



Does the development of executive functioning in infants born preterm benefit from maternal directiveness?

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ABSTRACT

Objective: Problems in early development of executive functioning may underlie the vulnerability and individual variability of infants born preterm for behavioral and learning problems. Parenting behaviors may aggravate or temper this increased risk for dysfunction. This study assessed how maternal parenting behaviors predict individual differences in early development of executive functioning in infants born preterm, and whether this varies with infant temperament, i.e., self-regulation.

Methods: Participants were 76 infants born preterm (≤ 36 weeks' gestation and < 2500 g birth weight) and their mothers. Maternal sensitive responsiveness and directiveness were observed during a mother-infant interaction situation at 7, 10 and 14 months corrected age. At the same ages, executive functioning was measured using the A-not-B task. An infant self-regulation questionnaire (IBQ-R) was completed by mothers at 7 months.

Results: After controlling for perinatal risk factors, Multivariate Latent Growth Modeling showed that consistently higher levels of maternal directiveness predicted a stronger increase in A-not-B performance, which did not vary with infant self-regulation. No relationship between maternal sensitive responsiveness and development in A-not-B performance in infants born preterm was found.

Conclusions: These results suggest that preterm infants' early executive functioning development in the first year of life may benefit from a more and consistent directive approach by their mothers. These findings have important implications for early intervention programs aimed at facilitating preterm infants' development.

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1. Introduction

At school-age, children born preterm (gestational age < 37 weeks) are at heightened risk for deficits in executive functioning (EF), such as working memory, inhibition and attentional control [1]. The term EF relates to planned, self-generated and goal-directed behaviors that require higher-order control over more automatic responses. Problems in early EF development may underlie the individual variability between preterm infants and their vulnerability as a group for more global cognitive, behavioral and learning problems [2,3]. In fact, it has been suggested that EF might be a better predictor of academic success than intelligence [4].

The development of EF is related to the functioning of the prefrontal cortex, more specifically the dorsolateral prefrontal cortex (DLPFC), which starts to mature when infants develop into toddlers. Between 9 and 12 months of age, the DLPFC seems to reach the maturity level

necessary to support certain critical cognitive functions, although it will not be fully developed until many years later [5]. DLPFC functioning during infancy has been linked to performance on reversal tasks, such as the A-not-B task [6]. In the A-not-B task infants retrieve a hidden object from one of two (or more) locations after a delay. After retrieving the object successfully two times in a row at the first location (location A), the side of hiding is reversed (to location B). Performance on this 'reversal trial' is dependent on the infant's ability to keep the location of the toy in mind (working memory), to inhibit reaching to the previously rewarded location (inhibitory control), and to control attention during the task. The difficulty of the task is increased by increasing the delay between hiding and seeking.

A review on EF development in infants and preschoolers born preterm has indicated that differences in performance between children born preterm and born at term on the A-not-B tasks and similar delayed response tasks become more apparent when infants grow into toddlers, with children born preterm making more perseverative errors of reaching toward the original A location [2]. Individual differences in developmental change in A-not-B performance in infants born preterm are associated with subsequent global cognitive functioning [7]. Preterm children's elevated risk at EF problems may be a consequence of both

Abbreviations: CA, Corrected age (for prematurity); EF, Executive function; LGM, Latent Growth Modeling.

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preterm birth and white matter injury [8] or specific forms of cerebral injury, including intraventricular hemorrhage [9]. In line with neurodevelopmental research showing a link between DLPFC functioning and A-not-B performance [6], Woodward and colleagues found that reductions in DLPFC tissue volume at term were associated with preterm children's A-not-B performance at 2 years of age [10].

The effects of perinatal risk factors on cognitive development can be aggravated or tempered by the quality of the social environment, in particular by the way a mother interacts with her infant [11]. Two parenting behaviors that are frequently investigated in relation to child development are sensitive responsiveness (i.e., the degree to which a parent focuses on, and interprets correctly and responds contingently to the infant's signals) and directiveness (i.e., the degree to which a parent selects topics of conversation or play, uses imperatives and prompts to control or regulate the child's attention or behavior) [12,13]. Although directiveness and sensitive responsiveness are often negatively related, a highly sensitive responsive mother may use some directive strategies as well, and a very unresponsive mother may use little directive strategies [14]. Research indicates that differences between mothers in sensitive responsiveness are fairly stable over time during infancy, while directiveness is less stable over time [15].

It has been repeatedly demonstrated that sensitive responsive parenting facilitates *global* cognitive development in preterm infants and children [15–17]. The influence of directive parenting is less clear [15]. It has been proposed that directiveness may hinder development when it is not adapted to an infant's needs and becomes intrusive [11], or when it persists beyond the first two years [17]. So, it may be important for mothers to gradually withdraw this type of support when infants become more active agents and reach a higher level of autonomy. For example, Landry and colleagues found that directiveness positively supported full term and preterm children's early *global* cognitive development but that high levels of directiveness negatively influenced their cognitive functioning at 4.5 years [18]. Although no differences between full term and preterm children were found, other research indicates that preterm infants' characteristics may moderate the effects of parenting on *global* cognitive development [16]. That is, infants born preterm are often characterized as being less active, less predictable, more irritable and easily overstimulated than infants born preterm [19,20], which indicates that they have more difficulties in regulating their own state of arousal and behavior (i.e., self-regulation) [20]. The concept of self-regulation refers to the developmental progress in regulation of physiological, behavioral, emotional and cognitive processes, which is strongly dependent on contextual influences during infancy and is considered to be characterized by plasticity [19]. It has been suggested that infants born preterm may benefit from a more directive and structured approach by their parents as it may help to regulate their attention and behavior [21,22]. Since the development of executive function and self-regulation are thought to be strongly linked [23], such external support provided by parents may also facilitate EF development. Indeed, previous research indicates that interactions with preterm infants are more challenging and may lead mothers to respond more directive [11]. Although some researchers argue that these patterns of mothers' behaviors are over-stimulating and inadequate [24], others have argued that it may be an adequate adaptation to the special needs of these infants [21].

Despite growing evidence that parenting behaviors also influence EF development in full-term (pre)school children [25], studies on the effects of parenting on EF development in preterm children are scarce, and are often conducted from the age of 2 years and onwards [26]. However, since the period of infancy is characterized by rapid brain organization and cognitive growth, this is a period in which cognitive development in general and EF development in particular are probably most susceptible to the influences of parenting [27].

In this study we therefore examined: 1) how (changes in) maternal parenting behaviors are related to preterm infants' developmental trajectories in EF between 7 and 14 months of age (CA), and 2) how

these relationships vary with differences in infant self-regulation. Since the study focused on predictors of individual variability *within* the preterm population, a full-term control group was not included. We expected high levels of sensitive responsive parenting to be positively related to infants' rate of EF development. In addition, directiveness was expected to be positively related to EF development, although this effect may diminish during the study period. Finally, the effects of parenting on EF were expected to be stronger for infants with self-regulation difficulties.

2. Materials and methods

2.1. Study design

A longitudinal design comprising three time points was used in which mothers and infants were visited at home at 7 months (± 1 week) CA and 10 months (± 1 week) CA, and were invited for an assessment at our laboratory at 14 months (± 1 week) CA. Assessments included parent-report questionnaires, behavioral assessments of infant cognitive functioning, and observations of mother-infant interaction. Measurement occasions were chosen around ages during which important transitions in infant EF development are expected to occur [5].

2.2. Participants

Participants were families of singleton infants who were born at ≤ 36 weeks gestation with a birth weight of <2500 g at the Wilhelmina Children's Hospital (Utrecht, The Netherlands) between April 2004 and August 2005. Informed parental consent was obtained. Ethical permission for the study was granted by the hospital's ethics committee.

Of the 325 singleton infants who were admitted to the Neonatal Intensive or Medium Care Unit during the inclusion period, 237 infants were eligible for inclusion. Exclusion criteria were reported in a previous publication [7]. A total of 119 children and their parents were randomly selected and invited to participate. Parents of 76 infants (63.9% of those invited) consented for participation.

2.3. Measurements

Information about medical complications was extracted from hospital files. Respiratory problems were scored based on the presence and severity of infant respiratory distress syndrome (IRDS; grades I–IV) [28] and/or bronchopulmonary dysplasia (BPD), which resulted in a lung score, ranging from 0 (no lung problems) to 5 (BPD). IVH was scored ranging from 0 (no IVH) to 4 (IVH grade IV) [29]. Periventricular leukomalacia (PVL) was scored ranging from 0 (no PVL) to 4 (PVL grade IV) [30].

Maternal parenting behaviors were rated based on videotaped mother-infant interactions at 7, 10 and 14 months CA during a 5-min free-play session. At 7 and 10 months CA, mothers were provided with 6 age-appropriate toys and played with their infant while sitting on the ground at a small table (60×60 [width \times depth]) with raised edges to prevent the toys from falling. Infants were seated in a car seat at the opposite side of the table, facing their mother to enable eye-contact. At 14 months CA, mothers and their infants played with two different toys consecutively (i.e., First, they played for 2.5 min with a jigsaw puzzle and then for 2.5 min with a pop-up toy with four animals). Positioning of the mother and her infant, duration of the interaction, and the toys that were used were standardized. Mothers were asked to play with their infant as they would normally do. Video-observations were rated on a nine-point 'sensitivity' scale and 5 five-point scales measuring 'quality of handling', 'timing', 'nondirectiveness', 'noninterference', and 'responsiveness' (ELO scales) [21,31]. The maternal behaviors observed with these scales have shown to be related to maternal anxiety and predictive of contingency learning in preterm infants [31–33], supporting criterion validity. A principal component analysis (PCA)

with varimax rotation revealed two factors that are concurrent with the interactive behaviors mentioned in the introduction, explaining 80.6% of the total variance at 7 months CA, 72.9% at 10 months CA, and 82.3% at 14 months CA. The first factor, called 'sensitive responsiveness', explained between 45.9% and 53.9% of the total variance across the three different ages and related to 'timing', 'noninterference', 'sensitivity' and 'responsiveness'. These scales were summed and divided by their number. Scores ranged from 1 (very low sensitive responsiveness) to 6 (very high sensitive responsiveness). The second factor, called 'directiveness', explained between 26.9% and 31.8% of the total variance across the three different ages and related to 'quality of handling' and 'nondirectiveness'. These scales were summed and divided by their number and then re-scored so that a higher score related to higher directiveness. Scores ranged from 1 (not directive at all) to 5 (very directive). Sensitive responsiveness and directiveness were significantly negatively correlated at each age (r ranged from $-.45$ to $-.72$). The first author observed all videos and trained a second observer, by watching two videos together, then five videos independently. After scores on these five videos were found reliable between the observers, the second observer scored 10 randomly selected videos at every age (30 in total), to assess inter-rater reliability. Inter-rater reliability (single measures intraclass correlations) ranged from .95 to .99 for sensitive responsiveness and from .66 to .90 for directiveness at the three different ages.

Infant self-regulation at 7 months CA was assessed with the revised Infant Behavior Questionnaire (IBQ-R) [34] translated to Dutch by Van der Pal and coworkers. Cronbach's alpha for the Dutch version ranged from .74 to .89 [35]. Mothers rated a subset of 70 items on a 7-point Likert-type scale (1 = not present, 7 = always present) from 5 behavioral scales which load onto the factor Orienting/Regulation: low intensity pleasure, cuddliness/affiliation, duration of orienting, soothability, and smiling and laughter. Construct validity of the IBQ-R has been shown in several studies, for example by stability in parent-reports over childhood [36], associations with observed behaviors [37].

Executive functioning was measured using looking and reaching versions of the A-not-B task, at 7, 10 and 14 months CA. In this task, infants search for a hidden object from one of two locations following a delay of several seconds. After two successful retrievals at location A, the side of hiding is changed to location B. Performance on this 'reversal trial' is scored. Increasing the delay between hiding and seeking increases task-difficulty. See our earlier publication for assessment and scoring details [7].

2.4. Statistical analysis

A Latent Growth Model (LGM) makes it possible to investigate individual variability in developmental trajectories. In LGM, each individual's growth over time is represented by a regression line, which is described by a unique intercept (initial level) and slope (rate of change). The sample is described by group means and variances for intercept and slope. Analyses were conducted in three steps.

First, univariate LGMs were used to determine the models that best described the developmental trajectories for the two maternal parenting behaviors as well as infant EF. In all models, the first measurement occasion was chosen as time point zero. To account for differences in time interval between measurements, regression weights for the slope were fixed at 1 and 2.3 for the measurements at 10 and 14 months CA, respectively. Because variances, by definition, cannot be smaller than zero (i.e., a negative value) and thus two-sided testing gives an underestimated significance level, one-sided p values were considered to investigate the significance of variance around the intercept and slope means.

Secondly, since maternal educational level is identified as an important predictor of parenting and child outcome [38], it was included as a predictor for maternal parenting behaviors and infant EF. The perinatal

risk factors identified in an earlier study (i.e., gestational age [GA], BW, and gender) were also included as predictors for infant EF.

Thirdly, two bivariate LGMs were used to model the association between infant EF and maternal behaviors. We investigated covariations between intercepts (levels), between intercepts and slopes (over-time relationships), and between slopes (associated change) of parenting behaviors and infant EF. One-sided p values were considered when covariations between variables were in the expected direction.

Fourth, multi-group LGMs were used to assess whether the association between parenting and EF varies with infant self-regulation. Infants were assigned to a Low or High self-regulation group based on a score below or above the median IBQ-R score (median 5.10). Nested model comparisons were made between a constrained model (e.g., all aspects of the model are equal between groups) and a model in which covariances between parenting behaviors and infant outcome were estimated freely.

Growth models were analyzed using Amos version 7.0 and Mplus version 5.0 when bootstrapping with missings was deemed useful. Overall model fit was evaluated by Chi-square (χ^2), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI). In the multi-group comparisons the nested models (equal versus not equal) were evaluated using Chi-square differences ($\Delta\chi^2$).

2.5. Missing values

LGM software can handle missing data without statistical imputation. Since at least two measurements are needed for participants to contribute to the slope, only participants with data on two or three waves were included. Two of the 76 infants did not complete the study beyond the first measurement due to attrition, and were excluded from the analyses. From the remaining infants, data were available over two and three waves for 6 and 68 infants respectively ($n = 74$). Some data were missing completely at random (i.e., due to technical problems with video equipment or incorrect administration of the task). Sample characteristics are presented in Table 1.

Table 1
Sample characteristics ($n = 74$).

Variable	Mean	SD	Range			
Infant characteristics						
Gestational age (weeks)	30.49	2.23	26–35			
Birth weight (grams)	1441	425	830–2370			
Bayley MDI score (14 months CA)	103.1	15.68	66–136			
IRDS grade/BPD	Grade I $n = 13$	Grade II $n = 8$	Grade III $n = 11$	Grade IV $n = 1$	BPD $n = 8$	
IVH grade	Grade I $n = 6$	Grade II $n = 4$	Grade III $n = 6$	Grade IV $n = 1$		
PVL grade	Grade I $n = 11$	Grade II $n = 1$	Grade III $n = 0$	Grade IV $n = 0$		
Asphyxia	$n = 5$					
SGA	SGA $n = 2$	Extreme SGA $n = 2$				
Gender	$n = 48$ boys (65%)					
Maternal characteristics						
Educational level	Median 3 (HAVO/VWO)		Range 2–5			
Cultural background	Western 84%		Non-Western 16%			

Note: SD = standard deviation, MDI = Mental Development Index, CA = corrected age, IRDS = infant respiratory distress syndrome, BPD = bronchopulmonary dysplasia, IVH = intraventricular hemorrhage, PVL = periventricular leukomalacia, SGA = small for gestational age (3rd percentile > BW < 10th percentile), Extreme SGA (BW < 3rd percentile), Educational level ranged from elementary school (score 1) to academic education (score 5). HAVO/VWO refers to the two highest levels of secondary education in the Dutch education system.

3. Results

Descriptive values and correlations for maternal parenting behaviors, A-not-B performance and infant self-regulation are presented in Table 2.

3.1. Univariate models

3.1.1. Maternal parenting behaviors

Sensitive responsiveness was best described by a linear model with a mean intercept of 3.72 and a mean slope of .15 ($p < .01$). Variation around the intercept mean (.43) was significant (one-sided $p < .001$), indicating that mothers differed significantly from each other in their level of sensitive responsiveness. Variation around the slope mean was not significant, indicating that mothers did not differ significantly from each other in their rate of change in sensitive responsiveness over time. The covariance between intercept and slope was not significant (see Table 3 for model fit indices). Maternal educational level was not predictive of differences in sensitive responsiveness.

Secondly, directiveness was best described by a linear model with a mean intercept of 2.66. The slope mean had to be fixed to zero in order to fit the model, indicating there was no significant mean change in directiveness at group level. Mothers differed significantly from each other in their level of directiveness (Intercept variance = .30, one-sided $p < .01$). The variance around the slope (.06) failed to reach significance (one-sided $p = .07$). However, fixing this value to zero led to a decrement in model fit (TLI < .90, CFI < .95, RMSEA > .08). Therefore, we assume that there is at least some variance between mothers in their rate of change. Moreover, intercept and slope tended to be negatively related ($r = -.67$, $p = .08$), indicating that at an individual level, mothers who were more directive initially, showed less change over time. Maternal educational level was not predictive of differences in directiveness.

3.1.2. Infant executive functioning

The LGM for A-not-B performance was presented previously and is only summarized here [7]. At group level, infants showed a linear

Table 2
Descriptives and correlations for parenting behaviors and infant outcome measures.

	Mean (SD)	7 months CA	10 months CA
Parenting behaviors			
Sensitive responsiveness			
7 months CA	3.68 (1.02)		
10 months CA	3.92 (0.91)	.48**	
14 months CA	4.05 (0.94)	.53**	.46**
Directiveness			
7 months CA	2.74 (0.75)		
10 months CA	2.60 (0.63)	.47**	
14 months CA	2.67 (0.67)	.20*	.35**
Infant measures			
		7 months CA	10 months CA
A-not-B task		looking	reaching
7 months CA	Looking	1.74 (0.99)	
	Reaching	1.53 (1.05)	.013
10 months CA	Looking	2.81 (1.36)	.000
	Reaching	3.94 (2.01)	.008
14 months CA	Reaching	6.61 (2.16)	.048
Self-regulation (IBQ-R) at 7 months CA			
Total sample	5.12 (0.47)		
High Regulation group	5.48 (0.35)		
Low regulation group	4.76 (0.27)		

Note. $n = 51-74$, SD = standard deviation, CA = corrected age.

** $p < .01$ (1-tailed significance).

* $p < .05$ (1-tailed significance).

Table 3

Model fit indices for best fitting univariate and multivariate models.

	n	χ^2	df	p	TLI	CFI	RMSEA
Univariate models							
Parenting behaviors							
Sensitive responsiveness	74	2.66	3	.447	1.016	1.000	.000
Directiveness	74	2.48	2	.289	.931	.977	.057
Infant outcome							
A-not-B performance	74	24.36	23	.384	.970	.981	.028
Multivariate models							
Sensitive responsiveness / A-not-B	74	51.53	50	.414	.982	.987	.020
Directiveness / A-not-B	74	49.51	47	.373	.961	.972	.027

Note: χ^2 = Chi-square, df = degrees of freedom, TLI = Tucker-Lewis Index, CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation.

increase in A-not-B performance. At an individual level, infants showed significant differences compared to one another in level of performance as well as rate of developmental change. Higher GA predicted a higher level of performance, while higher BW and female gender predicted a faster rate of developmental change. Maternal educational level was not predictive of differences in performance.

3.2. Multivariate models

3.2.1. Maternal parenting behaviors and executive functioning

Level of sensitive responsiveness was not related to level of A-not-B performance, nor to rate of change in A-not-B performance. Since significant differences in rate of change in sensitive responsiveness were not established, their associations with EF were not further pursued (see Table 3 for model fit indices).

Level of directiveness was not related to level of A-not-B performance. Level of A-not-B performance was also not related to rate of change in directiveness. Fixating these covariances to zero did not result in a significant decrement in model fit ($\Delta\chi^2 = 0.71$, $\Delta df = 2$, two-sided $p = .70$). Level of directiveness, however, was significantly positively related to rate of change in A-not-B performance ($r = .54$, one-sided $p < .05$), indicating that higher maternal directiveness is associated with faster developmental change in A-not-B performance when controlling for the influence of perinatal risk. Rate of change in directiveness was not related to level of A-not-B performance, but did show a significant negative relationship with rate of change in A-not-B performance ($r = -.98$, $p < .05$), indicating that stability in maternal directiveness was related to faster developmental change in A-not-B performance (see Table 3 for fit indices).

Since very high levels of directiveness might become intrusive and moderate levels of directiveness might be more optimal, the distribution of ratings was inspected. The vast majority of mothers received low to moderate scores. Only a minority of mothers received a score of 4 or higher ($n = 7$, $n = 4$, and $n = 3$ at 7, 10 and 14 months CA, respectively; total $n = 12$). We reran the analysis without the mothers who received a rating of ≥ 4 or higher. The covariance between initial directiveness and A-not-B development became stronger ($r = .64$, $p < .01$), whereas the covariance between change in directiveness and A-not-B development remained similar ($r = -.72$, $p < .05$), indicating that the relationship between directiveness and A-not-B development was not caused by this small group of highest scoring mothers, but was rather an effect of moderate levels of directiveness.

3.2.2. Infant self-regulation as a moderator

Multi-group analyses showed that the relationship between sensitive responsiveness or directiveness and A-not-B development did not differ between the Low and High regulation groups (see Table 4 for nested model comparisons).

4. Discussion

This longitudinal study investigated how (changes in) maternal parenting behaviors are related to developmental trajectories in EF in preterm infants between 7 and 14 months CA, and how these relationships vary with differences in infant self-regulation.

Consistent with previous findings [15], individual differences between mothers in sensitive responsiveness were fairly stable during the study period, while differences in directiveness were less stable. Also, mothers who were more directive initially showed higher stability than mothers who were less directive initially.

Sensitive responsiveness showed no contemporary or over-time relationships and no associated change with EF development, which is not in agreement with earlier studies on *global* cognitive and EF functioning [17,26]. Directiveness did show an over-time relationship as well as associated change with EF development. Mothers who were more directive initially and who were consistently directive over time had infants who showed faster developmental progression in EF, but it appears that this effect was largely due to medium levels of directiveness.

Our results suggest that EF development of preterm infants is facilitated by mothers who show a consistently medium level of directiveness. It may be that a medium level of directiveness compensates for the unresponsiveness and passivity many preterm infants show [22]. An alternative explanation might be that the developmental progression of infant EF in itself triggers consistent maternal directiveness. However, this would be in contrast to the common finding that *lower* levels of functioning in children evoke higher levels of directiveness [39]. The conclusion that EF development is influenced by directiveness, instead of vice versa, is supported by the fact that we did not find a relationship between initial level of EF and rate of change in directiveness. The finding that the relationship between initial directiveness and A-not-B development became stronger when highly directive mothers were removed from the analysis may even suggest that when directiveness levels become too high, and perhaps even become intrusive, this may already start to have a negative effect during infancy.

The finding that sensitive responsiveness was not related to EF in infants born preterm needs further consideration. In contrast to our findings, Ayoun found that 11-month-old full-term infants performed better on the A-not-B reversal trial when they had a more responsive mother [40]. The study by Ayoun however, did not use (increasing) delays between hiding and seeking and therefore most likely measured short-term memory instead of working memory, making it difficult to compare results. In addition, perhaps sensitive responsiveness levels showed too little variation and were generally 'good enough' in our sample to find effects. Inspection of the educational level of mothers in our sample indicates a rather homogeneous sample, with medium to high socioeconomic status (SES), which is not representative for the

whole population. Since there is a large body of evidence from previous studies showing that a higher SES is related to higher parenting quality [38], this might explain our results. Perhaps effects of sensitive responsiveness will be found in more heterogeneous samples. We recommend future studies to use a combined measure of directiveness and sensitive responsiveness when investigating their predictive value, with a distinction between supportive and intrusive directiveness (i.e., directives that either *support* or *redirect* the attentional focus of attention) [13]. Also, future studies are recommended to use a more extensive battery of delayed response tasks to strengthen conclusions. Also, since parenting behaviors are dependent on infant behaviors to a certain extent, scoring infant behavior in parent-infant interaction tasks is recommended for future studies.

Our results did not confirm that the predictive value of maternal parenting behaviors varies with infant self-regulation, which may have several reasons. First, assigning infants to groups based on the median score probably resulted in differences too small to evaluate. Larger samples are needed to compare infants with more extreme scores. Second, maternal report of infant self-regulation may be influenced by mothers' characteristics (e.g., personality), which may have confounded results. Objective observations of self-regulation during mother-infant interaction or experimental paradigms in which stress is manipulated (e.g., by arm-restraint or still-face procedures) [19] may provide more reliable information on differences between infants.

Although we controlled for perinatal risk factors, our sample was too small to investigate how the effects of perinatal risk are moderated by parenting behaviors. It is possible that certain parenting behaviors mitigate the adverse effects of certain perinatal risk factors. Preterm children may not just be more negatively affected by poor environmental experiences (i.e., diathesis stress hypothesis), but may also be more susceptible to positive effects of environmental support (i.e., differential susceptibility theory) [42]. A recent study has shown that sensitive parenting can indeed mitigate the effects of perinatal risk on academic achievement in preterm children [43]. However, no indication was found that preterm children were also *more* susceptible to the positive effects of sensitive parenting than healthy full-term children. More research on this topic is needed, also taking into account the moderating effects of a more directive parenting style.

5. Conclusions

The results from this study suggest that the structure provided by mothers with a consistently medium level directive approach facilitated EF development in their infants born preterm. This may have important implications for early intervention programs, since many intervention programs focus on increasing maternal sensitive responsiveness and reducing directiveness [44]. A recent meta-analysis revealed that mothers of preterm children are generally not less sensitive or responsive toward their children than mothers of fullterm born children [22]. Our findings suggests that it might be effective to coach parents in how to combine a sensitive responsive approach with an appropriate level of structure, adapted to changing infant needs. Sensitive responsiveness should *not* be omitted from these interventions, because of its demonstrated importance for *global* cognitive and social-emotional development.

Conflict of interest statement

None declared.

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Table 4
Nested model comparisons for self-regulation groups (Low versus High).

	Model fit indices						Model comparison		
	χ^2	df	p	TLI	CFI	RMSEA	$\Delta\chi^2$	Δdf	p
Sensitive responsiveness/A-not-B									
Equal	70.13	70	.473	.997	.997	.005			
Not equal	69.18	68	.437	.968	.970	.016	.95	2	.662
Directiveness/A-not-B									
Equal	51.60	69	.942	3.978	1.000	.000			
Not equal	51.13	67	.925	3.798	1.000	.000	.475	2	.789

Note: χ^2 = Chi-square, df = degrees of freedom, TLI = Tucker-Lewis Index, CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation, Δ = difference. Model comparison p value > 0.05 indicates that model 'not equal' does not provide a significant improvement.

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