

Long-term effects of preterm birth on language and literacy at eight years*

ANNALISA GUARINI, ALESSANDRA SANSAVINI,
CRISTINA FABBRI AND SILVIA SAVINI

Department of Psychology, University of Bologna

ROSINA ALESSANDRONI AND GIACOMO FALDELLA

Institute of Neonatology, University of Bologna

AND

ANNETTE KARMILOFF-SMITH

Birkbeck Centre for Brain and Cognitive Development, University of London

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ABSTRACT

The aims of this study were to investigate whether specific linguistic difficulties in preterm children persist at eight years and to examine the interrelationships between language and literacy in this population, compared with a control group of full-term children. Sixty-eight monolingual Italian preterms and 26 chronologically matched controls were recruited. Language (grammar comprehension, lexical production and phonological awareness), literacy (reading comprehension, reading and writing) and general cognitive development were investigated. Results showed no general delay in preterms, but slight difficulties in specific linguistic abilities (grammar, lexicon, phoneme synthesis and

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deletion of the first syllable), more difficulties in literacy (speed in reading and accuracy in writing) and certain correlations among competencies turning out to be different from the control group. In conclusion, our study established that a partially atypical trajectory emerged in preterms, showing specific long-term effects of preterm birth on language and literacy development.

INTRODUCTION

Preterm birth constitutes a premature transition from intra-uterine to extra-uterine life that exposes an immature central nervous system (CNS) to inadequate and often invasive and painful stimuli. Assuming that the development of brain functions, and consequently the development of sensory, motor and cognitive systems, depend upon complex interactions between neurobiological maturation and environmental stimuli (Karmiloff-Smith, 2009), it may be hypothesised that early preterm birth can affect foetal brain development and lead to alternative developmental trajectories in comparison to full-term birth. Indeed, neurological differences have been found between the preterm brain and the full-term brain at eight years, with regional cortical volumes smaller in preterms with a gestational age at birth ≤ 33 weeks than in full-terms (Peterson *et al.*, 2000). In addition, studies which have employed behavioural measures have found significant differences on general cognitive development between preterms and full-terms in the first years of life as well as at preschool and school age (for a review see Bhutta, Cleves, Casey, Cradock & Anand, 2002). Beside these general difficulties, delays in language development have been observed in preterm children. However, few studies have investigated the long-term effects of preterm birth on language and literacy as well as on the relationship between them.

Preterm language and literacy development

With regard to specific linguistic competencies, preterms' lexical production (vocabulary size) at ages 2;0 and 2;6 was examined in children exposed to several mother tongues (Foster-Cohen, Edgin, Champion & Woodward, 2007; Sansavini, Guarini, Alessandrini, Faldella, Giovanelli & Salvioli, 2006). Although not completely concordant in their results, these studies revealed that the preterm population in general did not differ from full-term children in lexical production, but some difficulties characterised preterms with greater immaturity (birthweight ≤ 1000 grams or gestational age ≤ 32 weeks). At preschool and school age, difficulties were found in preterms (birthweight < 1500 grams or ≤ 32 weeks) with respect to full-terms in

lexical comprehension and production at age 5;0 (Luoma, Herrgård, Martikainen & Ahonen, 1998), in naming at age 6;0 (Sansavini, Guarini, Savini, Alessandrini & Faldella, 2008) and at age 9;0 but no longer at age 16;0 (Saavalainen *et al.*, 2006). The results found in the first years of life and until school age highlighted how preterm birth may similarly affect lexical development across different languages. Besides the lexicon, grammar appears to be affected by preterm birth as well across different languages. Preterms have been found to have a shorter mean length of utterance (MLU) at age 2;6 (in preterms with greater immaturity; Sansavini *et al.*, 2006), at age 3;6 (Sansavini, Guarini, Alessandrini, Faldella, Giovanelli & Salvioli, 2007) and at age 5;0 (Crunelle, Le Normand & Delfosse, 2003). Preterms showed difficulties also with specific grammar abilities, such as verb conjugation and noun–adjective declination at age 5;0 (Wolke & Meyer, 1999), grammar comprehension at age 6;0 (Sansavini *et al.*, 2008) and use of proper grammatical forms at age 7;0 (Pietz *et al.*, 2004). Concerning phonological awareness, less developed abilities were found in preterms at age 6;0 (Sansavini *et al.*, 2008; Wolke & Meyer, 1999). As suggested by the studies presented above, preterm children present some difficulties in linguistic competencies (lexicon, grammar and phonological awareness) at preschool age, while the outcome of these competencies at school age and beyond is less clear, since very few studies have been carried out.

With regard to literacy, several studies, which mainly concern the English language, have shown diffuse difficulties at school age in reading and writing abilities in preterms with a high neonatal immaturity (gestational age <28 weeks and birthweight <1000 g), even when children with cerebral and sensorial damages (Anderson, Doyle & Victorian Infant Collaborative Study Group, 2003; Saigal *et al.*, 2003) and with severe cognitive delays (Whitfield, Grunau & Holsti, 1997) were excluded. These results confirmed the argument proposed by Marlow, Roberts & Cooke (1993) that a high frequency of learning difficulties becomes more evident at school age in preterms with high immaturity but no major brain impairments. Difficulties in writing were also evident in preterms with minor neonatal immaturity. In fact, preterms with a birthweight <1250 grams had lower abilities in handwriting legibility and in speed of writing in the first year of primary school (Feder, Majnemer, Bourbonnais, Platt, Blayney & Synnes, 2005), and preterms with a birthweight <1500 g showed lower writing abilities at age 12;0, while no difference was found in reading (Chaudhari, Oti, Chitale, Pandit & Hoge, 2004). These studies underlined the importance of studying both reading and writing processes, which both appeared impaired in the case of high neonatal immaturity (gestational age <28 weeks and birthweight of <1000 g), while writing was more compromised than reading in healthy preterms with minor neonatal immaturity.

The studies presented above have highlighted the presence of several difficulties in preterms' language and literacy. However, all previous works on preterms have focused either on language (at preschool age) or on literacy (at school age) and none has investigated whether impairments emerge in specific competencies (such as the lexicon, grammar, phonological awareness, reading comprehension, reading and writing abilities) at school age. The comparison between language and literacy is important in preterms, since it makes it possible to assess whether preterms' competences develop at different rates, with some abilities compromised and others remaining proficient. Moreover, the reciprocal relationships between language and literacy have rarely been investigated in preterms, although their relevance has been shown in both typical and atypical populations. The study of these reciprocal relationships in preterms makes it possible to understand whether difficulties, revealed by some studies in preterms' language and literacy, might determine different relationships among these skills with respect to typical development. This investigation is relevant both at the theoretical level in order to outline the developmental trajectory of preterm children, and at the clinical level in order to propose interventions for improving language and literacy skills and their reciprocal relationships.

Relationships between language and literacy

One of the first studies concerning the relationships between language and literacy in typical development was conducted by Bradley & Bryant (1983). The results of this work showed strong relationships between phonological awareness and children's acquisition of literacy, challenging the hypothesis of a discontinuity between language and literacy development. However, not only phonological awareness, but also lexical and grammar skills are linked to literacy (Storch & Whitehurst, 2002). For this reason, besides phonological awareness, several linguistic abilities should be taken into account. In fact, lexico-semantic abilities at age 3;0 (vocabulary, language comprehension) and MLU, as well as phonological awareness at age 6;0, have been found to predict successful reading abilities (Frost, Madsbjerg, Niedersøe, Olofsson & Sørensen, 2005). This study underlined that phonological awareness turned out to be more important during the acquisition phase of literacy, while lexico-semantic abilities were more important during the consolidation phase. In addition, some authors stressed the importance of rapid automatized naming (RAN) as a predictor of reading abilities in languages with transparent and opaque orthography (Di Filippo *et al.*, 2005).

In recent years, the relationships between language and literacy have started to be investigated also in atypically developing children. Studies carried out on children with a history of speech disorders yielded strict

relationships between phonological awareness and literacy, highlighting the efficacy of phonological awareness intervention strategies to increase reading and writing abilities in these children (Hesketh, 2004). Concerning developmental trajectories in populations affected by genetic disorders, individuals with Down Syndrome (DS), for instance, displayed an atypical relationship between phonological awareness and reading abilities (Gombert, 2002), since they did not catch up in phoneme awareness. Recently, relationships between language and literacy have also been studied in individuals with Williams syndrome (WS) (Laing, Hulme, Grant & Karmiloff-Smith, 2001). The authors found a relationship between phonological tasks and reading abilities during the acquisition phase in WS, although this relationship was weaker than in healthy controls. In addition, during the consolidation phase some relationships between phonological awareness of the syllable and reading were present only in participants with WS (Menghini, Verucci & Vicari, 2004).

These studies indicated that the relationships between language and literacy change as a function of both the learning phase of literacy (acquisition vs. consolidation) and of the type of population (typical vs. atypical). Notwithstanding the relevance of this field of research, relationships between language and literacy have not been investigated in at-risk populations, such as preterm children, except for two studies. A longitudinal study has shown that preterms at risk for lexical and grammatical problems in the first years of life had several delays (34%) on reading at age 7;0 (Crunelle *et al.*, 2003). Another study highlighted that in preterm children (with a gestational age <30 weeks) phonological awareness and expressive vocabulary at age 8;0 were correlated to reading, while RAN was associated with reading and spelling (Wocadlo & Rieger, 2007). However, the authors could not compare the relationships among linguistic competences of preterms to those of typical development, since they did not have a control group.

Our study thus had two aims: first, to investigate whether preterm children show delays in specific linguistic and literacy abilities up to age 8;0, evaluating also their general cognitive development; and second, to ascertain whether relationships between language and literacy in preterm children follow a typical trajectory similar to that of full-term children or a specific trajectory which could be defined as atypical. Rather than studying these relationships during the acquisition phase of literacy abilities, we focused on the initial phase of consolidation, since few studies exist on this phase. Specifically, we hypothesized that during the initial phase of consolidation of literacy, when children move from phonological recoding to lexical reading and writing and when a diagnosis of learning disabilities can be done (at the end of the second year of primary school for Italian children; Consensus Conference, 2007; Orsolini, Fanari, Tosi, De Nigris &

Carrieri, 2006; Sartori, Job & Tressoldi, 1995), not only phonological awareness, but also other language abilities, would be strongly correlated with literacy.

METHOD

Participants

Sixty-eight monolingual Italian preterms took part in the study, which was conducted at the Unit of Neonatology of Bologna University. The children were examined at the end of the second year of primary school (chronological age: $mean=8;0\cdot18$, $SD=0;3\cdot27$, $range=7;5-8;10$). Birth dates ranged from January 1996 to December 1998. Cerebral echography had been routinely carried out at birth, as well as at the presumed date of birth, and at 0;3 (corrected age). Contact between mothers and their preterm neonates in the incubators had been strongly encouraged.

For the present study, preterm children were recruited if, at birth, they had had a gestational age ≤ 33 weeks. Their mean gestational age at birth was 30·44 weeks ($SD=2\cdot22$), with a range from 25 to 33 weeks, and their mean birthweight was 1243 grams ($SD=264$), with a range from 600 to 1840 grams. There were 36 males and 32 females, giving a total preterm population of 68. We allowed for some degree of medical complication related to their premature birth (respiratory distress with or without mechanical ventilation, bronchopulmonary dysplasia, apnoea, intra-ventricular haemorrhage of grade I or II, intrauterine growth retardation, retinopathy of prematurity at birth of grade I or II, visual problems at age 8;0, persistent hyperechogenicity, hyperbilirubinemia with phototherapy). By contrast, any child with cerebral palsy, leukomalacia, intra-ventricular haemorrhage > grade II, hydrocephalus, significant motor and sensory impairments, at birth or at subsequent medical assessments, was excluded. With respect to social factors, mean maternal length of education was 12;8·23 ($SD=3;0\cdot11$, $range=8;0-18;0$) and mean paternal length of education was 11;7·28 ($SD=3;7\cdot13$, $range=5;0-19;0$).

A comparison group of 26 monolingual Italian full-term children, who had experienced normal birth (gestational age > 37 weeks and birthweight > 2800 grams) and absence of neonatal complications, was recruited from the Ferrarin Primary School (Institute of Bellaria, Rimini) at the end of the second year of primary school (chronological age: $mean=7;10\cdot8$, $SD=0;3\cdot29$, $range=7;4-8;4$). Seventeen were males and 9 were females. With respect to social factors, mean maternal length of education was 11;8·4 ($SD=3;4\cdot28$, $range=5;0-17;0$) and mean paternal length of education was 10;6 ($SD=3;6\cdot4$, $range=5;0-18;0$). Independent sample *t* tests and chi-square analysis revealed that the preterm and control samples

did not differ significantly on either maternal length of education, paternal length of education or gender.

Measures

Measures for this study comprised tasks to investigate language, literacy and general cognitive development.

With respect to language, in order to evaluate grammar comprehension a standardized Italian task *Test di Comprensione Grammaticale per Bambini* (TCGB; Chilosi & Cipriani, 1995) was administered to each participant individually. Each item had four simple, black-and-white illustrations arranged in a multiple-choice format. The subject's task was to select the picture considered to best illustrate the meaning of a stimulus sentence presented orally by the examiner (e.g. *la bambina è vestita dalla mamma* 'the child is dressed by the mum'). Errors were scored according to the test manual. To evaluate lexical production an Italian naming task, 'Test di Vocabolario Figurato' (Brizzolara, Cipriani, Chilosi & de Pasquale, 1994), was used. It consists of 52 black-and-white images illustrating objects or actions (e.g. the guitar, to run). The examiner asked the child: 'What is this?' The number of total errors was scored. In order to evaluate phonological awareness an Italian battery, *Valutazione delle competenze metafonologiche* (CFM; Marotta, Trasciani & Vicari, 2004) was administered to a subgroup of the preterms (46 children) and to all the controls, since it was introduced later in the research project after a group of preterms had already been tested. This battery included different tasks on phonological awareness of both syllables and phonemes for children aged from 5;0 to 10;0. In particular, in this research all the tasks indicated by Marotta and colleagues (2004) for Italian children at the end of the second year of primary school were administered. These tasks were chosen by Marotta and colleagues (2004) from among several tasks of phonological awareness because they are both representative indicators of the general acquisition of phonological awareness and, at the same time, particularly relevant for the age investigated. The choice, proposed by the authors, to investigate specific abilities of phonological awareness, depends on the necessity to create a battery which is at the same time informative and not very long for the children who are coping with several tasks, taking into account the specific characteristics of the Italian language. For each task administered an example was provided to the child. In the phoneme synthesis task the child was asked to blend phonemes into bisyllabic and multisyllabic words (e.g. the examiner says /m/a/t/i/t/a/ and the child repeats *matita* 'pencil'). In the deletion of the first syllable task the child was asked to delete the first syllable from a bisyllabic or multisyllabic word (e.g. the examiner says *regalino* 'gift' and the child repeats *galino*). In the rhymes task the examiner

showed four coloured illustrations and asked the child which word ended with the same sound as the target word (the first stimulus): the examiner said aloud the name of all the objects represented (e.g. *sacco* – the target – followed by *toro*, *pacco*, *calza*), then the child said aloud the word that ends with the same sound as the target word (e.g. *pacco*). In the phoneme segmentation task the child was asked to produce all the phonemes, in the correct order, of each bisyllabic or multisyllabic word presented (e.g. the examiner says *mela* and the child repeats /m/e/l/a/, ‘apple’). In the alliteration fluency task the child was asked to say as many words with an initial letter sound (/f/, /a/, /s/) as he can in 1 minute; number words and proper names were not counted. In the deletion of the last syllable task the child was asked to delete the last syllable from a bisyllabic or multisyllabic word (e.g. the examiner says *medicina* ‘medicine’ and the child repeats *medici*). In the spoonerisms task the child was asked to exchange the initial sounds of two words (e.g. *pane collo* ‘bread neck’ becomes *cane pollo* ‘dog chicken’).

With respect to literacy, to examine reading comprehension the Italian test ‘Prova di lettura MT per la scuola elementare – 2’ (Cornoldi, Colpo & Gruppo MT, 1998) was used. The child was asked to read alone a story and then answer 10 multiple-choice reading comprehension questions (5 comprising illustrations, 5 based only on text). To evaluate reading abilities two Italian tests were used. The test ‘Prova di lettura MT per la scuola elementare – 2’ (Cornoldi *et al.*, 1998) was administered in order to investigate accuracy (errors) and speed (total second/number of syllables) for each child in story reading, according to the test manual. Two subtests of the Italian battery ‘Batteria per la valutazione della dislessia e della disortografia evolutiva’ (Sartori *et al.*, 1995) were used to evaluate accuracy (errors) and speed (total second/number of syllables) in word (the child was asked to read aloud 112 words) and non-word reading (the child was asked to read aloud 48 non-words obeying Italian phonotactics). To evaluate writing abilities from dictation three subtests by Sartori *et al.* (1995) were used: sentence (the child was asked to write 12 sentences), word (the child was asked to write 48 words of different length and orthographical complexity) and non-word writing (the child was asked to write 24 bisyllabic or multisyllabic non-words obeying Italian phonotactics).

With regard to general cognitive development, the Italian version of the ‘Kaufman Brief Intelligence Test’ (K-BIT, Italian version; Bonifacci, Santinelli & Contento, 2007) was administered. The K-BIT test consists of both verbal and non-verbal subtests. The verbal subtest is based on two parts: expressive vocabulary (requiring the child to provide the name of a pictured object) and definitions (requiring the child to provide the word that best fits two clues – a phrase description and a partial spelling of the word). The non-verbal test consists of matrices composed of several types

of items involving visual stimuli (the child is asked to understand the relationships among the stimuli). Raw scores were used, since standardized scores for Italian were not then available.

Procedure

All children were tested at the end of their second year of primary school (from May to June) by two psychologists previously trained. Preterm children were tested individually in a quiet room at the Unit of Neonatology of Bologna University. Control children were tested individually with the same tests in a quiet room at their school. During the administration of the tests (about two hours for each child with a pause in the middle), both preterms and controls were videotaped. The order of test administration was randomized for each child.

Statistical analyses

Independent sample *t* tests were run in order to compare preterm and full-term scores. Bonferroni correction was applied to further analyse the differences between preterms and full-terms. Comparison across measures was facilitated by inspection of the effect size, calculated as Cohen's *d*. Pearson correlations were performed in both preterm and full-term samples in order to investigate the interrelationships between language and literacy skills in each group. In addition, the differences between preterms' *r* and full-terms' *r* were analysed, using the solution proposed by Fisher. Statistical analyses (independent sample *t* tests and Pearson correlations) were run using SPSS 12 for Windows.

RESULTS

Differences between preterms and controls

Our first aim was to investigate whether preterm children showed delays in specific language and literacy abilities, evaluating also the presence of differences between preterms and controls in general cognitive development.

With respect to language, independent sample *t* tests showed that preterms made more errors than controls in grammar comprehension, even if this difference did not reach significance, and in lexical production (see Table 1). Concerning phonological awareness (this battery was administered to 46 of the preterms – see 'Procedure' – and to all 26 controls), preterms gave significantly fewer correct responses than controls in phoneme synthesis and in the deletion of the first syllable, while no significant differences were found in rhymes, phoneme segmentation, alliteration fluency, deletion of the last syllable and spoonerisms (see Table 1). These differences between preterms and full-terms were no longer significant when the Bonferroni

TABLE 1. Scores for language in preterm and full-term children

		Preterms			Full-terms			<i>t</i> test		ES	
		<i>No.</i>	<i>M</i>	<i>SD</i>	<i>No.</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>	<i>d</i>	
Language	Grammar comprehension	Total errors	68	6.04	4.27	26	4.77	2.17	1.90	0.061	0.37
	Lexical production	Total errors	68	10.06	3.39	26	8.04	3.81	2.50	0.014	0.56
	Phonological awareness (total correct responses)	Phoneme synthesis	46	11.59	3.32	26	13.12	2.05	-2.12	0.037	-0.55
		Deletion first syllable	46	11.11	4.17	26	12.73	2.46	-2.08	0.042	-0.47
		Rhymes	46	13.65	2.44	26	14.23	1.80	-1.06	0.295	-0.27
		Phoneme segmentation	46	11.57	3.76	26	11.96	2.25	-0.49	0.626	-0.13
		Alliteration fluency	46	16.61	5.53	26	15.77	3.82	0.76	0.451	0.18
		Deletion of last syllable	46	11.71	3.96	26	12.77	2.39	-1.40	0.165	-0.32
	Spoonerisms	44	9.43	5.71	26	11.04	4.58	-1.22	0.227	-0.31	

ES: effect size.

correction was applied. In addition, concerning phonological awareness, a general index was computed based on the mean of correct responses among all the tasks: phoneme synthesis, deletion of the first syllable, rhymes, phoneme segmentation, alliteration fluency, deletion of the last syllable, and spoonerisms. No significant difference between preterms and full-terms, but only a trend, was found on this general index of phonological awareness (preterms' $mean=13.09$ and $SD=2.98$; full-terms' $mean=12.18$ and $SD=1.23$; $t(1,65.54)=1.81$, $p=0.075$).

With regard to literacy, 1 out of 68 preterm children was unable to perform all the tasks administered. In addition, 2 preterms did not perform the task of reading comprehension and they did not complete the word and non-word reading (since they had several difficulties in reading), and another preterm child refused the administration of sentence writing. Taking into account the children who performed the tasks, preterms made more errors than controls in story reading and in all writing tasks (sentence, word and non-word) and they were also slower than controls in all reading tasks (story, word and non-word), while no significant differences between preterms and controls were found in reading comprehension and in accuracy on word and non-word reading (see Table 2). The differences between preterms and full-terms in reading speed (story, word and non-word) and in writing accuracy (sentence) remain significant after Bonferroni correction (see Table 2). In addition, with regard to literacy, besides reading comprehension, three general indexes were computed: mean of accuracy in reading (mean of errors in story, word and non-word reading), mean of speed in reading (mean total second/number of syllables in story, word and non-word reading) and mean of accuracy in writing (mean of errors in sentence, word and non-word writing). Significant differences between preterms and full-terms emerged both in reading speed (preterms' $mean=0.80$ and $SD=0.43$; full-terms' $mean=0.57$ and $SD=0.12$; $t(1,82.19)=-3.94$, $p<0.001$) and in writing accuracy (preterms' $mean=9.22$ and $SD=8.20$; full-terms' $mean=5.05$ and $SD=2.16$; $t(1,83.15)=-3.81$, $p<0.001$), while no significant difference, but only a trend, was present on reading accuracy (preterms' $mean=9.03$ and $SD=9.01$; full-terms' $mean=6.69$ and $SD=2.72$; $t(1,85.22)=-1.88$, $p=0.063$).

With respect to general cognitive development, no significant differences were found between preterms and controls on raw scores of verbal (preterms' $mean=42.73$, $SD=7.31$; controls' $mean=44.23$, $SD=5.45$) and performance abilities (preterms' $mean=21.77$, $SD=3.69$; controls' $mean=22.54$, $SD=3.94$).

Comparison between preterms and full-terms was facilitated by inspection of the effect size, which was calculated as Cohen's d . Effect sizes of 0.20 can be considered small; 0.50, medium; and 0.80, large. We calculated d as the difference between preterm and full-term means, divided by the pooled

standard deviation (pooled standard deviation is the square root of the average of the squared standard deviations). With regard to language (see Table 1), measures of lexicon, phoneme synthesis, and deletion of the first syllable yielded medium effects, whereas grammar, rhymes, deletion of the last syllable and spoonerisms yielded small effects. No effects emerged for phoneme segmentation and alliteration fluency. With regard to literacy (see Table 2), measures of speed in story, word and non-word reading yielded medium-to-large effects, as well as sentence, word and non-word writing. In addition, small effects were found for accuracy in story, word and non-word reading. Finally, no effects were found in reading comprehension (see Table 2), with small effects for cognitive raw scores of verbal and performance abilities.

Relationships between language and literacy

The second aim was to investigate the relationships between language and literacy, in both preterm and full-term children. For this investigation, we have chosen to use the general indexes of phonological awareness, accuracy and speed of reading and accuracy of writing.

With respect to the relationships between grammar comprehension and literacy, significant correlations emerged in both preterms and controls between grammar comprehension and reading comprehension (see Table 3). In addition, grammar comprehension in preterms was correlated with reading accuracy, reading speed and writing accuracy, while no relationships were found between grammar comprehension and literacy in controls. The correlations found in preterms between grammar comprehension and reading and writing accuracy remained significant when Bonferroni correction was applied (see Table 3).

Concerning the relationships between lexical production and literacy, a significant correlation was found only between lexical production and reading comprehension in preterms.

With respect to the relationships between phonological awareness and literacy, in the preterm sample phonological awareness was correlated with reading comprehension, reading accuracy, reading speed and writing accuracy. In the control sample phonological awareness was correlated with reading accuracy, reading speed and writing accuracy. The correlations found in both preterms and full-terms between phonological awareness and writing accuracy remained significant when Bonferroni correction was applied. In addition, the correlation between phonological awareness and reading accuracy remained significant in the preterm sample after Bonferroni correction (see Table 3).

Finally, we investigated the difference between preterm's r and full-term's r . Results revealed two significant differences in the relationships

TABLE 2: Scores for literacy in preterm and full-term children

		Preterms			Full-terms			<i>t</i> test		ES	
		<i>No.</i>	<i>M</i>	<i>SD</i>	<i>No.</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>	<i>d</i>	
Literacy	Reading Comprehension	Total errors	65	2.68	1.55	26	2.65	1.16	0.07	0.946	0.02
	Reading abilities	Story accuracy (errors)	67	7.00	12.17	26	3.50	2.10	2.27	0.026	0.40
		Word accuracy (errors)	65	10.37	9.75	26	8.30	4.94	1.33	0.186	0.27
		Non-word accuracy (errors)	65	10.17	7.25	26	8.27	3.63	1.66	0.101	0.33
		Story speed (sec/syll)	67	0.59	0.43	26	0.42	0.87	3.13	0.002 ^a	0.56
		Word speed (sec/syll)	65	0.75	0.48	26	0.51	0.12	3.62	0.001 ^a	0.66
		Non-word speed (sec/syll)	65	1.10	0.52	26	0.77	0.17	4.40	0.001 ^a	0.83
	Writing abilities	Sentences accuracy (errors)	66	17.00	14.7	26	8.88	4.59	4.02	0.001 ^a	0.75
		Word accuracy (error)	67	5.51	6.77	26	2.77	3.28	2.61	0.011	0.52
		Non-word accuracy (error)	67	5.24	4.04	26	3.5	1.84	2.84	0.006	0.55

ES: effect size.

^a *p* value reaching a significant level also using Bonferroni correction ($\alpha = 0.005$).

TABLE 3: *Correlations between language and literacy in preterm and full-term children*

	Preterms			Full-terms			Fisher's z	
	No.	r	p	No.	r	p	z	p
READING COMPREHENSION								
Grammar comprehension	65	0.29	0.018	26	0.41	0.038	0.55	0.582
Lexical production	65	0.26	0.039	26	0.27	0.191	0.04	0.968
Phonological awareness	44	-0.33	0.031	26	-0.32	0.110	0.04	0.968
READING (ACCURACY)								
Grammar comprehension	65	0.52	0.000 ^a	26	-0.34	0.093	3.80	0.000 ^a
Lexical production	65	0.05	0.717	26	-0.12	0.560	0.68	0.497
Phonological awareness	44	-0.55	0.000 ^a	26	-0.50	0.008	0.27	0.787
READING (SPEED)								
Grammar comprehension	65	0.25	0.041	26	-0.03	0.894	1.18	0.242
Lexical production	65	0.00	0.996	26	-0.08	0.683	0.34	0.734
Phonological awareness	44	-0.41	0.005	26	-0.38	0.059	0.16	0.873
WRITING (ACCURACY)								
Grammar comprehension	66	0.47	0.000 ^a	26	0.00	0.999	2.09	0.037
Lexical production	66	-0.15	0.221	26	-0.17	0.418	0.05	0.960
Phonological awareness	45	-0.73	0.000 ^a	26	-0.57	0.002 ^a	1.08	0.280

Fisher's z: difference between two independent *r*s.

^a *p* value reaching a significant level also using Bonferroni correction ($\alpha=0.004$).

between preterms and full-terms. In particular, preterms showed strict relationships, not observed in full-terms, between grammar comprehension and reading and writing accuracy. The difference in the relationships between preterms and full-terms concerning grammar comprehension and reading accuracy remained significant when Bonferroni correction was applied (see Table 3).

DISCUSSION

The first aim of our study was to investigate specific language and literacy abilities at age 8;0 in a sample of preterms, without cerebral damage, compared to a full-term sample. The results yielded no differences between preterms and controls on cognitive abilities (verbal and performance), while difficulties were found in specific language and literacy abilities. These results highlight the importance of studying specific abilities with specific tools in order to fully understand the developmental trajectory of preterm children, as suggested by Aylward (2002).

With regard to language, grammar comprehension (tendency), lexical production and phonological awareness (phoneme synthesis and deletion of the first syllable) were affected by preterm birth, even though these abilities

were not severely compromised, since these differences were no longer significant when Bonferroni correction was applied. These results highlight that some difficulties in grammar and the lexicon, found in preterms in the first years of life (Foster-Cohen *et al.*, 2007; Sansavini *et al.*, 2006, 2007) and at preschool age during the acquisition phase (Luoma *et al.*, 1998; Sansavini *et al.*, 2008), persist up to school age, despite the fact that these skills are already consolidated in typically developing Italian children (Brizzolara *et al.*, 1994; Chilosi & Cipriani, 1995). In addition, our study, showing that some competences of phonological awareness were affected by preterm birth at school age, adds a crucial dimension to earlier research, since this topic has rarely been investigated at this later age. Although Wocadlo & Rieger (2007) did address this topic in preterms at age 8;0, they failed to use a comparison group of full-term children, so their findings needed further evidence. In particular, the difficulties in phoneme synthesis and deletion of the first syllable found in preterms by our current study at age 8;0 concern phonological awareness skills that are in the consolidation phase for Italian children at the end of the second year of primary school (Marotta *et al.*, 2004). As shown by a previous study, these abilities (phoneme synthesis and recognition of the first syllable) were particularly affected by preterm birth also in their acquisition phase at age 6;0, and they were related to difficulties highlighted in preterms' phonological short-term memory (Sansavini *et al.*, 2008).

With regard to literacy, no differences were found between preterms and controls in reading comprehension, despite differences in reading abilities. In particular, preterms were slower than controls in all reading abilities, highlighting an important effect of preterm birth on the automatization of the reading process. In fact, the difference found between preterms and full-terms in reading speed was very evident, as confirmed by both the effect size and Bonferroni correction. Moreover, preterms made more errors in story reading, but not in word and non-word reading (even if a trend was observed), showing that they did not benefit from the contextual clues provided by the story during the reading process. These results confirm the difficulties found by previous studies on reading abilities in English-speaking preterms (Anderson *et al.*, 2003; Pritchard, Clark, Liberty, Champion, Wilson & Woodward, 2009; Whitfield *et al.*, 1997), but also add a detailed analysis of reading difficulties in Italian preterms. In fact, at the end of the second year of primary school Italian preterms have no difficulties in reading comprehension, while they show less automatized reading abilities than full-terms, with a specific difficulty in reading speed. This result has already been found in children with atypical development. In fact, dyslexic child native speakers of orthographically regular languages, such as Italian (Zoccolotti, De Luca, Di Pace, Judica, Orlandi & Spinelli, 1999), showed more difficulties in reading speed than in accuracy.

With respect to writing, preterms showed a larger variability and made about twice the errors of controls in all tasks, showing some delays in writing abilities (see also Chaudhari *et al.*, 2004; Feder *et al.*, 2005). In particular, more problems arose in sentence writing, as suggested by both the effect size and Bonferroni correction, and in the use of auxiliary verbs (e.g. *avere* 'to have'), which are normally learned during the second year of primary school. Thus, preterm birth was closely associated with a difficulty in writing accuracy and in reading speed, but not with problems in reading comprehension. This observation outlines the presence in preterms of a specific developmental trajectory for literacy, with an important distinction between reading comprehension, reading and writing.

In relation to the first aim, we can conclude that, compared to controls, preterm children at age 8;0 still present some difficulties in language, even if these difficulties are not particularly strong, probably because these skills are already in a consolidation phase in the Italian language. By contrast, more difficulties emerged in literacy, which is in the initial phase of consolidation, and a wide variability was still present especially concerning reading speed and accuracy in complex sentence writing. In fact, in these specific skills rapid changes occur in Italian children from the second year of primary school and in the following years since children move from phonological recoding to lexical reading (Orsolini *et al.*, 2006). Our study adds a far more detailed analysis than previous work of specific linguistic abilities affected by preterm birth, pointing to an atypical trajectory of development. Moreover, our study is the first to detail these abilities in Italian preterms at school age.

The second aim of the present study was to investigate the reciprocal relationships between language and literacy abilities in order to ascertain whether these relationships differ in preterms' developmental trajectory in comparison to controls.

Concerning grammar comprehension, relationships were found with reading comprehension in both preterms and controls. These relationships, even if not particularly tight after Bonferroni correction, suggest that grammatical skills are likely to play an important role in reading comprehension, as suggested by Muter, Hulme, Snowling & Stevenson (2004) in relation to typical development. In addition, grammar comprehension showed significant reciprocal and tight correlations with accuracy in reading and writing processes but this only held for the preterm sample. We argue that the presence only in preterms of several tight relationships between grammar and literacy can be explained by the difficulties that preterms experience with these abilities, since an atypicality can have ramifications in other domains across developmental time (Karmiloff-Smith, 2009). Therefore, delays in specific linguistic abilities affect the relationships among them.

Lexical production showed no tight relationships with literacy either in preterms or controls at age 8;0. A significant but not very tight correlation was found between the lexicon and reading comprehension, but only in the preterm sample, stressing how delays in grammar and lexical development were correlated with difficulties in reading comprehension. These results differ from those found by Frost *et al.* (2005), who observed a strict relationship between the lexicon (vocabulary) at age 3;0 and subsequent successful reading abilities. This underlines the importance of tracing changing developmental relationships over time. It thus seems that, in the first years of life, the lexicon is a good predictor of successful literacy, but that in subsequent development other factors like phonological awareness and grammar play a more important role. However, it is also possible that at school age, naming abilities, which were tested in our research, are not linked to reading and writing, while other measures of lexical development, such as the RAN, correlate with literacy, as shown by some studies on typically and atypically developing children (Di Filippo *et al.*, 2005; Wocadlo & Rieger, 2007).

With regard to phonological awareness, strong relationships with literacy were found. First, a relationship was found in preterms, but not in full-terms, between phonological awareness and reading comprehension, confirming that in typical development reading comprehension 'depends on skills outside of the phonological domain' (Muter *et al.*, 2004: 678) and that reading comprehension and reading accuracy are influenced by different sets of abilities (Storch & Whitehurst, 2002). Second, tight relationships, which remained after Bonferroni correction, were found between phonological awareness and reading and writing accuracy both in preterms and full-terms. These findings highlight how, in both groups, phonological awareness was linked to accuracy in reading and writing and show a strong relationship between these skills in Italian children also during the initial phase of consolidation of literacy. Similar results have been found in Czech and English typically developing children (Caravolas, Volin & Hulme, 2005) and in children with a history of speech problems (Hesketh, 2004). In addition, relationships between phonological awareness and reading speed emerged both in preterms and full-terms (tendency), even if less tight with respect to accuracy.

In relation to the second aim, the findings show the presence of tight and reciprocal relationships between language and literacy. Using the distinction proposed by Storch & Whitehurst (2002) between code-related skills (e.g. phonological awareness) and language (e.g. lexicon and grammar), our results show that, during the initial phase of consolidation of literacy in Italian preterms, not only code-related skills but also grammar are strongly related to literacy abilities. In particular, in preterm children grammar and phonological awareness were mainly linked to accuracy in literacy (both in

reading and writing), while these linguistic skills were not particularly associated to reading comprehension and reading speed. With respect to full-term children, only code-related skills were linked to accuracy in literacy (reading and writing), as already found in the preterm sample.

Some limitations of our study need to be taken into account, both as suggestions for future studies and as cautions for the generalization of the results. First, although in this research several linguistic and literacy skills were evaluated, other linguistic abilities might be examined, such as RAN, in order to better understand the relationships between language and literacy, as it has been done in populations with typical and atypical development. In addition, other abilities, such as short-term memory, attention skills and executive function, might be taken into account in further studies for their relevant role in the development of linguistic skills and literacy. Second, the design of the study includes children with a wide range of gestational ages age (25–33 weeks). For this reason, this aspect should be taken into account in the generalization of the results. However, it is relevant to highlight that in the present study, different from other studies in the literature, we purposely excluded some of the variables (i.e. severe neurological damage, bilingualism) that could complicate the preterm picture and the generalization of the results. Third, our study has investigated the relationships between language and literacy in the initial phase of consolidation of literacy in Italian preterms, adding new results to the preterm literature. However, since these relationships may change during development (i.e. in the acquisition phase of literacy skills – the first year of primary school – or when those are completely consolidated – the last year of primary school), new longitudinal studies could be run to further explain the developmental trajectory of preterm children. Finally, although our full-term group was adequate for comparison with the preterm one, some caution is required in generalizing the results to typical development, because of the smaller size of our full-term sample.

CONCLUSION

Taking into account the results of both our present and past studies, it has become clear that early preterm birth may cause difficulties in specific linguistic abilities which persist up to age 8;0, even in absence of a general delay. Difficulties are already present at age 2;6 in the more immature preterms during the acquisition of the lexicon and grammar and tight relationships between these abilities were found in both preterms and full-terms (Sansavini *et al.*, 2006). Difficulties continue to be present in preterms at age 3;6 during the acquisition and consolidation of grammar and the development of phonological working memory abilities, with tight relationships between these competences observed both in preterms and

full-terms (Sansavini *et al.*, 2007). Difficulties in grammar comprehension, lexical production and phonological awareness are also present at age 6;0 (Sansavini *et al.*, 2008). In this last study, linguistic abilities were strictly linked to short-term memory in both preterms and full-terms, even if only preterm children also showed specific relationships between phonological awareness of syllable and short-term memory, not present in full-terms. Our current study has shown that difficulties are still obvious in preterms at age 8;0 during the consolidation phase of language (grammar comprehension, lexical production and phoneme synthesis) and the initial phase of the consolidation of literacy (reading and writing). In addition, several relationships between language and literacy are similar in preterms and full-terms, except for grammar comprehension, which yielded specific relationships with literacy in preterms, but not in controls. The difference in the relationships found in the preterm sample could be explained by the fact that an atypicality in one ability can have ramifications in others, since domains are not isolated from one another in their developmental trajectories (Karmiloff-Smith, 2009).

Therefore, language and literacy in preterm children display an atypical developmental trajectory over the course of time, as suggested by a different rate of development and differences in the relationships among competencies.

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