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Cognitive Functioning in Toddlerhood: The Role of Gestational Age, Attention Capacities, and Maternal Stimulation

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Why do many preterm children show delays in development? An integrated model of biological risk, children's capacities, and maternal stimulation was investigated in relation to cognitive functioning at toddler age. Participants were 200 Dutch children (gestational age = 32–41 weeks); 51% boys, 96% Dutch nationality, 71.5% highly educated mothers. At 18 months, attention capacities were measured using eye-tracking, and maternal attention-directing behavior was observed. Cognitive functioning was measured at 24 months using the Bayley-III-NL. Cognitive functioning was *directly* predicted by children's attention capacities and maternal attention-maintaining behavior. Gestational age was *indirectly* related to cognitive functioning through children's attention capacities and through maternal attention-redirecting behavior. In this way, a combination of gestational age, children's attention capacities, and maternal stimulation was associated with early cognitive development.

Keywords: cognitive functioning, gestational age, attention capacities, mother–child interaction

Preterm children (gestational age 23–36^{+6} weeks) are at risk for developmental delays in all domains of functioning, including cognition (e.g., Poulsen et al., 2013).[1] Compared with term-born children, preterm children on average show lower cognitive functioning at (pre)school age (e.g., Poulsen et al., 2013), with more children scoring below the level expected for their age (Talge et al., 2010; Wolke & Meyer, 1999). Furthermore, compared with the general population, a larger subgroup of school-aged preterm children needs special education (Johnson et al., 2009; van Baar, Vermaas, Knots, De Kleine, & Soons, 2009). Why preterm children experience problems in cognitive functioning, and why some children have more difficulties than others is not clear. It has been suggested that the attention capacities of these children play a central role in the association between gestational age and cognitive development (e.g., Lawson & Ruff, 2004). In this study, we examined how cognitive development at 24 months of age, as shown during standardized tasks of exploration, memory, and problem solving, is related to gestational age, and how it is related to the attention capacities of these children at 18 months of age, and to maternal behavior directing their children's attention during interaction at the same age. The focus was on toddler age because children develop in a rapid pace during the first years of life regarding cognition and attention capacities (Bornstein, 2014; Ruff & Rothbart, 1996; Thompson, 2001). In addition, the difference in cognitive functioning between very preterm and term-born children was found to become more pronounced between 1 and 2 years of age, which indicates that this might be a critical period in the development of preterm children (van Baar et al., 2006). There are also indications that cognitive functioning at 2 years of age is predictive of later cognitive functioning and school problems in very preterm children (van Baar et al., 2006). Early detection of developmental difficulties, and possible predictors of development, will enable the implementation of existing intervention programs or design of new support measures for children at risk at an earlier age.

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[1] "+6" indicates the number of days: 36^{+6} equals 36 weeks and 6 days.

Although all children born before 37 weeks of gestation are designated as preterm, many studies focused on the development of very preterm children, born before 32 weeks of gestation. However, most preterm children are born moderate-to-late preterm between 32 and 36^{+6} weeks of gestation (Blencowe et al., 2012). There is increasing evidence that these moderate-to-late preterm children are also at risk for developmental problems, such as lower cognitive functioning (e.g., de Jong, Verhoeven, & van Baar, 2012; Potijk, de Winter, Bos, Kerstjens, & Reijneveld, 2012; van Baar et al., 2009). This is even the case for relatively healthy moderate-to-late preterm children who did not need admittance to a tertiary neonatal intensive care unit (NICU; van Baar et al., 2009). Gradual effects of gestational age on child developmental outcome have been found (Eryigit-Madzwamuse & Wolke, 2015; Jaekel, Baumann, & Wolke, 2013). In addition, some studies showed that even within a full-term group, gestational age matters: Children born at 37 or 38 weeks have more school problems (Chan & Quigley, 2014; Noble, Fifer, Rauh, Nomura, & Andrews, 2012) and more behavior problems (Robinson et al., 2013) than do children born between 39 and 41 weeks of gestation. This might indicate that there is an optimal period for the brain to develop within the womb. Therefore, we studied gestational age as a continuous variable, varying between 32 and 41^{+6} weeks for children that did not need neonatal intensive care treatment. This range of gestation represents 95.7% of all births in the Netherlands (Perined, 2016).

The finding that preterm-born children are at risk for problems in cognitive functioning is often explained as a direct consequence of biological risk reflected in low gestational age. Lower gestational age reflects less mature brain development at birth (Kinney, 2006). In addition, preterm-born children are exposed to different sensory experiences (e.g., brighter light, louder sounds, and sometimes painful procedures) than are unborn children of the same gestation within the womb. These experiences might specifically affect brain maturation (i.e., structure and function) and influence further cognitive functioning and development of preterm children (Als et al., 2004). Jaekel and colleagues (2013) showed, for children at 8.5 years of age, that a lower gestational age (varying from 23–41 weeks)—and a more immature brain—was associated with lower cognitive scores. However, not all preterm children develop cognitive problems, and cognitive functioning is not solely affected by gestational age and the consequences of preterm birth. According to Sameroff's Unified Theory of Development (Sameroff, 2010), development is an outcome of the interplay between nature and nurture and can be understood using four models. First, the personal change model, which focuses on biological and psychological growth processes, or in other words, factors within the child. Second, the contextual model, which is based on the bioecological model of Bronfenbrenner (1979), stating that development is also influenced by the interaction of an individual with his or her (social) environment. The third model, the regulation model, reflects that development is an outcome of dynamic interactions between the child and his or her environment: The child is not passively influenced by the environment but also shapes this environment, which in turn influences the child. The fourth model is the representational model, which implies that one has representations of their early environment and experiences, that form a background for interpretation of new experiences and therewith further shape one's development. This line of thinking underlies the current study, because a combination of the personal change model (i.e., child development in attention and cognition in relation to characteristics like gestational age and gender), contextual models (mother–infant interaction in different situations), and regulation models (i.e., parental behavior in relation to attention skills of the infants) will be studied.

Regarding child characteristics, attention capacities have been hypothesized as a mediator of the relationship between gestational age and cognitive functioning (Reuner, Weinschenk, Pauen, & Pietz, 2015; Rose, Feldman, Jankowski, & Van Rossem, 2008; Voigt, Pietz, Pauen, Kliegel, & Reuner, 2012). This is based on findings that attention capacities are predictive for cognitive functioning in typically developing children (e.g., Bornstein & Sigman, 1986; Lawson & Ruff, 2004). In addition, preterm children more often showed attention problems than did term-born children (Aarnoudse-Moens, Weisglas-Kuperus, Van Goudoever, & Oosterlaan, 2009; Anderson et al., 2011; de Kieviet, Van Elburg, Lafeber, & Oosterlaan, 2012). Attention can be defined as a multidimensional construct, based on the model of Posner and Petersen (1990), including three attention systems: orienting, alerting, and executive attention. Orienting concerns the ability to engage, disengage, and shift attention. Functioning of this system improves vastly over the first year of life and continues to develop up to mid-childhood (Rueda & Posner, 2013; Ruff & Rothbart, 1996). Alerting is defined as the ability to achieve and maintain a state of alertness. This system also improves largely during the first year of life, but development continues until childhood and early adolescence (Rueda & Posner, 2013; Ruff & Rothbart, 1996). Executive attention concerns goal-directed and planned attention, or attentional control (Posner & Petersen, 1990), and starts to develop by the end of the first year of life up to at least early adolescence (Rueda & Posner, 2013; Ruff & Rothbart, 1996).

Three studies investigated the hypothesis that attention capacities might mediate the relation between gestational age and cognitive functioning (Reuner et al., 2015; Rose et al., 2008; Voigt et al., 2012). Rose et al. (2008) found that in very preterm children, orienting attention capacities measured at 12 months of age, mediated the relation between birth status (i.e., preterm vs. term) and cognitive functioning at 2 and 3 years of age. These findings may not be generalized to the large group of moderate-to-late preterm-born children, because these very preterm children are more immature at birth and are at higher risk for difficulties such as respiration problems or infections in the neonatal period (i.e., the first weeks until 1 month after the expected date of birth). This is shown in the study by Voigt et al. (2012), who found a mediating role of observed effortful control, a measure related to executive attention, in the relation between gestational age and cognitive functioning at 24 months of age. This was, however, found only for very preterm children, not for moderately to late preterm children. No mediating role was found for mother-reported orienting and alerting attention capacities. In contrast, Reuner et al. (2015), who studied a sample with gestational ages varying from 23 to 41 weeks, found that focused attention (i.e., part of the alerting attention system) measured at 7 months of age mediated the relation between gestational age and cognitive functioning. This mediating role of attention capacities at 7 months of age was only found for cognitive functioning measured at the same age, but not for cognitive functioning measured at 24 months of age. Focused attention at 7 months of age was not found to be related to cognitive functioning at 24 months of age. Reuner et al. (2015)

suggested that the absence of a longitudinal association between focused attention and cognitive functioning might be because focused attention capacities only starts to develop at 7 months of age. According to Ruff and Rothbart (1996), toddler age, and more specifically the period around 18 months, is an age during which important variation might be detected in attention development for orienting, alerting, and executive attention. Therefore, this might be an appropriate age to investigate the mediating role of attention capacities between gestational age and cognitive outcome.

Next to the child characteristics, environmental factors might also be of importance as reflected in contextual and regulation models of development (Sameroff, 2010). Parents form a crucial part of the environment of young children, and one way in which parents are known to promote development of their children is by a process called "scaffolding" (Wood, Bruner, & Ross, 1976), which is related to Vygotsky's theory of "zone of proximal development" (Vygotsky, 1978). Scaffolding means that a parent stimulates and helps the child to gradually perform increasingly more difficult tasks. One way in which parents support their child's development (i.e., scaffolding), is by directing their children's attention. With these "attention-directing" behaviors, parents support the children's attention capacities. Two types of attention-directing behavior can be distinguished: (1) maintaining behaviors, used by parents to help their child to stay focused on an object or activity for a longer period of time, such as by giving instructions to perform a certain task; (2) redirecting behaviors, used by parents to support the child to focus on another interesting object or activity than the one he or she was engaged in; for example, by introducing a new toy (Bono & Stifter, 2003).

Previous studies found that mothers who showed more behavior directed at maintaining their child's attention had preterm and term-born children who showed better cognitive functioning in infancy, at toddler age, and at preschool age (Conway & Stifter, 2012; Landry, Smith, Swank, & Miller-Loncar, 2000; Smith et al., 1996). A concurrent relation was found in infancy and at toddler age (Landry et al., 2000; Smith et al., 1996). Conway and Stifter (2012) found a longitudinal relation between maternal behavior measured at 24 months of age and cognitive functioning measured at 4[1/2] years. These studies indicate that maternal behavior helping the child to maintain attention is beneficial for the cognitive development of their child.

For maternal behavior aimed at redirecting the child's attention, results are mixed. In infancy, it was found that mothers who showed a high frequency of redirecting behavior at 8 months of age had preterm and term-born children who showed worse cognitive functioning at this same age (Pridham, Becker, & Brown, 2000). The opposite was found at toddler age in a similar maternal behavior that also implies redirection of the child's attention: More maternal directiveness (defined as a request that provided structured information about what was expected, which offered less choice to the child and was irrespective of the child's focus of attention) at 2 years of age was related to better cognitive functioning of their preterm and term-born children measured at the same age (Landry et al., 2000). At preschool age, the relation found was again negative, as in infancy: More directiveness of the mothers was related to worse cognitive functioning of their term and preterm-born children both concurrently (Landry et al., 2000) and longitudinally when maternal behavior was assessed at 24 months of age and cognitive functioning at 4[1/2] years (Conway & Stifter, 2012). Further research on the relationship between maternal redirection, or directiveness and children's cognitive functioning, is needed, in view of these inconsistent results.

It is possible that maternal attention-directing behavior directly influences cognitive functioning and behavior of their children. However, because mothers may respond specifically to the attention behavior of their children during interactions, it is also likely that this relationship is mediated by the children's attention capacities. This has not been studied before. Cross-sectional studies have found that mothers who showed more attention maintaining behavior had (preterm and term-born) children who were better able to focus their attention for a longer period of time during infancy and at toddler age (Bono & Stifter, 2003; Findji, 1998; Findji, 1993; Landry & Chapieski, 1988; Pridham et al., 2000). This is in line with the suggested supportive role of *maintaining behavior*. In line with the suggestion that *redirecting behavior*, on the other hand, would interrupt children's attention (Pridham et al., 2000), two studies found that children of mothers showing *more* behavior implicating redirecting the child's attention showed less attention capacities in infancy and at toddler age, when maternal behavior and attention capacities were measured at the same age (Bono & Stifter, 2003; Landry & Chapieski, 1988). Because children's attention capacities were found to predict their cognitive functioning (e.g., Bornstein & Sigman, 1986; Lawson & Ruff, 2004), the current study investigates whether observed maternal attention-directing behavior is directly related to children's cognitive functioning at 24 months of age and whether the attention capacities of toddlers at 18 months of age mediate that relationship.

In sum, we will investigate a model concerning the combined longitudinal relationships of biological factors (i.e., gestational age), child characteristics (i.e., attention capacities), and maternal stimulation (i.e., maternal attention-direction behavior) on cognitive functioning at toddler age (Figure 1). Based on previous research, we expect a positive indirect effect of gestational age on cognitive functioning through attention capacities, in the sense that gestational age is positively related to attention capacities, which in turn are positively related to cognitive functioning (gestational age → attention capacities → cognitive functioning). Furthermore, we expect an indirect effect of maternal attention-direction behavior on children's cognitive functioning through their attention capacities (maternal behavior → attention capacities → cognitive functioning). We expect that maternal maintaining behavior is positively related to the attention capacities of the children, while maternal redirecting behavior is expected to be negatively related to attention capacities. Indications were found that mothers of preterm children differ in interaction behavior from mothers of term-born children, because they were found to be more controlling, more stimulating, and less sensitive (e.g., Miles & Holditch-Davis, 1995; Muller-Nix et al., 2004). Therefore, we also explore whether gestational age is predictive of maternal attention directing behavior, and whether this results in a second indirect effect of gestational age on child developmental outcome through maternal behavior (gestational age → maternal behavior → attention capacities → cognitive functioning). Finally, because mothers might also be responsive to their children, a model will be investigated with the attention capacities of the child placed before maternal behavior (gestational age → attention capacities → maternal behavior → cognitive functioning).

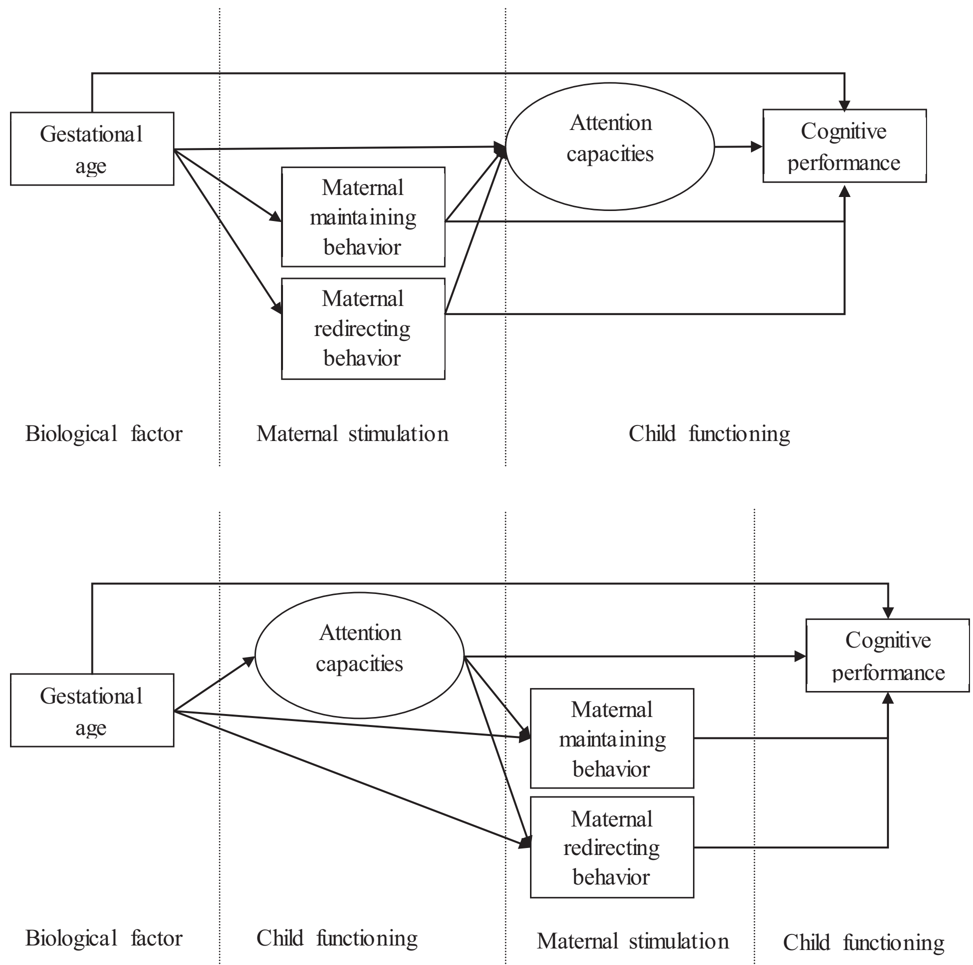

Figure 1. Hypothesized models. Squares represent observed variables, circle represents latent factors.

Method

Participants

The full sample consisted initially of 226 children. At 18 months of age, 214 children (94.7%) provided data regarding the observations of mother–child interaction. For 207 children (91.6%), the eye tracking procedure was performed, and for 214 children (94.7%) data on developmental outcome at 2 years of age were available. The sample used in the analyses contained 200 children (88.5% of the full sample) who had data available of the eye tracker, the mother–child interaction observation, and the developmental test. Of these children, 104 were born moderate-to-late preterm (gestational age $M = 34.64$ weeks, $SD = 1.34$), and 96 were born at term (gestational age $M = 39.46$ weeks, $SD = 0.98$).

The children included in the analyses ($n = 200$) did not differ from the other participants ($n = 26$) in gestational age, gender, birth weight, number of days in hospital after birth, ethnic origin, maternal education level, and maternal marital status. Moreover, we found no difference between children who were included in ($n = 200$) or excluded from ($n = 26$) the analyses on the study variables: Included children did not differ from the excluded children on the eye tracking measures, Wilks' $\Lambda = 1.00$, $F(3,203) = .37$, $p = .77$, maternal attention-directing behavior (both maintaining and redirecting), Wilks' $\Lambda = 0.99$, $F(2,211) = 1.06$, $p = .35$, and the measure of cognitive functioning, $F(1,212) = .16$, $p = .69$.

Sample characteristics are presented in Table 1. Around half, 51%, of the children were boys and 57.5% were firstborn. A total of 96% had the Dutch nationality. The remaining 4% of the children were of Western European origin. The children were on average 17.53 months ($SD = .50$) at Wave 1, and 23.64 months ($SD = .58$) at Wave 2. Almost all mothers lived together with a partner (i.e., 98.5%), and the majority of the mothers were educated at high school or university level (71.5%).

Procedure

This study is part of an ongoing longitudinal project on the development of moderate-to-late preterm children, the STAP Project (i.e., Study on Attention of Preterm children). The children were born between March 2010 and April 2011, at a gestational age between 32 and 41^{+6} weeks in nine hospitals in and around Utrecht in the Netherlands. Exclusion criteria were dysmaturity

Table 1
Background Characteristics of the Participants

Variable	Total sample gestational age 32–41 weeks, $n = 200$
Age in months Wave 2	
M (*SD*)	17.53 (.50)
Range	17–18
Age in months Wave 3	
M (*SD*)	23.64 (.58)
Range	23–27
Gestational age in weeks	
M (*SD*)	36.96 (2.68)
32 weeks	5.5%
33 weeks	5.5%
34 weeks	9.5%
35 weeks	13.0%
36 weeks	18.5%
37 weeks	2.0%
38 weeks	5.0%
39 weeks	16.0%
40 weeks	19.0%
41 weeks	6.0%
Boys (%)	51.0%
First born (%)	57.5%
Birth weight, g	
M (*SD*)	3,059 (698)
Range	1,420–5,330
Days in hospital	
M (*SD*)	6.46 (9.29)
Range	0–42
Ethnic origin (% Dutch)	96.0%
Maternal education level	
Low[a]	5.5%
Medium[b]	23.0%
High[c]	71.5%
Marital status (% married/living together)	98.5%

[a] No education, elementary school, special education or lower general secondary education. [b] High school or vocational education. [c] College, university, or higher.

(i.e., birth weight below 10th percentile according to Dutch reference curves from Perined, 2016), multiple birth, admission to a tertiary NICU, severe congenital malformations, antenatal alcohol or drug abuse by the mother, and chronic antenatal use of psychiatric drugs by the mother. The parents were invited by letter in which they were informed about the purpose and procedure of the study through their pediatricians or midwives, when their child was 10 months old. Parents were told that the purpose of the study was to investigate development of moderate-to-late preterm and term-born children during the first years of life. Furthermore, the letter included information about the ages at which measurements were done (i.e., 12, 18, and 24 months of corrected age), what would be expected from them at every wave (e.g., answering questionnaires and visiting us twice for the eye tracking measurement, observation of mother–child interaction, and the developmental test in the lab), and how much time this would take. Age correction indicates that the age of the preterm-born child is corrected for the number of weeks the child was born premature. For example, a child that was born 6 weeks premature is 2 years of corrected age 6 weeks after his or her actual birthday. By using the corrected age, preterm children, and their brain, would have had the same amount of time to develop as a child that is born at term (from 37 to 43 weeks' gestation).

When the parents agreed to participate, they gave informed consent. The study was approved by the medical ethical committee of the Utrecht Medical Center. Data were collected between March 2011 and May 2013. A power analysis based on a medium effect size of .3, a desired statistical power of .8, a probability level of .05, one latent variable, and five observed variables showed that the recommended minimum sample size was 100 (Soper, 2017).

In this article, data were used from children born at 32 to 41 weeks' gestation, including perinatal data, data of the assessments of cognition at 24 months, and attention capacities and mother–toddler interaction at 18 months, corrected for prematurity when appropriate. Parts of this dataset were used in previous publications concerning different research questions (de Jong, Verhoeven, Hooge, & van Baar, 2016a; de Jong, Verhoeven, Hooge, & van Baar, 2016b; de Jong, Verhoeven, Lasham, Meijssen, & van Baar, 2015; de Jong, Verhoeven, & van Baar, 2015).

When the children were 18 months of age (corrected for prematurity; Wave 1), they visited our lab for an evaluation of attention capacities by means of an eye tracking procedure, and for an observation of mother–child interaction.

For the eye tracking procedure, children were seated in a car seat at a distance of approximately 65 cm from the eye tracker. In line with Hunnius and Bekkering (2010), a 9-point calibration was used, in which a movie clip of a bouncing ball accompanied by a sound was presented at nine different points on the screen (i.e., left, middle, and right at the top, center, and bottom of the screen). Calibration was accepted when the child looked at seven or more of the calibration points. Missed calibration points were recalibrated with a maximum of two attempts. When more than two attempts were needed ($n = 4$), calibration was accepted when the children looked at five or more of the calibration points, which was the case for all four participants. After calibration, four tasks were presented in the following fixed order: (1) disengagement task, (2) face task, (3) alerting task, and (4) delayed response task. The whole procedure took about 18 min to complete.

After the eye tracking procedure, mothers were asked to play with their child for 15 min: 5 min of free play and 10 min of structured play (i.e., reading a book and making a puzzle, both for 5 min). The interaction was videotaped and coded afterward. Coders were blinded for gestational age of the children. At 24 months of (corrected) age (Wave 2), the children and their mothers visited us for a developmental assessment. Examiners were blinded for gestational age of the children. After both visits, the children received a small gift and the parents received a refund of their travel expenses.

Apparatus

The Tobii T60 eye tracker with an integrated 17-inch TFT screen with a resolution of 1280 by 1024 pixels (i.e., 28.0° by 23.0°) was used (Tobii Technology, Stockholm, Sweden). The Tobii T60 measures corneal reflection at a frequency of 60 Hz with an accuracy of 0.5°, and it has a spatial resolution of 0.2°. Using a white background, the precision (i.e., amount of RMS noise) is 0.50° (Tobii, 2011). The head box, or freedom of head movements, is 44*22*30 cm. Head movements are compensated by the eye tracker, which results in a temporary accuracy error of 0.2°. When the eye tracker loses track of the children's eyes (e.g., fast head movements of more than 25 cm/s), it recovers in 300ms. E-Prime

2.0 software (Psychology Software Tools, Pittsburgh, PA) was used to present the stimuli on the screen.

Instruments

Attention capacities. The Utrecht Tasks of Attention in Toddlers using Eye tracking (UTATE) were used at 18 months of (corrected) age to measure the attention capacities including four tasks: (1) disengagement task, (2) face task, (3) alerting task, and (4) delayed response task (de Jong at al., 2016a). In the *disengagement task*, a visual stimulus was first presented at the center of the screen, and after 2-s a second stimulus appeared at the left or the right side of the central stimulus, while the central stimulus stayed on the screen. This task consisted of 20 trials. In the *face task*, two identical pictures of child faces were shown, and after 8.5 s one of the pictures changed into a new picture and stayed on the screen together with the previously shown picture for 8 s. The face task consisted of eight trials. In the *alerting task*, a visual stimulus was presented on the screen, in half of the trials preceded by a signaling sound. The alerting task consisted of 32 trials. In the *delayed response* task, a voice-over points the child toward the dog on the screen and tells that the dog wants to play "hide-and-seek" and that the child should pay attention because the dog is going to hide himself. Next, the dog moves to one out of two doghouses. After standing in front of the doghouse for 1,000 ms, he disappears to hide himself. Then a worm pops up in the center of the screen to distract the child from watching to the dog houses, and after a certain delay (varying from 0 to 10 s) the child was asked to search for the dog by a voiceover. This task consisted of 18 trials in which the delay increased from 0–10 s with steps of 2 s after three consecutive trials. Timing and stimulus size of the tasks are presented in Figure 2. The tasks are described in more detail elsewhere (de Jong et al., 2016a). For the orienting measure, split-half reliability was good (r = .71–.83) for four of six variables, moderate (r = .55) for one (i.e., latency), and low (r = .15) for one (i.e., proportion of correct refixations). Because proportion of correct refixations had a small factor loading, the impact on the reliability of the orienting measure is expected to be small as well. For the alerting measure, split-half reliability was good (r = .85–.95) for four of the five variables, and moderate (r = .41) for one (i.e., difference in latency). For the executive attention measure, split-half reliability was good (r = .76) for one of the two variables (i.e., number of correct searches) and moderate (r = .35) for the other (i.e., mean delay).

Different aspects of looking behavior during these four tasks were coded in 13 variables (Table 2). A confirmatory factor analysis had shown that this information could be reduced into three latent constructs: the orienting, alerting, and executive attention systems (de Jong et al., 2016b). Measurement invariance testing confirmed that this three-factor model was invariant between moderate-to-late preterm children and term-born children (de Jong, Verhoeven, & van Baar, 2015). Scores on these latent constructs were used as measures of attention. For all constructs, higher scores were indicative of better attention skills.

Maternal attention-directing behavior. Mother–child interaction was observed in a lab setting at 18 months of (corrected) age, in a room with a play mat on the floor, and a table and chair on the side. First, three types of toys (i.e., a shape sorter, building blocks, and a pop up toy) were placed on the play mat, and mothers were instructed to play with their child as they would do at home for 5 min (free play). Second, mothers were asked to read a book with their child for 5 min (task situation). Finally, mothers were asked to make a puzzle with their child, again for 5 min (task situation).

The video-taped interactions were coded afterward with Parental Attention Directing observation system (PAD) based on Landry, Smith, and Swank (2006). In this system, the frequency of maternal attention-directing behavior is coded separately for maintaining and redirecting behavior. Maintaining behaviors are attempts of mothers to keep the children focused on the object or activity he or she is already engaged in, such as praise or encouragement. Redirecting behaviors are attempts to redirect the children's attention to another object or activity, such as calling the children's name or showing and naming a new toy. To get an impression of maternal behavior over specific task settings in general, composite scores were used, based on the sum scores of the frequencies of maintaining behaviors and on the sum scores of the frequencies of redirecting behaviors during the free play and task settings. This approach was supported by the significant and positive relationships that were found across task situations for maintaining behavior (correlations ranged from r = .50 to r = .62) as well as for redirecting behavior (ranges from r = .19 to r = .34). The correlations between maintaining and redirecting behavior for each different setting separately were: r = .23 during free play, r = −.35 during book reading, and r = −.31 during puzzle making, showing a somewhat different pattern for structured and unstructured situations that will both occur in daily life. Overall the correlation between maternal maintaining and redirecting behavior was only .003.

The data were coded by eight trained observers who were blinded for gestational age of the children. For interrater reliability approximately half (53%) of the videotapes were double coded. The interrater reliability was good with an intraclass correlation of .88.

Cognitive functioning. At 24 months of (corrected) age, a trained examiner performed the Dutch version of the Bayley-III (Bayley, 2006)—the Bayley-III-NL (van Baar, Steenis, Verhoeven, & Hessen, 2014)—to assess the children's developmental level.

The Bayley-III-NL consists of five subtests: Cognition, Fine Motor, Gross Motor, Receptive Communication, and Expressive Communication. In the current study, only the score on the Cognition subtest was used. The Cognition subtest is intended to measure sensorimotor development, exploration and manipulation, object relatedness, concept formation and memory. Items include, for example, searching for a hidden object and making puzzles. The index score based on Dutch norms was used, which has a mean of 100 and a *SD* of 15 (van Baar et al., 2014). The reliability and validity of the Bayley-III-NL is good (van Baar et al., 2014).

Data Analyses

Information on the measures that are derived from the eye tracking data and how these map onto the latent measures of

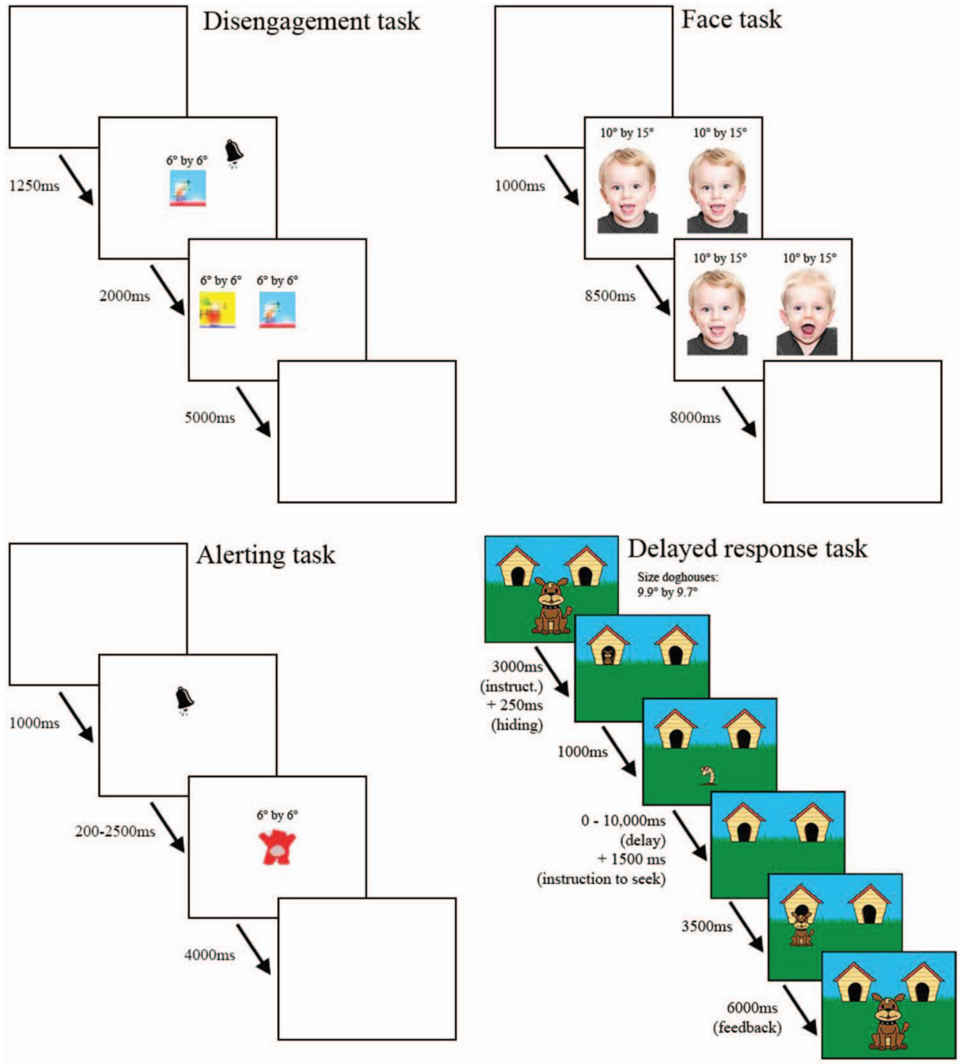

Figure 2. Visualization of timing and size of the stimuli in the different eye tracker tasks. From Factor Structure of Attention Capacities Measured With Eye Tracking Tasks in 18-Month-Old Toddlers by M. de Jong, M. Verhoeven, I. T. C. Hooge, & A. L. van Baar (2016a). *Journal of Attention Disorders, 20,* 230–239. Copyright 2016 by SAGE Publications. Reprinted with permission. See the online article for the color version of this figure.

attention is presented in Table 2. Matlab 7.11 (The MathWorks, Inc.) was used to analyze gaze data from the eye tracker. Fixation detection was done by a self-written Matlab program that marked fixations by an adaptive velocity threshold method (Hooge & Camps, 2013). We used an adaptive velocity threshold method to detect fixations, because the amount of noise may vary a lot in eye tracking data (especially with low frequency trackers such as the Tobii T60 and with non-grown-up participants). Many modern saccade and fixation detection methods are partly or fully adaptive to the noise in the data (Nyström & Holmqvist, 2010; Smeets & Hooge, 2003). Velocities were obtained by first fitting a parabola through three subsequent data points. Then we used the derivative of this parabola to estimate the value of the velocity of the second (center) data point. This procedure was repeated for all data points (except the first and the last). In the present analyses, everything that was not a saccade was called a fixation. To remove the saccades from the signal, we calculated average and *SD* from the absolute velocity signal. All data points with absolute velocities higher than the average velocity plus three times the *SD* were removed. This procedure was repeated until the velocity threshold converged to a constant value or the number of repetitions reached 25. Then we removed fixations with durations shorter than 50 ms from the analysis. The value of 50 ms was chosen because it was equal to three data samples. When a saccade was removed, the preceding and succeeding fixations were added together. Data of the children were included when they looked at the stimuli at least once during a task, thereby providing data on the variables of this task.

To compute scores on the latent constructs, multiple imputation was used for children with missing data on some of the eye

Table 2
Definitions of the Observed Variables From the Eye-Tracker Tasks

Outcome measure	Task	Definition
Orienting system		
Mean dwell time	DIS, FACE,	Average length of the dwells. A dwell is the length of "one visit in an area of interest [AOI], from entry to exit" (Holmqvist et al., 2011)
Transition rate	DIS, FACE	The number of transitions (i.e. "movement from one AOI to another", Holmqvist et al., 2011) divided by the total dwell time.
Proportion of correct refixations	DIS	A correct refixation indicates that the participant refixated from the central stimulus to the new stimulus after the new stimulus is presented. The proportion of correct refixations is the number of correct refixations divided by the total number of trials in which the child looked at the central stimulus when the new stimulus appeared.
Latency	DIS	The average time between appearance of the new stimulus and fixation on the new stimulus in trials in which the participant correctly refixated.
Alerting system		
Total dwell time	DIS, FACE, AL, DR	Sum of the length of all dwells. A dwell is the length of "one visit in an area of interest [AOI], from entry to exit" (Holmqvist et al., 2011)
Latency difference	AL	Difference between latencies in the trials in which a signal preceded the appearance of the stimulus (i.e. signal trials) and the trials in which the stimulus appeared without signal (no-signal trials).
Executive attention system		
Correct searches	DR	The number of trials in which the child looked at the correct dog house directly in response to the voice over asking where to find the dog.
Mean delay	DR	The mean delay between hiding and the instruction to seek the dog in the trials in which the child correctly searched for the dog.

Note. DIS = disengagement task; FACE = face task; AL = alerting task; DR = delayed response task.

tracking variables, who did provide data for at least one of the 13 variables ($n = 11$). Multiple imputation was done with the R package Amelia (Honaker, King, & Blackwell, 2011) with 10 iterations. The mean score of these 10 iterations was used for the analyses.

Pearson's correlations were used to examine the univariate relationships between the variables in the proposed model and to decide which paths to include in the tested models (see Figure 1). To test the indirect effects, structural equation modeling was conducted using the Lavaan package (Rosseel, 2012) in the R system for statistical computing (R Core Team, 2012). Indirect effects were tested using the product of the coefficients of the predictor and mediation variable. The model was tested separately for each of the three attention systems. Furthermore, the models were tested adjusted for maternal education level and gender, as this could be possible confounders. This was done by including two dummy coded variables for maternal education level, as the original variable had three possible values (i.e., low, middle or high), and one dummy variable for gender, as predictors of cognitive functioning. Because gestational age was not equally distributed in the data, all models were bootstrapped and the 95% bootstrapped confidence intervals (CIs) were used as indicator of significance of the coefficients and indirect effects in the model (Finney & DiStefano, 2006). To assess model fit, the chi-square test statistic (χ^2), the root mean square error of approximation (RMSEA), the standardized root mean squared residual (SRMR), the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the Bayesian Information Criterion (BIC) were used. A model was considered to show a good fit when: p value of $\chi^2 > .05$, RMSEA $< .06$, SRMR $< .08$, CFI $> .95$, and TLI $> .90$ (Hu & Bentler, 1999). The BIC value was used to compare results of different models. The model with the lowest BIC value is the best-fitting model (Kenny, 2015).

Results

Descriptive Statistics

The means and *SD*s, as well as the intercorrelations of the variables in the model are presented in Table 3. With a mean cognitive index score of 102.30 (*SD* = 10.98, range = 77–134) on

Table 3
Descriptive Statistics of the Outcome Variables of the Eye Tracking Procedure

Outcome measure	*M*	*SD*	Range
Orienting system			
DIS mean dwell time	1389	321	643–2,520
DIS transition rate	.52	.18	.17–1.27
DIS proportion of correct refixations	.97	.06	.67–1.00
DIS latency	634	268	311–2,283
FACE mean dwell time	1,224	295	539–2,397
FACE transition rate	.64	.17	.28–1.19
Alerting system			
DIS total dwell time	86,359	25,529	12,865–125,981
FACE total dwell time	72,673	26,117	5,486–113,896
AL total dwell time	51,281	2,286	300–111,283
AL latency difference	83	379	−1,942–1,601
DR total dwell time	73,911	29,080	300–140,866
Executive attention system			
DR Correct searches[a]	9.30	3.48	0–18
DR Mean delay	5.38	1.50	0–10

Note. DIS = disengagement task; FACE = face task; AL = alerting task; DR = delayed response task.
[a] On average, the children searched correctly in 63.8% of the trials in which they searched, which is more than the 50% that would be expected based on chance, $t(198) = 12.25$, $p < .001$.

the Bayley-III-NL, the children in this sample on average showed normal cognitive development. Seven children (i.e., 3.5%) showed a mild developmental delay indicated by an index score below 85. Girls showed somewhat higher scores than boys ($M_{\text{girls}} = 104.00$, $SD_{\text{girls}} = 11.35$ vs. $M_{\text{boys}} = 100.67$, $SD_{\text{boys}} = 10.40$), $F(1,198) = 4.69$, $p = .03$), which was also found in the Dutch norm sample (van Baar et al., 2014). Concerning maternal attention-directing behavior, it was found that the composite scores of the frequencies of maintaining and redirecting behavior were not related, $r = .003$, $p = .97$. No differences in frequencies of maternal attention-directing behavior were found between mothers of boys and mothers of girls (Wilks' $\Lambda = .98$), $F(2,197) = 1.56$, $p = .21$). The means of the three attention measures reflect the standardized scores on the latent constructs. The correlations between these three attention measures were moderate to strong ($r = .39$ to .80). No gender differences were found in the means of these attention measures (Wilks' $\Lambda = 1.00$), $F(3,196) = .30$, $p = .83$.

Correlations Between Model Variables

Gestational age was not related to cognitive functioning or executive attention, but it was positively related to orienting and alerting attention abilities. Furthermore, gestational age was negatively related to maternal redirecting behavior, whereas no relationship was found with maternal maintaining behavior. Orienting, alerting, and executive attention abilities were positively related to cognitive functioning. Maternal maintaining behavior was positively related to cognitive functioning, but it was unrelated to attention capacities. The opposite was found for maternal redirecting behavior, which was unrelated to cognitive functioning, but negatively related to orienting, alerting, and executive attention abilities (Table 4). Based on these correlations, we tested the model presented in Figure 3 for both orienting and alerting abilities separately. Because maternal redirecting behavior was not directly related to cognitive functioning, we only present the model in which maternal behavior precedes attention capacities of the children, and not the other way around. Because executive attention was unrelated to gestational age, no further analyses were conducted for this attention system.

Orienting Abilities

The fit measures showed that the model adjusted for maternal education level and gender had good fit ($\chi^2 = 11.11$, $p = .35$, RMSEA = .02, SRMR = .04, CFI = .98, TLI = .96, BIC = 7315) and explained 12.9% of the variance in cognitive functioning. However, although the bivariate correlation was significant, the paths of the dummy variables of maternal education level to children's cognitive functioning were not significant (95% CI [−4.18, 11.21] and [−.15, 14.41]), indicating no relation between maternal education level and cognitive functioning in the model. Therefore, we investigated whether model fit improved for the more parsimonious model in which we only adjusted for gender.

The model adjusted for gender also had good fit ($\chi^2 = 5.16$, $p = .52$, RMSEA = .00, SRMR = .04, CFI = 1.00, and TLI = 1.00, BIC = 7143). This model, adjusted only for gender, is interpreted, as it fitted the data better ($BIC_{\text{adjusted for gender}} = 7143 < BIC_{\text{adjusted for maternal education level and gender}} = 7315$). All parameters were statistically significant (Table 5). Lower gestational age was predictive of less orienting abilities and more maternal redirecting behavior. More maternal redirecting behavior was predictive of less orienting abilities. Less orienting abilities were predictive of lower cognitive scores. More maternal maintaining behavior was predictive of better cognitive functioning. The four indirect effects that were tested were all significant: (1) the effect of gestational age on cognitive functioning through orienting abilities, (2) the effect of gestational age on orienting abilities through maternal redirecting behavior, (3) the effect of gestational age on cognitive functioning through both orienting abilities and maternal redirecting behavior, and (4) the effect of maternal redirecting behavior on cognitive functioning through orienting abilities. In this model, 10.0% of the variance in cognitive scores was explained by gestational age, orienting capacities, and maternal maintaining and redirecting behavior.

Alerting Abilities

For alerting abilities, the fit measures for the model adjusted for maternal education level and gender were good ($\chi^2 = 12.56$, $p =$

Table 4
Means, SDs of, and Correlations Between Model Variables

Variable	1	2	3	4	5	6	7	8
1. Gestational age	1							
2. Maternal maintaining behavior	.04	1						
3. Maternal redirecting behavior	−.23**	.003	1					
4. Orienting	.23**	.11	−.21**	1				
5. Alerting	.22**	.12	−.27**	.80**	1			
6. Executive attention	.05	.05	−.17*	.39**	.57**	1		
7. Cognitive functioning	.14	.22**	−.14	.21**	.19**	.12	1	
8. Maternal education level	.23**	.07	−.15*	.21**	.23**	.14	.22**	1
Mean	36.96[a]	185.98[b]	48.49[b]	.00[c]	.00[c]	.00[c]	102.30[d]	—
SD	2.66	59.08	30.95	.44	.61	.70	10.98	—
Min	32	63	0	−1.47	−1.56	−2.00	77	—
Max	41	366	188	1.31	1.09	2.06	134	—

[a] Weeks. [b] Frequency. [c] Standardized scores. [d] Index score.
* $p < .05$. ** $p < .01$.

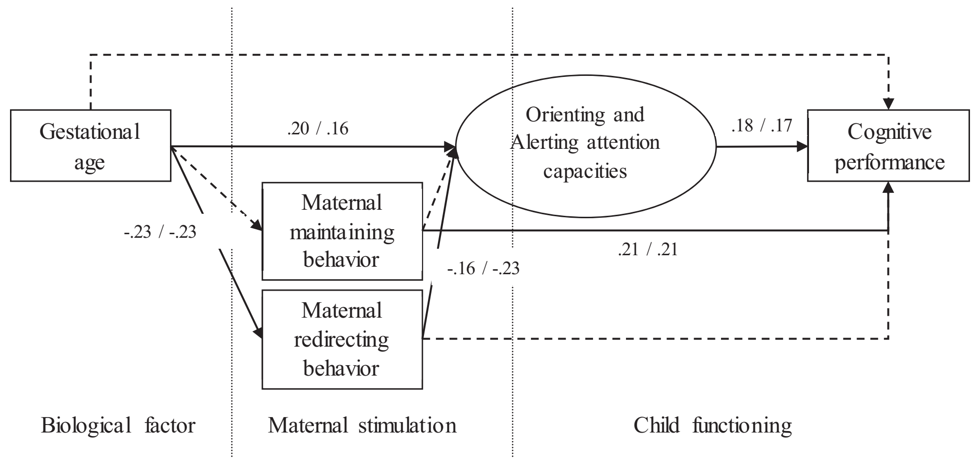

Figure 3. Model tested for orienting and alerting attention abilities. For a more parsimonious model, paths indicated by dashed lines were not included in the model, as those univariate correlations were small and not significant; Betas are presented for orienting on the *left* and alerting on the *right*; squares represent observed variables, circles represent latent factors.

.25, RMSEA = .04, SRMR = .04, CFI = .95, TLI = .92, BIC = 7445, explained variance = 12.8%). However, as with orienting abilities, the paths of the dummy variables of maternal education level to children's cognitive functioning were not significant (95% CI [−4.37, 11.51] and [−.44, 14.46]), indicating no relation between maternal education level and cognitive functioning in the model. Therefore, the model adjusted only for gender was investigated.

The model adjusted for gender also showed good fit (χ^2 = 5.85, *p* = .44, RMSEA = .00, SRMR = .04, CFI = 1.00, and TLI = 1.00, BIC = 7274) and explained 10.0% of the variance in cognitive functioning. This model, adjusted only for gender, is interpreted, as it fitted the data better ($BIC_{\text{adjusted for gender}}$ = 7274 < $BIC_{\text{adjusted for maternal education level and gender}}$ = 7445). All parameters were significant, see Table 4. Lower gestational age was predictive of less alerting abilities and more maternal

Table 5
Parameter Estimates of the Final Model for Orienting Attention and the Final Model for Alerting Attention

Variable	Estimate	Beta	95% CI low	95% CI high
Orienting				
GA → orienting	.03	.20	.01	.06
GA → redirecting	−2.67	−.23	−4.24	−1.15
Redirecting → orienting	−.002	−.16	−.004	−.001
Maintaining → cognitive functioning	.04	.21	.02	.06
Orienting → cognitive functioning	4.43	.18	1.21	7.77
Gender → cognitive functioning	−3.64	−.17	−6.50	−.80
Indirect effect				
GA → orienting → cognitive functioning	.14	.04	.03	.29
GA → redirecting → orienting	.01	.04	.001	.01
GA → redirecting → orienting → cognitive functioning	.03	.01	.003	.08
Redirecting → orienting → cognitive functioning	−.01	−.03	−.03	−.001
Alerting				
GA → alerting	.04	.16	.01	.07
GA → redirecting	−2.67	−.23	−4.32	−1.00
Redirecting → alerting	−.005	−.23	−.008	−.002
Maintaining → cognitive functioning	.04	.21	.02	.06
Alerting → cognitive functioning	3.05	.17	.79	5.47
Gender → cognitive functioning	−3.80	−.17	−6.66	−.87
Indirect effect				
GA → alerting → cognitive functioning	.11	.03	.01	.26
GA → redirecting → alerting	.01	.05	.004	.02
GA → redirecting → alerting → cognitive functioning	.04	.01	.005	.10
Redirecting → alerting → cognitive functioning	−.01	−.04	−.03	−.002

Note. CI = confidence interval; GA = gestational age. 95% bootstrapped confidence intervals indicate significance of the coefficients in the model when these contain no zero.

redirecting behavior. More maternal redirecting behavior was predictive of less alerting abilities. Less alerting abilities were predictive of lower cognitive scores. More maternal maintaining behavior was predictive of better cognitive functioning. Again, all four indirect effects were significant.

Discussion

Findings from this study showed that an integrated model of biological risk, child attention characteristics, and maternal stimulation of children's attention at 18 months of age was related to children's cognitive functioning at 2 years of age. Gestational age was found to show no direct effect, but an indirect effect on cognitive functioning as gestational age was related to cognitive functioning at 24 months of (corrected) age through orienting and alerting attention capacities of the children and maternal redirecting attention behavior at 18 months of (corrected) age. A lower gestational age was associated with less orienting and alerting attention skills of the children, and more redirecting behavior of the mothers, which in turn was related to lower cognitive scores of the children. Also, maternal behavior redirecting attention was only *indirectly* related to cognitive functioning, through orienting and alerting capacities of the children. Maternal behavior maintaining attention, on the other hand, was only *directly* related to cognitive functioning: more maintaining behavior predicted better cognitive scores. These results fit the Unified Theory of Development from Sameroff (2010) in that different factors and processes are found to be differentially associated with the children's attention capacities and their cognitive developmental outcome at 2 years of age. We conclude that it is important to study the relationship between gestational age as a continuous variable and developmental outcomes. In addition, because some previous studies show that even within the full term group, gestational age does matter: children born at 37 or 38 weeks had more school problems (Chan & Quigley, 2014; Noble, Fifer, Rauh, Nomura, & Andrews, 2012) and more behavior problems (Robinson et al., 2013) than did children born between 39 and 41 weeks of gestation.

Previous studies on attention capacities in relation to gestational age mainly included very preterm children and measured attention in infancy (Reuner et al., 2015; Rose et al., 2008). Our study adds information because we found an indirect effect of gestational age on cognitive functioning through attention abilities for our sample of children at toddler age, with gestational ages varying from moderate-to-late preterm to term birth. These findings show that lower gestational age is negatively related to later developmental outcomes, such as attention capacities at 18 months of age and cognitive functioning at 24 months of age. This concurs with the findings from previous studies comparing moderate-to-late preterm and term-born children on several developmental and behavioral outcomes (e.g., de Jong et al., 2012; van Baar et al., 2009).

Concerning the attention systems, orienting and alerting were found to be strongly related. Posner and Petersen (1990) theoretically distinguished the three attention systems, but they already stated that although each system has unique functions, the systems are assumed to be interconnected. Regarding the Attention Network Test (ANT) no relation between the three measures of attention (orienting, alerting, and executive attention) were found in adults (Fan, McCandliss, Sommer, Raz, & Posner, 2002), although the results did suggest that the networks would not operate independently in all situations. In addition, early in development the attention systems maybe differently related to each other than later in life. It has been suggested that orienting and alerting are developing at an earlier stage than executive attention (Colombo, 2001), which also might explain the high correlation between orienting and alerting and the somewhat lower correlation with executive attention in our study. Research on the development of the different attention systems in early life and the relation between the three systems is, however, still limited.

With respect to alerting attention capacities, Reuner et al. (2015) found an indirect effect of gestational age on cognitive functioning through alerting attention capacities only when attention and cognitive functioning were measured at the same age (i.e., 7 months), but not for cognitive functioning measured at 24 months of age. Reuner et al. (2015) suggested that this might have been because of the fact that alerting attention capacities just start to develop at that age, and that alerting attention capacities measured after the child's first birthday might be more predictive of later cognitive functioning. The current study indeed showed a positive predictive relation of alerting attention capacities measured at 18 months of age on cognitive functioning measured 6 months later. Our findings differ from the result of Voigt et al. (2012) who found no relation between mother-reported attention focusing (i.e., a measure of alerting attention) and cognitive functioning, both measured at 24 months of age. This might be because of the difference in methods used, as mother-report and eye-tracking might measure different types of attention capacities. This interpretation is supported by our previous finding that attention measured with mother reports and eye tracking were unrelated to each other (de Jong et al., 2015a). Our finding that orienting capacities at 18 months of age were predictive of cognitive functioning at 24 months of age are in accordance with the findings of Rose et al. (2008), who showed a predictive relation of orienting capacities on later cognitive functioning when orienting was measured at 12 months of age. While in our study no difference was found regarding the predictive value of orienting and alerting capacities, the two studies done in infancy showed contrasting findings. It might be the case that during the first year of life, the predictive value of orienting and alerting capacities differ. Further longitudinal studies of attention capacities in relation to later cognitive functioning could investigate at which age specific attention capacities become predictive of later development, and whether this differs for orienting and alerting attention capacities.

Regarding maternal attention-directing behavior, we expected an indirect effect on cognitive functioning through attention capacities of the children. For maternal redirecting behavior, results indeed showed that less redirecting behavior was related to better attention skills, which led to better cognitive functioning six months later. The finding that maternal redirecting behavior was negatively related to attention capacities of the children is in line with previous studies (Bono & Stifter, 2003; Landry & Chapieski, 1988), but this study adds to the previous literature by showing that through attention capacities, maternal redirecting behavior indirectly affects cognitive functioning.

Maternal attention-maintaining behavior, on the other hand, was directly and positively related to cognitive functioning. This direct relation between maternal attention-maintaining behavior and cognitive functioning has also been found in previous studies (Conway & Stifter, 2012; Landry et al., 2000; Smith et al., 1996).

Maternal attention-maintaining behavior might be directly related to cognitive functioning, as this results in a situation where the child is actually stimulated to learn how to handle an object or how to complete a task, which may facilitate development of cognitive functioning. However, previous studies also found a positive relation between maternal maintaining behavior and attention capacities of their child (Bono & Stifter, 2003; Findji, 1998; Findji, 1993; Landry & Chapieski, 1988; Pridham et al., 2000), which was not found in our study. This might be explained by the different developmental period, toddler age, we studied. Four of the five studies on the relation with attention capacities, measured maternal behavior when the children were between 5 and 8 months of age (Findji, 1993, 1998; Landry & Chapieski, 1988; Pridham et al., 2000), while in our study, maternal behavior was measured at 18 months of age. It might be that maternal behavior has different effects during infancy than at toddler age. Bono and Stifter (2003) measured maternal behavior at 10 and 18 months of age and also did not find a relation between maternal maintaining behavior and child functioning measured at the same time. Further research is needed to study whether the influence of maternal maintaining behavior on the children's attention capacities needs to be differentiated for different age periods.

Furthermore, in the current study, we chose to combine maternal behavior during a free play and two task settings into one score, because the same behaviors during different settings were found to be significantly related and we wanted to evaluate an impression of maternal behavior in general. Our approach is an important first step, but a next step might be to study more specifically when and where maintaining and redirecting behavior are especially important. Our scores of maternal maintaining and redirecting behavior showed a differentiated relationship per setting, with a positive relation in the free play setting and negative relations in the task situations. Further study might focus in greater detail on the timing of maternal behavior in relation to children's initiatives and responses during the interaction as well as on the profiles of maternal attention directing behaviors over different settings.

Gestational age was found to be negatively related to redirecting behavior, but no relation was found with maternal maintaining behavior. Because redirecting behavior can be seen as a type of controlling behavior, this may support the finding that mothers of preterm children are more directive during interaction than mothers of term-born children (Muller-Nix et al., 2004). The finding that the relation with gestational age differs for redirecting and maintaining behavior might also be because of a reciprocal relationship between maternal behavior and child functioning.

For the measurement of executive attention, no significant relationships were found with both gestational age and cognitive functioning. Regarding the lack of association with gestational age, it might be that moderate-to-late preterm children do not have difficulties with executive attention at toddler age. This is in line with the finding of Voigt et al. (2012) who only found a mediating role of observed effortful control, of which executive attention is part, for very preterm children and no effects for moderate-to-late preterm children. However, for somewhat older children, previous studies did find that moderate-to-late preterm children performed worse than term-born peers in executive attention tasks (Baron, Kerns, Müller, Ahronovich, & Litman, 2012; Cserjesi et al., 2012). Executive attention skills start to develop at the end of the first year (Ruff & Rothbart, 1996). Significant gains in working memory performance, that is related to executive attention skills, were found to occur in the second half of the first postnatal year on a delayed match retrieval task (Káldy, Guillory, & Blaser, 2016). Such developmental processes will also continue to develop after 18 months. Our null findings may be because of our delayed response task that may not be have been sensitive enough to evaluate the important individual differences. The delayed response task we used is intended to measure functioning of a brain area, that is, the dorsolateral prefrontal cortex, that is involved in working memory capacity and in executive attention (Kane & Engle, 2002). The latent score of executive attention, which is based solely on the delayed response task, did show the largest *SD* from all latent scores, but more study should be done to evaluate the cognitive functions (e.g., arousal, working memory, executive attention) reflected in the performance at this task. The specific combination of efforts regarding arousal, working memory and executive attention may be important (Reynolds & Romano, 2016).

The lack of association between executive attention and cognitive functioning is not in accordance with some previous studies that did found a relation between executive attention and school competence (e.g., Blair & Razza, 2007; Checa & Rueda, 2011). This might have to do both with the age of the toddlers we studied and with the executive attention task that we used. In addition, the cognitive functions measured with the tasks in the Bayley scales require also sensorimotor action of the children and this may differ more from the executive attention factor, than from the more basic and general orienting and alerting attention factors.

Although we investigated a combination of potentially important factors, only a relatively small amount of variance in cognitive functioning was explained by those factors (i.e., around 10%). This means that a large proportion of variance in cognitive functioning is explained by other factors. Other factors of importance might be of a biological nature also in relation to gestational age: neonatal morbidity, such as infections or hyperbilirubinemia, was found to be associated with cognitive functioning in preterm children (e.g., Baron, Erickson, Ahronovich, Baker, & Litman, 2011; Perlman, 2001); in our moderate-to-late preterm sample, however, no associations with neonatal difficulties and later developmental outcome were found (de Jong, Verhoeven, Lasham, et al., 2015). Other basic cognitive functions might also play a role. Rose et al. (2008) found that, next to attention capacities, recognition memory, processing speed, recall memory, and representational competence also predicted cognitive outcome. In addition, child temperament has been found to be related to cognitive functioning (e.g., Lemelin, Tarabulsy, & Provost, 2006; Salley & Dixon, 2007) and difficult temperament was present more often in preterm than in term-born children (e.g., Hughes, Shults, McGrath, & Medoff-Cooper, 2002). Next to such child characteristics, other environmental factors may need to be considered. We focused on maternal attention-directing behavior, but other types of parenting behavior might also play a role. Examples are parental sensitivity and intrusiveness, which were repeatedly found to be related to cognitive functioning (e.g., Tamis-LeMonda, Shannon, Cabrera, & Lamb, 2004). Furthermore, we focused on maternal behavior, but it might be important to include fathers as well, as paternal behavior was found to be related to child outcome (e.g., Verhoeven, Junger, Van Aken, Deković, & Van Aken, 2010). Next to focusing on the role of other factors of influence, it is important to investigate in future research how gestational age, attention capacities of the children, maternal stimulation of attention and cognitive functioning at toddler age are predictive of functioning of the children at school age.

The strength of the current study is that an integrated model of biological factors, child attention characteristics and maternal stimulation of attention was investigated in relation to cognitive outcome at 24 months in a longitudinal and multimethod design. Most previous studies focused on only one of these factors, or only on direct relations between various factors. Focusing on a combination of factors and on indirect effects provided more insight into which factors influenced the relation between biological risk (i.e., gestational age) and later developmental outcome. Gestational age is difficult to influence, but factors that increase or decrease the association of developmental outcome with low gestational age, like maternal behavior or child characteristics, might be a useful target for designing intervention or prevention programs.

A limitation of this study lies in the generalizability of the results as only relatively healthy preterm and term-born children, and only children born between 32 and 41^{+6} weeks of pregnancy, were studied. Only a few children in our study actually showed a mild delay in cognitive development, as indicated by a cognitive index score <85. Nevertheless, suboptimal development in attention capacities and in cognition might increasingly delay further development. Furthermore, our rather homogeneous sample of children of generally high educated mothers limits generalizability of our results. Also, the unequal distribution of number of children across the weeks of gestation might have biased our findings that are largely based on children born at 35 or 36 and 39 or 40 weeks of gestation. Future research should include a more evenly distributed sample. Next to that, the UTATE eye-tracking procedure used in this study is newly developed, and although the split-half reliability was good for most of the variables, further research regarding reliability and validity is still needed.

It is important to note that children who needed NICU admittance after birth were excluded from this study. This is a very small group, because only 1.6% of the children born between 32 and 41 weeks of gestation actually needs to be admitted to the NICU after birth (Perined, 2016). Nevertheless, this specific subgroup might have a higher risk for developmental difficulties (e.g., Baron et al., 2011), so it might be important to study this subgroup as well in future research. There are also indications that children born after 42 weeks of pregnancy have an increased risk for developmental difficulties as well (El Marroun et al., 2012). Finally, later follow-up evaluations are necessary to study the predictive value of the early assessments for development at school age.

In conclusion, an integrated model showed that gestational age had an indirect effect on cognitive functioning at 2 years of age, as this relation was mediated by orienting and alerting attention abilities of the children and maternal attention-directing behavior measured at 18 months of age. These findings reflect that a combination of biological risk, the children's attention capacities, and maternal stimulation of attention is associated with cognitive functioning at 2 years of age.

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