to the transgenerational transmission of psychopathology.

Numerous studies indicate that maternal well-being influences the quality with which mothers interact with their infants (review by Cummings & Davies, 1994), especially the importance attributed to the quality of emotional exchange during an interaction has been demonstrated and also been shown to predict to later social and cognitive development (Murray et al., 1993; Miller et al., 1993; Esser et al., 1996; de Wolff & van IJzendorn, 1997). With increasing age VLBW premature infants are influenced more in their development by social factors (e.g. social class and quality of parent-child relationship) than by perinatal and neonatal factors (Wolke & Meyer, 1999; Brazy et al., 1991).

Additionally to the neonatal intensive care unit (NICU) being a stressful environment which does not facilitate the formation of a relationship with ones' newborn, premature infants' neurological immaturity seems to make it difficult for mothers to interact with their infants. Various studies have shown premature infants in the first year of life to be less rewarding interactive partners when compared to full-term infants They show more negative affect (Brachfeld et al., 1980), less posititve affect (Garner & Landry, 1992) are more passive and less socially responsive (Malatesta et al., 1986). Als (1983) describes premature infants as being difficult to bring to an attentive state, and once in this attentive state, they are more likely to be overaroused. Pauli-Pott (1991) also found premature infants to be less reactive, more irritable, less able to regulate states of arousal, showing more negative affect and often avoiding eye contact.

It is not surprising that most mothers of premature infants when compared to mothers of full-term infants have been found to be more passive and less loving (Barnard et al., 1984) and show less positive facial expression (Crnic et al.,1983). So the interactions of VLBW premature infants and their mothers are possibly disadvantaged twofold, through maternal anxiety and infants' neurological immaturity.

However there are some studies which show that mothers seem to be able to compensate for the difficult circumstances. When interacting with their preterm infant mothers have also been shown to be more gentle (Crawford et al., 1982), seeking more physical contact (Malatesta, et al., 1986) and being more active (Crnic, 1983) when compared to mothers of full-term infants. Further research is needed to discover which factors enable mothers to compensate when interacting with their preterm infants as this information may be therapeutically valuable and relieve some of the helplessness often felt in this situation.

Study

A large longitudinal study was conducted focusing on the emotional, behavioural and cognitive development of VLBW premature infants in the first two years of life (Brisch et al., 1996). The focus of this paper will be on the mother-infant interaction at 3 months corrected age and ask to what extent these interactions differ between the preterm and the full-term control sample. Additionally how the degree of neurobiological risk and maternal anxiety contribute to the interactions will be investigated.

Sample Selection

Families were recruited for the study in the first days after the birth of their premature infant (<1500g) at the university hospital. All mothers who had given birth to a premature infant weighing less than 1500g and who fulfilled the following criteria were asked to participate in the study: they had good spoken German, their child survived the first three days, they did not take part in another psychotherapeutic intervention study conducted in the hospital and

their child was not transferred to another hospital in the first week. All mothers fulfilling these criteria were approached by one of the researchers while on the maternity ward. Out of a possible sample of N=374 mothers who had given birth to a premature infant (<1500g) at the university hospital during the period of recruitment, N=94 (25%) where excluded for one of the above reasons. The remaining 280 mothers were approached and asked to participate in the study, out of those 123 (44%) agreed to participate. The remaining 177 mothers gave the following reasons for refusing: too great a distance from hospital to home (N=34), child transferred to another hospital after the first week (N=5), too much stress (N=23), personal reasons (N=26). 69 mothers refused without giving a reason.

Preterm sample

123 families with VLBW premature infants took part in the study. However there was only data on 102 mother-infant pairs which included the mother-infant interaction at 3 months corrected age. Four children died before the 3 months assessment, 8 children were still or again inpatients at the time of the assessment, in one family the parents could not be separated from one another for dyadic interactions with their child, 7 families decided not to continue in the study and in one family only the father took part in the study.

Children‘s birth weight ranged from 450g-1490g (M=966g) with a mean gestational age of 27 weeks (range 23-35 weeks). 84% of children were delivered with cesarean section. The premature infants were in-patients for M= 82.4 days (range = 13-165 days) on the neonatal ward and on a ventilator for M= 12.5 days (range = 0-88 days). 27 of the children were small for gestational age. 51 were boys and 51 were girls. 59% of the children were firstborns. 20% of the sample were multiparous. From the multiparous families, one child was chosen at random to be included in this sample.
The average age of the mothers was M=31 years (range 18-42 years), 94% of the parents were married, 70% left school at 16 years of age. Parents almost all had a German cultural background and had good spoken german.
There was one significant difference between the sample who participated in the study and those who dropped out after initially having agreed to participate. The "drop out" sample (n=7) had significantly more multiparous births than the sample who continued to participate. (χ^2 = (1, N =109) 9.9, p = .007).

Full-term control group

Interactions of full-term healthy infants (n=35) with no psychosocial risk from the Mannheim Study of Risk Children (e.g. Laucht et al., 1994), a large longitudinal study (n= 362) were available as the control group. The Ulm study had been planned using a comparable experimental set-up of the mother-child interaction to the Mannheim sample, in order for this comparison to be possible. This enabled the full-term sample to be used as a baseline against

which the premature infants and their mothers could be compared. In the full-term sample, the children had no pre-, peri-, or neonatal complications, were all first borns, their mean gestational age was 39 weeks (range = 38-42, SD= 1.2) with an average weight of 3333g (range = 2600-4130, SD = 400.3). Parents were all german speaking, in stable partnerships and had skilled jobs. Mother-infant interactions were recorded when the infants were 3 months of age. It should be noted that differences found between the premature sample and the full-term sample may be due to different raters assessing the different samples. However as all the raters were trained by the same procedure, this should reduce this probability. Additionally one of the raters of the preterm sample (D.M.) assessed the interactions of a sample of mothers of full-term infants (N=45) using a shortened version (encompassing seven variables) of the mother-infant assessment. No significant differences were found in the ratings of the interactions between these full-term mothers and the mothers from the Mannheim sample on the available variables. Hence this would reduce the likelihood of differences found between the sample being due to different raters as opposed to an effect of the infant's maturity.

Procedure- premature sample

Mothers who had given birth to a premature infant (<1500g) and who fulfilled the inclusion criteria were approached on the maternity wards of the University hospital. One of the research psychologists informed them about the aim of the study, both parents were asked to participate. After mothers and/or fathers had agreed to take part in the study, they were asked to fill in a battery of questionnaires. These were numerous and only the ones relevant to this paper will be mentioned here.

An appointment for the initial interview was made with the research psychologist, who would be the contact person throughout the duration of the study. This first interview provided mothers and fathers with an opportunity to recount their experience of the premature birth. After this initial interview, parents were asked to fill out a series of questionnaires, including the trait and state forms of the STAI (German version Laux et al., 1981) and questionnaire recording sociodemographic data.

Four weeks later the second assessment was conducted, again the parents were interviewed and a series of questionnaires were handed out including the state anxiety form of the STAI. A week before the infants were discharged from hospital, mothers were again asked to provide an assessment of their state anxiety and again at the time of the observation of mother-child interaction when the child was 3 months corrected age.

The infant's neurobiological risk was determined by neonatologists during each hospital in-patient stay using the Neurobiological Risk Score (NBRS, Brazy et al., 1991, 1993), which was completed at the infant's discharge from the hospital by a pediatrician.

The mother-infant interaction was filmed at 3 months corrected age in the research laboratory (supported by the Köhler Foundation) of the Department of Psychotherapy and

Psychosomatic Medicine. This age was chosen, as at 3 months corrected age, most of the infants should have been discharged from hospital and mother-infant communication may be said to be at a stage where infant's are able to modulate their social communication on several channels.

As parents may have had to travel some distance, they were received with refreshments and an opportunity was given to catch up on recent developments in the family's life. This allowed for a "warming-up period" before the interaction was filmed, allowing mothers and their infants to feel a little more at ease in the unfamiliar environment. When the infant was awake, alert and not hungry, the mothers were asked to change their infant's nappy and play with them on a table in the laboratory for 10 minutes.

During the nappy changing and play episode the parent‘s and infant‘s interactive behaviour was filmed using a split-camera technique. The two cameras used to film the interaction (one focusing on the mother, the other on the infant) were visible to the parents. Using the split-screen technique (both mother and infant are visible on the TV screen simultaneously) allowed detailed observation of the interaction and reaction, which was required for the subsequent coding of the mother-infant interaction. Three colleagues (T.B., E.R., D.M.) who had no additional information about the families rated the interactions, after they had achieved good inter-rater reliability. The rating scale (micro-analytic coding system of mother-infant interaction, Jörg et al., 1994) focused on both mother's and infant's behaviours.

Figure 1 Timetable of measures used

T1 **one week after birth**	**T2** **one month after T1**	**T3** **one week before infant is discharged from the hospital**	**T4** **one week after infant is discharged from the hospital**	**T5** **premature infant is 3 months corrected age**
State-Trait Anxiety questionnaire (STAI) State and trait forms	State-Trait Anxiety questionnaire (STAI) State form	State-Trait Anxiety questionnaire (STAI) State form	Nursery neurobiologic risk score (NBRS)	State-Trait Anxiety questionnaire (STAI) State form
Sociodemographic data				Mother-infant interaction assessment

Measures

Spielberger Trait-State Anxiety Inventory STAI (German version: Laux et al., 1981)

The German version of the state-trait anxiety scale was used throughout the study. Two scales with 20 items each assess the state and trait anxiety of the parents after the birth of their premature infant. The state form of the State-Trait Anxiety Inventory provides an indication of the amount of anxiety the mother perceived herself as experiencing at a certain point in time. The trait form gives an indication of the amount of trait anxiety experienced and focuses on the tendency of a fear/anxiety reaction. The STAI is a well standardised and widely used measure for assessing anxiety. Items are rated on a 4-point scale ranging from *not at all* to

very much. For the following assessment points only the state form was given to the mothers to fill in. A total anxiety score is computed for each assessment point.

Nursery Neurobiologic Risk score (Brazy et al.,1991, 1993)

This scale is based on an assessment of mechanisms which are related to brain cell injury. The following seven items make up the total score: assisted ventilation, blood ph, seizures, intraventricular hemorrhage, periventricular leukomalacia, infection and hypoglycema. Scores were allocated on a four point scale for each item (0, 1, 2, 4) by the pediatrician. The scores encompassed the intensity and the duration of each risk item. The total score was the sum of the risk items. Some infants were in-patients in several hospitals, hence for each in-patient stay a NBRS score was allocated. The highest total score assigned to the infant during an in-patient hospital stay, was used for statistical analyses.

Micro-analytic coding system of mother-infant interaction

The videotaped interaction was coded by trained observers using the "Kategoriensystem zur Mikroanalyse der frühen Mutter-Kind-Interaktion" (Jörg et al., 1994), which enabled comprehensive ratings of the mother-child interaction. This coding system has been developed for use in a large longitudinal study in Mannheim investigating the longterm effects of psychosocial and biological risks on the developing child (Laucht et al., 1992, Schmidt et al., 1992, Esser et al., 1993).

Figure 2 : Microanalytic ratings of the mother-child interaction (Jörg et al., 1994)

Mother rating Rating per second	**Child rating** Rating per second	**Joint mother-child ratings** Rating every 15-30 seconds
direction of gaze: *at child/ at toy/ away*	direction of gaze: *at mother/ at toy/ away*	appropriateness of stimulation: (rating every 30secs) *overstimulation/ appropriate stimulation/ understimulation*
vocalisation: *vocalises/ does not vocalise*	vocalisation: *positive or neutral/ negative/ does not vocalise*	maternal reactivity: (rating every 15 secs) *facial/ physical/ vocal/ lack of sensitivity*
facial expression: *positive/ neutral / negative*	facial expression: *positive/ neutral / negative*	child reactivity: (rating every 15 secs) *facial/ physical/ vocal/ avoids eye contact*
content of interaction: *play or caress/ caretaking/ none*		
body distance: *near/ far*		

The interactions were assessed using time-sampling, with varying time intervals used to code the interactive behaviours (see Figure 2). For statistical analyses data was transformed into percentages. As far as possible the interactive variables were condensed. A subjective value was assigned to the variables, e.g. for maternal direction of gaze:

% of gaze away x 0 + % of gaze at toy x 1+ % of gaze at child x 2/
total % of gaze away + total % of gaze at toy + total % of gaze at child.
This left seventeen variables (originally there were 31) representing different aspects of the mother-child interaction. The seventeen variables were: Proximity, mother's direction of gaze, mother's facial expression, mother's vocalisation, mother's appropriateness of stimulation, content of interaction, mother's facial reactivity, mother's physical reactivity, mother's vocal reactivity, mother's lack of sensitivity, child's direction of gaze, child's facial expression, child's vocalisation, child's facial reactivity, child's physical reactivity, child's vocal reactivity, child avoids eye contact.

Reliability of MKI

Good reliability was achieved by the three raters (E.R., T.B., D.M.) and the instructor (G.S.). The interrater reliability ranged from kappa: $\kappa = .69$ (child facial expression) to kappa: $\kappa = .89$ (body distance) across the 11 scales. Continual supervision of the raters was assured throughout the complete rating procedure of the sample. G.S. had been trained by the raters of the Mannheim sample in assessing the mother-child interactions and achieved interrater reliability of $\kappa => .80$ on the scales. It should be noted that as premature infants do not tend to signal facially as clearly as full-term infants, it may also be more difficult for raters to decide upon a facial expression which could result in lower interrater reliabilities than if a full-term infants were rated. Field and colleagues (1984) also report these difficulties during the Brazelton examination, where faces of premature infants showed less distinctive codable expressions.

Hypotheses tested

1. The higher the biological risk of the infant, the more anxious the mothers are.
2. The interactions of the premature infants and their mothers will differ from the interactions of a control group of full-term infants and their mothers. Analyses will be exploratory and test whether premature infants and their mothers will be more or less reactive or sensitive than the control group mothers and their infants.
3. In the premature sample only, the association of anxiety and neurobiological risk with the mother-infant interaction will be tested. It is assumed that the higher the neurobiological risk of the infants, the less reactive and emotionally expressive they are during the interaction. However whether the neurobiological risk of the infant lets the mother be more or less reactive to her infant is to be tested in an exploratory fashion. Maternal anxiety is hypothesised to hinder a sensitive and positive interaction.

Results

1. The influence of neonatal risk on maternal anxiety

Levels of maternal state anxiety over time

The mother's assessment of state anxiety demonstrated a reduction in the level over time (Table 1). To test whether this reduction is significant, a repeated measures Manova is conducted over three assessments (T1, T2, T5). The data collected at T3 was excluded from hereon due to the extent of missing data. In a substantial number of families the infants were discharged from the hospital very suddenly which resulted in parents forgetting to fill out the questionnaire. Results show that the reduction in the levels of anxiety over time is highly significant ($F(2, 80)=36.81$, $p<.001$).

Table 1: Maternal anxiety scores from birth to 3 months corrected age

	M	SD	N	Min	Max.
Total STAI T1 (after birth)	51.87	13.27	97	25	79
Total STAI T2 (1mth after T1)	46.93	13.78	91	23	80
Total STAI T3 (before discharge)	46.45	13.22	66	22	75
Total STAI T5 (3 mths corr. age)	38.1	12.20	94	21	78

When compared to a German sample of pregnant mothers whose pregnancy was not at risk (STAI Score M = 39.1; SD = 10.9, N=166) (Munz et al., 1999/2000), the anxiety score of the mothers in the first week after the premature birth is much higher.
Selected maternal factors, which may contribute to the state anxiety levels of the mothers were tested for their relevance. The age of the mother, whether she has had previous at risk pregnancies, parity, level of education, were all not associated significantly with her anxiety. However the number of life events previous to the infant's birth were related to anxiety in the first weeks after the birth: High anxiety was associated with many life events (spearman-rho=.27, p=.008, N= 97). Testing which life event in particular may have accounted for this finding, uni-variate analyses were performed. Mothers who had experienced a separation from their partner (not necessarily permanent) in the year previous to the birth of their premature infant were significantly more anxious than mothers who had not (Mann-Whitney-U, 103,5, $p < .05$). However when performing the Bonferroni procedure, the level of significance should exceed p=.006, hence this result must be interpreted with caution.

Descriptive data of three parameters which give an indication of the infant's neonatal status are investigated: Birth weight and gestational age allow the data to be comparable to other studies and the neurobiological risk score (NBRS)(Brazy et al., 1991;1993) identifies the risk for developmental abnormalities due to neonatal medical events.

Table 2: Biological risk status of the premature infants

	Mean	SD	min	max
birth weight	949,2g	283	450g	1490g
gestational age	27,5wks	2,6	23	35
Neurobiological risk (NBRS score)	3,5	3,4	0	17

N=102

The inter-individual variance of the biological risk in the sample of premature infants is great. How these parameters are linked to maternal anxiety in the first months of the infant's life can be seen in Table 3.

Table 3: Maternal anxiety and biological risk of the premature infant

	Total STAI T1 N=97	Total STAI T2 N=91	Total STAI T5 N=94
birth weight	-,08	-,20	-,07
gestational age	**-,24***	**-,38****	**-,32****

N=102 mother-child pairs
Spearman-Rho Korrelation **p<0,01, *p<0,05

The gestational age of the infant is linked with assessments of the mother's level of anxiety at all three assessment points. However, no significant association was found with the infant's birth weight and maternal anxiety at any of the assessments.

The neonatal risk of the infant as determined by the NBRS was the neurobiological risk recorded during the hospital stay and was therefore only analysed in relation to anxiety at 3 months corrected age (T5) and not sooner. The correlation was found to be: spearman = .22, p =.05, n=94. Mothers assess themselves as more anxious the greater the biological risk for their infant. Hence for the gestational age and the NBRS assessment the hypothesis of higher biological risk being linked to higher levels of anxiety is confirmed.

2. Mother-infant interactions in full-term and premature infants

A Manova is conducted to test whether there is an overall difference in the interactions between the premature sample and the full-term control sample. The result reveals a highly significant difference between the interaction of the two samples ($F(17,117)= 8.84$, $p<.001$), supporting our hypothesis.

To test in which aspects of the interaction the two samples are seen to differ, separate Mann-Whitney comparisons were made (seventeen in all). The eight significant results where differences had been found between the two samples are listed in the table below.

Table 4: Mother-child interactions of the premature sample compared to full-term control sample

	Premature sample N=102		**Full-term Sample N=35**		**Effect size**	**Mann Whitney**
	M	**(SD)**	**M**	**(SD)**		
C. vocalises	1.21	(.17)	1.10	(.11)	.72	Z = -3.94 p < .001
C. vocally reactive	63.40	(24.37)	48.14	(17.16)	.67	Z = -3.72 p < .001
C. avoids eye contact	1.65	(3.46)	.38	(1.35)	.41	Z = -2.18 p = .029
M. appropriate stimulation	.70	(.29)	.59*	(.24)	.40	Z = -2.18 p = .029

M. vocalises	77.52 (15.09)	72.37 (10.52)	.37	Z = -2.63 p = .009
M. lacking sensitivity	1.45 (6.75)	2.43 (4.27)	-.16	Z = -2.98 p = .003
M. facially reactive	61.17 (23.88)	75.29 (16.80)	-.63	Z = -3.02 p = .003
C. facially reactive	27.57 (20.47)	66.51 (20.57)	-1.9	Z = -7.13 p < .001

* for this variable there is only data on 33 mother-infant interactions

Premature infants vocalise more, are more vocally reactive and avoid eye contact more of the interaction than full-term infants. Mothers of premature infants were appropriate in their stimulation for more of the interaction and vocalise more than mothers of the full-term sample. However mothers of full-term infants are more facially reactive during the interaction as are their infants, but lack sensitivity for more of the interaction when compared to the premature sample.

Hence support was found for mothers and infants of the premature sample to be less reactive facially than the full-term sample, however in the vocal channel, the premature sample are more vocally reactive, also they are rated to be more sensitive and appropriate when compared with the full-term sample. This may suggest mother-infant interaction of premature born infants and full-term infants have different ways of interacting. Perhaps this difference between the two samples may be explained by the neurobiological risk of the premature infant.

3. Association of infant's neurobiological risk, maternal anxiety, and mother-child interaction

How the mother-infant interaction differed according to whether the premature infants were of low or high risk according to the total NBRS score, was tested in a series of Mann-Whitney analyses. We used the cut-off criteria for low and high risk as had been defined by Brazy et al. (1991). Low risk prematures were defined as those infants with a total NBRS score of 4 or less, high risk prematures were defined as those with a total NBRS score of 5 or greater. Eckerman et al. (1999) also used this cut-off and showed a score of 5 or above was strongly associated with neurologic abnormalities and delays in behavioural, cognitive and motor development for at least the first two years adjusted age.

In our sample the low risk prematures (n=73) weighed M:1039.8g (266.2) at birth and had a gestational age of M:28.7, (2.5) weeks, the high risk prematures (n = 29) had a birth weight of M: 721g (176.9) and a gestational age of M: 25.3 (1.6) weeks.

The statistically significant analyses are listed below.

Table 5: Mother-infant interactions of low risk and high risk premature infants

	low risk n=73	**high risk n=29**	**Effect size**	**Mann Whitney**
	M (SD)	**M (SD)**		
C. facial expression	1.06 (.15)	1.00 (.13)	-.42	Z = -2.54 p < .011

C. direction of gaze	1.09 (.46)	.75 (.43)	-.75	Z = -3.31 p = .001
C. facially reactive	30.44 (19.81)	20.33 (20.65)	-.50	Z = -2.45 p < .014
C. physically reactive	13.07 (12.65)	7.34 (10.62)	-.47	Z = -2.41 p < .016
Proximity	27.07 (17.59)	41.80 (22.71)	.77	Z = -3.02 p < .003
M. lacking sensitivity	.35 (1.21)	4.23 (12.23)	.59	Z = -2.74 p = .006

At three months corrected age, when the mother-infant interaction was filmed premature infants of high neurobiological risk were found to show less positive facial expression, look less at the mother and be less facially and physically reactive to their mother when compared with low risk premature infants, hence confirming our hypothesis.
Mothers were shown to differ in two behaviours according to the risk status of their infants. Mothers whose infants were of higher risk were less sensitive in interaction than if their infant were of lower risk, however they were physically closer to their infant for more of the interaction if their infants were of high risk as opposed to of low risk. This may suggest mothers may be more sensitive to their high risk infants, however when maternal proximity is correlated with other interaction measures, significant correlations are found with mothers looking at their infant (.25, $p<.05$), mothers overstimulating (.20, $p<.05$), infants avoiding eye contact (.29, $p<.01$) and infants being less vocally reactive (-.29, $p<.01$). This would suggest maternal proximity is associated with mothers perhaps doing too much and infants being withdrawn from the interaction.

The association of maternal anxiety on the seventeen variables characterising the mother-infant interaction was tested using spearman correlations. Four associations reached statistical significance. The more anxious mothers were at 3 months corrected age, the less the mothers looked at their infant (-.22, $p<.05$). High levels of maternal anxiety were also associated with infants showing less positive affect during the interaction (-.26, $p<.05$), less facial (-.30, $p<.01$) and less vocal reactivity (-.26, $p<.05$). This confirms the hypothesis that high levels of anxiety are not associated with a sensitive and positive interaction.

Discussion

Mothers' level of anxiety is very high in the week after their premature birth. This level decreases in the following months and at 3 months is comparable to the level of anxiety of mothers with a normal full-term birth. The decrease of anxiety over time may be explained by mothers adjusting to the situation of having a premature infant. Additionally most premature infants have overcome many of the difficulties with which they had to cope at the beginning

of their life (e.g. being artificially ventilated, operations, difficulties feeding, infections), which could also contribute to this decrease.
Results from our study support the hypothesis that maternal anxiety is also associated with the infants' biological risk (also Blumberg, 1980). Mothers are more anxious the sooner the infant is born (low gestational age) and the higher the neurobiological risk score. To date infants may survive from 23 + weeks gestation and it is known that the longer a mother can carry her baby (if there are no complications), the better for the infant's health. Interestingly birth weight was not significantly associated with maternal level of anxiety. No specified weight indicates survival of a newborn (Weiss et al., 1998), which may account for the lack of association with maternal anxiety in this VLBW sample.
One factor leading mothers to be more anxious which was not related to the infant's health, were the number of life events experienced before the birth, especially if there had recently been a separation from their partner. Hence mothers seem to be more anxious in this demanding situation if they do not have a stable partnership. Pederson et al. (1987) showed husbands to be a major source of support to their wives after a premature birth confirming the importance of the partner in this time of crisis.

As hypothesised, results reveal there are differences in the mother-infant interactions between the premature sample and the full-term sample. More specifically the premature sample are more vocally active and reactive than the full-term sample, however facially the premature infants and their mothers are reactive for less of the interaction. Also premature infants were shown to avoid eye contact to a greater extent than the full-term infants, which makes them less receptive to facial communication. One explanation being that premature infants regulate their arousal by turning away (Pauli-Pott, 1991). Hence the ability to be more or less reactive seems to be dependent on the channel of communication. Stevenson Barratt et al. (1992) in their sample of comparatively healthy premature infants (birth weight M= 2099g, gestational age M=34 weeks) also found mothers to be particularly sensitive to their preterm infants vocal signals. In comparison to full-term infants, preterm infants were more successful at capturing their mothers attention with use of the vocal channel. It is suggested that the vocal channel may be particularly used by preterm infants and their mothers as a compensatory strategy. The present sample is more at risk, however similar mechanisms of communicating via the vocal channel as opposed to the facial one seem to apply. Esser et al. (1996) have stressed the importance of eye contact for sensitive interaction between mothers and infants. For infants who look elsewhere apart from their mother, results show a developmental path leading to later cognitive or motor deficits, implying that disturbed facial communication may be a marker for later difficulties. To what extent the lack of facial communication may be compensated by the vocal channel and whether this will have an impact on the developmental path is not known, but should be the focus of further reserach.

The results also support studies which have shown mothers of premature infants to be more responsive and attuned to their infants (e.g. Crawford, 1982, Greene et al., 1983). Mothers are rated as being more sensitive and more appropriate in their stimulation than mothers of the full-term sample. However, when the neurobiological risk is taken into account, infants of high biological risk have mothers who are less sensitive than if they are of low biological risk. This would suggest a slight degree of biological risk (being born premature but scoring less than 5 on the Neurobiological risk score) would encourage more sensitivity, than being a full-term infant. Hence there seems to be a level of risk at which mothers are able to be more sensitive. What we may conclude is that mothers may activate special abilities when interacting with their premature infants (also see Stevenson Barratt et al., 1992) even though they may have high levels of anxiety and the infants are less reactive facially. Results suggest there are strengths and weaknesses in the interactions of premature infants and their mothers when compared to the full-term sample.

We also wanted to assess the influence of anxiety on the mother-infant interaction, as this is known to accompany the birth of VLBW premature infants (Cobiella et al., 1990, Gennaro et al. 1988, Catlett et al., 1994). During the mother-infant interaction surprisingly only one maternal behaviour was shown to be associated with maternal level of anxiety. Anxious mothers look elsewhere for more of the interaction than mothers who have little anxiety and therefore offer less possibility for communication. Infants of mothers with higher levels of anxiety are less positive in their affect and reactive for less of the interaction both facially and vocally. Hence maternal anxiety is not conducive to positive and supportive interactions. However one should assume a bi-directional effect between maternal anxiety and the mother-infant interaction. If a child shows little positive affect and little facial and vocal reactivity mothers may react with more anxiety. Equally mothers who are more anxious may be less emotionally available to the infant which may lead the infants to be less reactive in the interaction (for discussion of bi-directional effects see Dunn, 1999). For reasons of practicability, the mother-infant interaction was only filmed once at 3 months corrected age and not earlier when maternal anxiety level is at its peak. It might be speculated that if the mother-infant interaction were to be recorded when maternal anxiety is higher (in the first months), there may also be stronger associations between anxiety and mother-infant interaction.

To conclude, mother- infant interactions of a sample of VLBW preterm infants have strengths and weaknesses which partly depends on the channel of communication. Vocally the preterm sample communicate more of the interaction than the full-term sample. If this finding were to be confirmed by other studies and it were shown that more vocal communication would have beneficial effects on the developmental path of premature infants, mothers may be encouraged to vocalise more with their premature infants. Additionally mothers of low risk premature

infants are able to be particularly sensitive to their infants, which would suggest mothers are able to activate resources even though they have had to cope with the trauma of a premature birth and their infants are less reactive facially.

Reducing the high levels of maternal anxiety especially in the first months of the premature infant's life should be another focus for intervention. Higher levels of maternal anxiety are associated with less facial reactivity between mother and infant during the interaction. Stress reduction treatments have been successful in teaching mothers of premature infants relaxation techniques and cognitive coping strategies and resulted in a decrease of anxiety levels (Cobiella et al., 1990).

It is seen as important that parents are helped as much as possible to adapt to the premature birth. If they do not, they may have difficulty during interaction with their preterm infants who are less able to be rewarding interactive partners than full-term infants. This could have negative effect on the long term development of the premature infant (Pauli-Pott, 1991).

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