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C. R. Marshall [ab]; S. Harcourt-Brown [a]; F. Ramus [c]; H. K. J. van der Lely [a]
[a] University College London, [b] City University, London, UK [c] Laboratoire des Sciences Cognitives et Psycholinguistique, EHESS/CNRS/DEC-ENS, Paris, France

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Research Report

The link between prosody and language skills in children with specific language impairment (SLI) and/or dyslexia

C. R. Marshall[†‡], S. Harcourt-Brown[†], F. Ramus[§] and H. K. J. van der Lely[†]

†University College London
‡City University London, UK
§Laboratoire des Sciences Cognitives et Psycholinguistique, EHESS/CNRS/DEC-ENS, Paris, France

Abstract

Background: Children with specific language impairment (SLI) and dyslexia are known to have impairments in various aspects of phonology, which have been claimed to cause their language and literacy impairments. However, 'phonology' encompasses a wide range of skills, and little is known about whether these phonological impairments extend to prosody.
Aims: To investigate certain prosodic abilities of children with SLI and/or dyslexia, to determine whether such children have prosodic impairments, whether they have the same pattern of impairments, and whether prosodic impairments are related to language and literacy deficits.
Methods & Procedures: Six subtests of the Profiling Elements of Prosodic Systems — Child version (PEPS-C) were used to investigate discrimination/comprehension and imitation/production of prosodic forms that were either independent of language or that had one of two linguistic functions: chunking (prosodic boundaries) and focus (contrastive stress). The performance of three groups of 10–14-year-old children with SLI plus dyslexia, SLI, and dyslexia were compared with an age-matched control group and two younger control groups matched for various aspects of language and reading.
Outcomes & Results: The majority of children with SLI and/or dyslexia performed well on the tasks that tested auditory discrimination and imitation of prosodic forms. However, their ability to use prosody to disambiguate certain linguistic structures was impaired relative to age-matched controls, although

Address correspondence to: Heather K. J. van der Lely, Center for Developmental Language Disorders and Cognitive Neuroscience, Division of Psychology and Language Sciences, University College London, 2 Wakefield Street, London WC1N 1PF, UK; e-mail: h.vanderlely@ucl.ac.uk

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these differences disappeared in comparison with language-matched controls. No, or only very weak, links were found between prosody and language and literacy skills in children with SLI and/or dyslexia.
Conclusions & Implications: Children with SLI and/or dyslexia aged 10–14 years show an impaired ability to disambiguate linguistic structures for which prosody is required. However, they are able on the whole to discriminate and imitate the actual prosodic structures themselves, without reference to linguistic meaning. While the interaction between prosody and other components of language such as syntax and pragmatics is problematic for children with SLI and/or dyslexia, prosody itself does not appear to be a core impairment.

Keywords: specific language impairment, dyslexia, prosody, PEPS-C, language development.

What this paper adds

What is already known on this subject

The prosodic skills of children with specific language impairment and dyslexia are under-researched, despite extensive evidence that other types of phonological skills are impaired in those groups.

What this study adds

The study found that older children with specific language impairment and/or dyslexia showed impaired ability to disambiguate linguistic structures where prosody interacts with syntax (chunking, that is, prosodic boundaries) and pragmatics (focus, that is, contrastive stress). However, the majority of children were able to discriminate and imitate the prosodic structures themselves, without reference to linguistic meaning. Links between prosody and language and literacy skills were weak in children with specific language impairment and/or dyslexia.

Introduction

Specific language impairment (SLI) and dyslexia are developmental disorders of neurobiological origin characterized by different profiles of language and literacy impairment. Children with SLI show atypical language development, while children with dyslexia have difficulty in learning to read. Importantly, both groups have otherwise typical intellectual functioning, hearing,[1] and an adequate learning environment (Leonard 1998, Snowling 2000). Both disorders affect a sizeable proportion of the school-aged population (Law *et al.* 1998), and many children diagnosed with SLI are also dyslexic, and vice versa (Bishop and Snowling 2004). There has been considerable research into the speech perception, phonological awareness, and phonological working memory skills in these groups, with claims that deficits in these aspects of phonology cause the language and literacy impairments (Gathercole and Baddeley 1990, Joanisse *et al.* 2000, Tallal 2003, Joanisse 2004). Indeed, phonological deficits are claimed to be central to the overlap between SLI and dyslexia (Bishop and Snowling 2004). However, there has been far less research into another area of phonological ability, namely prosody.

Prosody is 'supra-segmental', that is, it applies to a linguistic domain longer than a single sound segment. It can be described as the melodic and rhythmic dimensions of speech and includes variations in pitch/fundamental frequency, loudness, duration, pauses, intonation, rate, stress and rhythm. These dimensions are used to convey a number of different things, for example, lexical stress, focus, some aspects of meaning and emotion. Prosody therefore fulfils a variety of linguistic, pragmatic and affective/emotional functions, and so is essential for many different aspects of communication.

Prosody delineates prosodic constituents that form a hierarchy and bear a relationship with syntactic constituents (Nespor and Vogel 1986). Prosody and syntax, therefore, interface in many constructions. For example, a sentence such as 'she washed and dressed the baby' has two syntactic structures, and therefore two meanings, which are disambiguated by prosody: [she washed] [and dressed the baby] (that is, she washed herself, and dressed the baby) and [she washed and dressed the baby] (it was the baby that she both washed and dressed). For this reason, understanding the prosodic abilities in children who have syntactic impairments is highly relevant. Furthermore, by organizing utterances, prosodic phrasing is proposed to aid comprehension by arranging linguistic units to be maintained in memory, prior to subsequent cognitive processing (Frazier *et al.* 2006). Given the evidence that children with SLI and dyslexia have poor short-term phonological memories, this raises the question about whether poor prosody is part of the cause (Wells and Peppé 2003). Moreover, given the bootstrapping role that prosody plays in early language acquisition (Gleitman and Wanner 1982, Morgan and Demuth 1996, Christophe *et al.* 1997), an impairment in prosody might conceivably create some difficulties in language acquisition (Ramus *et al.* 1999).

Previous research

Previous research provides evidence that children with SLI and a variety of non-specific language impairments (LI) have prosodic difficulties. Children with SLI have been found to be poor at imitating linguistic and affective intonation contours using prosody (Van der Meulen *et al.* 1997), while children with LI are reported not to mark boundaries in an utterance by lengthening the final syllable (Crary and Tallman 1993). Moreover, it has been argued that children with SLI do not use prosodic cues when repeating sentences or when learning rules in a miniature language (Weinert 1992). In a more recent study, Fisher *et al.* (2007) tested children's abilities to match low-pass-filtered sentences (which have lost segmental information and retain only prosodic information) to unfiltered sentences, manipulating the degree of prosodic similarity of the sentences. They found that children with SLI were significantly less successful than age-matched controls at this task.

However, other studies have failed to find prosodic impairments in children with SLI and LI. Snow (1998) investigated the use of prosodic boundary features that indicate phrase and clause boundaries. He reported that young children with SLI show typical use of falling tones and have normal 'expressive control of prosodic boundary features' (Snow 1998: 1167). Similarly, children with LI showed age-appropriate ability on a task that required the child to imitate the falling contours in statements and the rising contours in yes/no questions (Snow 2001).

Wells and Peppé (2003) used the Profiling Elements of Prosodic Systems — Child version (PEPS-C) tasks with a group of 18 children with LI (who had a variety of language, speech, hearing and pragmatic impairments, and some of whom had below-average non-verbal IQ scores and attention-deficit hyperactivity disorder

(ADHD)) and found that they had good prosodic skills. This finding is relevant to the current study, which uses an updated version of the PEPS-C.

The PEPS-C targets both receptive and expressive skills, and targets four different types of prosody: chunking, focus, affect and interaction (Peppé and McCann 2003). Chunking is the prosodic grouping of words to delimit speech into 'chunks', often reflecting syntactic divisions. Focus is the phenomenon whereby focal information in an utterance is indicated prosodically, by means of accent/stress. The PEPS-C assesses 'narrow' or contrastive stress, whereby the accent is placed on the stressed syllable of the most important word. Affect is the mood, emotion or attitude conveyed by intonation, for example, like or dislike. The fourth type of prosody, interaction, concerns the different intonations used at conversational turn-ends to indicate the type of response that is required, for example, a request for repetition or an understanding of what the speaker has said. Furthermore, the PEPS-C profiles both form-level processing, that is the ability to perceive and produce different prosodic elements, and function-level processing, the ability to appreciate and effectively make use of prosodic elements when they are linked to linguistic meaning. The PEPS-C is therefore a useful tool for building a detailed profile of a child's prosodic abilities within a psycholinguistic framework (Peppé and McCann 2003).

Wells and Peppé (2003) found that the LI group's scores were not significantly lower than those of their chronological age matched controls on the majority of tasks, but were significantly worse on five: chunking reception (form), chunking expression (form), focus reception (function), interaction reception (function), and interaction expression (function). Poor performance on the receptive form tasks was interpreted as LI children having difficulties in retaining information over longer prosodic domains where phrasal boundaries (that is, chunking) and phrasal accents (that is, focus) are required. However, LI children did not perform significantly worse than language controls on any of the PEPS-C tasks. This lack of difference was interpreted as indicating that the LI children's language problems could not be caused by problems with prosody.

Relationship between prosody and language

A theoretical question in linguistics concerns whether prosody is independent from other aspects of language, such as syntax and segmental phonology. Studies of children with SLI and LI, who have impairments in different components of language, promise to bring important empirical evidence to this debate. Snow (1998) found typical use of intonation alongside significantly lower mean length of utterance (an indication of expressive syntactic ability) in children with SLI. He also observed a robust negative correlation between percentage of consonants correct (PCC) and intonation in children with LI, supporting a strong form of the dissociation hypothesis (Snow 2001). Wells and Peppé (2003) found few correlations between PEPS-C subtests and scores on a range of language and phonology tasks, and concluded that prosody is relatively discrete from other areas of language.

The PEPS-C is potentially an important tool in addressing the degree of relationship between prosody and other language skills such as syntax and pragmatics. It allows the researcher to determine whether any deficits in prosodic function reside in the prosodic system proper, or in the interaction between prosody and other components of language such as syntax and pragmatics.

Aims of this study

Despite the research discussed in the previous section, there has been little systematic study of prosodic skills in SLI and dyslexia. Part of the difficulty is that researchers have used small and heterogeneous groups of children, and found substantial variability within those groups on experimental measures (Snow 2001, Wells and Peppé 2003). Secondly, the term 'prosody' refers to an array of different abilities: as a result, different researchers have investigated different aspects of prosody using a variety of assessments.

For the purpose of the present study we used the PEPS-C, which is beginning to be used with other atypically developing populations, and therefore offers a valuable tool for comparison across these different groups (Williams syndrome, Stojanovik *et al.* 2007; high-functioning autism, McCann *et al.* 2007). We used three sections of the PEPS-C — chunking, focus and long-item. 'Chunking' refers to boundary-signalling or prosodic delimitation of the utterance into units for syntactic purposes. The examples in the PEPS-C make use of minor phrase boundaries that can be used to distinguish between items in a list, as in colour combinations (for example, '[pink] [and green and black socks]', with the boundary after the first item, versus '[pink and green] [and black socks]', with the boundary after the second item) or single and compound food items ('[fruit], [salad] [and milk]', with the boundary after the first item, versus '[fruit-salad] [and milk]', with the boundary after the second item). 'Focus' refers to the use of phonetic prominence (stress) to indicate which word or syllable is most important in an utterance, as shown by the capitalized words in the following pair of phrases: 'BLUE and green socks' (focus on the first colour) versus 'blue and GREEN socks' (focus on second colour). Focus is an aspect of pragmatics: the speaker uses it to direct the listener towards important information that is worthy of attention. 'Long-item' refers to tasks which assess the child's ability to discriminate and imitate prosodic differences of the types that are used in the chunking and focus tasks, without reference to meaning.

The current study investigates the prosodic abilities of children with SLI and/or dyslexia, in order to build a broader profile of their language impairments. We use a larger sample of SLI children than has been the case in previous studies, and we investigate the relationship between prosody and a wide range of language and literacy skills. We address three principal questions. Do children with SLI and/or dyslexia have impairments in prosody? Do children with SLI and/or dyslexia have the same prosodic impairments? Are impairments in prosody related to impairments in language and literacy?

Methods

Participants

Three clinical groups (SLI plus dyslexia, SLI only, and dyslexia only) and three control groups (two younger groups matched for different aspects of language and literacy abilities, and one group matched for chronological age) participated in the study. The children in the clinical groups were recruited two years prior to the current study, to take part in a comprehensive investigation of phonological abilities in SLI and/or dyslexia. Note that all participants continued to be in special education during this time and were tested every six months as part of that investigation (Marshall *et al.* forthcoming, Marshall and Van der Lely forthcoming). The children in the clinical groups were aged between 8;00 and 12;11 at the time of recruitment, and between 10;00 and 15;00 at the time of this particular study. The following criteria were used to select children for the clinical groups:

- A minimum standard score of 80 on two tests of non-verbal cognition (Raven's Standard Progressive Matrices (RPM), Raven 1998; and block design subtest from British Ability Scales — 2 (BAS), Elliott 1996) and an average combined minimum score of 85 (that is, higher than –1 standard deviation (SD) below the mean).
- No additional diagnoses of ADHD, autistic spectrum disorder (ASD) or dyspraxia.
- A statement of special educational need and attendance at a special school or unit for children with SLI or dyslexia.

Selection for SLI was based on the following criteria:

- A standard score of 78 or below (that is, seventh percentile, *z*-score $= -1.5$) on at least one of the following: Test for Reception of Grammar — 2 (TROG; Bishop 2003); British Picture Vocabulary Scales — 2 (BPVS; Dunn *et al.* 1997); Sentence repetition subtest of Clinical Evaluation of Language Fundamentals — 3 (CELF; Semel *et al.* 1995); and Test of Word-Finding — 2 (TWF; German 2000).

Selection for the dyslexia group used the following criteria:

- A standard score of 78 or below (that is, seventh percentile, *z*-score $= -1.5$) on the single word reading subtest of the Wechsler Objective Reading Dimensions (WORD; Wechsler 1990), which comprises phonologically regular and irregular words).

In order to obtain a very detailed profile of our participants' language, literacy and phonological abilities, we carried out some additional tests. We administered two unstandardized language tests: the Test of Active and Passive Sentences (TAPS; Van der Lely 1996) — a test of reversible active and passive sentence comprehension — and the Verb Agreement and Tense Test (VATT; Van der Lely 2000) — a test of third-person agreement and past tense-marking on regular and irregular verbs. These two tests target language structures that are particularly impaired in SLI: passive sentences and finite verb morphology. We calculated *z*-scores for the TAPS and the VATT on the basis of the control data. In addition, we administered the single word spelling and comprehension subtests of the WORD, four subtests of the Phonological Assessment Battery — rhyme, spoonerisms, rapid naming (digits) and non-word reading (Frederickson *et al.* 1997), and the digit span subtest of the Wechsler Intelligence Scales for Children (Wechsler 1992). For ease, we refer to the Phonological Assessment Battery (PhAB; Frederickson *et al.* 1997) and Wechsler Intelligence Scales for Children (WISC; Wechsler 1992) subtests as 'phonological tests' in the remainder of this paper, although we are aware that they tap a range of different abilities that traditionally fall under the rubric of 'phonology' (phonological working memory, rapid access to lexical phonological representations, phonological awareness), whilst by no means providing a complete picture of children's phonological abilities. The results of all these tests are set out in tables 1 and 2.

Table 1. Number of participants, their age at time of experimental testing[†], and results of non-verbal and language tests

		SLI plus dyslexia (n=28)		SLI only (n=10)		Dyslexia only (n=18)		LA1 controls (n=15)		LA2 controls (n=16)		CA controls (n=30)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age		12.75	(1.15)	12.44	(1.74)	12.32	(1.23)	7.92	(0.50)	9.23	(0.50)	11.84	(1.26)
Test	Score												
RPM	Raw	33.71	(4.76)	37.9	(4.09)	38.11	(5.90)	18.87	(4.14)	27.88	(7.73)	39.00	(8.47)
	z	−0.55	(0.37)	0.20	(0.74)	0.19	(0.94)	0.48	(0.40)	0.80	(0.77)	0.63	(0.90)
BAS[‡]	*z*	−0.44	(0.46)	−0.18	(0.57)	0.22	(0.77)	0.77	(1.23)	0.47	(1.03)	0.70	(0.96)
TROG	Raw	10.75_{a}	(3.30)	$13.80_{b,c}$	(2.30)	$16.22_{c,d}$	(2.10)	$12.00_{a,b}$	(3.66)	$14.81_{c,d}$	(2.20)	16.93_{d}	(1.91)
	z	−1.64	(0.91)	−0.78	(0.71)	0.05	(0.72)	0.75	(0.92)	0.60	(0.70)	0.39	(0.54)
BPVS	Raw	78.14_{b}	(16.68)	$87.30_{b,c}$	(14.60)	$98.89_{c,d}$	(13.18)	64.73_{a}	(10.63)	85.19_{b}	(7.74)	102.07_{d}	(13.12)
	z	−1.28	(0.76)	−0.65	(0.76)	0.08	(0.67)	0.44	(0.76)	0.86	(0.56)	0.50	(0.64)
CELF	Raw	19.20_{a}	(8.96)	$23.95_{a,b}$	(5.82)	45.11_{c}	(12.65)	30.47_{b}	(8.88)	$37.75_{b,c}$	(9.27)	52.50_{c}	(9.65)
	z	−2.17	(0.25)	−2.00	(0.42)	−0.43	(0.78)	0.57	(0.50)	0.42	(0.76)	0.32	(0.69)
TWF	Raw	39.04_{a}	(10.24)	50.90_{b}	(8.17)	$60.83_{b,c}$	(7.98)	39.80_{a}	(12.35)	$58.63_{b,c}$	(6.28)	64.73_{c}	(7.39)
	z	−2.26	(0.61)	−1.25	(0.61)	−0.30	(0.76)	0.14	(0.61)	0.55	(0.78)	0.39	(0.79)
TAPS	Raw	26.14_{a}	(5.90)	26.30_{a}	(5.52)	32.83_{b}	(2.31)	27.13_{a}	(5.77)	$30.06_{a,b}$	(3.07)	31.90_{b}	(3.60)
	z	−1.37	(1.28)	−1.29	(1.31)	0.16	(0.53)	−0.12	(1.19)	0.21	(0.65)	0.05	(0.78)
VATT	Raw	17.18_{a}	(10.44)	27.50_{b}	(6.87)	$34.28_{b,c}$	(4.24)	29.13_{b}	(6.72)	$33.81_{b,c}$	(3.37)	37.37_{c}	(2.22)
	z	−4.09	(1.95)	−2.10	(1.09)	−0.67	(0.81)	−0.28	(1.23)	0.22	(0.61)	0.07	(0.52)

Raw scores with different subscripts differ significantly at the p=0.05 level on *post-hoc* testing with Bonferroni correction.

[†]Children were an average of 24 months younger than this at the time that the standardized language and literacy tests were administered.

[‡]The authors do not report raw scores for the BAS because, depending on their age, children attempt a different number of items — the raw scores, therefore, vary in ways that do not reflect performance on this task.

BAS, British Ability Scales, block design subtest (Elliott 1996); BPVS, British Picture Vocabulary Scales (Dunn *et al.* 1997); CELF, Clinical Evaluation of Language Fundamentals, sentence repetition subtest (Semel *et al.* 1995); RPM, Raven's Progressive Matrices (Raven 1998); TAPS, Test of Active and Passive Sentences (Van der Lely 1996); TROG, Test of Reception of Grammar (Bishop 2003); TWF, Test of Word Finding (German 2000); VATT, Verb Agreement and Tense Test (Van der Lely 2000); SD, standard deviation.

Table 2. Results of literacy and phonological tests

			SLI plus dyslexia (n=28)		SLI only (n=10)		Dyslexia only (n=18)		LA1 controls (n=15)		LA2 controls (n=16)		CA controls (n=30)	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
WORD	Reading	Raw	18.39$_{a}$	(7.05)	36.90$_{b}$	(9.55)	20.00$_{a}$	(5.52)	18.60$_{a}$	(9.66)	34.63$_{b}$	(4.67)	44.57$_{c}$	(5.86)
		z	−2.07	(0.46)	−0.18	(0.81)	−1.83	(0.33)	1.20	(0.95)	1.39	(0.88)	0.96	(0.73)
	Spelling	Raw	16.57$_{a}$	(4.32)	27.40$_{b}$	(7.31)	17.28$_{a}$	(3.04)	15.20$_{a}$	(4.97)	24.38$_{b}$	(4.83)	33.17$_{c}$	(5.48)
		z	−1.95	(0.41)	−0.43	(0.54)	−1.78	(0.45)	1.01	(0.62)	1.09	(0.93)	0.58	(0.76)
	Comprehension	Raw	6.79$_{a}$	(4.86)	16.30$_{b,c}$	(5.83)	10.89$_{a,b}$	(6.35)	8.40$_{a}$	(7.14)	18.75$_{c}$	(3.87)	27.30$_{d}$	(3.75)
		z	−2.58	(0.55)	−1.10	(0.72)	−1.88	(0.65)	0.80	(0.94)	0.91	(0.69)	1.06	(0.89)
PhAB	Non−word reading	Raw	6.12$_{a}$	(4.47)	14.00$_{b,c}$	(4.88)	9.39$_{a,b}$	(3.63)	10.53$_{b}$	(4.87)	14.75$_{c}$	(2.98)	17.90$_{c}$	(2.92)
		z	−1.03	(0.55)	−0.03	(0.53)	−0.56	(0.49)	0.77	(0.34)	0.67	(0.34)	1.06	(0.75)
	Rhyme	Raw	8.21$_{a}$	(4.25)	17.00$_{c}$	(3.77)	12.28$_{b}$	(5.72)	13.20$_{b}$	(5.02)	17.50$_{c}$	(3.27)	18.63$_{c}$	(1.69)
		z	−1.56	(0.49)	−0.09	(0.50)	−0.82	(1.15)	0.82	(0.33)	0.88	(0.57)	0.48	(0.60)
	Spoonerisms	Raw	6.89$_{a}$	(5.41)	15.40$_{b}$	(7.43)	11.11$_{a,b}$	(6.52)	7.67$_{a}$	(2.58)	15.00$_{b}$	(6.13)	22.97$_{c}$	(4.78)
		z	−1.18	(0.54)	−0.23	(0.77)	−0.63	(0.60)	0.38	(0.15)	0.78	(0.59)	0.97	(0.65)
	Rapid naming	Raw	73.86$_{a,b}$	(23.67)	54.80$_{b,c}$	(12.70)	76.44$_{a,b}$	(23.74)	94.07$_{a}$	(24.66)	65.63$_{b,c}$	(15.87)	47.37$_{c}$	(15.11)
		z	−1.12	(0.71)	−0.19	(0.69)	−1.05	(0.76)	−0.24	(0.43)	0.53	(0.79)	0.78	(0.95)
WISC	Digit span	Raw	9.43$_{a}$	(1.81)	10.30$_{a}$	(2.21)	10.94$_{a}$	(2.07)	14.40$_{b}$	(3.81)	13.69$_{b}$	(2.55)	15.83$_{b}$	(3.01)
		z	−1.57	(0.48)	−1.27	(0.78)	−1.04	(0.50)	1.13	(1.15)	0.58	(0.85)	0.49	(0.91)

Raw scores with different subscripts differ significantly at the p=0.005 level on *post-hoc* testing with Bonferroni correction.
PhAB, Phonological Assessment Battery (Frederickson *et al.* 1997); WISC: Wechsler Intelligence Scales for Children (Wechsler 1992); WORD, Wechsler Objective Reading Dimensions (Wechsler 1990); SD, standard deviation.

Table 3. Group matches

Language/literacy measure	LA1 controls	LA2 controls	CA controls
Sentence comprehension — TROG	SLI plus dyslexia	SLI only	Dyslexia only
Receptive vocabulary — BPVS		SLI plus dyslexia SLI only	Dyslexia only
Single word reading — WORD	SLI plus dyslexia Dyslexia only	SLI only	

We found a substantial overlap between the SLI and dyslexia groups even though many of the children had an official diagnosis of only a single deficit. Thus, many children fulfilled our criteria for both SLI and dyslexia, and so were allocated to the SLI plus dyslexia group. For this round of testing, the numbers in each group were as follows: 28 SLI plus dyslexia, ten SLI only and 18 dyslexia only.

Children in the control groups had to have a score of 85 or above on every language and literacy task along with no history of speech or language delay or special educational needs. They were aged between 5;00 and 12;11 years old at the time of recruitment and divided into three age bands (7;01–8;06, 8;07–10;00, and 10;01–14;11 for this current round of testing). The oldest group were a chronological age-matched (CA) control group for the SLI and dyslexic groups, and therefore allow us to investigate whether the prosodic skills of children with SLI and dyslexia fall below age expectations. However, younger control groups matched for different aspects of language and literacy, as described in the next section, allow us to investigate more closely the link between prosody and other language skills, and literacy. These groups are termed LA1 (7;01–8;06) and LA2 (8;07–10;00), where LA stands for language/literacy age.

Matching criteria

In order to determine which of the control groups provide matches for each of the clinical groups for sentence comprehension, receptive vocabulary and single-word reading abilities, we used three sets of raw scores: the TROG, the BPVS and the WORD single word reading. We ran a series of *t*-tests comparing the performance of each clinical group with each control group for each of those three tests. Only the results relevant to matching are reported here.

The SLI plus dyslexia group did not differ from the LA1 group on the TROG, $t(41)=-1.140$, $p=0.261$, or the WORD, $t(41)=-0.081$, $p=0.936$, and did not differ from the LA2 group on the BPVS, $t(42)=-1.588$, $p=0.120$. The SLI only group did not differ from the LA2 group on the TROG, $t(24)=-1.123$, $p=0.273$, and did not differ from the LA2 group on the BPVS, $t(24)=0.484$, $p=0.633$, or the WORD, $t(24)=0.816$, $p=0.423$. The dyslexia only group did not differ from the LA1 group on the WORD, $t(31)=0.522$, $p=0.605$, nor from the CA group on the TROG or the BPVS, $t(46)=-1.202$, $p=0.235$ and $t(46)=-0.811$, $p=0.421$, respectively. These matches are set out in table 3 for clarity.

Finally, this section investigates how the SLI and dyslexic groups' raw scores on the tasks in table 1 and 2 compared with each other and to their language and literacy controls. A series of one-way analyses of variance (ANOVAs) on raw scores revealed, unsurprisingly, significant group differences at $p<0.001$ for all these tests, with F values ranging between 8.497 and 61.149. We followed up these results with a series of

Bonferroni-corrected comparisons, and the results of these comparisons are shown in tables 1 and 2, where scores with different subscripts are significantly different. Here we discuss only the comparisons within the clinical groups, in order to give a picture of their relative levels of language, literacy and phonological abilities.

Of the three clinical groups, the SLI plus dyslexia group performed numerically worst overall, and sometimes significantly so, as was the case for the TROG, TWF, VATT and the rhyme subtest of the PhAB. Indeed, they performed worse than even the youngest control group on the VATT and rhyme subtest. Not surprisingly, the dyslexia only group performed numerically better than the SLI only group on the language tasks in table 1, and significantly so for the recalling sentences subtest of the CELF and the TAPS. The reverse pattern was true for the literacy and phonological tests in table 2: the SLI only group performed numerically better than the dyslexia only group, significantly so for the reading and spelling subtests of the WORD and the rhyme subtest of the PhAB. The only test for which this pattern did not hold is the digit span subtest of the WISC — there were no significant differences between any of the three clinical groups, and all performed worse than the three control groups.

Experimental tasks

The experimental tasks were carried out an average of 24 months after the standardized assessments which were used for selection and characterization of the participants. A subset of six PEPS-C tasks were used since we were interested in those that require language processing, and their related prosodic forms. We did not use those tasks that require the comprehension or expression of emotional state (affect) or regulation of conversational behaviour (turn-end type). The tasks we selected tested receptive and expressive skills in chunking and focus. We also selected the two 'long-item' form tasks. The chunking and focus tasks are 'function' tasks in that they require the child to comprehend or express linguistic meaning. In particular, they require the interaction between prosody and syntax (chunking) and pragmatics (focus). The long-item tasks, on the other hand, are 'form' tasks in that no meaning is involved. The PEPS-C has undergone several developments in recent years, and we used the most recent version currently available, which was also used by Stojanovik *et al.* (2007) and McCann *et al.* (2007). We used the version with stimuli recorded in a Southern British accent. The tasks are described below.

Chunking

The chunking tasks assess the child's ability to use prosodic cues in order to understand or indicate boundaries or prosodic phrases. These prosodic phrase boundaries correspond to syntactic phrase boundaries, and therefore are essential for understanding and expressing meaning.

Receptive task. The child hears an utterance, sees two sets of pictures on the computer screen, and is required to choose which set of pictures matches the utterance. For example, for the utterance '[fruit] [salad] [and milk]' (where [ ] represents a boundary) there is the choice between a set of pictures of fruit-salad and milk (incorrect), and another set of fruit, salad and milk (correct). Items are either food items, as in the previous example, or different coloured socks, for example, '[red] [and black and pink socks]', where the child has to choose between a set of pictures featuring a pair of red socks and a pair of black and pink socks (correct), and a set of pictures featuring a pair of red and black socks and a pair of pink socks (incorrect).

Expressive task. The child sees a set of pictures and is required to say what each picture shows. The pictures used and the target utterances are the same as those used in the chunking input task. The tester judges whether the child produces a prosodic boundary after the first or second food item/colour.

Focus

The focus tasks assess the child's ability to use intonation prominence (emphasis) to understand and indicate the word or syllable that is most important (stressed) in an utterance.

Receptive task. The child hears an utterance where two colours are mentioned and the child has to identify which colour the speaker has focussed the utterance on. The child makes his/her choice by clicking on one of two colours presented on the screen.

Expressive task. This assesses the child's ability to use intonation prominence to focus on a specific item for the purposes of repair. This task uses a football game between different teams of coloured sheep and cows. The child has to correct a commentator's utterance about which sheep or cow has the ball. The tester makes a judgement as to whether the child correctly emphasizes the error that s/he is correcting.

Long-item

These tasks assess the child's ability to perceive and produce prosodic elements in an utterance, such as stress, rhythm and timing.

Receptive task (discrimination). The child has to make same-different judgements. The child is presented with pairs of stimuli which are laryngograph signals only — there is no audible lexical or grammatical information. These signals are from natural speech, made using stimuli from the chunking and focus input tasks. These are short phrases.

Expressive task (imitation). The child hears an utterance played via the computer and has to repeat it exactly the way the speaker said it. The sentences are similar to those used in the chunking and focus tasks and are said by the speaker with variations in intonation and stress. Examples include '[red] [and pink and black socks]' and 'green and BLUE socks'. The tester judges how accurately the child repeats the prosody on a three-point scale: good, fair and poor. 'Good' is awarded for exact an imitation. 'Fair' is given for a response that is not an exact repetition, but whose function is maintained, for example, the stress is on the same word as the stimulus, but the stress is either exaggerated or minimal compared with the stimulus. 'Poor' is awarded for an incorrect response, for example, the chunking is misleading, or stress is on the wrong word.

The PEPS-C was presented using a laptop computer. Participants made their responses for the receptive tasks using a mouse. For the expressive tasks, a Samson C01U microphone was used to record children's responses directly onto the laptop.

Procedure

Participants completed the selected PEPS-C tasks in a quiet room at school, at home or at the UCL Centre for Developmental Language Disorders and Cognitive Neuroscience. It took approximately 20 minutes to work through these six tasks, which were completed in the order in which they are described above. The session began with a vocabulary check to ensure the children knew the objects depicted in the tasks. Each task began with two example items to ensure the child understood what he or she should be doing, and then another couple of practice items which did not contribute to the child's final score. The experimenter worked through these items with the child. Children who appeared to be struggling or had not fully understood the task were given the opportunity to repeat the practice. However, the experimenter did not prompt or explicitly instruct the children to use prosodic cues.

Scoring and inter-rater reliability

The three receptive tasks were scored automatically by the computer. Responses for the expressive tasks were rated by the first author, and half the children in each group were then rated independently by the second author. Expressive items were randomized and hidden from the raters, so that the raters were blind to the target. Following Stojanovik *et al.* (2007) we excluded unscorable responses, calculating each child's score as the number of correct responses divided by the total of scorable responses, and then multiplied by 16 to make it comparable with scores on other subtests. Examples of unscorable responses were as follows.

Chunking expressive task. '[red] [and black and pink socks]' realized as 'red socks and black and pink socks', where it is not the prosody but rather 'socks' inserted after 'red' that gives the clue to meaning.

Focus expressive task. The child said just the name of the animal rather than both the colour and the animal, for example, 'the COW' instead of the 'black COW'.

Long-item imitation task. The child omitted one or more lexical items so that target prosody could not be maintained, for example, instead of '[red] [and black and pink socks]', the child said 'black and pink socks'.

Item-by-item agreement between the two raters for the expressive tasks was as follows: clinical groups, chunking 93.75%, focus 89.01% and long-item 92.89%; control groups, chunking 93.75%, focus 95.83%, long-item 96.02%. Although item-by-item agreement for the focus responses of the clinical groups might seem comparatively low, in actual fact there was only a discrepancy of 1.97% on overall scores. This is because some children's responses were difficult to score, leading to higher disagreement over individual items, but the overall scores given by the two raters for each child differed little.

Results

Each group's scores for the six tasks of the PEPS-C are set out in table 4. Following Stojanovik *et al.* (2007) we used non-parametric analyses, because our data, like theirs, were not normally distributed. For each task we carried out a Kruskal–Wallis test, which is a non-parametric equivalent of a one-way ANOVA.

Receptive tasks

First, we analysed the receptive tasks. For chunking reception, $\chi^2(5, 117)=29.777$, $p<0.001$; focus reception χ^2 $(5, 117)=32.112$, $p<0.001$; long-item discrimination, $\chi^2(5, 117)=11.846$, $p=0.037$. We followed up these significant group differences with a series of Mann–Whitney tests, with an alpha value set at $p=0.003$ to correct for multiple comparisons. The results of all comparisons are presented in table 5, and we report only the significant results here. For the SLI plus dyslexia group, comparisons with the CA group (but not the LA groups) were significant. For the chunking receptive task, $Z=-4.685$, $p<0.001$ and for focus reception, $Z=-4.838$, $p<0.001$. The comparison for the long-item discrimination task just missed significance at this strict alpha level, $Z=-2.817$, $p=0.005$. For the SLI only group too, only comparisons with the CA group were significant. For chunking reception, $Z=-3.322$, $p=0.001$, and focus reception $Z=-3.234$, $p=0.001$, but not for long-item discrimination, $Z=-0.265$, $p=0.791$. This pattern was repeated for the dyslexia only group, which performed significantly worse than the CA group on the chunking and focus receptive tasks, $Z=-4.119$, $p<0.001$, and $Z=-3.862$, $p<0.001$, respectively, but not on the long-item discrimination task, $Z=-1.272$, $p=0.203$. Only one other comparison reached significance: the LA1 group performed significantly worse than the CA group on the chunking reception task, $Z=-3.578$, $p<0.001$.

Expressive tasks

For chunking expression, $\chi^2(5, 116)=10.041$, $p<0.074$; focus expression $\chi^2(5, 116)=22.949$, $p<0.001$; and long-item imitation, χ^2 $(5, 116)=20.869$, $p=0.001$. We followed up the significant group differences for the focus and long-item expressive tasks with a series of Mann–Whitney tests (alpha value, $p=0.003$). Four comparisons reached significance. The SLI plus dyslexia group performed worse than the LA2 group on the focus expression task, $Z=-3.178$, $p=0.001$, and worse than the CA group on this same task, $Z=-3.688$, $p<0.001$. The SLI plus dyslexia group performed worse than the CA group on the long-item imitation task, $Z=-3.613$, $p<0.001$. The dyslexia only group also performed worse than the CA group on the long-item imitation task, $Z=-3.174$, $p=0.002$.

Given the poor performance of the SLI plus dyslexia group relative to the controls on the focus and long-item expressive tasks, we were concerned that we might have been overlooking meaningful group differences on the chunking expression task, even though the ANOVA by group had just missed significance for that task. We therefore performed a series of Mann–Whitney tests to test all pairwise comparisons. A significant difference was found between the SLI plus dyslexia and CA groups, $Z=-3.046$, $p=0.002$.

Table 4. Mean and standard deviation (SD) for each group on each task of the PEPS-C, out of a possible total of 16

		SLI plus dyslexia (n=28)		SLI only (n=10)		Dyslexia only (n=18)		LA1 controls (n=15)		LA2 controls (n=16)		CA controls (n=30)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
CHUNKING	Reception	12.50_{a}	(2.10)	13.00_{a}	(2.00)	12.83_{a}	(1.76)	12.13_{a}	(3.00)	$13.63_{a,b}$	(2.25)	15.17_{b}	(1.39)
	Expression	12.80_{a}	(2.52)	$13.81_{a,b}$	(2.03)	$14.08_{a,b}$	(1.92)	$13.17_{a,b}$	(2.77)	$13.73_{a,b}$	(2.10)	14.65_{b}	(1.60)
FOCUS	Reception	10.11_{a}	(2.06)	10.10_{a}	(2.60)	10.06_{a}	(2.90)	$11.73_{a,b}$	(2.76)	$12.69_{a,b}$	(3.03)	13.77_{b}	(2.51)
	Expression	13.28_{a}	(2.57)	$13.09_{a,b}$	(2.76)	$14.46_{a,b}$	(1.81)	$15.12_{a,b}$	(1.14)	15.31_{b}	(0.95)	15.10_{b}	(2.01)
PROSODY	Reception	13.32_{a}	(2.71)	15.10_{a}	(0.74)	14.06_{a}	(2.82)	14.00_{a}	(1.89)	14.88_{a}	(0.81)	14.83_{a}	(1.72)
	Expression	14.28_{a}	(1.60)	$15.55_{a,b}$	(0.96)	14.52_{a}	(1.51)	$15.19_{a,b}$	(0.95)	$15.31_{a,b}$	(0.96)	15.48_{b}	(1.21)

Within each task scores with different subscripts differ significantly at the p=0.003 level.
SD, standard deviation.

Table 5. *Z*-values for Mann–Whitney pair-wise tests

		SLI plus dyslexia	SLI only	Dyslexia only	LA1	LA2	CA
Chunking	SLI plus dyslexia		−1.052	−1.815	−0.806	−0.989	−3.046*
	SLI only	−0.672		−0.439	−0.393	−0.027	−1.243
	Dyslexia only	−0.479	−0.340		−0.551	−0.457	−1.167
	LA1	−0.399	−0.616	−0.711		−0.661	−1.721
	LA2	−1.493	−0.827	−1.053	−1.547		−1.321
	CA	−4.685*	−3.322*	−4.119*	−3.578*	−2.393	
Focus	SLI plus dyslexia		−0.034	−1.889	−2.640	−3.178*	−3.688*
	SLI only	−0.220		−1.345	−2.063	−2.401	−2.830
	Dyslexia only	−0.263	−0.024		−1.090	−1.570	−2.060
	LA1	−1.869	−1.325	−1.570		−0.310	−0.532
	LA2	−2.733	−1.922	−2.283	−1.021		−0.489
	CA	−4.838*	−3.234*	−3.862*	−2.477	−1.199	
Long-item	SLI plus dyslexia		−2.551	−0.609	−1.889	−2.237	−3.613*
	SLI only	−2.219		−2.358	−1.193	−0.911	−0.169
	Dyslexia only	−1.376	−0.879		−1.333	−1.845	−3.174*
	LA1	−0.778	−1.534	−0.670		−0.421	−1.485
	LA2	−2.123	−0.732	−0.396	−1.118		−1.090
	CA	−2.817	−0.265	−1.272	−1.818	−0.897	

Production scores are shaded, receptive scores are unshaded.
*Significant result at the adjusted alpha level of 0.003. Comparisons are reported for the expressive chunking tasks, even though the Kruskal–Wallis test did not reach significance (see the text).

In summary, the pattern for the receptive tasks was that all three clinical groups performed below age expectations on the two function tasks — chunking and focus reception — but not on the long-item discrimination task. For the expressive tasks some differences with the CA group (the age-matched controls) reached significance, and it was the SLI plus dyslexia group that performed the worst. The SLI plus dyslexia group scored significantly lower than the CA group on the chunking expressive and the focus expressive tasks, The SLI plus dyslexia and dyslexia only groups fell below age expectations on the long-item imitation task. The SLI plus dyslexia group fell below their vocabulary-matched controls, the LA2 group, on the focus expressive task, but otherwise all three clinical groups performed in line with their LA controls.

Individual results

We also calculated how many children in each group passed each task. This is important because significant group differences may be found even when performance levels are high. We followed McCann *et al.* (2007) in setting the pass rate for the receptive and expressive tasks at 12/16 (75%). The results are set out in table 6. Inspection of these results indicates that although the SLI plus dyslexia and dyslexia only groups performed worse than their age-matched controls on the long-item imitation task, the majority of children in both groups passed, as is also reflected in high group mean scores (table 4). In contrast, fewer children passed the function tasks, with the focus receptive task proving particularly difficult not only for the clinical groups, but also for the control groups.

Table 6. Number (percentage) of children in each group passing each subtest (that is, achieving a score of twelve or more out of a possible 16)

		SLI plus dyslexia	SLI only	Dyslexia only	LA1 controls	LA2 controls	CA controls
CHUNKING	Reception	19/28 (68)	8/10 (80)	13/18 (72)	8/15 (53)	11/16 (69)	28/30 (93)
	Expression	19/27 (70)	8/10 (80)	17/18 (94)	10/15 (67)	12/16 (75)	28/30 (93)
FOCUS	Reception	8/28 (29)	2/10 (20)	5/18 (28)	8/15 (53)	11/16 (69)	24/30 (80)
	Expression	21/27 (78)	7/10 (70)	17/18 (94)	15/15 (100)	16/16 (100)	29/30 (97)
PROSODY	Reception	24/28 (86)	10/10 (100)	17/18 (94)	12/15 (80)	16/16 (100)	29/30 (97)
	Expression	25/27 (93)	10/10 (100)	16/18 (89)	15/15 (100)	16/16 (100)	29/30 (97)

Correlations between the PEPS-C and language and literacy measures

Finally, we investigated correlations between each of the PEPS-C tasks and the standardized language and literacy tests, and also the digit span subtest of the WISC. We did this for the three clinical groups combined (table 7) and the three control groups combined (table 8). Correlations were carried out on raw test scores, with non-verbal IQ (a composite of Raven's and British Ability Scales — Block Design subtest scores) and age partialled out. Correlations between subtests of the PEPS-C and the language and literacy measures were weak, and few reached significance for either group. The strongest correlation for the combined clinical groups was between the long-item imitation task and the Verb Agreement and Tense Test, at r=0.350, amounting to 12% shared variance. For the control groups, the strongest correlation was between the chunking receptive task and the TROG, at r=0.537, amounting to 29% shared variance.

Discussion

We investigated how children with SLI and/or dyslexia imitate and discriminate certain prosodic forms in isolation, and how they produce and comprehend those same forms when they interact with syntax (chunking) and pragmatics (focus) to serve a linguistic function. We used six tasks from the PEPS-C (Wells and Peppé 2003). The SLI plus dyslexia group performed the worst, falling below chronological age expectations on all but the long-item discrimination task. The SLI only group fell below age expectations on the two receptive function tasks: chunking and focus. The dyslexia only group performed worse than their age-matched controls on those

Table 7. Correlations between raw scores on PEPS-C tasks and language and literacy tests, clinical groups combined (*n*=56), and age and non-verbal IQ partialled out

		Chunking reception	Chunking expression	Focus reception	Focus expression	Prosody reception	Prosody expression
TROG	*r*	0.094	0.225	0.225	0.106	0.332*	0.274*
	p	0.502	0.106	0.106	0.451	0.015	0.047
BPVS	*r*	0.051	0.186	0.200	0.123	0.219	0.264
	p	0.719	0.182	0.151	0.380	0.116	0.056
CELF-rs	*r*	0.135	0.125	0.183	0.181	0.124	0.220
	p	0.335	0.374	0.191	0.194	0.376	0.113
TWF	*r*	0.014	0.211	0.124	0.154	0.280*	0.226
	p	0.920	0.129	0.378	0.271	0.043	0.104
VATT	*r*	0.019	0.235	0.099	0.311*	0.255	0.350**
	p	0.893	0.090	0.480	0.024	0.065	0.010
TAPS	*r*	0.061	0.209	0.092	0.308*	0.201	0.122
	p	0.663	0.133	0.512	0.025	0.148	0.386
WORD — reading	*r*	0.087	0.074	−0.008	0.030	0.165	0.183
	p	0.534	0.600	0.953	0.829	0.238	0.190
WORD — spelling	*r*	0.107	0.192	−0.049	−0.009	0.102	0.041
	p	0.446	0.169	0.726	0.947	0.469	0.772
WISC — digit span	*r*	−0.183	0.075	0.189	0.225	0.213	0.169
	p	0.189	0.594	0.176	0.105	0.125	0.228

*Significant at the 0.05 level (two-tailed); **significant at the 0.01 level (two-tailed); and ***significant at the 0.001 level (two-tailed).

Table 8. Correlations between raw scores on PEPS-C tasks and language and literacy tests, control groups combined (*n*=61), and age and non-verbal IQ partialled out

		Chunking reception	Chunking expression	Focus reception	Focus expression	Prosody reception	Prosody expression
TROG	*r*	0.537***	0.372**	0.102	0.150	0.205	0.171
	p	0.000	0.005	0.455	0.269	0.130	0.207
BPVS	*r*	0.116	0.143	−0.094	0.190	0.137	−0.040
	p	0.397	0.293	0.493	0.160	0.313	0.772
CELF-rs	*r*	0.227	0.109	−0.084	0.069	0.163	0.109
	p	0.093	0.423	0.538	0.614	0.229	0.424
TWF	*r*	0.389**	0.242	0.298*	−0.026	0.079	0.110
	p	0.003	0.072	0.026	0.848	0.561	0.421
VATT	*r*	0.528***	0.291*	0.333*	0.153	−0.037	0.144
	p	0.000	0.029	0.000	0.262	0.785	0.290
TAPS	*r*	0.001	0.244	−0.104	0.289	−0.090	0.067
	p	0.992	0.070	0.445	0.031	0.512	0.624
WORD — reading	*r*	0.434***	0.233	0.379**	0.058	−0.024	0.159
	p	0.001	0.083	0.004	0.672	0.863	0.243
WORD — spelling	*r*	0.327*	0.107	0.324*	0.040	−0.004	−0.050
	p	0.014	0.433	0.015	0.769	0.980	0.715
WISC — digit span	*r*	0.073	0.093	−0.002	0.052	0.147	0.072
	p	0.593	0.498	0.990	0.704	0.281	0.599

*Significant at the 0.05 level (two-tailed); **significant at the 0.01 level (two-tailed); and ***significant at the 0.001 level (two-tailed).

same two tasks, plus long-item imitation. However, all three groups generally performed in line with language and reading age expectations. For the long-item imitation task, we caution that the SLI plus dyslexia and dyslexia only groups actually achieved good scores, and that few individuals failed.

We conclude that few children with SLI and/or dyslexia have difficulty with the form tasks of the PEPS-C, but that a greater proportion have difficulty when these prosodic forms interact with syntax or pragmatics to serve a linguistic function. None of the children in the SLI only group had difficulty imitating and discriminating the prosodic forms that we tested, and so poor prosodic skills of the type we investigated in this study do not appear to underlie the language difficulties characteristic of SLI. These results should, of course, be interpreted with caution as there were only ten children in the group. Nevertheless, our interpretation is that at the interface between prosody and syntax/pragmatics, it is not the prosodic form of the utterance that causes difficulty for children with SLI. Rather, difficulties arise where the creation of the appropriate structural, syntactic, representation is required for interpretation, consistent with poor scores on syntactic (TAPS; Van der Lely 1996) and morphosyntactic (VATT; Van der Lely 2000) tasks (table 1).

Some of the children in the dyslexia only group did have difficulty with the function tasks, but only a couple with the form tasks, again suggesting that poor prosody does not underlie dyslexia. As we often find in our studies (Marshall *et al.* forthcoming, Marshall and Van der Lely forthcoming), children with a double deficit — both SLI and dyslexia — performed the worst. However, even the majority of that group were successful at the form tasks. Interestingly, the dyslexia only group performed below language-age expectations on the chunking and focus receptive tasks, suggesting that children with dyslexia can have subtle language comprehension difficulties involving the interaction between prosody and syntax and prosody and pragmatics. We also found weaknesses in this particular group of children for sentence repetition and word-finding abilities (Table 1).

The different tasks of the PEPS-C correlated only very weakly, and rarely significantly, with the standardized language and reading tests that we administered, when considering the clinical groups combined and the control groups combined. This finding suggests that in children with SLI and dyslexia, as well as in typically developing children, at least of the ages studied here, prosody has only a very weak relationship with general language and literacy skills. These results support Wells and Peppé's (2003) findings on a smaller group of children with a variety of language impairments.

Investigating correlations between the PEPS-C tasks and two language measures that stress phonological working memory — the CELF repeating sentences subtest and the WISC digit span task — is particularly important from a theoretical point of view. This is because Wells and Peppé (2003) claim that the chunking receptive task, with its relatively long stimuli, might tap into phonological memory deficits. In this study, the CELF repeating sentences and WISC digit span tests were not significantly correlated with any of the PEPS-C subtests, for either typically or atypically developing children.

In the 'Aims' section of the Introduction we set out three principal questions that our study sought to address, and we answer them here. (1) Do children with SLI and/or dyslexia have impairments in prosody? The answer is that the majority are able to discriminate and imitate the prosodic forms that we investigated here. However, all groups demonstrated delayed receptive functional prosodic ability, indicating comprehension difficulties when prosody has to interact with syntax and pragmatics. (2) Do children with SLI and dyslexia have the same prosodic impairments? No comparisons between the SLI only and dyslexia only groups reached significance. Both performed poorly relative to age-matched controls on the chunking and focus receptive tasks. Although only the dyslexia only group performed significantly worse than the age controls on the long-item imitation task, the difference between the SLI only and dyslexia only groups on that task did not reach significance at the strict alpha level that we adopted for multiple comparisons. However, it might be meaningful that the only clinical children who failed the long-item imitation test were in the two groups with dyslexia. (3) Are impairments in prosody related to impairments in language and literacy? The answer to this question is no — there was at most only a very weak correlation between certain PEPS-C tasks and general language and literacy tasks in the SLI and dyslexic groups. This may be partly due to uneven profiles of performance within these groups, and we have to caution that there was a two year lag between the administration of standardized measures and the PEPS-C, but our results are consistent with Wells and Peppé's (2003) study of children with language impairments.

The relative sparing of the discrimination and imitation of prosodic forms, independent of linguistic meaning, in groups of children who have severe impairments in other components of language (such as inflectional morphology and syntax) supports the view that linguistic components can be independently impaired (Van der Lely 2005), and suggests that prosody itself is not a core impairment. Of particular interest is the fact that all three clinical groups were impaired relative to controls on measures of phonological working memory (digit span), explicit phonological manipulation (rhymes, spoonerisms) and rapid access to phonological representations of lexical items (rapid naming: digits) (table 2). The contrast between poor performance on those tasks and good performance on prosodic tasks suggests that 'phonology' is not just one component of language but several different bodies of knowledge and skills with corresponding underlying mechanisms that can potentially be dissociably impaired. Greater detail is needed in models of SLI and dyslexia that attribute the overlap in the two disorders to a deficit in 'phonology', to clarify exactly what aspects of phonology are impaired in children with one or both of these disorders (for example Joanisse *et al.* 2000, Bishop and Snowling 2004).

Of course, we have only investigated children at a relatively old age — our participants were aged between 10 and 14. It is possible that the PEPS-C is not sensitive or broad enough to pick up subtle prosodic deficits. It is also possible that during the course of development, an earlier deficit in prosody 'recovered', but while it was active affected other aspects of language and literacy that have remained impaired. In order to investigate this possibility, researchers would need to test prosodic skills in much younger children, and the PEPS-C is probably not the best tool for this — it is difficult for typically developing children under the age of 5 to do (Stojanovik *et al.* 2007, Wells and Peppé 2003). Certainly, infants demonstrate an awareness of the regular correspondences between prosodic features and phrase boundaries in motherese (Kemler Nelson *et al.* 1989), consistent with the claim that prosodic cues help the child to discover syntactic structure in the input (Morgan and Demuth 1996). Such work with babies at risk of developing language and literacy impairments remains to be done, but would be very valuable. Findings that young children with SLI have difficulty producing iambic stress (Goffman 1999), and tend to omit unstressed syllables (Gerken and McGregor 1998) suggest that the relationship between prosody and language in children with SLI is an important one to explore further.

Finally, the PEPS-C has been used in studies of children with high-functioning autism (HFA) and Williams syndrome (WS). What comparisons can be made across these different populations on the six tasks that our children undertook? McCann *et al.* (2007) found that children with HFA (aged 6–13 years) performed worse than vocabulary-matched controls on the focus expressive, prosody receptive and long-item imitation tasks. They therefore showed the same poor performance relative to vocabulary matched controls as our SLI plus dyslexia group did for the focus expressive task. Otherwise, however, children with HFA appear to have greater weaknesses in prosody than children with SLI and/or dyslexia. Furthermore, the function tasks of the PEPS-C, but not the form tasks, correlated highly with language tasks, unlike our results and those of Wells and Peppé (2003) for children with speech and/or language impairments.

Stojanovik *et al.* tested children with WS (aged 6–13 years) alongside two groups of controls, matched for age and for sentence comprehension scores on the TROG. The group with WS performed worse than the age-matched controls on all tasks. There were no significant differences between the WS and language control groups on either of the chunking or focus tasks, or on the long-item discrimination task. The group with WS did, however, perform significantly worse than their language controls on the long-item imitation task. This led Stojanovik *et al.* to conclude that children with WS have specific difficulty in retaining pitch pattern information over long prosodic domains in instances where no linguistic context is present. This pattern of performance does not mirror what we found for children with SLI and dyslexia. The linguistic similarities and differences between children with SLI and

WS have long been of interest to developmental psycholinguists (Pinker 1991, Stojanovik *et al.* 2004, Thomas and Karmiloff-Smith 2005), and here we have shown another aspect of language for which the two groups behave differently with respect to one another — the imitation of prosodic forms.

Conclusions

Children with specific language impairment (SLI) and/or dyslexia between 10 and 14 years of age show an impaired ability to disambiguate linguistic structures where prosody is required to interact with syntax or pragmatics. However, they are able on the whole to discriminate and imitate the prosodic structures themselves, without reference to linguistic meaning. No, or only very weak, links were found between prosody and language and literacy skills in these children. Hence, prosody *per se* is not a core impairment, given their impairments in other areas of phonology and language.

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Note

1. SLI is also reported in deaf children who are acquiring sign language as their first native language (Morgan *et al.* 2007).

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