Mother and child behaviour in very preterm and fullterm dyads at 6;3 and 8;5 years

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Abstract

Aim. Mothers of very preterm children have been reported to behave less sensitive and more controlling. It is unknown whether this is the result of maternal factors or due to maternal adaptation to children's cognitive problems.

Method. In a geographically defined prospective whole-population sample of very preterm (<32 weeks gestation) or very low birth weight children (<1500 g birth weight; VLBW/VP; *n* =267, 124 females, 143 males) and their fullterm controls (*n* =298, 146 females, 152 males) in Germany, mother-child interactions were videotaped during a play situation and analysed with a standardized coding system at 6;3 and 8;5 years.

Results. At both 6;3 and 8;5 years, VLBW/VP children were less task persistent and socially active (p <0.001) whereas their mothers behaved less sensitive and more controlling compared to fullterm mother-child dyads (p <0.001). Cross-sectional group differences in maternal behaviour remained when scores where adjusted for social factors but disappeared once adjusted for child IQ. High maternal sensitivity predicted higher task persistence (p <0.001), in particular in those children with cognitive problems.

Interpretation. Mothers of VLBW/VP children adapt their behaviour to their children's level of cognitive functioning. High maternal sensitivity is particularly beneficial for task persistence in children with cognitive deficits.

Running head: VLBW/VP dyads' mother and child behaviour

What this paper adds

- Mothers of VLBW/VP children are not in general less sensitive or more controlling than those of fullterm children, but adapt their behaviour to their children's cognitive level of functioning.
- High maternal sensitivity is particularly beneficial to improve task persistence in children with mild to severe cognitive deficits.

Very preterm children are at increased risk for a range of neuro-developmental, cognitive, behavioural and social problems.[1] Consistent differences between fullterm and preterm mother-infant dyads have been reported, with preterm infants being described as more compliant and less active[2] and their mothers as less sensitive and more controlling.[3 4] The differences are usually attributed to stress[4] and increased social disadvantage[5] associated with preterm birth. However, a recent study suggests that preterm children's poor attention abilities negatively influence their active involvement in social interactions.[6]

Child social competence and self-regulation increase with age and are affected by maternal behaviour.[7 8] However, it is not known whether the often observed lower sensitivity and higher control of very preterm children's mothers are the result of maternal factors,[9] or due to VLBW/VP children's higher rates of behaviour difficulties ranging from ADHD and autism spectrum disorders to cognitive and peer problems.[10 11] Depending on their level of cognitive functioning, VLBW/VP children may require different levels of mother-child synchrony than healthy fullterm children.[12]

Maternal sensitivity and control are moderately negatively related and reflect two separate dimensions of parenting behaviour.[13] Intuitively, mothers of preterm children may provide more control to scaffold interactions with their children.[14] Scaffolding takes place through explicit verbal direction and enables young children to sustain their focus of attention and accomplish challenging goals.[15 16] However, it should decrease with increasing competence and self-regulation of the normally developing child.[7] Conversely, for children with developmental delays or learning disabilities more controlling maternal behaviour has been reported throughout childhood.[17] On the other hand, there is evidence that increased maternal sensitivity may be beneficial for preterm infants' development.[2] It has been suggested that children's characteristics and levels of functioning may result in differential susceptibility to parenting behaviour.[18 19] Accordingly, children with persistent cognitive deficits may benefit from increased maternal sensitivity and verbal control to regulate their behaviour but this has not been studied prospectively so far.

The present study investigated the quality of mother and child behaviour at 6;3 and 8;5 years of age in VLBW/VP and fullterm dyads and addressed the following questions: Are VLBW/VP compared to fullterm control children less persistent and socially active? Are mothers of VLBW/VP children less sensitive and more verbally controlling, and are VLBW/VP mother-child interactions less harmonious? Are cross-sectional differences in maternal and child behaviour between VLBW/VP and fullterm dyads explained by maternal social factors or child IQ? Does increased maternal sensitivity or verbal control promote task persistence in children with cognitive deficits?

Method

Participants

The data were collected as part of a prospective and geographically defined whole population study in South Germany, the Bavarian Longitudinal Study.[20]

Very Low Birth Weight (VLBW) and/or Very Preterm (VP) Children. Of 70600 children born in South Bavaria during a 15-month period in 1985/86, 682 were VLBW (birth weight < 1500 g) or VP infants (< 32 weeks gestation), or both. Of these VLBW/VP children, 173 died during the initial hospitalization and seven died during the first six years of life. Seven parents did not give written consent to participate and 47 parents and their children were non-German speakers (i.e. the parents did not speak German and children scored <-2 SD on German language tests). These mother-child dyads were excluded from the study as their verbal behaviour could not be coded and

cognitive assessments not administered. Of the 448 VLBW/VP survivors eligible for inclusion, 338 (75%) and 313 (70%) participated at the 6;3 and 8;5 year assessment, respectively; 267 (60%) participated at all three measurement points, i.e. neonatal, 6;3 and 8;5 years of age, and only these cases were included in the analysis. A comparison of these children with those who dropped out during the course of the study showed no differences in biological, medical, and social variables (please see Appendix 1).

Control group. Of 916 potential controls (>36 weeks gestation; normal postnatal care) identified at birth from the same hospitals in Bavaria[20], 350 survivors were selected to be similar regarding the overall distribution of child gender, family socioeconomic status (SES), and maternal age of the VLBW/VP group. 342 (92%) and 320 (91%) attended at 6;3 and 8;5 years, respectively, and 298 children (85%) participated across the three time points.

Procedure

Details of pre-, peri-, and neonatal data have been described elsewhere[20] and are only briefly outlined here. Participating parents were approached within 48 hours of the infant's hospital admission and were included in the study once they had given written informed consent to participate. Ethical approval was obtained from the University of Munich Children's Hospital Ethics Committee.

Measures

Gestation and Birth Weight. Gestational age was determined from maternal reports of the last menstrual period and serial ultrasounds during pregnancy. When the estimates of these two differed by more than two weeks, postnatal Dubowitz examination results were used. Birth weight was documented in the birth records.

Cognitive Assessment. At 6;3 years, children's intelligence was assessed with the German version of the Kaufman Assessment Battery for Children, K-ABC Mental Processing Composite (MPC). The MPC is the total of the Sequential (3 subtests) and Simultaneous (5 subtests) Processing Scales.[21] Reliability is good (.83-.98, split-half method) and construct validity is high (e.g. correlation of .70 with the WISC-R total score). All cognitive assessments were carried out by trained assistant psychologists who were blind to VLBW/VP and fullterm child groups.

Family Social Factors. Social information was obtained by structured interviews within the first 10 days of the infant's life. Maternal education was entered into 11 categories (min.: *1 = no educational qualification* to max.:*11 = doctoral degree*). Family adversity after birth was determined by eight psychosocial variables as a composite index score (FAI; 1. mother < 20 years, 2. Over-crowding: family living space < 15m²/person, 3. parent without completed educational qualifications, 4. single parent, 5. $\geq$ 4 children in family, 6. child in foster care, 7. no back-up in case of emergency, 8. Parent mental health problems; each item scored yes = 1, no = 0).[22] Family socioeconomic status (SES) was entered into 3 categories (low, middle, high) and place of living was coded as 1 = urban (city) or 2 = rural.

*Assessment of Mother-Child-Interactions with the Etch-a-Sketch (AMCIES) at 6;3 (T1) and 8;5 years (T2).*Dyadic mother-child interactions were observed in a task which simulates a homework situation before children began elementary school and again after two years of schooling. At the time of the six-year assessment, 94% of the children were still in kindergarten, and 6% had less than three months of schooling.[20]

At both 6;3 and 8;5 years participants were recorded during a standardized play situation using an Etch-a-Sketch, a toy that allows to produce pictures by means of

two buttons, one that draws horizontal lines and one that draws vertical lines. The instruction was that the mother should use one button and the child the other button, thus both had to work together to copy the template (see Appendix 2). The use of different buttons by mother or child was counter-balanced across dyads and groups. If after 12 minutes there was no complete picture, the session was stopped. Individual sessions took place in quiet, specially equipped, and dedicated assessment rooms with appropriate lighting. They were videotaped and evaluated afterwards by two independent experienced raters (psychologists) who were blind to group and family characteristics.

Coding. Mother and child behaviour was analysed with a standardized coding system, the "Assessment of Mother-Child-Interaction with the Etch-a-Sketch (AMCIES)".[23 24] Rating scales consisted of 6 subscales for the mother, 5 subscales for the child, and 2 subscales for mother-child joint behaviour (for a detailed description see Appendix 3) of established inter-rater reliability (*Kappa*) previously reported between .76 and .89.[23]

Guided by principal component analysis, we reduced nine of the 13 subscales to three index scales: 1. Maternal Sensitivity (incorporating the subscales sensitivity, non-verbal control, and criticism; T1: Cronbach's α = .56; T2: α = .60), 2. Maternal Verbal Control (incorporating the subscales maternal verbal control and joint control of the session; T1: α = .52; T2: α = .80), and 3. Harmony (incorporating the subscales maternal and child dissatisfaction and emotional tone, and joint harmony of the session; T1: α = .80; T2: α = .76). The remaining child behaviour scales correlated poorly with each other and could not be summarized into clusters. Thus the scores in the subscales Child Task Persistence (a measure of attention span), Child Social Interactions with the mother, and overall Physical Activity are reported separately.

Inter-rater reliability. At 6;3 years, inter-rater reliabilities were computed for 12 videotapes of mother-child interactions. By using a one-way (absolute agreement) model,[25] intra-class correlation coefficients (*ICC*) for single scores were calculated and revealed ICCs of .92 for Maternal Sensitivity, .74 for Maternal Verbal Control, and .72 for Harmony, respectively. *ICCs* of the child behaviour scales ranged from .69 to .73. At 8;5 years, *ICCs* were computed for 16 videotapes of mother-child interactions and were .75 for Maternal Sensitivity, .84 for Maternal Verbal Control, .86 for Harmony, and .48 to .75 for child behaviour scales, respectively (please see Appendix 4).

Statistical Analyses

Data were analysed with SPSS 19.0[26] and Stata[27]. Comparisons between VLBW/VP and full term children for descriptive variables were carried out with Student's t-test, Mann-Whitney U-test, or Chi-Square test depending on distribution characteristics of variables. Cross-sectional mean differences in AMCIES mother and child scales were compared with Student's t-tests and then repeated adjusting in Model 1 for social factors assessed at birth, and in Model 2 additionally adjusting for child IQ assessed at 6;3 years of corrected age. Analyses were conducted for all children (Table 2) and repeated for singleton births only (Appendix 5). Finally, the prediction of child task persistence at 8;5 years by maternal sensitivity, verbal control, and child IQ at 6;3 years were analysed with linear regressions adjusted for heteroscedasticity with Huber/White robust standard errors estimates. Linear assumptions of the model were checked with Ramsey RESET test.[28 29]

Results

Gestational age, birth weight, functional and social sample characteristics. The VLBW/VP children were born at younger gestational age, had lower birth weights, were more often multiple and small for gestational age (SGA) births, they had slightly less educated mothers and higher family adversity scores, and they more often lived in rural areas than fullterm controls. There were no group differences in child sex and maternal age. Compared to fullterm children, the VLBW/VP children had lower K-ABC MPC scores (IQ) (Table 1).

- Table 1 about here -

Child behaviour. At both 6;3 and 8;5 years, VLBW/VP children were less task persistent and socially interactive compared to fullterm controls, but they did not differ in overall physical activity (Table 2).

Maternal behaviour. At both 6;3 and 8;5 years, mothers of VLBW/VP children were less sensitive and more verbally controlling. At 6;3 years, harmony among VLBW/VP compared to fullterm mother-child dyads was lower, however, there was no group difference at 8;5 years (Table 2).

Mother-child interactions adjusted for maternal social factors and child IQ. At both time points, VLBW/VP children's social interactions were significantly lower compared to fullterms even when we adjusted for maternal education and family adversity at birth (Model 1), and child IQ at 6;3 years (Model 2). The same pattern was found for task persistence at 6;3 years, however, at 8;5 years adjusting for child IQ (Model 2) eliminated any differences between VLBW/VP and fullterm children. Furthermore, at both time points group differences in maternal sensitivity remained when we adjusted for social factors (Model 1) but were eliminated when additionally adjusted for child IQ (Model 2).The same pattern was found for maternal verbal control at 6;3 years, however, two years later differences between VLBW/VP and fullterm mothers remained significant after adjusting for child IQ (Model 2). At 6;3 years, harmony among VLBW/VP compared to fullterm dyads remained lower in both Model 1 and Model 2.

- Table 2 about here -

We repeated the group comparisons for singletons only (Appendix 5). Overall, the findings showed the same pattern as reported for the total sample with one exception: differences in maternal verbal control between VLBW/VP and fullterm mothers of singletons disappeared at 8;5 years when adjusted for both social factors and child IQ (Model 2).

Prediction of child task persistence at 8;5 years by maternal sensitivity, maternal verbal control, and child IQ at 6;3 years. Linear regressions were performed across the whole sample ($N = 565$, please see Table 1 for descriptive values) and revealed that maternal sensitivity at 6;3 years promoted child task persistence at 8;5 years, in particular in children with cognitive problems. First, unadjusted models showed significant relationships of maternal sensitivity and verbal control with child task persistence (Table 3, Models 1 and 2). However, when we adjusted for child IQ the results were attenuated (Table 3, Models 3 and 4). Second, we adjusted maternal sensitivity, verbal control, and child IQ for each other and, as a result, the effect of maternal verbal control disappeared (Table 3, Model 5). In addition, there was an interaction effect of maternal sensitivity and child IQ on child task persistence. Finally, we adjusted for possible confounding variables (Table 3, Models 6 and 7). Results remained the same: maternal sensitivity and child IQ had positive effects. In addition, a decrease in maternal sensitivity from 6;3 to 8;5 years was detrimental to children's task persistence, boys did worse than girls, and the interaction effect of maternal sensitivity and child IQ was significant.

- Table 3 about here –

To scrutinize the interaction of maternal sensitivity and child IQ, we calculated effects of maternal sensitivity on child task persistence for various levels of child IQ, based on the results of Model 7. Table 4 shows that the positive effect of maternal sensitivity increased with decreasing child IQ, i.e. maternal sensitivity had a stronger positive effect on task persistence of those children with mild to severe cognitive problems (0.62 SD increase in task persistence with 1 SD increase in maternal sensitivity among children with IQ scores at mean-2 SD compared to 0.29 SD increase in task persistence with 1 SD increase in maternal sensitivity among children with IQ scores at mean+2 SD).

- Table 4 about here –

Discussion

The present study found robust differences between VLBW/VP and fullterm mother and child behaviour from preschool to middle childhood. VLBW/VP children were less persistent and socially active, and their mothers were less sensitive and more verbally controlling compared to fullterm dyads. However, differences in maternal behaviour between the groups were accounted for by child IQ, an indicator of neurodevelopmental integrity. In contrast, child behaviour differences were only partly explained by IQ. Maternal sensitivity at 6;3 years predicted higher task persistence at 8;5 years, in particular in those VLBW/VP and fullterm children with mild to severe cognitive problems, after controlling for the change in sensitivity from 6;3 to 8;5 years, family social variables, maternal age, child sex, and multiple birth status.

At both measurement points, VLBW/VP children were less persistent and socially active during the Etch-a-Sketch task compared to fullterm controls. As found before, these differences remained significant after adjusting for social factors and child IQ.[30] Thus reduced attention regulation is a specific problem associated with VLBW/VP birth[1 11] that also affects interaction with parents in challenging situations.

Consistent with previous research in infancy, VLBW/VP mothers were less sensitive and more controlling than mothers of fullterm children.[3 4] However, once we controlled for the cognitive deficits that are more prominent in preterm children most differences in maternal behaviour disappeared. We found no evidence that increased maternal control may be beneficial for preterm children's behaviour regulation. However, maternal sensitivity at 6;3 years promoted child task persistence at 8;5 years, in particular in children with mild to severe cognitive problems. As found by other studies investigating effects of parenting,[31 32] effect sizes were small and the increase of 0.62 SD in child task persistence with 1 SD increase in maternal sensitivity among children with IQ scores at mean -2 SD was only moderate. This indicates that other factors such as genetic effects may be relevant to predict child task persistence which were, however, not included in our model. Nevertheless, with regard to the low intellectual capacities of these children it is a promising finding that parents can significantly promote attention and behaviour regulation in cognitively challenging situations. Our results suggest that children with persistent cognitive deficits are more susceptible to sensitive parenting behaviour. Children with IQ scores above the mean may be better at pursuing a challenging task and thus don't need their mothers' sensitive regulation to succeed as do children with IQ scores below the mean. Unfortunately, our analyses also showed that maternal sensitivity, on average, is lower when children have lower cognitive abilities. Thus children benefitted most for their task persistence when mothers bucked the trend and were highly sensitive despite

their child's cognitive problems. In addition, an increase in maternal sensitivity from 6;3 to 8;5 years promoted children's task persistence whereas a decrease had detrimental effects. This shows that not only does maternal sensitivity before school entry benefit task persistence but increases in sensitivity during the primary school years have an added advantage for children's attention and behaviour regulation – which is important for possible interventions.

Strengths and limitations. This study is the first to describe dyadic interactions of VLBW/VP children and mothers in middle childhood. The data reported here have been collected from a large whole-population sample of VLBW/VP children studied longitudinally. In contrast to previous studies of social relationships in VLBW/VP dyads which typically relied on self-report measures,[9] dyadic interactions were evaluated by independent raters. While up to 75% of the VLBW/VP participated in the follow-up in middle childhood, participation with complete datasets for the interaction data was lower across all three assessment points (60%). However, there was no selective subject loss. The data set is based upon a cohort recruited in 1985/86. Medical and nursing care has changed since then, and the major impact has been increased survival of ever lower gestation infants while rates of learning disabilities and psychiatric problems have remained high.[5 10] Thus the impact of child neurofunctional integrity on mother-child interactions is as relevant for current as previous preterm children.[12] In our VLBW/VP sample, 22% were multiple births, compared to 0.4% of the fullterm controls. A significant number of preterm children are twin or higher multiple births. For the findings to be generalizable to population level, we considered all mother-child interactions but also repeated the analysis for singleton births only. When singletons were considered only (Appendix 5) we found the same overall pattern of differences compared to the total sample. Interestingly, however, at 8;5 years adjusting for social factors and child IQ (Model 2) eliminated any differences in verbal control between mothers of singleton VLBW/VP and fullterm children. Our data suggest that maternal verbal control may be further elevated among mothers of multiples due to more demanding dyadic interaction patterns and discordant twin characteristics.[26] Future research will have to investigate this in more detail and may additionally consider the effect of intrauterine growth retardation and other specific biological risk factors within the preterm group.

Conclusion. Firstly, the assumption that lower levels of sensitivity and higher levels of control among mothers of preterm children are mainly the result of higher family adversity needs to be revised. Rather the quality of interaction crucially depends on the child's cognitive level of functioning, especially in situations that are challenging for the child. Secondly, maternal sensitivity before school entry promotes child task persistence two years later, in particular in children with mild to severe cognitive deficits.

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Table 1: Biological, functional, and social characteristics of the VLBW/VP and fullterm control children

	VLBW / VP (*n*=267)	Fullterm (*n*=298)	*Mean difference (95% CI)*	*p*-value
Biological and medical variables				
Mean birth weight, g	1296 (308)	3388 (450)	2092 (2029, 2156)	<0.001
Mean gestational age, weeks	30.4 (2.3)	39.6 (1.2)	9.2 (8.9, 9.5)	<0.001
Child's sex, male	143 (54%)	152 (51%)	0.9 (0.6, 1.3)	0.54
Multiple births, yes	59 (22%)	12 (0.4%)	6.8 (3.5, 12.9)	<0.001
Mean maternal age at birth, years	28.8 (4.9)	28.7 (4.8)	-0.1 (-0.9, 0.7)	0.77
SGA birth (< 10th percentile)	116 (43%)	30 (10%)	6.9 (4.4, 10.7)	<0.001
Child IQ				
Mean K-ABC MPC score at 6;3 years	88.3 (14.2)	100.5 (10.9)	12.2 (10.2, 14.4)	<0.001
Social variables				
Mean maternal education (min = 1, max = 11)	4.5 (2.2)	5.0 (2.3)	0.4 (0.1, 0.8)	0.02
Family adversity after birth	1 (1 - 2)	1 (0 - 2)	0 (-1, 1)	0.01
Place of living, city	84 (31%)	122 (41%)	0.8 (0.7, 1.0)	0.02

Descriptive values of the whole sample (*N* = 565) as relevant for regression analyses	
Mean child persistence at 8;5 years	7.3 (1.5)
Mean maternal sensitivity at 6;3 years	16.4 (2.9)
Mean change in maternal sensitivity (6;3 years minus 8;5 years)	0.5 (3.3)
Mean maternal verbal control at 6;3 years	12.4 (2.4)
Mean K-ABC MPC score at 6;3 years	94.7 (14.0)

Data are presented as mean (SD) for symmetrical continuous variables, median (IQR) for skewed, and numbers (%) for categorical variables. The p-values are based on t-test, Mann-Whitney U-test, or χ^2-test (all two-tailed), correspondingly. Differences (95% CI) between the groups (fullterm - VLBW/VP) are presented as mean differences for symmetrical continuous, median differences for skewed continuous, and risk ratios for categorical variables.

Table 2: Means and standard deviations (in parentheses) of child, mother and joint behaviour rating scales of observed behaviour in the Etch-A-Sketch interaction for VLBW/VP children and controls at 6 and 8 years, comparing raw scores with scores adjusted for maternal education and family adversity at birth (Model 1), and additionally child IQ at 6 years (Model 2)

		6 years				8 years			
		VLBW / VP (*n*=267)	**Fullterm (*n*=298)**	***Mean difference (95% CI)***	***p*-value**	**VLBW / VP (*n*=267)**	**Fullterm (*n*=298)**	***Mean difference (95% CI)***	***p*-value**
Child									
Persistence	raw scores	5.79 (1.78)	7.42 (1.24)	1.63 (1.38, 1.89)	<0.001	7.11 (1.50)	7.48 (1.41)	0.37 (0.13, 0.61)	0.003
Model 1: adjusted for social factors		5.80 (1.52)	7.41 (1.52)	1.61 (1.36, 1.86)	<0.001	7.14 (1.45)	7.45 (1.45)	0.31 (0.07, 0.55)	0.01
Model 2: adjusted for child IQ		5.99 (1.55)	7.24 (1.55)	1.25 (0.99, 1.50)	<0.001	7.27 (1.52)	7.33 (1.50)	0.07 (-0.18, 0.32)	0.60
Social Interaction	raw scores	5.94 (1.66)	7.49 (1.11)	1.55 (1.31, 1.79)	<0.001	6.28 (2.00)	7.44 (1.56)	1.16 (0.86, 1.46)	<0.001
	Model 1	5.95 (1.41)	7.49 (1.40)	1.54 (1.30, 1.77)	<0.001	6.29 (1.78)	7.43 (1.78)	1.15 (0.85, 1.44)	<0.001
	Model 2	6.14 (1.44)	7.32 (1.42)	1.19 (0.95, 1.42)	<0.001	6.49 (1.85)	7.25 (1.83)	0.76 (0.46, 1.07)	<0.001
Activity	raw scores	2.96 (0.92)	2.97 (0.74)	0.01 (-0.13, 0.15)	0.92	3.37 (0.63)	3.32 (0.56)	-0.06 (-0.15, 0.04)	0.27
	Model 1	2.96 (0.83)	2.98 (0.83)	0.02 (-0.12, 0.16)	0.78	3.37 (0.59)	3.32 (0.59)	-0.05 (-0.14, 0.05)	0.34
	Model 2	2.93 (0.88)	3.00 (0.86)	0.07 (-0.08, 0.21)	0.36	3.38 (0.64)	3.31 (0.62)	-0.07 (-0.18, 0.03)	0.18
Mother									
Sensitivity	raw scores	15.92 (3.22)	16.89 (2.60)	0.97 (0.48, 1.46)	<0.001	15.42 (3.37)	16.29 (2.55)	0.87 (0.37, 1.37)	0.001
	Model 1	15.94 (2.89)	16.87 (2.90)	0.93 (0.45, 1.41)	<0.001	15.49 (2.94)	16.24 (2.93)	0.75 (0.27, 1.24)	0.003
	Model 2	16.32 (2.96)	16.53 (2.93)	0.21 (-0.28, 0.70)	0.40	15.70 (3.07)	16.04 (3.06)	0.34 (-0.16, 0.85)	0.19
Verbal Control	raw scores	12.70 (2.58)	12.16 (2.19)	-0.54 (-0.94, -0.15)	0.01	12.31 (3.51)	11.17 (3.21)	-1.14 (-1.70, -0.58)	<0.001
	Model 1	12.69 (2.40)	12.17 (2.40)	-0.52 (-0.92, -0.12)	0.01	12.29 (3.37)	11.19 (3.37)	-1.10 (-1.66, -0.54)	<0.001
	Model 2	12.50 (2.50)	12.34 (2.49)	-0.16 (-0.57, 0.25)	0.44	12.06 (3.53)	11.40 (3.50)	-0.66 (-1.24, -0.07)	0.03
Joint Behaviour									

Harmony	raw scores	28.47 (4.35)	30.19 (3.60)	1.72 (1.06, 2.39)	<0.001	26.01 (5.28)	26.73 (5.06)	0.73 (-0.13, 1.58)	0.10
	Model 1	28.50 (3.95)	30.17 (3.95)	1.66 (1.01, 2.32)	<0.001	26.10 (5.15)	26.66 (5.14)	0.56 (-0.29, 1.41)	0.20
	Model 2	28.84 (4.13)	29.86 (4.11)	1.02 (0.34, 1.71)	0.003	26.50 (5.38)	26.30 (5.35)	-0.20 (-1.08, 0.69)	0.67

Data are presented as mean (SD) and mean difference (95% CI). In Model 1, raw scores were adjusted for maternal education and family adversity assessed at birth; in Model 2, scores were adjusted for maternal education and family adversity assessed at birth, and additionally child IQ assessed at 6;3 years. Differences (95% CI) between the groups are presented as fullterm - VLBW/VP.

Table 3: Effects of maternal sensitivity, maternal verbal control, and child IQ (K-ABC MPC score) at 6;3 years on child task persistence at 8;5 years from various regression models (N = 565)

	Regression coefficients (95% CI)						
	Model 1 R^2 = 0.08	**Model 2** R^2 = 0.02	**Model 3** R^2 = 0.10	**Model 4** R^2 = 0.06	**Model 5** R^2 = 0.11	**Model 6** R^2 = 0.27	**Model 7** R^2 = 0.27
Maternal Sensitivity 6;3 y	0.14 (0.10, 0.18)		0.11 (0.07, 0.16)		0.44 (0.16, 0.71)	0.50 (0.13, 0.69)	0.51 (0.26, 0.77)
p-value	<0.001		<0.001		0.002	<0.001	<0.001
Maternal Verbal Control 6;3 y		-0.09 (-0.15, -0.03)		-0.06 (-0.12, 0.01)	-0.03 (-0.09, 0.02)	- □	- □
p-value		0.002		0.03	0.27		
Child IQ 6;3 y			0.02 (0.01, 0.03)	0.02 (0.01, 0.03)	0.08 (0.02, 0.13)	0.06 (0.01, 0.11)	0.06 (0.01, 0.11)
p-value			<0.001	<0.001	0.004	0.02	0.02
Interaction of Maternal Sensitivity with Child IQ					-0.004 (-0.01, -0.001)	-0.003 (-0.006, -0.0002)	-0.003 (-0.006, -0.0003)
p-value					0.02	0.05	0.04
Change in Maternal Sensitivity from 6;3 to 8;5 years						-0.20 (-0.25, -0.16)	-0.20 (-0.25, -0.15)
p-value						<0.001	<0.001
Family adversity (FAI) at birth						-0.10 (-0.21, 0.01)	-0.10 (-0.21, 0.004)
p-value						0.08	0.06
Child Sex (male)						-0.29 (-0.50, -0.08)	-0.28 (-0.49, -0.07)
p-value						0.01	0.01
Multiple birth (yes)						0.20 (-0.09, 0.48)	0.21 (-0.07, 0.49)
p-value						0.17	0.14
Maternal age						0.01 (-0.01, 0.03)	- □

		p-value	0.41	
Maternal education			0.04 (-0.02, 0.11)	- □
		p-value	0.54	
Place of living (city)			0.12 (-0.11, 0.34)	- □
		p-value	0.31	
SES	**high = reference group**			
	middle		0.13 (-0.15, 0.41)	- □
	low		0.20 (-0.13, 0.53)	- □
		p-value	0.50	

Data are presented as standardized regression coefficients *ß* (95% CI) and as explained variance R^2. Regression models were adjusted for heteroscedasticity with Huber/White robust standard errors estimates. Model 1 tests the effect of maternal sensitivity at 6;3 years on child task persistence at 8;5 years. Model 2 tests the effect of maternal verbal control at 6;3 years on child task persistence at 8;5 years. Model 3 adjusts Model 1 further for child IQ at 6;3 years. Model 4 adjusts Model 2 further for child IQ at 6;3 years. Model 5 tests the effect of maternal sensitivity at 6;3 years, maternal verbal control at 6;3 years, child IQ at 6;3 years, and the interaction between maternal sensitivity at 6;3 years and child IQ at 6;3 years on child task persistence at 8;5 years simultaneously. Model 6 adjusts Model 5 further (maternal verbal control at 6;3 years excluded) for the change in maternal sensitivity from 6;3 to 8;5 years (calculated as scores at 6;3 minus scores at 8;5 years), Family Adversity Index (FAI) at birth, child sex and multiple birth status, maternal age and education, place of living, and socioeconomic status (SES). Model 7 adjusts for significant predictors from Model 6, FAI at birth, and multiple birth status. □ Variable removed from analysis because of non-significance of *p*-value.

Table 4: Effect of maternal sensitivity at 6;3 years on child task persistence at 8;5 years for various levels of child IQ (K-ABC MPC score) at 6;3 years, calculated based on the results of Model 7 (Table 3)

Child IQ at 6;3 years	**Child IQ at 6;3 years**	**Child task persistence at 8;5 years change with 1 point increase in maternal sensitivity at 6;3 years (95% CI)**	**Child task persistence at 8 years SD change with 1 SD increase in maternal sensitivity at 6;3 years (95% CI)**	
distribution point	**value**	**Expressed in absolute values**	**Expressed in SD**	***p*-value**
Mean + 2 SD	122	0.14 (0.03, 0.25)	0.29 SD (0.07 SD, 0.51 SD)	0.01
Mean + SD	109	0.18 (0.10, 0.26)	0.37 SD (0.21 SD, 0.52 SD)	<0.001
Mean	95	0.22 (0.17, 0.28)	0.45 SD (0.34 SD, 0.56 SD)	<0.001
Mean - SD	81	0.27 (0.21, 0.32)	0.54 SD (0.42 SD, 0.65 SD)	<0.001
Mean – 2 SD	67	0.31 (0.23, 0.39)	0.62 SD (0.46 SD, 0.78 SD)	<0.001

Data are presented as unstandardized and standardized values (95% CI).

Appendix 1. Biological, functional, and social variables of the VLBW/VP participants and dropouts

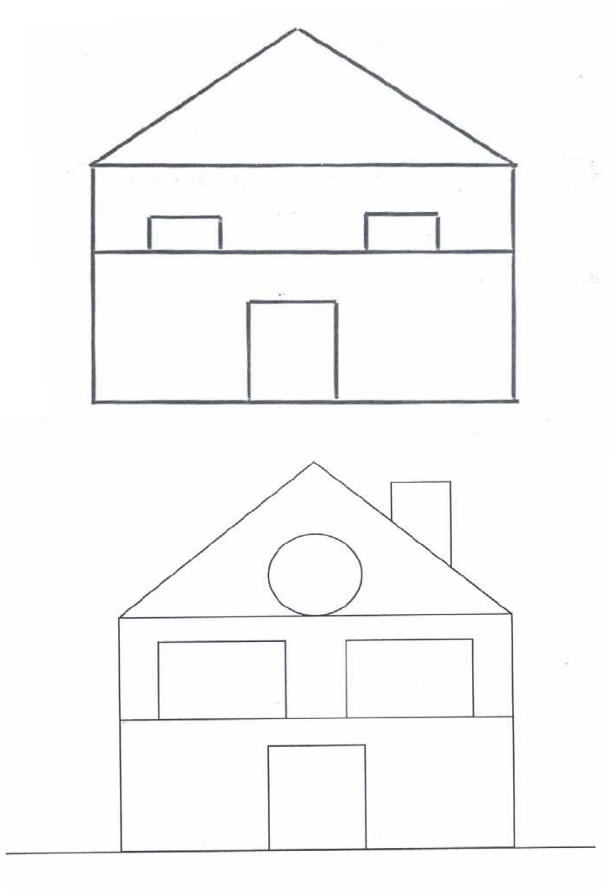
	VLBW / VP Participants (*n*=267)	**VLBW / VP Dropouts (*n*=181)**	***p*-value**
Biological and medical variables			
Mean birth weight, g	1296 (308)	1315 (298)	0.52
Mean gestational age, weeks	30.4 (2.3)	30.5 (2.2)	0.60
Child's sex, male	143 (54%)	91 (50%)	0.50
Mean maternal age at birth, years	28.8 (4.9)	28.4 (5.0)	0.41
Intensity of Neonatal Treatment	10	10	0.26
SGA birth, < 10th percentile	116 (43%)	74 (41%)	0.59
Social variables			
Mean maternal education (min = 1, max = 11)	4.5 (2.2)	4.3 (1.8)	0.31
Family adversity after birth	1.0	1.0	0.63

Data are presented as mean (SD) for symmetrical continuous variables, median for skewed, and numbers (%) for categorical variables. The p-values are based on t-test, Mann-Whitney U-test, or χ^2-test (all two-tailed), correspondingly.

Appendix 2. Assessment of mother-child-interactions with the etch-a-sketch (AMCIES) instruction and house templates, as presented at 6;3 (top) and 8;5 years (below)

AMCIES instruction. *To mother and child:* "Have you seen this before? – This is an Etch-a-Sketch. You can draw pictures with it. This button draws horizontal lines. This button draws vertical lines. You can draw diagonal or round lines by using the left and right buttons together."
To mother: "Would you and ... (*name of child*) like to play with this Etch-a-Sketch together? Could you do it here on this table?"

After two minutes joint play: "Now I would like you to draw this house shown in the picture for me. I want you to do it together. You (*mother*) take this button (*e.g. left*) and you (*child*) take this button (*e.g. right*). So this is (*child's name*) button and this is mummy's button.



Appendix 3. AMCIES subscales and index scales

Mother	
Verbal Control Scale 1 (high) – 9 (low)	The extent to which the mother verbally interacts/instructs in a directive controlling manner.
Non-verbal Control Scale 1 (high) – 9 (low)	The extent to which the mother interacts in a directive manner, physically interfering, cutting in or taking over the Etch-a-Sketch or the child's knob.
Criticism Scale 1 (high) – 5 (low)	Frequency with which the mother criticizes the child's actions, correcting or directing the child verbally with a negative tone of voice, or with high irritation.
Sensitivity Scale 1 (low) – 9 (high)	The extent to which the mother provides a framework in which the child is given the space to take initiative in carrying out the task as well as providing the child with encouragement and instructions when needed.
Dissatisfaction Scale 1 (high) – 5 (low)	The extent to which the mother expresses dissatisfaction with her performance during the play session, e. g. by saying this is too hard, we are useless at it or by rubbing out the drawing herself.
Emotional Tone Scale 1 (low) – 9 (high)	This scale refers to the extent to which the mother is happy during the play session.
Child	
Dissatisfaction Scale 1 (high) – 5 (low)	The extent to which the child expresses dissatisfaction with his/her performance during the play session, either verbally or through action.
Emotional Tone Scale 1 (low) – 9 (high)	This scale refers to the extent to which the child is happy during the play session.
Persistence Scale 1 (low) – 9 (high)	The extent to which the given task is pursued by the child, including the interest shown as well as the cooperativeness in undertaking it.

Physical Activity Scale 1 (low) – 9 (high)	This scale refers to how physically active the child is during the task of drawing the house.
Social Interaction Scale 1 (low) – 9 (high)	The extent to which the child uses the mother to complete the task. Behaviour indicating social interaction/referencing are those such as looking, listening, and incorporating suggestions.
Joint Behaviour Scales	
Harmony[1] Scale 1 (low) – 9 (high)	The extent to which mother and child carry out the task in a harmonious way. This involves reciprocity and general atmosphere of the whole play session.
Control of the Session[2] Scale 1 (child) – 9 (mother)	The extent to which the mother or the child are in control of the play session, influencing each other's behaviour, and determining the outcome of the session.

[1] incorporated in Index Scale of Maternal Verbal Control, the subscale Verbal Control was recoded before merging
[2] incorporated in Index Scale of Maternal Sensitivity
[3] incorporated in Index Scale of Harmony

Appendix 4. Intra-class correlation coefficients (ICCs) of the AMCIES scales at 6;3 (*N* = 12) and 8;5 years (*N* = 18)

	Inter-rater reliabilities at 6 y, *N* = 12				Inter-rater reliabilities at 8 y, *N* = 16			
	ICC	*95% CI*	*p*-value	*within-person SD*	*ICC*	*95% CI*	*p*-value	*within-person SD*
Mother								
Verbal Control	.74	.33 - .92	0.001	1.41	.84	.60 - .94	<0.001	1.38
Sensitivity	.92	.75 - .98	<0.001	0.94	.75	.44 - .95	<0.001	1.68
Child								
Persistence	.73	.31 - .91	0.003	0.94	.75	.43 - .90	<0.001	0.50
Physical Activity	.69	.24 - .90	0.002	0.35	.58	.14 - .83	0.01	0.31
Social Interaction	.72	.29 - .91	0.002	0.94	.48	.004 - .78	0.02	1.25
Joint Behaviour								
Harmony	.72	.30 - .91	0.002	1.66	.86	.65 - .95	<0.001	2.56

Appendix 5. Means and standard deviations (in parentheses) of child, mother and joint behaviour rating scales of observed behaviour in the Etch-A-Sketch interaction for VLBW/VP and fullterm singleton dyads at 6 and 8 years, comparing raw scores with scores adjusted for maternal education and family adversity at birth (Model 1), and additionally child IQ at 6 years (Model 2)

		6 years				8 years			
		VLBW / VP (*n*=208)	**Fullterm** (*n*=286)	***Mean difference (95% CI)***	***p*-value**	**VLBW / VP** (*n*=208)	**Fullterm** (*n*=286)	***Mean difference (95% CI)***	***p*-value**
Child									
Persistence	raw scores	5.78 (1.76)	7.42 (1.25)	1.63 (1.35 – 1.91)	<0.001	7.00 (1.58)	7.48 (1.42)	0.48 (0.22 – 0.75)	<0.001
Model 1: adjusted for social factors		5.81 (1.49)	7.40 (1.49)	1.59 (1.32 – 1.85)	<0.001	7.03 (1.49)	7.46 (1.49)	0.43 (0.16 – 0.69)	0.002
Model 2: adjusted for child IQ		6.03 (1.56)	7.24 (1.52)	1.20 (0.92 – 1.48)	<0.001	7.20 (1.57)	7.34 (1.54)	0.15 (-0.13 – 0.42)	0.30
Social Interaction	raw scores	5.94 (1.71)	7.49 (1.12)	1.56 (1.29 – 1.82)	<0.001	6.34 (2.04)	7.43 (1.57)	1.09 (0.76 – 1.43)	<0.001
	Model 1	5.95 (1.40)	7.49 (1.40)	1.54 (1.29 – 1.79)	<0.001	6.36 (1.79)	7.42 (1.78)	1.05 (0.73 – 1.37)	<0.001
	Model 2	6.17 (1.46)	7.32 (1.44)	1.15 (0.89 – 1.41)	<0.001	6.62 (1.86)	7.23 (1.83)	0.61 (0.28 – 0.94)	<0.001
Activity	raw scores	3.02 (0.88)	2.97 (0.74)	-0.06 (-0.21 – 0.09)	0.42	3.37 (0.62)	3.32 (0.56)	-0.05 (-0.15 – 0.06)	0.38
	Model 1	3.02 (0.81)	2.97 (0.79)	-0.05 (-0.19 – 0.10)	0.54	3.36 (0.59)	3.32 (0.59)	-0.05 (-0.15 – 0.06)	0.40
	Model 2	2.98 (0.87)	3.00 (0.85)	0.02 (-0.13 – 0.18)	0.76	3.38 (0.63)	3.31 (0.63)	-0.07 (-0.18 – 0.05)	0.26
Mother									
Sensitivity	raw scores	15.63 (3.36)	16.91 (2.60)	1.27 (0.72 – 1.82)	<0.001	15.29 (2.94)	16.25 (2.94)	0.97 (0.44 – 1.49)	<0.001
	Model 1	15.67 (2.94)	16.88 (2.93)	1.21 (0.68 – 1.74)	<0.001	15.29 (2.94)	16.25 (2.94)	0.97 (0.44 – 1.49)	<0.001
	Model 2	16.12 (3.04)	16.55 (2.99)	0.43 (-0.11 – 0.96)	0.12	15.56 (3.13)	16.06 (3.06)	0.50 (-0.05 – 1.05)	0.08
Verbal Control	raw scores	12.72 (2.54)	12.15 (2.21)	-0.57 (-0.99 to -0.15)	0.01	12.00 (3.55)	11.15 (3.25)	-0.85 (-1.46 to -0.25)	0.01
	Model 1	12.71 (2.37)	12.16 (2.37)	-0.55 (-0.97 to -0.13)	0.01	11.97 (3.39)	11.17 (3.38)	-0.81 (-1.42 to -0.20)	0.01
	Model 2	12.47 (2.51)	12.32 (2.47)	-0.15 (-0.60 – 0.29)	0.51	11.62 (3.59)	11.42 (3.52)	-0.20 (-0.84 – 0.43)	0.53
Joint Behaviour									
Harmony	raw scores	28.32 (4.42)	30.22 (3.59)	1.90 (1.17 – 2.64)	<0.001	25.87 (5.29)	26.62 (5.28)	0.95 (0.00 – 1.90)	0.05
	Model 1	28.37 (3.95)	30.18 (3.94)	1.81 (1.10 – 2.51)	<0.001	26.43 (5.34)	26.65 (5.25)	0.76 (-0.19 – 1.70)	0.12
	Model 2	28.81 (4.18)	29.86 (4.09)	1.06 (0.32 – 1.80)	0.01	26.33 (5.62)	26.29 (5.51)	-0.04 (-1.04 -0.96)	0.94

Data are presented as mean (SD) and mean difference (95% CI). In Model 1, raw scores were adjusted for maternal education and family adversity assessed at birth; in Model 2, scores were adjusted for maternal education and family adversity assessed at birth, and additionally child IQ assessed at 6;3 years. Differences (95% CI) between the groups are presented as fullterm - VLBW/VP.