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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.

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 × 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)