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Preverbal skills as mediators for language outcome in preterm and full term children

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ABSTRACT

Language delay is a well documented problem that occurs on a higher rate in preterm children compared to full term children. Preverbal social skills, such as the ability to share attention to an object with another person (i.e., triadic interaction), are suggested to reflect part of the processes through which children learn language. This longitudinal study examined preverbal and verbal skills in 25 preterm and 35 full term children in order to investigate if birth status affects language development through the proposed mediating processes of preverbal dyadic and triadic skills. Dyadic initiatives during the still-face episode were assessed at 6 months. Triadic responsiveness (gaze following) was examined at 9 and 14 months. Triadic initiatives (joint attention and behavioral request) were also assessed at 14 months. At 30 months, receptive and expressive language was examined. The data showed group differences in 6-month dyadic initiatives, 9-month triadic responsiveness, 14-month triadic behavioral request initiatives and 30-month receptive and expressive language skills at the expense of the preterm children, confirming their risk for a less favorable preverbal and verbal development. Multiple mediation analyses confirmed the hypothesis that birth status affects language development partially through preverbal skills, which is important for clinical practice.

Birth status can strongly influence the early developmental trajectories of children, illustrated by the association between preterm birth and adverse minor and major neurodevelopmental outcomes on multiple domains [4,40,47,49]. It is well documented that a disproportional high rate of preterm children develops language delay [16,35,41,48]. The biological risk associated with preterm birth influences later development, as elevated risk on language delay comes together with lower gestational age and birth weight, and as certain medical conditions related to preterm birth increase this risk [4,5]. However, it is highly improbable that children are predisposed from birth on to develop language delay, and the causal relationship between preterm birth and language development is not straightforward, as is illustrated by the high heterogeneity of language skills in this at risk group. The question of concern in the current study is to investigate if preverbal communicative skills can be a potentially affected process making preterm children at increased risk for language delay.

Normative development shows that during the first months of post term life, the social-communicative skills of an infant develop in a dyadic infant–caregiver context [6,39]. This dyadic interaction lays the foundation for subsequent development such as the acquisition of triadic skills [42,50], attachment [9] and behavioral outcome [23]. The infant's social-communicative skills gain tremendous complexity when the infant proceeds from communication in a dyadic face-to-face interaction to a triadic child–person–object interaction throughout the first year of postnatal life. In this triadic context, infants coordinate and share attention with another person around a third object or event with the intention to share an experience (i.e., joint attention) or to obtain a goal (i.e., behavioral request) [26]. In a triadic context, an infant can follow the direction of gaze or gestures of another person (i.e., responding) or the infant can try to direct the attention of the person himself (i.e., initiating). The age of emergence of the triadic skills is typically situated in the second 6 months of postnatal life, although it varies according to the specific skill that is the scope of investigation. For example, 6-month-old infants can follow the direction of gaze when the target is located within their visual field and when no other distracting objects are present [25], and it is with growing age that infants become able to follow gaze in situations with more complex spatial layouts [22].

In this preverbal stage, before elevated language delay in preterm children is of concern, differences in the social-communicative development are present between preterm and full term children. In the first 6 months of life, preterm infants show more negative affect and withdrawn behavior during interactions [12], they vocalize less in response to the utterances of their mother [34] and they are less active

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Table 1
Medical characteristics of the preterm sample ($N = 25$).

	M	*SD*	Range
Birth weight (g)	1296.00	412.82	520–2240
Gestational age (weeks)	29.44	1.80	26–32
Apgar score 1 min	6.24	2.39	1–9
Apgar score 5 min	7.40	2.16	1–9
Time on respirator (days)	4.84	5.37	0–21
Time on oxygen (days)	22.20	31.06	0–100
Time in NICU (days)	55.76	30.21	16–121
		N	%
Small for gestational age[a]		4	16
Respiratory distress syndrome		14	56
Grade III/IV		1	4
Intraventricular hemorrhage		4	16
Grade III/IV		2	8

Note.
[a] Birth weight below 10% of the population mean for a given gestational age.

(sounds, smiles, and responsiveness) during feeding situations [15] as opposed to full term infants, although age is corrected for prematurity. Also in triadic interactions, preterm children seem to be less competent. Especially the amount of initiations seems to be significantly lower in preterm children [10,14,18], although evidence can be found that the responding joint attention capacities are also affected by preterm birth [31].

Several studies reported that the better these triadic skills are developed and the more frequently they are being used by a child, the better the process of language acquisition will be [7,24,26,28,30]. Although few studies investigated this relationship in preterm children, the same correlation has been reported in this at-risk group. Preverbal triadic skills in 13-month old preterm infants predicted the language skills of the children in toddlerhood [46] and in middle childhood apart from variance explained by the cognitive development of the children and apart from biomedical risk [38]. Among the different triadic skills, the ability to initiate triadic interactions both with a proto-declarative (joint attention) and a proto-imperative (behavioral request) function was the most consistent predictive factor of later outcome.

It is assumed that triadic skills are important because the ability to share attention with another person creates a context for the child to map a word to the correct object or activity of shared attention [30]. Although later in life children can also learn words without the process of mutual sharing of attention (e.g., listening to the interactions of others; [2,3]), it can be assumed that, especially early in life, the more infants are motivated to initiate triadic interactions with another person, the higher their chances on 'learning word'-experiences will be. Furthermore, the social motivation to interact is already present within a dyadic interaction [6,39], before the emergence of triadic skills, and it can be assumed that these early dyadic skills will also be related to language development, although this relationship is not well-studied.

In sum, there is evidence that preverbal skills are important within the process of language acquisition. Although studies report that preterm children are at higher risk for a less optimal development of preverbal and verbal skills, to our knowledge, no study addressed the question if the effect of preterm birth on language development is partially mediated through preverbal skills, and no study used analytic techniques to investigate this mediation.

In this study, preterm and full term children were longitudinally assessed on preverbal (i.e. dyadic and triadic skills) and verbal skills. At 6 months, infants interacted with a stranger in a dyadic context, which was interrupted by a still-face episode [45], during which the interaction partner suddenly adopted a neutral still-face and became unresponsive. It has been shown that infants will try to elicit responsiveness in the adult via re-engagement behavior [42], and this re-engagement behavior in infants reflected the dyadic skills. At 9 months, the triadic ability to follow gaze (responsiveness) to a target situated at the side was assessed. At 14 months, both initiatives as well as responses in triadic situations were assessed. Eventually, the receptive and expressive language skills were assessed at 30 months.

First, it is expected that the preverbal and verbal development will be affected by preterm birth, such that group differences will be found at all ages at the expense of the preterm children. Second, preverbal skills are expected to partially mediate the link between birth status and language acquisition. We do not expect complete mediation as other processes, such as parent interaction style and the amount of language input a child receives, will be of additional importance [8]. Increased knowledge in this domain can enhance clinical practice, as knowledge on the processes that are important within language acquisition can offer possibilities for social-communicative assessment at an age language skills are not yet assessed, and additionally, can suggest possible mechanisms on which to intervene.

1. Method

1.1. Subjects

The sample consisted of 35 full term and 25 preterm infants. The preterm infants were recruited by a neonatal intensive care unit and were included in this study if they had a gestational age of 32 weeks or less at birth. Table 1 shows the medical characteristics of the preterm sample. Infants were excluded from the study if they were diagnosed by the attending neonatologist with sensory impairments, meningitis, encephalitis, symptomatic congenital syphilis, congenital abnormality of the brain, or short bowel syndrome. They were also excluded if the primary caregiver was younger than 18 years of age, abused drugs, or was non-Dutch speaking. Six additional preterm infants and their parents (19%) did not wish to participate for a variety of reasons.

The full term group consisted of infants who were born after a normal pregnancy history, between 38 and 42 weeks of gestation. Physical exam was normal at birth. The same exclusion criteria as in the preterm group counted for the primary caregiver. The infants and their parents were recruited by local primary health services and hospitals. The mean socio-economic status score (SES; [17]) was based on the educational and occupational levels of both parents and indicated that families were from middle to high SES. SES differed marginally significant, $F(1,59) = 3.22$, $p < .10$. Full term infants had a slightly higher SES background. The groups did not differ on gender ratio and birth order; however, there were more boys than girls in both groups (see Table 2). The parents gave their consent for

Table 2
Demographic characteristics of the preterm and full term samples.

	Preterm ($N = 25$)		Full term ($N = 35$)	
Variables	*N*	%	*N*	%
Gender				
Male/female	19/6	76/24	22/13	63/37
Birth order				
First born/ later born	16/9	64/36	19/16	54/46
	M	*SD*	*M*	*SD*
Socio-economic status[a]	43.46	10.08	47.95	9.19
Age (days)[b]				
Six months	185.54	5.73	181.58	4.39
Nine months	270.62	4.66	273.62	4.66
Fourteen months	430.08	9.97	420.91	3.93
Thirty months	921.44	17.88	923.91	13.96

[a] Hollingshead [17].
[b] Age corrected for prematurity.

participation and received a small gift and a videotape of the sessions. The study was approved by the ethical committee.

1.2. Procedure

Infants were invited at the laboratory within 10 days before or after the date they became 3, 6 and 9 months, and within 14 days before or after the age of 14 and 30 months. These intervals were chosen for practical reasons. However we tried to see all the children as close as possible around the above mentioned ages. Age was corrected for prematurity at 3, 6, 9 and 14 months. The data at 3, 6 and 9 months are presented elsewhere (names deleted to maintain the integrity of the review process). Only part of the 6- and 9-month data are repeated in the present article and extended with the data at 14 and 30 months.

Wave nonresponse was present in the data, such that data for some children were missing at 6 months (preterm: $n=6$; full term: $n=9$), at 9 months (full term: $n=9$), at 14 months (preterm: $n=5$; full term: $n=10$) and at 30 months (preterm: $n=5$; full term: $n=2$). The main reasons for the missingness were fussiness or fatigue during the examination (mainly at 6 and 9 months), illness during the time period of examination and technical failure. In addition, at 14 months problems to make appointments with the parents arose due to several reasons, that were mainly practical, rather than due to a lack of interest (because most of them participated at a later age): parents were too busy, families were on holiday, the occupancy rate of the research laboratory was high what made it difficult to attune the agenda of the researcher to the agenda of the parents. These practical reasons led to data missing completely at random for 10 children at that age. At 30 months, the parents of 3 preterm children refused to participate due to lack of time. These reasons made us to conclude that the missingness was completely at random (MCAR; [37]). Moreover, Little's [21] MCAR chi-square was nonsignificant, confirming that the pattern of missingness indeed was completely at random. Schafer and Graham [37] pointed out that listwise deletion is not a good way to deal with missing data (in this study, we would lose half of the sample when using listwise deletion) and described maximum likelihood (ML) or Bayesian multiple imputation as 'the state of the art' when data are missing at random. Therefore, the Expectation-Maximization (EM) algorithm [11], available in SPSS, an iterative imputation method computing ML estimates [37], was used to impute the missing data, so that $N=60$ for all analyses. All analyses were also conducted with the dataset in which the data were not imputed (thus, listwise deletion), yielding similar results, but with less power, as could be expected if missingness was completely at random.

The procedure took place in a child development laboratory room, covered with black curtains to prevent visual distraction. Children were not allowed to have a toy or pacifier during the experiment. There was a warm-up phase for each child until the parent and/or the experimenter judged that the child was at ease.

1.2.1. Dyadic interaction at 6 months

The infant was seated in a commercial seat, placed on a table. Two cameras on the ceiling recorded the experiment and were mixed into a split-screen. One camera made a close-up of the child. The other camera recorded the infant as well as the experimenter from the side, mainly focused on the face of the infant. Infants were placed in the seat by the caregiver when he or she judged that the infant was alert and quiet. The caregiver then left the room and followed the experiment through a monitor. A female experimenter (E) examined the children. Another experimenter timed the interaction, out of view of the child, and visually cued E when to start and stop each condition. E interacted with the infant, without touching him or her.

A modified still-face procedure was carried out, based on Striano and Rochat [42]. The procedure lasted three minutes and consisted of three episodes of one minute each. In the first episode, E interacted with the child in a playful way, by singing, vocalising, smiling, and imitating the infant. After this first episode, E suddenly adopted a still face for one minute. She became silent, displayed a neutral, static, unresponsive face while keeping eye contact with the infant. In the third episode, E resumed the normal interaction with the infant.

Infant measures were duration of: (1) smiling: cheeks raised and upturned motion of at least one corner of the mouth while gazing to the experimenter, (2) positive vocalising: vocalisation while gazing to the experimenter, and (3) motor re-engagement actions: clapping, waving, banging, and reaching to the experimenter while gazing to the experimenter.

The Observer (Noldus) was used to analyse all tapes. Coding of all behaviors was performed at half-speed by two coders. They were blind to the birth status of the children and they had no knowledge about personal or familial information of the children. They only knew in general that the research was about the social-communicative development of preterm and full term children. Twenty percent randomly selected tapes were double coded. A tolerance window of one second was accepted. Cohen's Kappa was .89 or higher for all variables across groups.

In order to limit the number of variables, and as there were no specific hypotheses that one of these variables would have stronger predictive value than the others, these three measures were combined to be used in the analyses. A composite score of the z-scores of the three variables (in percentage duration of time) was computed.

1.2.2. Triadic interaction at 9 months

The same set-up was used as at 6 months, however, infants were seated in a highchair. Two black stands, one to the right and one to left of the infant, were placed approximately 75 cm and 35° away from the infant's midline. A bright-colored toy of 12 cm was placed on each stand. Infants interacted with E for five minutes. E did not touch the infants during the experiment. Minutes 1, 3 and 5 consisted of normal, dyadic interactions between infant and E during which E was singing, smiling, imitating and/or talking to the infant. Based on Striano and Stahl [43], minutes 2 and 4 consisted of two different gaze following conditions. In the normal gaze following condition, E alternated her attention between one of the objects and the infant. She looked away from the infants to look at the object for about 5 seconds, smiled and said phrases such as 'What a nice thing' or 'The thing is yellow and red' with a quiet but positive tone of voice. E turned back to the infant, established eye contact for about five seconds while talking and smiling. She repeated the same procedure for one minute. In the modified gaze following task, E looked for the whole one minute at the target object, without alternating attention between the object and the infant. She continued to talk and smile at the object. The same types of phrases as in the first condition were used. The order of the conditions was counterbalanced across infants. These two different conditions were used to test a hypothesis that was not in the scope of this article.

Infant measures were duration of: (1) gazing to the experimenter: looking at the face of E1, (2) gazing to the target object, (3) gazing to the non-target object, and (4) gazing away: looking away from the objects and the experimenter (e.g., looking at the ceiling, own feet or in the direction of the target object but not exactly). The tapes were coded in the Observer (Noldus) by two independent coders. Cohen's Kappa was .87 or higher for all variables across groups.

Following Flom and Pick [13] reliable gaze following was computed by subtracting the percentage duration of gazing at the non-target object from the percentage duration of gazing at the target object. This latter variable (i.e., percentage reliable gaze following averaged over the two gaze following conditions, namely minutes 2 and 4) will be the variable of interest in the results section. A repeated measures analysis of variance showed that there was no difference in reliable gaze following in both conditions.

1.2.3. Triadic interaction at fourteen months

The Early Social Communication Scales [27] were assessed. This is a structured play observation that elicits triadic skills in children. Infants sat at a table on the caregiver's lap in front of E. A camera was positioned sideward behind E, and videotaped the session with a frontal view of the infant's face and upper body, and a sideward view of E. Several toys were placed on a table next to E within the view but out of reach of the infant. Four posters hung on the wall. Two of them were positioned 90° to the left and right of the infant and the other two were 160° left and right behind the infants. During the assessment, toys were presented one at a time to the infants as described in Mundy et al. [27]. Several wind-up mechanical toys and hand-held mechanical toys were presented at the infant mainly to elicit triadic *initiations* from the infants. First, the toys were activated in front but out of reach of the infant. Thereafter the infant was allowed to play shortly with the toy. Each toy was presented for 3 times. The posters served to assess gaze/point *following* skills of the infant. First, E brought the infant's attention to her face, where after, E tried to direct the attention of the infant toward the posters (left, left behind, right, and right behind).

Additionally, the ability to follow commands was assessed, and several social interactions were administered, however, these were not in the scope of the current investigation. The ESCS measures of initiating joint attention (IJA), initiating behavior request (IBR) and responding joint attention (RJA) were of interest and were scored based on Mundy et al. [27]. IJA-low level contained the frequency of (a) making eye contact with E while manipulating a toy and (b) alternated eye contact between E and an active toy. IJA-high level contained the frequency of (a) pointing toward an active or distal toy and (b) showing of an object while making eye contact with E. IBR-low level contained the frequency of (a) making eye contact and (b) reaching at an object with or without eye contact when an active toy has ceased or when an object is moved out or reach. IBR-high level contained the frequency of (a) pointing at a toy that is out of reach and (b) giving a toy to E in order to get aid. RJA-side and RJA-behind contained the percentages of time infants followed the line of regard correctly toward the poster positioned at the side and behind the infants.

The tapes were coded by two coders who were trained to code the ESCS with the aid of the ESCS reliability tape. To examine the interrater reliability 15 randomly selected videotapes (25% of the sample) were double coded. Single measure intraclass correlations were IJA-low = .78, IJA-high = .85, IBR-low = .79, IBR-high = .83, and RJA = .95.

1.2.4. Receptive and expressive language at 30 months

The Dutch version of the Reynell Developmental Language Scales (RTOS; [36]) was administered. This is an examiner administered, standardized test designed to assess language acquisition in young or developmentally delayed children, and is used for children between 2 and 5 years. It yields scores for receptive and expressive language.

1.3. Analysis plan

Different statistical analyses were performed. First, a multivariate analysis of variance (MANOVA) was performed to investigate if the preterm group differs from the full term group on the preverbal and verbal skills, as would be in line with literature. Second, Pearson correlations were computed between the preverbal and verbal skills to investigate the premise that these skills are interrelated. Third, receptive and expressive language scores were the outcome variables in two multiple hierarchical regression analyses. These analyses were performed to investigate the unique contribution of birth status and of preverbal skills to explain variance in the verbal skills. At last, bootstrapping was used to investigate the hypothesis that birth status partially affects language acquisition indirectly through the preverbal skills as multiple mediators. Bootstrapping is highly recommended by Preacher and Hayes [32] to assess multiple mediation, especially in small sample studies.

2. Results

2.1. Group differences

A MANOVA was performed on the 8 preverbal and 2 verbal skills with group (preterm versus full term) as between-subject variable. The preverbal and verbal skills were significantly affected by group, $F(10,49) = 5.93$, $p < .01$ (Wilks' criterion). The tests of between-subjects effects (see Table 3) yielded that preterm infants showed less re-engagement behavior during the dyadic still-face episode at 6 months than full term infants. They showed less reliable gaze following (duration) at 9 months to a target positioned within their visual field. At 14 months, the preterm children showed less frequent initiations of behavioral request on both a low and high level. They followed gaze

Table 3
Group differences in preverbal and verbal skills.

Preverbal skills	Preterm infants		Full term infants		*F*(1,59)	ω^2 (effect size)
	M	*SD*	*M*	*SD*		
6 months						
Dyadic re-engagement[a]	−.21	.44	.15	.76	4.413*	.054
9 months						
RJA-side[b]	6.14	11.88	15.68	12.50	8.856**	.116
14 months						
RJA-side[c]	78.40	21.21	78.82	25.31	*ns*	.000
RJA-behind[c]	22.11	25.26	33.86	34.15	*ns*	.018
IJA-low[d]	4.91	1.49	4.78	1.58	*ns*	.000
IJA-high[d]	0.60	0.76	0.87	0.95	*ns*	.005
IBR-low[d]	1.78	0.80	2.63	0.76	17.087**	.211
IBR-high[d]	2.05	1.93	3.86	1.69	14.895**	.188
30 months						
Receptive language	21.62	9.98	32.25	8.15	20.600**	.246
Expressive language	17.93	11.34	33.67	12.37	25.264**	.288

[a] Composite of z-scores of the percentage of time the infant tried to re-engage the experimenter (smiles, vocalizations and motor actions).
[b] Percentage duration of gazing at the target minus gazing at the non-target.
[c] Frequency of gaze following (in percentage).
[d] Frequency of initiations (relatively to the total amount of time the object was presented to the child).
* $p < .05$.
** $p < .01$.

Table 4
Interrelations between preverbal and verbal skills ($N = 60$).

	1	2	3	4	5	6	7	8
6 months								
1. Dyadic re-engagement	–							
9 months								
2. RJA-side	.11	–						
14 months								
3. RJA-side	.37**	.10	–					
4. RJA-behind	.01	.40**	.52**	–				
5. IJA-low	−.12	−.05	−.03	−.14	–			
6. IJA-high	.11	.04	.05	.02	−.07	–		
7. IBR-low	.19	.34**	.05	.10	.31*	.22†	–	
8. IBR-high	.19	.28*	.17	.08	.05	.36**	.16	–
30 months								
9. Receptive language	.22†	.31*	.12	.33*	.20	.22†	.37**	.39**
10. Expressive language	.29*	.30*	.19	.38**	.13	.23†	.17	.53**

* $p<.05$.
** $p<.01$.
† $p<.10$.

to a similar degree as full term children at 14 months when the target was at the side or behind the children. Preterm children initiated joint attention interactions to a similar degree as full term children. Regarding the verbal skills at 30 months, the mean receptive and expressive language scores were significantly lower in preterm children than in full term children.

2.2. Preverbal and verbal Skills

Pearson correlations were computed between the preverbal skills (see Table 4). The 6-month dyadic re-engagement composite score was positively related to RJA-side at 14 months. RJA-behind at 14 months was positively related to RJA-side at 9 and 14 months. Regarding the correlations between responding and initiating of triadic interactions, only RJA-side at 9 months was positively correlated with IBR-low and IBR-high at 14 months.

Regarding the correlations with the verbal skills, dyadic re-engagement at 6 months was positively related to expressive language at 30 months and marginally related to receptive language. Triadic responding to a target at the side at 9 months and to target behind the child at 14 months was positively correlated with receptive and expressive language at 30 months. Furthermore, initiating joint attention and behavior request interactions on a high level at 14 months were respectively marginally and significantly related to both receptive and expressive language. Last, initiating behavior request interactions on a low level at 14 months was positively related to receptive language at 30 months.

2.3. Predictive value of birth status and preverbal skills

Multiple hierarchical regression analyses were computed separately for receptive and expressive language. In Step 1, group was entered. In the next step(s), only the preverbal skills that were significantly correlated with the receptive or expressive language scores were entered in order to reduce the amount of variables. Preliminary analyses showed that RJA-side at 9 months and RJA-behind at 14 months lost their predictive value when they were both entered into the model due to collinearity, and therefore RJA-side at 9 months was excluded.

The hierarchical linear regression for receptive language yielded that birth status was an important variable to explain variance within the receptive skills, and that, in addition to this, the preverbal skills improved the model with marginal significance. Of the variables that were correlated with receptive language, only triadic responding to a target behind the child at 14 months predicted receptive language on top of group (see Table 5). The addition of SES in a third step yielded no significant results, $F_{change}<1$, $ß=.11$.

The hierarchical linear regression to explain variance in expressive language existed of four steps. The 6-month dyadic skill was entered in Step 2 as this skill chronologically preceded the triadic skills assessed at 14 months that were entered in Step 3. The analyses revealed that triadic responding to a target behind the child at 14 months, and initiating behavioral request on a high level at 14 months explained unique variance on top of birth status (see Table 6). The 6-month dyadic skills and the initiating joint attention skill on a high level at 14 months did not explain additional variance on top of these variables. The addition of SES in Step 4 of the analyses yielded no significant effect, $F_{change}=2.55$, *ns*, $ß=.15$.

2.4. Mediation analyses

The hierarchical linear regression revealed that some preverbal skills explained unique variance in verbal skills on top of the variance

Table 5
Stepwise linear regression to predict receptive language.

Variables	R	Adjusted R^2	ß	F change
Step 1 $df=(1,59)$	.55**	.29		
Group			.55**	
Step 2 $df=(4,56)$	.64**	.35		2.393†
Group			.37**	
RJA-behind 14 m			.25*	
IJA-high 14 m			.07	
IBR-low 14 m			.12	
IBR-high 14 m			.16	

* $p<.05$.
** $p<.01$.
† $p<.10$.

Table 6
Stepwise linear regression to predict expressive language.

Variables	R	Adjusted R^2	ß	F change
Step 1 $df=(1,59)$	.54**	.28		
Group			.54**	
Step 2 $df=(2,58)$	.56**	.29		2.435
Group			.50**	
Dyadic re-engagement 6 m			.18	
Step 3 $df=(4,56)$	.71**	.46		6.930**
Group			.31**	
Dyadic re-engagement 6 m			.15	
RJA-behind 14 m			.31**	
IJA-high 14 m			.04	
IBR-high 14 m			.33**	

** $p<.01$.

explained by birth status. Furthermore, the standardized coefficient of group decreased when the preverbal skills were included in the model (see Tables 5 and 6). In the last step of the analyses, it was investigated if preverbal skills are partially mediating the relationship between birth status and language outcome. Bootstrapping was used to investigate this. It is a nonparametric resampling procedure that yields confidence limits for indirect effects. Preacher and Hayes [32] developed a macro for SPSS to compute multiple mediation via bootstrapping, which was used in the present study with 5000 resamples. The bootstrap method gives bias-corrected and accelerated intervals for the indirect effect of group (IV) on the verbal skills (DV) through the preverbal skills as the proposed mediators. If zero is not included in the 95% confidence interval, it can be concluded that an indirect effect is different from zero ($p<.05$).

2.4.1. Receptive language

The proposed mediators were RJA-behind, IJA-high, IBR-low and IBR-high at 14 months, as these variables were correlated with receptive language. The analyses yielded that these four variables were mediating the relationship between birth status and receptive language. The 95% CI of the total indirect effect was estimated between .8529 and 8.6032. However, the specific indirect effects of the preverbal skills were not significantly different from zero, for RJA-behind, [−.1345, 2.8041], IJA-high, [−.2558, 1.6217], IBR-low, [−.9280, 4.5417] and IBR-high, [−.3775, 4.4484]. The direct effect of birth status to receptive language remained significant, 6.18, $p<.05$.

2.4.2. Expressive language

Dyadic re-engagement at 6 months, RJA-behind, IJA-high and IBR-high at 14 months were the proposed mediators. The true indirect effect was estimated to lie in the 95% CI between 1.1432 and 12.8731. There was a specific indirect effect of IBR-high, [.0077, 9.6804]. No other specific indirect effects were found, for dyadic re-engagement, [−.1777, 3.3235], for RJA-behind, [−.3093, 4.9277], and for IJA-high [−.4451, 2.2540]. The direct effect of birth status to expressive language remained significant, 8.66, $p<.01$.

3. Discussion

The present study confirms earlier findings on the risk that preterm birth poses on the social-communicative development of children. Significant group differences were found each time moment of the assessment. Preterm children showed less re-engagement attempts during the still-face episode at 6 months, they followed gaze to a target at the side to a lesser degree at 9 months, and they were less inclined to reach, point, or give something in order to get aid or to receive an object (i.e., IBR-low and IBR-high) at 14 months. The frequency of responding and initiating joint attention bids at 14 months did not differ between the groups. At 30 months, the outcome of preterm children was less favorable, as they had a significant lower score for receptive and expressive language than full term children. The percentile scores gave evidence for problems (<pc 16) in receptive and expressive language for respectively 44% and 60% of the preterm sample.

As was found in observational studies in normally developing children [7,26,28], children with autism [1] and – of particular interest – children born preterm [38,46] and as was found in questionnaire-based research in population cohort studies [33], the data gave evidence for the predictive value of preverbal communication skills in the context of language acquisition. The correlational data indicated that children who showed more dyadic re-engagement attempts at 6 months, who followed gaze to a target at the side longer at 9 months, who followed gaze to a target behind them more frequently at 14 months and who initiated triadic interactions (IBR-high, IBR-low, and IJA-high) more frequently at 14 months had more favorable receptive and/or expressive language scores at 30 months.

It is known from previous work that both preverbal and verbal skills can be affected by preterm birth [10,12,16,18,34], and that the capacity to initiate triadic interactions in preterm children, both for declarative (joint attention) as for imperative (behavior request) reasons, can predict verbal skills apart from the variance explained by biomedical risk [38,46]. As an extension to this work, the main objective was to investigate if preterm birth affects language acquisition partially through the mediating effect of preverbal skills. The multiple hierarchical regression analyses revealed that some preverbal skills explained unique variance of language acquisition on top of birth status. Of the preverbal skills that were correlated with receptive language, only the ability to respond to joint attention bids to a target situated behind the child at 14 months explained unique variance of receptive language. For expressive language, both responding (RJA-behind) as initiating (IBR-high) triadic interactions explained variance on top of the variance explained by birth status. One possible reason that IBR-high was a more valuable predictor than IJA-high in the model to predict expressive language is methodological: the procedure at 14 months elicited more higher-level behavioral request initiations than higher-level joint attention initiations in the sample, making its variability more present.

As the parameter estimates of group (preterm versus full term) decreased after the inclusion of the preverbal skills in the hierarchical model, this signals for the assumed mediating effect of the preverbal skills. To strengthen this conclusion, bootstrapping analyses were used. These analyses yielded a significant indirect effect between birth status and language acquisition through the preverbal skills that were correlated with receptive and expressive language. Taken as a set, responding (RJA-behind) and initiating (IBR-low, IBR-high and IJA-high) triadic interactions at 14 months mediated the effect of birth status on receptive language. For expressive language, initiating triadic interactions at a high level (IBR-high) was the most important mediator, as the other preverbal skills did not contribute to the indirect effect above and beyond this preverbal skill. To our knowledge, this study is the first to provide evidence that part of the relationship between birth status and language acquisition can be explained by preverbal skills. In conclusion, it seems that preterm birth affects preverbal skills, which are on their turn affecting the process of language acquisition. This is one step further in exploring processes leading to less favorable outcome in preterm infants.

The addition of the preverbal skills as mediating variables did not cancel out the direct effect between birth status and language acquisition. Obviously, additional processes are important in explaining the developmental link between preterm birth and language delay. Apart from biological factors related to the preterm birth, it is known that, for example, the language input a child receives is important [8], especially when it follows into the focus of attention of the child [7]. Also, it is known that children from at least 2 years onwards, are additionally learning words by listening to conversations of others during which speech is not directed to them [2,3].

The findings of the study can open new perspectives for intervention. Stimulating preverbal skills, both responses as well as initiatives, can improve the prognosis of the language development in preterm children. There is evidence that preverbal skills in preterm children are susceptible to intervention, as an approach which focuses on parental responsiveness can have a positive effect on preterm infants' growth in social-communicative skills [19,20].

Apart from the main objective of the current study, other results are worth highlighting. The findings of the current study fit best within the theoretical framework of the parallel and distributed information-processing model (PDPM; [30]), postulating that underneath the ability to share attention there are unique processes – in addition to common processes – differentially related to different triadic skills. One hypothesis extracted of this model and confirmed by the current data is that there would be more evidence of correlations *within* triadic dimensions (as RJA-behind at 14 months was correlated with RJA-side at 9 and 14 months) than *between* triadic dimensions (as no correlations between frequency of initiating and responding triadic bids at 14 months were found). In addition, different triadic skills were differentially related to language acquisition.

What is less highlighted in that model is that the manifestation of a specific triadic dimension is not static, but will have other expressions dependent on the age of measurement. Responding to joint attention when the target is situated at the side will develop at an earlier stage than when the target is located behind the child [22]. Regarding our data, RJA-side at 9 months and RJA-behind at 14 months were valuable predictors of language acquisition, whereas RJA-side lost predictive value at 14 months. This suggests that the capacity to follow the direction of regard to an object at the side is consolidated around the age of 14 months, making its variability less present and less important among children at that age. However, the data show that the RJA-behind gains importance at that age.

Also the initiating triadic skills are age-specific as higher level initiations comprise behaviors that develop in a further stage of development than the lower level initiations [29]. Regarding our data, the ability to initiate triadic interactions at a higher level at 14 months was a more valuable and consistent predictor of language acquisition than lower level initiations. In sum, it seems valuable to differentiate *within* triadic initiatives (different levels) and *within* triadic responsiveness (different locations in space) in preterm as well as in full term children.

The study gives limited evidence for a developmental link between dyadic functioning and triadic and language development. Children who tried longer at 6 months to re-engage the interaction partner were more inclined to follow gaze/point to a target situated at the side at 14 months and had developed better expressive language at 30 months. These data suggest that there seems to be some continuum in the social-communicative development, beginning in the first months of life in a dyadic frame, gaining complexity with the entrance of triadic skills and going through to the acquisition of language.

Limitations must be acknowledged. First, longitudinal studies often suffer from missing data, and this was also the case in the current study. A complete data set is something to aim for. However, especially at the age of 14 months a rather large proportion of the data was missing (one quarter of the sample). Efforts were made to handle the missing data as it is currently advised although it is always debatable if the proportion of missing data at 14 months was not too large. Although the analyses yielded similar results with the method of listwise deletion, the analyses were less efficient as they lacked power. Moreover, rather than the proportion of missing data, the fact that data are missing at random (MAR) or completely at random (MCAR) is a necessary criterion for estimation of the missings [37], and M(C)AR is not related to the proportion of missing data in a study. Therefore, we preferred to impute the missing data, even at 14 months, as is recommended in Schafer and Graham [37]. Second, in the model to predict language acquisition based on the preverbal skill, we could not control for general cognitive abilities. However, as in previous studies [26,38], we would expect that controlling for general aspects of cognitive development would not remove the predictive power of preverbal skills. What we learn from those studies is that preverbal and verbal skills are not merely an expression of general cognitive abilities. A third important remark is that preverbal and verbal skills were assessed in interaction with a stranger. The advantage of this is that we had more control on the standardization of the assessment. The disadvantage is that placing the focus on the development within a child over time does not pertain to make conclusions on the important transactions between the child and his proximal environment. However, given the relatively complex data that were collected, this remark can better be interpreted as a departure point for other studies. A forth limitation, related to the previous one, is that we did not include variables such as gender and birth order into the analyses. In studies with a larger sample size it would of interest to investigate the effect of gender and birth order on top of the effect of preterm birth. A last remark is that the study permits us to make conclusions based on the group level, but that it is far more difficult to make conclusions on the individual level. In their cohort-study, Thal, Bates, Goodman, and Jahn-Samilo [44] had to conclude that making individual predictions of language status based on demographic and communication factors was far more difficult and less reliable as one-third of the children were misclassified. In practice, it stays hard to give an individual prognosis for children based on their birth status and preverbal development. However, together with previous work, congruence is growing that (1) preverbal skills, chiefly triadic skills, are of particular importance within the context of language acquisition and (2) that preverbal skills can partially mediate the link between birth status and language development.

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