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Attention capacities of preterm and term born toddlers: A multi-method approach

Marjanneke de Jong *, Marjolein Verhoeven, Anneloes L. van Baar

Child and Adolescent Studies, Utrecht University, P.O. box 80140, 3508 TC Utrecht, The Netherlands

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ABSTRACT

Objective: Many preterm children show difficulties in attention at (pre)school age. The development of attention capacities of preterm and term toddlers was compared using a longitudinal and multi-method approach at 12, 18 and 24 months.

Method: Attention was measured for 123 preterm (32–36 weeks gestation) and 101 term born children, using eye tracking (18 months), observations during mother–child interaction (18 months), and mother-reports (12, 18, and 24 months).

Results: Preterm toddlers had lower scores than term children on the eye-tracking measures of orienting and alerting. No group differences were found with observations, mother-reports, and the eye-tracking measure of executive attention. More preterm than term children had suboptimal scores on measures of the alerting system at 18 months, possibly indicating difficulties in attention development.

Conclusion: Preterm children showed an increased risk for suboptimal functioning in alerting attention capacities, as early as at a toddler age.

1. Introduction

Around 9% of all children worldwide are born preterm after a gestational age of between 32 weeks and 36 weeks and 6 days [1]. These children are at increased risk for a wide range of cognitive, school and behavior problems [2], which include attention problems. When a child is born preterm, the brain is still immature. Therefore, brain development may have been affected in the neonatal period, which might result in attention problems or other difficulties in functioning [3]. Attention problems were reported in preterm children at preschool [4,5] and school age [6,7]. Furthermore, 6 to 19 year old preterm children were found to have an increased risk for Attention Deficit Hyperactivity Disorder [8].

The development of attention capacities of preterm children needs to be studied, since these capacities are a crucial part of everyday life, and attention problems might underlie other difficulties, such as cognitive problems [9]. Few studies as yet studied attention capacities in preterm children at toddler age. Studies at this age are important, because it is in this critical developmental phase that children gain increasingly more control over their attention capacities [10]. Furthermore, if differences between preterm and term born children are already noticeable at this age, early detection of difficulties in attention development might be facilitated. Such information could help designing interventions to improve these capacities and reduce problems in daily functioning.

Attention can be defined as a multi-dimensional construct including three attention systems: orienting, alerting, and executive attention [11]. Orienting represents the ability to engage, disengage, and shift attention. Alerting is the ability to achieve and maintain a state of alertness (i.e. sustained attention). Executive attention is a more self-generated form of attention, which is goal-directed and planned [11,12]. Research focusing on the three attention systems, as opposed to more general attention problems, could give more insight into the specific problems that preterm children might have, which would enable the development of intervention methods targeting these specific skills. Concerning very preterm children, born before 32 weeks' pregnancy, a few studies were done on the functioning of attention systems and these showed mixed results. There are indications that preterm children temporarily have better orienting skills (i.e. faster disengagement) during the first months of life than term born peers, but that this benefit disappeared after 3 to 4 months and the groups were found to perform equal [13–15]. At later age, both Snyder et al. [16] and Pizzo et al. [17] found that the preterm children performed slower than term children on all three attention systems at 4–6.5 years of age. In contrast, De Kievit et al. [9] found no group differences on the three attention systems at 7–8 years of age. Although it

* Corresponding author.
E-mail addresses: M.deJong@uu.nl (M. de Jong), J.C.T.Verhoeven@uu.nl (M. Verhoeven), A.L.vanbaar@uu.nl (A.L. van Baar).

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has been found that preterm children showed more attention problems [4,5], no studies were found as yet that investigated the functioning of the *separate attention systems* in detail in these children at toddler age.

Different methods may be used to measure attention, such as computerized tasks, observations and parent-reports. Previous studies with toddlers mainly used observations during play settings and/or questionnaires filled out by parents or caregivers in order to measure attention [18,19]. A few studies investigated the relation between different methods, multiple informants and varying contexts, to measure attention [18,20–22]. When mothers reported better sustained attention capacities at 13.5 months of age, more sustained attention was observed during a free play session in a lab setting [21]. Gaertner et al. [18] also found a (small) positive correlation between mother-reported and observed sustained attention at 30 months of age: children who had better sustained attention capacities according to their mother, were observed to play by themselves for a longer period of time. However, in the same study no relations were found between the assessments of sustained attention by different instruments, in different contexts or at different ages [18]. Wass [22] found no relation between peak look duration during computerized tasks, which can be considered a measure of the orienting system, and naturalistic/play tasks at 11 months of age. Davis et al. [20] also found no relation between maternal report and attention measured with computerized tasks at 4–5 years of age.

It might be the case that different methods focus on different systems of attention. It is not clear yet what instrument, or which combination of measurements, is the best method to obtain a good impression of the attention capacities of toddlers. Therefore, in the current study, attention capacities were measured repeatedly and by different types of instruments and informants. Recently, we have concluded that it is feasible to measure functioning of all three attention systems (i.e. orienting, alerting, and executive attention) in toddlers with a test battery of four computerized eye tracking tasks; the Utrecht Tasks of Attention in Toddlers Using Eye tracking (UTATE, [23]). Aside from the UTATE, video-taped observations during mother–toddler interaction in lab situations were used, as well as repeated mother-reports. The relationships between these different methods will be explored.

In the current study, attention capacities of preterm children born with a gestational age between 32 weeks and 36 weeks and 6 days, are compared to attention capacities of term born peers at toddler age using a multi-method approach with measurements at different time-points. Based on previous studies at (pre)school age [4–7], preterm children are expected to show suboptimal functioning, compared to their term born peers at toddler age, on the different indicators of attention capacities.

2. Method

2.1. Participants

Parents of preterm children born at a gestational age of 32 weeks and 36 weeks and 6 days in eight hospitals in and around Utrecht in the Netherlands were invited by letter by their pediatrician to participate in the study when their child was 10 months old. For the control group, parents of term born children with a gestational age of ≥37 weeks, born in four hospitals in and around Utrecht, were invited by letter by their midwives when their child was 10 months old to participate in the study. These children were all born between March 2010 and April 2011. For both groups, exclusion criteria were dysmaturity (i.e. birth weight below 10th percentile according to Dutch reference curves from Stichting Perinatale Registratie Nederland [24]), multiple births, admission to a tertiary Neonatal Intensive Care Unit, severe congenital malformations, antenatal alcohol or drug abuse by the mother, and chronic antenatal use of psychiatric drugs by the mother.

The medical ethical committee of the Utrecht Medical Center approved this study. Informed consent was given by the parents. The children received a small gift after the visit and the parents received refund of travel expenses.

2.2. Procedure

This study is part of an ongoing longitudinal project on the development of preterm children, the STAP Project (i.e. Study on Attention of Preterm children). When the children were 12, 18, and 24 months of age, corrected for prematurity, the mothers were asked to answer questionnaires concerning the development and behavior of their children and their parenting behavior. When the children were 18 months of corrected age, they visited our lab for an evaluation of attention capacities by means of an eye tracking procedure and an observation of mother–child interaction. The visits were planned in such a way that these would not interfere with the children's sleeping schedules. The eye tracking procedure was described in detail in BLINDED [25]. After the eye tracking procedure, the 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 afterwards.

2.3. Instruments

Attention capacities were measured by eye tracking techniques, observations, and questionnaires.

2.4. Eye tracking measures

The Utrecht Tasks of Attention in Toddlers using Eye tracking (UTATE) was used at 18 months of age to measure attention capacities, using four tasks: 1) a disengagement task, 2) a face task, 3) an alerting task, and 4) a delayed response task [25]. 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 children's 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, preceded in half of the trials by a signaling sound. The alerting task consisted of 32 trials. In the *delayed response task*, a dog was hiding in one of two visible doghouses and after a certain interval (i.e. varying from 0–10s) the child was asked to search for the dog. This task consisted of 18 trials in which the interval increased from 0–10 s with steps of 2 s after three consecutive trials. The tasks are described in more detail elsewhere [25]. For the total group of children, the split half reliability of the UTATE was found to be good (r = .71–.95) for nine of thirteen variables. Moreover, evidence for construct validity was found as a Confirmatory Factor Analysis showed that the different aspects coded during the four tasks (see Table 1) could be reduced to three latent constructs: orienting, alerting and executive attention [23].

The amount of root mean square (RMS) noise of the eye tracking signals is a measure of data quality. Comparison of the RMS noise between the preterm and term born group showed no significant difference, indicating that the quality of the eye tracking data was equal across the two groups, Wilk's $\Lambda = .93$, $F_{8,190} = 1.88$, $p = .07$.

A measurement invariance test on the factor structure that was confirmed in a sample of term born children [23], following the procedure described by Van de Schoot et al. [26], showed scalar invariance. This indicated that the same factor model applied to the preterm sample, and enabled a comparison of the mean scores on the three latent constructs across the two groups. Hence, scores on the latent

Table 1
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" [36]
Transition rate	DIS, FACE	The number of transitions (i.e., "movement from one AOI to another", [36]) 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" [36]
Latency difference	AL	Difference between latencies in the trials in which the stimulus appeared without signal (no-signal trials) and the trials in which a signal preceded the appearance of the stimulus (i.e., 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 the child to find the dog.
Mean delay	DR	The mean delay between hiding and the instruction to find the dog in the trials in which the child correctly searched for the dog.

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

constructs were used as measures of attention. For all constructs, higher scores were considered to be indicative of better attention skills.

2.5. Observational data

Mother–child interaction was observed in a lab setting at 18 months of age, in a room with a play mat on the floor, and a table and chair on the other 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 the mothers were instructed to play with their child as they would do at home for 5 min (free play).Then the mothers were asked to read a book with their child for 5 min (task situation). Finally, the mothers were asked to make a puzzle with their child, again for 5 min (task situation).

The video-taped data were coded afterwards with the Coding Interactive Behavior observational system which is a global rating system [27]. In the current study, the child subscale "On-Task Persistence" was used as measure of functioning of the alerting system. On-task persistence is defined as persistence of a child for one activity, without quickly skipping from one activity to the next. On-Task Persistence was coded during both the unstructured free play (i.e. the first 5 min) and the structured task setting (i.e. 5 min reading a book and 5 min making a puzzle together) on a 5-point rating scale varying from low (1) "the child showed little persistence (i.e. lack of focus) and often moved from one activity to another activity" to high (5) "the child was consistently focused on one activity". One score was given for the total observation period of the free play setting (i.e. 5 min) and one score for the total observation period of the structured task setting (i.e. 10 min).

The scales were coded by nine trained and independent observers who were unaware of the birth status of the children. Interrater reliability, based on 21% of the videotapes that were double coded, was acceptable with an intraclass correlation of 0.76.

2.6. Questionnaires

The subscales "Attention Focusing" and "Attention Shifting" of the Early Childhood Behavior Questionnaire (ECBQ) [19] were used at 12, 18 and 24 months of (corrected) age. Attention Focusing is a measure of functioning of the alerting system, and Attention Shifting measures the orienting system. These subscales both consist of 12 descriptions of behaviors. The mothers had to rate how often their child engaged in the behaviors during the last two weeks on a 7-point Likert scale varying from "never" (1) to "always" (7). Subscale scores consist of the average of the 12 items of that subscale. Cronbach's α of the

Table 2
Neonatal and demographical characteristics of the participants.

	Term born GA 37–41 weeks n = 101	Moderately and late preterm GA 32–36 weeks n = 123
Age in months wave 1		
Mean (SD)	11.5 (.7)	11.4 (.7)
Range	11–15	11–14
Age in months wave 2		
Mean (SD)	17.3 (.5)	17.3 (.5)
Range	17–18	17–19
Age in months wave 3		
Mean (SD)	23.7 (.9)	23.3 (.5)**
Range	23–30	23–25
Gestational age in weeks		
Mean (SD)	39.5 (1.0)	34.7 (1.3)***
32 weeks (%)		9.8%
33 weeks (%)		11.4%
34 weeks (%)		17.1%
35 weeks (%)		24.4%
36 weeks (%)		37.4%
37 weeks (%)	4.0%	
38 weeks (%)	10.9%	
39 weeks (%)	31.7%	
40 weeks (%)	40.6%	
41 weeks (%)	12.9%	
Birth weight in grams		
Mean (SD)	3572 (457)	2585 (517)***
Range	2795–5330	1420–3850
Gender (% boys)	45.5%	56.9%
First born (%)	51.5%	63.4%
Days in hospital		
Mean (SD)	.4 (1.0)	11.9 (9.8) ***
Range	0–6	1–42
Need for oxygen[a](%)	0%	21.1%***
Photoherapy (%)	0%	35.0%***
Hypoglycemia (%)	0%	4.9%*
Ethnic origin (% Dutch)	96.0%	96.7%
Maternal education level		
Low[b]	3.0%	8.9%***
Medium[c]	11.9%	36.6%***
High[d]	85.1%	54.5%***
Maternal age at birth		
Mean (SD)	32.6 (4.2)	31.1 (4.5)**
Range	20–43	21–41

Note. [a]i.e. additional oxygen right after birth, nasal cannula, and/or continuous positive airway pressure (CPAP; n = 17); [b]no education, elementary school, special education or lower general secondary education; [c]high school or vocational education; [d]college, university or higher; *p < .05; **p < .01; ***p < .001.

attention focusing subscale varied between .86 and .88, and between .66 and .73 for the attention shifting subscale.

2.7. Neonatal and background characteristics

Neonatal characteristics concerning hypoglycemia (yes or no), phototherapy (yes or no), possible need for additional oxygen, and duration of hospital stay were based on the discharge letters in the hospital files. Background characteristics were provided by the parents on a short questionnaire.

2.8. Data analysis

Analyses of Covariance (ANCOVAs) were used to examine group differences on background characteristics. Multivariate Analyses of Covariance (MANCOVAs) were used to study group differences on eye tracking measures, and Repeated Measures ANCOVAs for group differences on observations and mother-reports.

The distribution of the scores between the two groups will be compared using boxplots, to evaluate if equal numbers of children showed low scores and possibly suboptimal functioning or actual problems in attention development. Furthermore, all scores on the attention measures were also dichotomized using one SD below the mean of the term born group as cutoff point. Such scores were defined as "suboptimal scores", indicating suboptimal attention capacities. Differences in percentages of suboptimal scores between the two groups were investigated with Logistic Regression Analyses and Chi-squared tests. The relationships between measures from different types of instruments and informants were investigated by Pearson Correlations.

3. Results

Parents of 123 out of 333 eligible preterm children (37%) consented to participate in this longitudinal study and data on at least one of the outcome variables was available for all of them. The participating preterm children did not differ from nonparticipants in gestational age, birth weight, number of days in hospital, additional oxygen requirement, phototherapy requirement, gender, and percentage of first born children. A slightly higher incidence of hypoglycemia was observed in nonparticipants (11.2% vs 4.9%, $\chi^2 = 3.76$, $p = .05$). Parents of 103 out of 457 term born children (23%) consented to participate and data was available for 101 (98%) of them. The participating term born children did not differ from nonparticipants in gender, gestational age, birth weight, number of days in hospital, additional oxygen requirement, phototherapy requirement, hypoglycemia, and percentage of firstborns.

Sample characteristics are shown in Table 2. Mothers of preterm children were more often low educated than mothers of term born children ($\chi^2 = 24.11$, $p < .001$). In addition, mothers of preterm children were slightly younger when their child was born (M = 31.1 years, SD = 4.5) than mothers of term born children (M = 32.6 years, SD = 4.2, $F_{1,222} = 6.96$, $p = .01$). Therefore, all analyses were adjusted for maternal education level and maternal age at birth. At 24 months of age (wave 3), preterm children were slightly younger according to their age corrected for prematurity (M = 23.3 months, SD = .5) than term born children (M = 23.7 months, SD = .9; $F_{1,207} = 11.38$, $p = .001$). As this age difference only occurred at wave 3, and adjusting for this age difference did not influence the results, we will only report the analyses in which no adjustment for the children's age was made.

3.1. Differences between preterm and term born children on attention measures

The mean scores and percentages of children per group with suboptimal scores (i.e. > 1 SD below mean of the term born group) for preterm and term born children on the 11 attention measures are presented in Table 3.

3.2. Orienting system

A significant difference in mean scores between the groups was found for orienting, as measured with eye tracking ($F_{1,192} = 6.37$, $p = .01$, partial $\eta^2 = .03$), with preterm children scoring below their term born peers. Inspecting the boxplot (see Fig. 1) shows a lower mean score for the preterm group while the distribution of the scores

Table 3
Mean scores and percentage of children with suboptimal scores on attentional measures.

	Term born GA 37–41 weeks			Moderately and late preterm GA 32–36 weeks				
	n	Mean (SD)	% suboptimal scores	n	Mean (SD)	% suboptimal scores	OR	95% CI OR
Orienting system								
Questionnaires								
Attention Shifting								
12 months	94	4.55 (.67)	14.3%	107	4.57 (.76)	17.6%	1.25	.58–2.72
18 months	94	4.62 (.58)	20.2%	107	4.62 (.62)	19.8%	1.22	.60–2.46
24 months	94	4.74 (.56)	15.6%	107	4.81 (.57)	14.4%	1.11	.50–2.47
Eye Tracking (18 months)								
Orienting	95	.00 (.53)	13.7%	101	−.23 (.41)*	19.8%	1.08	.47–2.46
Alerting system								
Questionnaires								
Attention Focusing								
12 months	94	3.75 (.81)	16.3%	107	3.73 (.88)	19.3%	1.07	.51–2.26
18 months	94	3.93 (.76)	14.1%	107	3.78 (1.00)	25.9%	1.86	.89–3.86
24 months	94	4.47 (.72)	16.8%	107	4.25 (.90)	29.7%	1.74	.86–3.54
Observations (18 months)								
On-task persistence								
Free play	98	3.33 (.73)	4.1%	116	3.20 (1.00)	19.0%	5.81**	1.87–18.00
Task	98	3.43 (1.00)	10.2%	116	3.13 (1.13)	25.9%	2.33*	1.03–5.23
Eye Tracking (18 months)								
Alerting	95	.00 (.49)	13.7%	101	−.33 (.61)**	38.6%	3.23**	1.54–6.75
Executive attention system								
Eye Tracking (18 months)								
Executive attention	95	.00 (.89)	13.7%	101	−.02 (.45)	4.0%	.18*	.05–.67

Note. Adjusted for maternal education level and maternal age at birth. OR = Odds ratio, CI = confidence interval; *p < .05, **p < .01.

seems equal across the groups. Comparing the percentages of suboptimal scores between the groups indeed showed no difference between the preterm and term born group in number of children with suboptimal orienting abilities.

No group differences were found on mother-reported Attention Shifting at 12, 18 and 24 months of age for both mean scores ($F_{1,197} = .01$, $p = .91$, partial $\eta^2 = .00$), as well as the amount of suboptimal scores. This can also be seen in the boxplots (Fig. 1), where both the mean scores as well as the distribution of the scores seem to be equal across the groups.

The amount of children having suboptimal scores on at least two of the four orienting attention measures is equal across both groups (13.8% in preterm versus 11.9% in term born group, $\chi^2 = 0.19$, $p = .67$).

3.3. Alerting system

Preterm children scored significantly below term born peers on the mean scores of alerting as measured with eye tracking ($F_{1,192} = 8.89$, $p = .003$, partial $\eta^2 = .04$). This is also visible in the boxplot (see Fig. 2). This boxplot also shows a different distribution of the scores between the two groups, with more lower scores in the preterm group. Comparison of the percentage of suboptimal scores showed that more preterm children had suboptimal scores on functioning of the alerting system as measured with eye tracking (OR = 3.23, p = .002) in comparison to the term children.

Regarding observed On-Task Persistence in both the free play and the task setting at 18 months of age, no group differences were found in mean scores ($F_{1,\ 210} = 1.23$, $p = .27$, partial $\eta^2 = .01$). Inspection of the boxplots (Fig. 2) indicates a quite equal distribution of scores between the groups for the free play setting. In the task situation, however, there seems to be a larger number of preterm children with low scores. Comparison of the percentage of suboptimal scores indeed showed a larger number of preterm children with suboptimal scores in both the free play (OR = 5.81, p = .002) and the task setting (OR = 2.33, p = .04).

No group differences were found in mean scores on mother-reported Attention Focusing at 12, 18 and 24 months of age ($F_{1,197} = .46$, $p = .50$, partial $\eta^2 = .002$). Although the boxplots (Fig. 2), seem to indicate somewhat more lower scores in the preterm group, comparison of the percentage of suboptimal scores showed no differences between the groups at 12, 18 and 24 months of age.

Of the preterm children, 42.3% had suboptimal scores on at least two of the six alerting attention measures; twice as many as in the term born group (21.0%, $\chi^2 = 11.34$, $p = .001$).

3.4. Executive attention system

Preterm children did not differ from term born children regarding mean scores on executive attention as measured with eye tracking ($F_{1,192} = .27$, $p = .60$, partial $\eta^2 = .001$). The distributions of the scores seem to differ between the groups (see Fig. 3), with a larger variation in scores in the term born group. The percentage of suboptimal scores on Executive Attention was found to be significantly smaller in the preterm group than in the term born group (OR = .18, p = .01).

3.5. Relations between outcomes of different types of instruments and informants

Correlations between the different attention measures are presented in Table 4. Generally, no significant correlations were found between the outcomes of different instruments and informants, with a few exceptions between some measures of the alerting attention system,

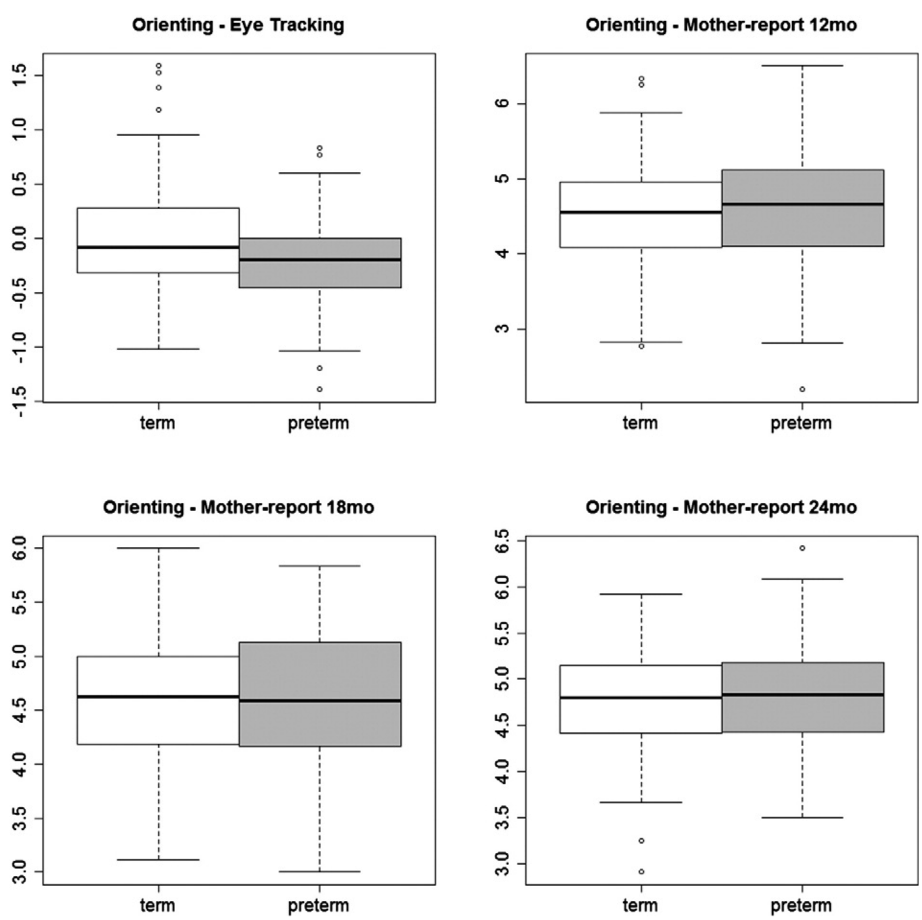

Fig. 1. Boxplots of the orienting attention measures.

which did not show a great effect. Observed on-task persistence in a task setting at 18 months of age was positively related to both the eye tracking measure of alerting at 18 months of age ($r = .21$, $p < .01$), and mother-report of Attention Focusing at 24 months of age ($r = .19$, $p < .01$).

4. Discussion

The preterm children were found to differ from term born children in orienting and alerting attention abilities as early as at a toddler age. As a group, preterm toddlers scored lower than term born peers on orienting and alerting as measured with eye tracking. Additionally, a two to five times larger subgroup of preterm children showed suboptimal scores on the alerting attention system, as measured with eye tracking, as well as with observations of mother–child interaction (both the free play and the task setting). Furthermore, more than 40% of the preterm children had suboptimal scores on at least *two out of the six* alerting measures; twice as many as in the term born group. This suggests that an important subgroup of preterm children shows, as early as at a toddler age, suboptimal capacities in focusing their attention for a longer period of time.

Previous studies found that preterm children showed an increased risk for attention problems at preschool [4,5] and school age [6,7]. The findings of the current study indicate that differences in attention capacities between preterm and term born children are already detectable at toddler age. The finding that our moderate to late preterm born toddlers scored lower on orienting and alerting abilities was in accordance with two of the three previous studies on very preterm, school-aged, children [9,16,17]. An explanation for the differences in attention capacities of preterm and term born children might lie in differences in brain development. Preterm children are born with a still immature brain, not only regarding size (i.e. at 34 weeks the brain weighs only 65% of a brain at term), but also regarding structure [3]. Recently, it was found that at term age, the brain of preterm children was still smaller and had a different structure compared to that of term born infants [28]. This indicates that brain development outside the uterus differs from brain development inside the uterus, which might be related to later functioning and development. Brain areas involved in orienting and alerting capacities are the parietal lobes, frontal eye fields, and the thalamus [29]. Further research to study whether those specific brain areas might differ between preterm and term born children and if this could explain the differences in attention capacities is worthwhile.

Preterm children as a group had lower scores than term born children on the orienting system as measured with eye tracking, whereas no differences appeared in the number and percentage of children with suboptimal scores on this measure. This might indicate a different distribution, and there with a possibly different developmental trajectory of the orienting attention capacities for the two groups. This adds to previous findings that in infancy, preterm and term born children showed a different developmental trajectory regarding latency of gaze shifts, also a measure of the orienting system [13–15]. Longitudinal studies of the development of functioning of the orienting system are needed to investigate whether the two groups continue to differ in their development.

The results regarding executive attention showed no mean difference between the two groups; the percentage of suboptimal scores was even smaller in the preterm group compared to the term born group. This finding differed from two of the three studies on very preterm children, that showed that preterm children were outperformed by their term born peers [9,16,17]. This difference in findings might be explained by the gestational age of the children. The previous studies

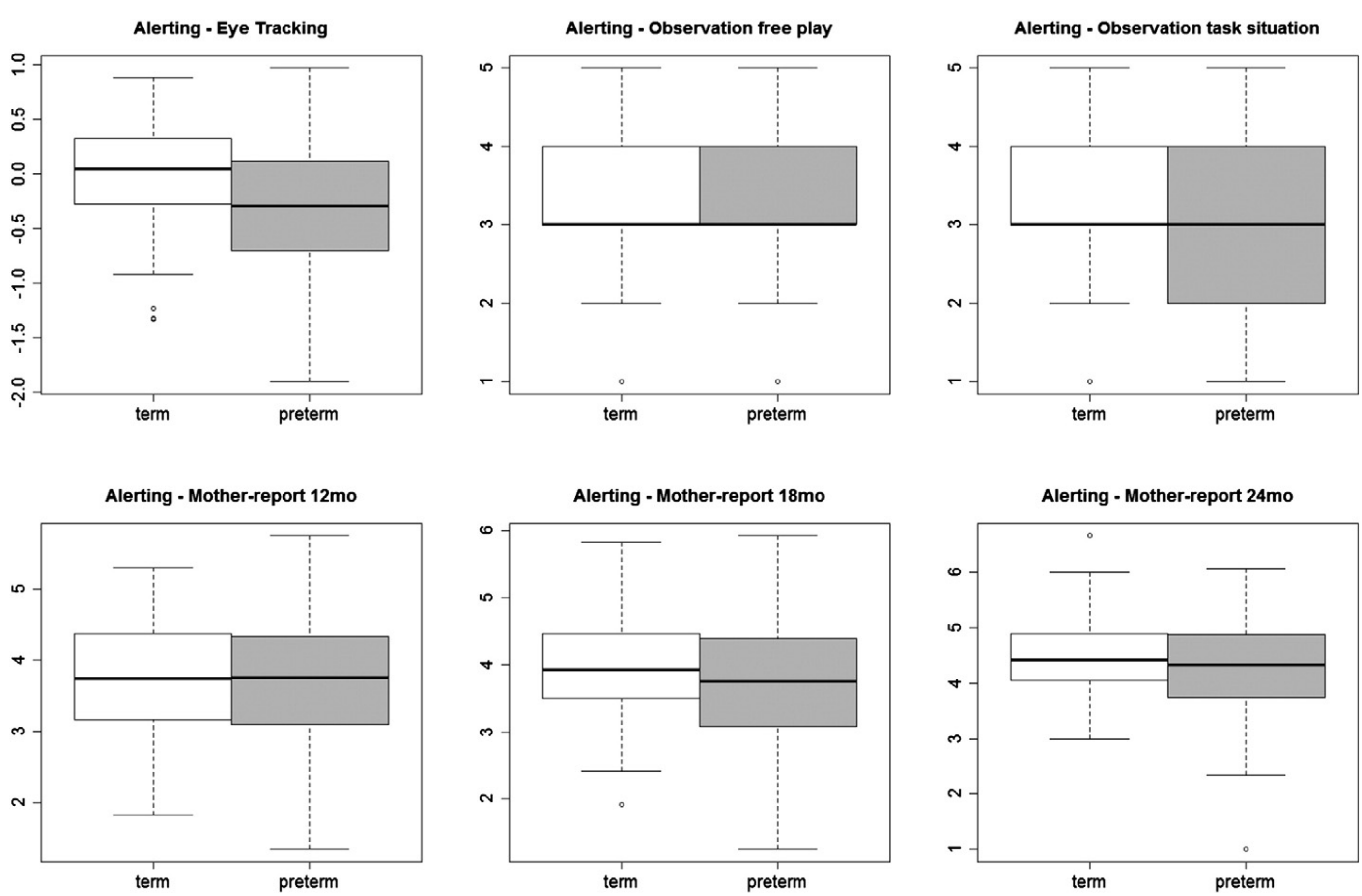

Fig. 2. Boxplots of the alerting attention measures.

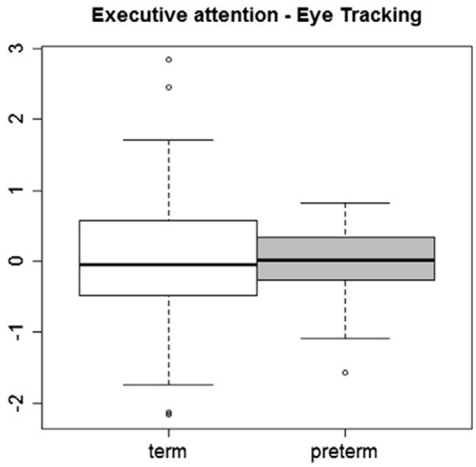

Fig. 3. Boxplot of the executive attention measure.

concerned very preterm children who were born more immature and experienced more neonatal difficulties after birth than the preterm children in our study, putting these children at a higher risk for attention problems. It is possible that there are no problems in the development of executive attention in preterm children. The difference in findings might also be explained by differences in the age at which the children's attention skills were studied. Snyder et al.[16] and Pizzo et al.[17] examined the children when they were 4–6.5 years of age, while in our study the children were only 18 months old. Executive attention only starts to develop at this young age [10] and so the difference between preterm and term born children may not yet be visible. Finally, it might be that the measurements used did not capture the construct of executive attention sufficiently. No tasks were available as yet to measure executive attention directly [25]. We therefore used a task that was supposed to measure functioning of the dorsolateral prefrontal cortex [30], a brain area that is involved in executive functioning [11]. It is not clear if this task sufficiently measures executive attention. In addition, the score on this attention system was based on only two indicators, both from the last task in the test battery. Further research is needed to investigate whether this task is a sufficiently reliable and valid measure of executive attention.

No differences were found in mother-reports in any of the three ages, in mean levels or in percentages of suboptimal scores, despite the differences found in attention capacities using eye tracking and observational measures. It is possible that attention difficulties at these ages are not yet apparent to the parents. The differences in the methods used to evaluate the attention capacities may also be an important factor. The questionnaires concerned attention in everyday situations, as opposed to both the eye tracking and observational measures, which were about attention in a (social) lab context. While questionnaires were answered by mothers, the eye tracking measures were technical measures, and the observations were coded by trained observers. Furthermore, the questions and response options in the questionnaires were of a general nature, while the eye tracking measures were very specific and precise. The attention of a child during mother–child interaction is probably also influenced by the mother.

It might also be the case that preterm children primarily experience more difficulties with attention in task situations. Both the eye tracking procedure and the observation were task situations: the child had to sit behind a computer screen, or play with his/her mother as instructed by the experimenter — even in the more unstructured situation labeled 'free play'. In contrast to the eye tracking procedure and the observations, the questionnaires concerned 'voluntary' attention, in natural situations at home.

Overall, the different contexts used during the assessments may trigger specific or different aspects of attention capacities, which is also reflected in the generally low correlations between the measures. It should, however, be noted that the UTATE eye-tracking procedure used in this study is newly developed, and although the variables included as a measure of attention were based on existing literature, further research, e.g. regarding predictive validity, is still needed. Furthermore, future research should also be focused on the relationship between different instruments and informants, as well as on the predictive value of these measures for later functioning, in order to learn which measures are the most useful for early detection of attention difficulties.

A limitation of this study might concern the generalizability of the findings. The relatively low response rate might have resulted in a biased sample, which was found to include many good functioning children of highly educated parents. The number of low educated mothers was small in both the preterm and term born group. As there were more low educated mothers in the preterm group, the analyses were controlled for maternal educational level. However, low maternal

Table 4
Correlations between the different attention measures.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Orienting system											
Questionnaires											
Attention shifting (ECBQ)											
1. 12 months	1.00										
2. 18 months	.46**	1.00									
3. 24 months	.41**	.51**	1.00								
Eye tracking (18 months)											
4. orienting	.02	.11	.07	1.00							
Alerting system											
Questionnaires											
Attention focusing (ECBQ)											
5. 12 months	.16*	.19*	.09	.11	1.00						
6. 18 months	.15*	.39**	.32**	.18*	.48**	1.00					
7. 24 months	.05	.27**	.33**	.14	.34**	.61**	1.00				
Observations (18 months)											
On-task persistence											
8. free play setting	−.22**	−.20**	−.19**	.07	−.13	−.10	−.05	1.00			
9. task setting	−.11	−.02	−.03	.23**	−.07	.11	.19**	.36**	1.00		
Eye tracking (18 months)											
10. alerting	.02	.09	−.004	.72**	.07	.13	.11	.12	.21**	1.00	
Executive attention system											
Eye tracking (18 months)											
11. executive attention	.06	.03	−.02	.30**	.09	.06	.08	.04	.04	.52**	1.00

Note.* = $p < .05$, ** = $p < .01$.

education level is a risk factor for premature birth [31,32]. Correcting for maternal education level might therefore be a form of overcorrection. Future research including a sample with more low educated mothers would allow investigation of the relationship between maternal education level and child outcome in both preterm and term born children. In addition, in this study only preterm children were included who did not need tertiary NICU admittance. Although this concerns the largest group of preterm children in the Netherlands (89.8% [33]), the results might be different for the subgroup of children who needed admission to the NICU. For example, a recent study found that especially the children who were admitted to the NICU experienced problems in cognitive functioning [34]. Maternal level of education, as well as other background characteristics associated with preterm birth and development of the children, such as gender of the child and neonatal characteristics, should be studied in greater detail in a more diverse sample in future research in relation to attention problems.

Attention difficulties are often not diagnosed until children fall behind their peers in other domains of functioning, for example school functioning [20]. In this study, preterm children were, as early as at a toddler age, found to show an increased risk for less optimal functioning in attention capacities. By focusing on the three attention systems instead of more general measures of attention, we found that preterm children specifically experienced difficulties in alerting attention capacities, and to a lesser extent in orienting capacities. These difficulties with alerting and orienting capacities might result in problems with learning other skills, as the ability to orient and sustain attention for a longer period of time, for example listening to instructions of a teacher, is needed to be able to learn new things. Therefore, further study and follow-up at older ages of attention capacities in preterm children is warranted. If the first signs of attention difficulties are already present and detectable at toddler age, even if these are only noticeable as suboptimal functioning, children could be supported sooner in their attention development using interventions. For example by a training to increase their focused attention using games, designed for toddlers [35] or by instructing parents how to stimulate the attention capacities of their children.

Conflict of interest

No conflict of interest to declare.

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