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The influence of biological, social, and developmental factors on language acquisition in pre-term born children.

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A large number of studies have provided evidence that certain developmental skills such as motor and cognitive abilities, recall and phonological-working-memory, lexical and grammatical development are at risk in premature children. This is the case even in those children who do not have perinatal and neonatal problems (Sansavini, Guarini, Alessandroni, Faldella, Giovanelli, & Salvioli, 2006; Sansavini, Guarini, Alessandroni, Faldella, Giovanelli, & Salvioli, 2007; Rose, Feldman, & Jankowski, 2005). Two sets of factors have been associated with delay. First, a biological factor, both specific to pre-term birth, e.g., weight at birth, gestational age, weight considering gestational age, and aspecific such as gender. The second factor is social and includes socio-economic status and mother's education level. In recent years, various studies have focused on language development as being a good early proxy for other areas of developmental (behavioral, social and cognitive) disorders. However, no consensus has been reached regarding which factors influence linguistic development (Sajaniemi, Hakamies-Blomqvist, Mäkelä, Avellan, Rita, & von Wendt, 2001; Marston, Peacock, Calvert, Greenough, & Marlow, 2007). The influence of gestational age on vocabulary size, measured at 24 months of chronological age with the French Communicative Development Inventory (Kern, 2003), was evaluated by Kern, & Gayraud (2007). This study compared moderately pre-term (MPT - 37 weeks gestational age), very pre-term (VPT - less than 32 weeks gestational age), and extremely pre-term (EPT - less than 28 weeks gestational age) children with a control group of full-terms (FT). Results indicated that extremely pre-term and children who were very preterm showed significantly inferior scores to full-terms. On the contrary, children with a gestational age higher than 37 week did not differ from FT children in any of factors examined. However, in the study of Marston, et al., (2007) at 24 months of corrected age children born between 23 and 28 weeks of gestation had a lexicon similar to that of FT group.

The role of birth weight is even more controversial. Le Normand, & Cohen (1999) found significant differences between pre-term children and full-terms in the number of main, auxiliary and non-finite verb types and tokens produced during the observational session at chronological ages 3;6 and 5;0. However these authors found no differences between the three sub-groups into which preterm children had been subdivided (ELBW - a birth weight less than 1000 g; VLBW – a birth weight less than 1500 g and LBW – a birth weight less than 2500 g). Further, in a longitudinal study from 9 to 24 months of corrected age, Stolt, Haataja, Lapinleimu, & Launonen (2009) found a slower growth of receptive lexicon and poorer language skills (measured by the Finnish version of CDI, Lyytinen, 1999) in VLBW children, compared to FT children. This result contradicts what these authors found in a previous study (Stolt, Klippi, Launonen, Munck, Lehtonen, Lapinleimu, Haataja, & The Pipari Study Group, 2007), in which no differences of vocabulary size were detected between VLBW and FT children at a corrected age of 2;0.

Some of these disagreeing results could be due to the intervening effect of other variables which interact in complex ways with gestational age or weight. For example, Stolt, et al. (2007) found a significant effect of gender (with an advantage of females) on measures of language development in the control group, but not in the group of pre-term children characterized by very low birth weight. Further, maternal education level was associated with the vocabulary size in VLBW, unlike in the control group. Sansavini, et al. (2006) also found an interaction between birth weight and gender, but in the opposite direction to that of Stolt, et al. (2007). No differences emerged between males and females in the control group, while ELBW males produced less words with respect to ELBW females.

As suggested by some authors (i.e., Menyuk, Liebergott, Schultz, Chesnick, & Ferrir, 1991; Menyuk, Liebergott, & Schultz, 1995; Siegel, 1982), prematurity could have a multifactorial diagnosis, with interactions between biological and social factors determining very different outcomes. So, it is fundamental to distinguish and consider several variables at same time, i.e., birth weight, gestational age, mother's education level, SES, etc. Furthermore, premature children exposed to clinical risk factors, i.e. fetal distress, infection or sepsis, respiratory distress syndrome, and metabolic problems, have severely delayed language developmental outcomes in comparison with premature children without severe disabilities (Largo, Molinari, Comenale Pinto, Weber, & Duc, 1986). They should thus be considered a specific sub-group (Marston, et al., 2007).

Most of the studies cited above evaluated language development by means of measures related to vocabulary size or word production. Further, assessment took place mostly at the end of the second year of life, a period in which a typically developing child has a well consolidated amount of lexical items. It would however be interesting to carry out evaluations at earlier ages to investigate if the pre-linguistic communicative competence of preterm children differs from that exhibited by full-terms and whether the slowness of vocabulary development also has an aversive effect on subsequent syntactic competence. Moreover, communicative and language development cannot be considered to be isolated skills. They are influenced and in turn influence other developmental competences, cognitive, social and emotional (Bloom, 1994). According to Rose, Feldman, Jankowski, & Van Rossem (2005, 2008), it is possible that later deficits evidenced by PT children may have their roots in infancy, due to the nature and interrelationships of the primary abilities scaffolding complex cognitive thought. In this view, pre-term birth can determine the loss of efficiency in some basic abilities or processes which influence the final outcome of language development. More specifically, Rose, et al. (2005, 2008) proposed a model of infant cognition which puts forth two central tenets. First, infant cognition is posited to be characterized by a cognitive cascade in which more fundamental or basic abilities underpin more complex ones that, in turn, influence general intelligence. Second, the measures of infant information processing involved are believed to mediate the relation between birth status and later cognition. Using data from a longitudinal study of PT and FT, their study (Rose, et al., 2008) evidenced how 12-month abilities (attention, processing speed, recognition, recall, and representational competence) mediated the relation between prematurity and mental development at 2–3 years, and how continuity and change in infant information processing from 7 to 12 months affected later outcome. The results indicated that two further basic abilities (attention and processing speed) influenced the more complex ones, which in turn influenced later cognition. In a similar way, Jansson-Verkasalo, Čeponiené, Valkama, Vainionpää, Laitakari, Alku, Suominen, & Näätänen (2003), and Jansson-Verkasalo, Korpilahti, Jäntti, Valkama, Vainionpää, Alku, Suominen, & Näätänen (2004) argued that the linguistic difficulties of VLBW children may be the effect of scarce abilities in auditory processing. In fact, the processing and categorization of brief, rapidly changing auditory stimuli is one of the basic skills critical to the acquisition of language. Difficulties in this ability may cause successive disease in language development. Sansavini, et al. (2007) highlighted the negative influence of a very immature preterm birth on phonological working memory, which can result in a delay in grammatical abilities. This perspective has been also found useful in interpreting individual differences in typical development: early combinatorial capacities depend on lexical abilities and both influence the more advanced syntactical productions (Bates, Bretherton, & Snyder, 1988; Devescovi, & Caselli, 2007; Caselli, et al., 1999).

In line with this approach, our study aims to evaluate language outcome in pre-term children considering a number of variables whose effects may differ as a function of the developmental stage. More specifically, we hypothesized that the effect of biological (prematurity, birth weight and gender) and social (maternal education level) factors are greater during the early developmental stages, influencing the acquisition of first communicative capacities (preverbal communicative utterances), while the acquisition of more advanced linguistic abilities (i.e. combinatorial and syntactic abilities), is mainly affected by the previously acquired communicative skills.

In our study communicative and linguistic capacities were evaluated at four different developmental stages: at 14 months of age, when infants pronounce their first words and babbling and gesturing (in particular, the use of deictic gestures such as pointing) are well established; at 24 months, when lexical abilities are quite advanced in typical development (on average, Italian children produce about 160 words at this age, see Caselli, Pasqualetti, & Stefanini, 2007); at 30 months, when the first multi-word utterances begin to be produced; at 36 months, when the acquisition of abstract syntactic categories is presumably acquired and children begin to produce syntactically complete utterances. In order to maintain (methodological) continuity pre-terms' age was calculated from the expected date of delivery (i.e. corrected ages) for all assessments, even though usually it is no longer used after the end of the second year of life. Considering that Menyuk, et al. (1991) found a delayed phonological, receptive and productive competence (measured during observational sessions) for VLBW, with respect to FT children over the first three years of life when chronological age was used, but not when comparisons were made on the basis of corrected age, a finding of delayed development at the more advanced ages in our pre-term children would be even more impressive.

Method

INSERT ABOUT HERE TABLE 1 AND 2

Participants

The sample consisted of 36 monolingual Italian infants and their mothers: 18 pre-term (PRE-TERM GROUP, PTG) infants and 18 healthy full-term (FULL-TERM GROUP – FTG) matched for age (chronological in FTG and gestational in PTG group); participation criteria for the first group was a birth weight between 750 and 1600 g (3 children were ELBW, 13 VLBW and 2 LBW), a gestational age ≤ 37 weeks (3 children were EPT, 10 VPT and 5 MPT), and the absence of prenatal and postnatal medical complications (see table 1 and table 2 for further information). The PTG and FTG groups did not differ significantly with respect to gender (Chi square = 1.83, $p < .176$) or maternal education level (Chi square = 3.167; $p < .205$).

Background clinical data on pregnancy, birth and the perinatal period were obtained from the "*Unità di Terapia Intensiva Neonatale* [Neonatal Intensive Therapy Unit]" of the Hospital of Bari (Italy), from 2005 to 2007.

Procedure

This longitudinal study included several sessions with the children, which were conducted, coded and analyzed in the observational laboratory of the Department of Psychology of the University of Bari (Italy). The corrected age was used for the PTG; the children's ages were calculated from the expected date of delivery. The use of corrected age during the first two years of life in pre-term children is a commonly accepted method used to compare the development of pre-term and full-term children at the same developmental age (Wolke, & Meyer, 1999). In this study corrected age was used also at 30 and 36 months, due to the longitudinal design, in order to maintain the same type of comparison with full-term children, whose ages are matched with corrected ages of pre-terms.

Assessment at 14 months of age (T1)

In order to verify the absence of serious cognitive or motor problems in pre-term and full-term children, during the first session, the children's motor and cognitive levels were measured using the Psychomotor Development Index (PDI) and the Mental Development Index (MDI) from the Bayley Scales of Infant Development (Bayley, 1993) (six full-term children missed this session). Following the Motor and Mental assessment, mother and child participated in a 3 minute video-recorded interaction session, during which the mother fed the child.

Assessment at 24 (T2) and 30 months of age (T3)

During the second and the third assessment, mothers and children participated in a 30-minute unstructured video-recorded play session (two pre-term children missed the session video-recorded at T3). After the video-recorded session, mothers were invited to fill in the Italian version of the MacArthur Communicative Development Inventory - *Primo Vocabolario del Bambino* – PVB (Caselli, et al., 2007) (one pre-term child did not participate in the 24 and 30 month vocabulary assessments).

Assessment at 36 months of age (T4)

During the fourth and final session, another 30-minute unstructured play session was video-recorded (one pre-term and three full-term children missed the video-recorded session).

Table 3 reports coding and measures for the different assessment times.

INSERT ABOUT HERE TABLE 3

Instrument

The Bayley Scales of Infant Development (Bayley, 1993). The PDI include items that assess the child's motor control, coordination, balance, dynamic movement, fine motor movements, perceptual-motor integration, and motor planning. The MDI is based on a child's performance on items that measure sensory-perceptual accuracy and discrimination, object constancy, memory, learning and problem-solving abilities, psycholinguistic ability, and generalization and classification abilities. The two Index scores obtained by PDI and MDI were used to compare groups.

The Italian version of the MacArthur Communicative Development Inventory - *Primo Vocabolario del Bambino* – PVB (Caselli, et al., 2007). The Italian version of CDI is modelled as closely as possible on the English version in terms of overall format, number and type of lexical categories and the number of items. The Italian Toddler form ("*Parole e Frasi*", corresponding to the "*Words and Sentences"* form of the CDI) contains a vocabulary production checklist of 670 words divided into 23 categories, including nouns, verbs, adjectives, function words, sound effects and animal sounds, people, games and routines, modal verbs, as well as another two sections designed to assess morphological and syntactical production. We only considered vocabulary production in this study.

The video-recorded session. During the first session (T1), video-recorded at home, the mother fed the child. This session lasted only 3 minutes. During the 30-minute unstructured video-recorded play sessions conducted at T2, T3 and T4, 5 different sets of toys were used in order to provide a wide vocabulary range: a farm, a "nurturing" set (a telephone, a doll with a bed, mattress and pillow), a "food" set (plastic fruit and vegetables with dishes and cutlery) and some illustrated books. Mothers were instructed to play with their children as usual, and to try to draw their attention to each set of toys. The experimenter attended the play-sessions and could participate if directly asked to do so by the children or their mothers. All video-recorded sessions were transcribed in a CHAT format (MacWhinney, 2000).

Statistical analysis

The comparisons between PTG and FTG on the different measures related to motor, mental, communicative and language development were performed using T-tests for independent samples. Within each group, continuity of individual differences in specific developmental areas was assessed by means of non-parametric Spearman rho correlations. This statistic was used also to evaluate reliability between direct and indirect assessment of vocabulary size, and to verify the relationships between lexical and grammatical development.

A series of hierarchical regression analyses were conducted to calculate the collective and unique contributions of the biological, social, and communicative factors that are hypothesized to predict outcome at the various stages of language acquisition. Categorical predictors (e.g., prematurity) were coded as dummy variables. Independent variables were inserted into the regression models in the order of their hypothesized effect and/or developmental acquisition: i.e., biological variables followed by social, cognitive and communicative variables. Dependent-outcome variables were chosen considering the linguistic ability typically acquired at a specific age: frequency per minute of utterances at T1; number of different word types produced at T2; percentage of W2-3 at T3; percentage of W4+ at T4.

Alpha level for all analyses was 0.05. Statistics were analyzed using SPSS version 15.0.1

Results

Motor and mental development

INSERT ABOUT HERE TABLE 4

Table 4 indicates the scores obtained by the FTG and PGT on the psychomotor and mental Scales at 14 and 36 months of age. At T1 the FTG children scored between the 16^{th} and 87^{th} percentile, while five children from the PTG group (28%) had mental and motor development values below the 25^{th} percentile, five children (28%) showed a delay only in motor development and eight children (44%) were developing typically with values above the 50^{th} percentile.

At T4, all children from the FTG developed within normal limits or had an accelerated performance, scoring between the 16^{th} and 93^{rd} percentile, while eight PTG children (44%) showed mental and motor delay, with values inferior to the 25^{th} percentile, while four PTG children (22%) showed only motor (three children) or mental (one child) delay; six children (33%) showed typical development (of these six, five were also developing typically at T1).

First stage of communicative development

INSERT ABOUT HERE TABLE 5

At T1, the frequency of spontaneous productions of the two groups did not differ significantly (see table 5); at this stage of communicative development, both groups used verbal communication very rarely. Moreover, there was no difference between the two groups in the use of gestures, either considering the total frequency or the frequency of different gestures.

Lexical development

INSERT ABOUT HERE TABLE 6

Vocabulary size – Only assessments performed at T2, T3 and T4 were used for this analysis. The first evaluation of communicative abilities (T1) was not considered for lexical development because, at that age, the two groups produced few words: (4 PT and 8 FT children produced only 1 word type). At T2, no differences emerged between the two groups on vocabulary size (evaluated by PVB questionnaire, Caselli, et al., 2007), but the FTG was credited by mothers, on average, by 100 words more than the PTG children (table 6), while the vocabulary size of both groups was comparable to that of the normal Italian range value (Caselli, et al., 2007). In the PTG group, however, there were many individual differences, in fact, three children (18%) had a vocabulary size inferior to the 10^{th} percentile (corresponding to 49 words), and three (18%) under the 25^{th} (corresponding to 80 words). Six months later, at T3 there were evident differences between the PTG and the FTG, with the former producing significantly fewer words. The vocabulary size of the PTG group was inferior to Italian normative data for 30 months of age, with three children (18%) scoring under the 10^{th} percentile and four children (24%) under the 25^{th} percentile. Only eight children (about 40%) of this group had a vocabulary size appropriate to their age at T2 and T3.

The evaluation of spontaneous speech also confirmed data obtained by PVB (Caselli, et al., 2007). At T2 and T3, FTG children produced double the amount of different types of words compared to PTG children. However it is important to note that not all PTG children showed a delay in language development in spontaneous speech; in fact, eight children produced a number of different words which placed them above the 25th percentile of our typically developing group (39 types of words in the 24 month session, 94 types of words in the 30 month session).

At T4, the evaluation of the children's lexical abilities performed on spontaneous speech only, showed that the PTG produced significantly fewer different types of words than the FTG. The eight children who showed a typical pattern of language development in the previous assessments, were placed above the 25th percentile in this assessment as well, producing more than 138 different types of words.

Because at 36 months of age (T4) the assessment of lexical facility was performed only on spontaneous speech and in literature the mothers' ability to evaluate their children's language by the PVB (Caselli, et al., 2007) was controlled for typical developers only (see, for example, Salerni, Assanelli, D'Odorico, & Rossi, 2007), we investigated these variables by correlating data obtained at T2 and T3 from spontaneous speech with data obtained by means of questionnaires. The strong correlation between the number of words filled in by the mothers in the questionnaire and the number of different word types produced by the children during the video-recorded session, indicates that mothers' recordings were reliable (T2: $r = .787$, $p < .001$; T3: $r = .655$, $p < .003$).

Grammatical development

INSERT ABOUT HERE TABLE 7

At T2 (table 7), the two groups differed on utterance length, with the PTG children producing shorter utterances (about 84% of the total production are W1). Though there was evidence that both groups were still in the single word phase, FTG children used a combination of two or more words in 35% of their utterances. Six months later, more than 50% of the utterances produced by the PTG were still in a single word form, while FTG children were in a combinatorial phase. At T4, differences regarding %W1 and %W2 parameters disappeared, but the use of complex combinations (%W4+) was higher for the FTG.

Relation between lexicon and grammatical development

The analyses of the relationships between measures of lexical and grammatical abilities showed both synchronic and diachronic significant relationships (see table 8).

INSERT ABOUT HERE TABLE 8

Data from our FTG sample confirmed that the grammatical abilities emerging at different age levels was related to vocabulary size. Moreover, vocabulary size at 24 months predicted the level of grammatical competence that was achieved 6 months later. The most advanced combinatorial capacities, resulting in the production of utterances of four or more words, however, were not associated to the vocabulary size at the same level, nor were they predicted by previous lexical abilities.

In PTG too, children with the largest vocabularies were those who, at the same age, produced simple combinations of words with greater frequency; moreover, the lexicon acquired at T2 was positively related to grammatical development at T3 and T4. In this group the production of utterances of four or more words also appeared related to the previous lexical development.

Individual profiles of development in PTG

The previous analyses suggested a great variability in preterm children with respect to the different communicative and linguistic abilities considered. A qualitative analysis identified three different developmental profiles: five children (28%) showed typical development; four children (22%) suffered general delay, affecting all communicative areas considered; nine children (50%) showed disharmonic development, with grammatical, but not lexical and communicative development being affected.

Predictability of language development

The previous analyses showed that pre-term children in our sample differed from full-term children both on lexical and grammatical development. However in the PTG we found a great variability and different developmental profiles, suggesting that prematurity alone cannot explain the particular development of the individual children. In order to evaluate the effect of the different factors we took into account each step of the process of language acquisition, and a series of hierarchical regression analyses were conducted. These were carried out in order to identify reliable predictors of linguistic ability at 24, 30 and 36 months of age. As suggested by Miles and Shevlin (2001), a sample size of about 40 subjects is sufficient to identify a large effect with four predictors.

In the first analysis, we investigated the effect of prematurity, birth weight, gender and maternal education level on communicative development (utterance frequency per minute). The results (see table 9) showed that only prematurity had a significant effect.

INSERT ABOUT HERE TABLE 9

A second analysis considered the effects of prematurity, birth weight, mothers' education level and the levels of production of prelinguistic communications on the number of different words spoken during the T2 session (table 10). At this age, prematurity continued to have a strong influence on the first production of words, accounting for approximately 18% of variance.

INSERT ABOUT HERE TABLE 10

A third analysis demonstrated that linguistic development at T3, as measured by the proportion of utterances with two or three words, could be predicted not only by being pre-mature or not, but also by the lexical competence reached at the previous stage of development (i.e., at T2) (table 11).

INSERT ABOUT HERE TABLE 11

Finally, the most advanced linguistic ability we observed in our sample, i.e. the production of utterances of four or more words, could be predicted both by lexical and grammatical competence acquired in the previous stage (see table 12).

INSERT ABOUT HERE TABLE 12

Discussion

At the earliest developmental phase we investigated (14 months of age), we did not find relevant differences between pre-term and full-term children in the use of gestures or in prelinguistic vocal communication. Our data confirmed findings by Reilly, Eadie, Bavin, Wake, Prior, Williams, Bretherton, Barrett, & Ukoumunne (2006) and McComish (2008) who demonstrated a less, although not significant, use of gesture in the pre-term population, in contrast with those obtained by studies focused on the ‘quality’ of prelinguistic sounds produced by pre-term children. For example Brown, Bendersky and Chapman (1986), found a delay in the onset of babbling and fewer vocal sounds in preterm children. Similarly, Jensen, Boggild-Andersen, Schmidt, Ankerhus, & Hansen (1988) found less canonical babbling at 11 months and at 14 months of age, however likewise our findings, communicative abilities did not differ between the two groups. At the next assessment, at 24 months, PTG vocabulary size, as measured by mothers’ report did not differ significantly from that of FTG children. This result is in line with Stolt, et al. (2007), Menyuk, et al. (1991, 1995), Marston, et al. (2007) and Sansavini, et al. (2006), who found scarce or no differences in vocabulary size between FT and PT children at this age. It must be considered, however, that our pre-term children probably used less words than they knew in their spontaneous speech, in so far the number of different words they produced during observational sessions was significantly smaller than that produced by full-terms.

With regard to prelinguistic communicative competence, it is possible that the variables we took into account were not representative of the communicative competence developed at this age or that the brief period we had at disposal for detecting them was not sufficient to obtain evidence of differences between groups. Taking into consideration however that previous studies (i.e., Marston, et al., 2007; Stolt, et al., 2007) also detected small differences in lexical competence, we can reasonably conclude that at the first stage of language development, the developmental gap due to premature birth may not be so large.

At 30 months of age, both vocabulary size and grammatical competence differed significantly between the two groups. Sansavini, et al. (2006), found that all pre-term children in their sample combined words, but our in-depth analysis of the nature of the multi-word utterances produced by children suggested a slow development of this ability in PT children. Their ability to combine 2 or 3 words (W2-3) and, successively, to produce longer utterances (W4+) was significantly lower respect those of FT, even at 36 months of age. Although this measure does not allow a qualitative analysis of the grammatical complexity of utterances, it is nevertheless a good index of the linguistic process on which the various stages of linguistic development are based (Bassano, & van Geert, 2007). These authors postulated that a strong dominance of W1 utterances is associated with an holophrastic, single-word (lexical) stage of language. Further, they speculated that a dominance of W2-3 utterances with a simple combinatorial stage of language, in which abstract syntactic categories is not necessarily required. And finally, they hypothesized that a dominance of W4+ utterances corresponds to a more sophisticated stage of grammar development in which productive categories and syntactic relational devices are used (Bassano, & van Geert, 2007). Our FT children demonstrated being in the combinatorial phase at 24 months of age, with more than 50% of their productions being given by more-than-one-word utterances. Instead, about half of the productions of the PT children were single-word utterances, even at 36 months of age.

Although the ability to produce multi-word utterances was delayed in our pre-term children, we nevertheless found the same relations between lexicon and grammar already found in typical development (Fenson, Dale, Reznick, Bates, Thal, & Pethick, 1994; Caselli, Bates, Casadio, Fenson, Fenson, Sanderl, & Weir, 1995; D'Odorico, & Fasolo, 2007). The predictive relationships found between vocabulary size and the production of multi-word sentences was quite similar to that obtained with typical children (Caselli, Casadio, & Bates, 1999).

Our results seem to indicate that PTG development is delayed rather than atypical. In fact, pre-term children obtained scores similar to those of younger full-term children, although later. In fact, at 30 and 36 months of age the PTG were using the number of words that typically developing children produce, respectively, at 24 and 30 months of age, indicating a delay of approximately 6 months. Even the assessments of spontaneous speech confirmed the results obtained by PVB (Caselli, et al., 2007). PTG children produced shorter utterances and showed delayed grammatical and syntactical development, with approximately 50% of their utterances being single words. However, even in this case, pre-term children demonstrated the typical relationships between lexicon and grammar, even if their competence had a delayed development.

The second part of this study focused on the factors which may affect developmental outcome, and can account for the great variability existing in pre-term outcomes. The principal variables considered in explaining the different outcomes of preterm children were biological (Kern, & Gayraud, 2007; Le Normand, & Cohen, 1999; Stolt, et al., 2009; Largo, et al., 1986; Marston, et al., 2007) and social variables (Stolt, et al., 2007). Our hypothesis is that unfavourable outcome in language development can be the result of a "cascade effect", in which the development reached in early communicative competence influences the more advanced linguistic abilities. An atypical development of basic abilities such as attention and memory due to pre-term birth, could negatively influence the development of the prelinguistic communicative abilities. The following stages would then be subjected to a two-fold setback, due to the compromised basic abilities and the compromised early developmental stages. This hypothesis is confirmed by the fact that differentiation between the PTG and the FTG is more evident in the more advanced stages of language development (a typical result of the "cascade effect"), as well as by the results of our predictive analyses. In the latter results lexical skills acquired at 24 months helped to explain the first stage of the ability to combine words at 30 months, while the latter was related to the following syntactic development.

Further studies are required to evaluate the differential effect of varying degrees of prematurity, including the sub-categories of very premature (gestational age < 28 weeks) and premature children (gestational age comprised between 29 and 37 weeks). Moreover, a more in-depth analysis of prelinguistic communicative competence (such as the complexity of the babbling produced) is needed to trace a more complete developmental trajectory from the first stage of communication to the more advanced syntactical competence.

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Table 1 Characteristics of the two groups

	PTG	FTG
	Mean (range)	Mean (range)
Birth weight (g)	1279 (800-1600)	3231 (2160-4200)
Gestational age (weeks)	29.5 (25-34)	39.4 (37-42)
Gender		
Males	8 (44%)	13 (72%)
Females	10 (56%)	5 (28%)
Mother's education level		
Graduate school	3 (17%)	7 (39%)
High school	9 (50%)	8 (44%)
Elementary and junior school	6 (33%)	3 (17%)

Table 2 Prenatal and postnatal medical risk of preterm born children

Prenatal	
Chorioamnionitis infection	0% (0/18)
Placental abruption	6% (1/18)
Eclampsia	0% (0/18)
Intrauterine growth restriction	6% (1/18)
Postnatal	
Intraventricular Hemorrhage I-II	17% (4/18)
Intraventricular Hemorrhage III-IV	0% (0/18)
Periventricular Leukomalacia	0% (0/18)
Bronchopulmonary Dysplasia	0% (0/18)
Necrotizing Enterocolitis	0% (0/18)

Table 3 Measures used to evaluate the developmental areas

Developmental area	Coding	Measures
Gestural communication		Frequency per minute
- ritual request	a whole hand pointing with fingers extended	Frequency per minute
- pointing	extension of the index finger	Frequency per minute
- showing	to put an object in the gaze line of mother	Frequency per minute
- conventional gestures	culturally acquired specific gestures (like shaking head "no", open-close arm "bye-bye")	Frequency per minute
Vocal preverbal communication		Frequency per minute
- onomatopoeic sounds	sound effects and animal sounds	Frequency per minute
- communicative vocalizations	vocalic sound produced with open mouth	Frequency per minute
- babbling	simple, reduplicated or variegated repetition of a vocal and a consonant sound	Frequency per minute
Lexical development		
- words (direct)	identified on the basis of phonetic similarity with an adult lexical term or if comprised and identified by mother	Number of different word types
- words (indirect)	words filled in the PVB (Caselli, et al., 2007) by mother	Number of different word types
Grammatical development		
- utterance length	one-word (W1)	Percentage
	two or three words (W2-3)	Percentage
	four and more words (W4+)	Percentage

Table 4 Psychomotor and Mental development. Index scores (and SD) obtained at Bayley's Scales by PTG and FTG at T1 and T4

	PTG		FTG			
	Mean	*SD*	Mean	*SD*	t	*p*
T1						
PDI	84	16	100	11	-3.075	0.005
MDI	95	16	98	8	-0.735	0.469
T4						
PDI	86	15	98	10	-2.857	0.007
MDI	86	15	97	6	-3.044	0.004

Table 5 Spontaneous communication. Mean (and SD) of preverbal and verbal production, gesture, and total spontaneous utterances of PTG and FTG at T1 (frequency per minute)

	PTG		FTG			
	Mean	*SD*	Mean	*SD*	t	*p*
Vocal/verbal utterances	1.981	2.021	2.889	1.822	-1.415	0.166
- Preverbal	1.869	1.957	2.629	1.738	-1.233	0.226
- Verbal	0.111	0.255	0.259	0.422	-1.277	0.21
Gestures utterances	1.278	1.222	1.07	0.612	0.631	0.532
- Ritual request	0.369	0.523	0.351	0.490	0.112	0.912
- Pointing	0.222	0.361	0.147	0.169	0.798	0.43
- Showing	0.166	0.347	0.277	0.383	-0.908	0.371
- Conventionals	0.518	1.073	0.296	0.395	0.823	0.416
Total	1.907	1.923	2.907	1.459	-1.758	0.088

Table 6 Lexical development. Mean (and SD) of vocabulary size of PTG and FTG measured with indirect and direct instruments

	PTG		FTG			
	Mean	*SD*	Mean	*SD*	t	*p*
Questionnaire						
T2	179	165	283	161	-1.904	0.065
T3	362	176	483	157	-2.153	0.039
Spontaneous speech						
T2	37	30	65	33	2.682	0.011
T3	75	49	126	47	3.052	0.005
T4	116	64	170	50	-2.593	0.015

Table 7 Grammatical development. Mean percentages of different utterance length (and SD) of PTG and FTG at T2, T3, and T4

	PTG		FTG			
	Mean	*SD*	Mean	*SD*	t	*p*
T2						
W1	79.14	28.43	64.97	14.16	1.893	0.067
W2-3	19.07	16.91	28.38	10.36	-1.991	0.055
W4+	2.05	4.05	6.65	6.41	-2.572	0.015
T3						
W1	57.26	21.92	48.22	12.78	1.489	0.146
W2-3	27.45	14.98	38.8	6.91	-2.891	0.007
W4+	5.85	6.1	12.99	8.22	-2.843	0.008
T4						
W1	48.45	19.39	40.82	9.09	1.394	0.174
W2-3	39.55	14.86	40.03	6.50	-0.116	0.908
W4+	12	8.95	19.16	5.8	-2.641	0.013

Table 8 Relationships between lexicon and grammatical development. Correlations between lexical and grammatical measures of FTG and PTG

		T2	T3		T4
		%W2+W3	%W2+W3	%W4+	%W4+
FTG					
	PVB at T2	0,591**	-0,296	0,482*	0,204
	PVB at T3		-0,202	0,592**	0,279
PTG					
	PVB at T2	0,777**	0,503*	0,630**	0,728**
	PVB at T3		0,609**	0,462*	0,728**

* $p < 0.05$ ** $p < 0.001$

Table 9 Summary table for hierarchical regression analysis with utterance frequency per minute at T1 as dependent variable

Model	Factors	B	Standard error of β	β	t	R^2	R^2 change
1	Prematurity	1.185	0.533	0.356	2.224*	0.127	0.127*
2	Prematurity	0.305	1.514	0.092	0.202	0.137	
	Birth weight	0.001	0.001	0.283	0.622		0.01
3	Prematurity	0.223	1.56	0.067	0.143	0.139	
	Birth weight	0.001	0.001	0.294	0.635		
	Gender	-0.172	0.578	-0.051	-0.297		0.002
4	Prematurity	-0.115	1.565	-0.035	-0.073	0.221	
	Birth weight	0.001	0.001	0.503	1.046		
	Gender	-0.039	0.582	0-.012	-0.068		
	Mother's education (I)	-0.303	0.708	-0.091	-0.428		
	Mother's education (II)	-1.316	0.825	-0.355	-1.596		0.082

* $p < 0.05$ ** $p < 0.001$

Table 10 Summary table for hierarchical regression analysis with number of different word types at T2 as dependent variable

Model	Factors	B	Standard error of β	β	t	R^2	R^2 change
1	Prematurity	28.333	10.563	0.418	2.682**	0.175	0.175**
2	Prematurity	13.373	30.057	0.197	0.445	0.182	
	Birth weight	0.008	0.014	0.236	0.532		0.007
3	Prematurity	19.863	31.424	0.293	0.632	0.207	
	Birth weight	0.004	0.016	0.114	0.238		
	Mother's education (I)	13.854	14.041	0.204	0.987		
	Mother's education (II)	9.125	16.378	0.121	0.557		0.025
4	Prematurity	19.897	31.942	0.293	0.623	0.207	
	Birth weight	0.003	0.016	0.106	0.214		
	Mother's education (I)	13.957	14.319	0.206	0.975		
	Mother's education (II)	9.563	17.377	0.126	0.55		
	F/m utterances T1	0.33	3.755	0.016	0.088		0.001

* $p < 0.05$ ** $p < 0.001$

Table 11 Summary table for hierarchical regression analysis with percentage of W2-3 at T3 as dependent variable

Model	Factors	B	Standard error of β	β	t	R^2	R^2 change
1	Prematurity	11.348	3.925	0.455	2.891**	0.207	0.207**
2	Prematurity	10.286	4.146	0.413	2.481*	0.260	
	Mother's education (I)	-3.727	4.798	-0.149	-0.777		0.053
	Mother's education (II)	3.238	5.679	0.115	0.57		
3	Prematurity	6.091	4.275	0.244	1.425	0.376	
	Mother's education (I)	-6.226	4.611	-0.25	-1.35		
	Mother's education (II)	2.589	5.313	0.092	0.487		
	Number of different word types T2	0.146	0.063	0.39	2.318*		0.116*

* $p < 0.05$ ** $p < 0.001$

Table 12 Summary table for hierarchical regression analysis with percentage of W4+ at T4 as dependent variable

Model	Factors	B	Standard error of β	β	t	R^2	R^2 change
1	Prematurity	6.626	2.751	0.414	2.409*	0.172	0.172*
2	Prematurity	6.662	2.951	0.417	2.258*	0.182	
	Mother's education (I)	1.581	3.355	0.099	0.471		0.011
	Mother's education (II)	-0.177	4.072	-0.009	-0.043		
3	Prematurity	2.587	2.806	0.162	0.922	0.428	
	Mother's education (I)	2.399	2.871	0.150	0.836		
	Mother's education (II)	2.190	3.547	0.116	0.618		
	Number of different word types T2	0.085	0.026	0.554	3.28**		0.246**
4	Prematurity	1.958	2.58	0.122	0.759	0.541	
	Mother's education (I)	2.878	2.634	0.180	1.093		
	Mother's education (II)	0.610	3.309	0.032	0.184		
	Number of different word types T2	0.046	0.029	0.296	1.576		
	%W2-3 T3	0.301	0.124	0.445	2.426*		0.113*

* $p < 0.05$ ** $p < 0.001$