Clinical Linguistics & Phonetics, June 2007; 21(6): 435–455

Non-word repetition: An investigation of phonological complexity in children with Grammatical SLI

NICHOLA GALLON[1], JOHN HARRIS[2], & HEATHER VAN DER LELY[1]

[1]*Centre for Developmental Language Disorders and Cognitive Neuroscience, Department of Human Communication Science, University College London, UK,* [2]*Department of Phonetics and Linguistics, University College London, UK*

(Received 8 August 2006; accepted 21 February 2007)

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Abstract
We investigate whether children with Grammatical Specific Language Impairment (G-SLI) are also phonologically impaired and, if so, what the nature of that impairment is. We focus on the prosodic complexity of words, based on their syllabic and metrical (stress) structure, and investigate this using a novel non-word repetition procedure, the Test of Phonological Structure (TOPhS). Participants with G-SLI (aged 12–20 years) were compared to language-matched, typically developing children (aged 4–8 years). The results reveal that, in contrast to the controls, the accuracy with which the G-SLI group repeated non-words decreased as prosodic complexity increased, even in non-words with only one- and two-syllables. The study indicates that, in G-SLI, complexity deficits in morphology and syntax can extend to prosodic phonology. The study highlights the importance of taking into account prosodic complexity in phonological assessment and the design of non-word repetition procedures.

Keywords: *SLI, G-SLI, phonological complexity, prosodic complexity, non-word repetition*

Introduction

Specific language impairment (SLI) is a disorder of language acquisition in an otherwise typically developing child (Leonard, 1998). SLI is a heterogeneous disorder that can affect one or more components of language—syntax, morphology, pragmatics and, to a lesser extent, vocabulary (lexicon). It has increasingly become recognized as a valuable testing ground for theories of linguistic and cognitive development (e.g. Pinker, 1991; van der Lely, 2005). In particular, it provides evidence bearing on the relation between domain-general and domain-specific cognitive mechanisms and on the relative autonomy of components within the language system.

Phonological Impairment

Previous linguistic investigations of SLI in children have largely focused on morpho-syntax (for reviews see Bishop, 1997; Leonard, 1998). However, significant impairment in

---

Correspondence: Heather van der Lely, UCL Centre for Developmental Language Disorders and Cognitive Neuroscience, Department of Human Communication Science, Eastman Dental Institute, 123–126 Grays Inn Road, London WC1X 8WD, UK. Tel: +44 (0)20 7679 4047. Fax: +44 (0)20 7713 0861. E-mail: h.vanderlely@ucl.ac.uk

ISSN 0269-9206 print/ISSN 1464-5076 online © 2007 Informa UK Ltd
DOI: 10.1080/02699200701299982

non-word repetition tasks suggest that an underlying phonological deficit might also be involved (Gathercole & Baddeley, 1990; Botting & Conti-Ramsden, 2001; Norbury, Bishop, & Briscoe, 2002). Indeed, phonological impairment, along with speech impairment, is thought by some researchers to be a primary cause of morpho-syntactic and lexical impairment in SLI (Joanisse & Seidenberg, 1998; Chiat, 2001). Where impairments in phonology and speech impact on language, they are often understood as involving auditory processing (Joanisse & Seidenberg, 1998; Leonard, 1998; Tallal, 2000; McClelland & Patterson, 2002), or phonological short-term memory (Gathercole & Baddeley, 1990), or phonological processing (Chiat, 2001). Van der Lely (2005) proposes an alternative account, based on a view of phonology as a computational system that forms part of a speaker-hearer's internalized grammar. A phonological deficit might co-occur with other grammar-internal impairments, including morphological and/or syntactic, but there is not necessarily any causal relation among these deficits, although they might interact. This view is supported by phonological impairments that occur in the absence of morpho-syntactic impairment, such as in the case of dyslexia (Ramus, 2001). Investigating the phonological dimensions of SLI has the potential to further our understanding of the way in which the language components of syntax, morphology and phonology interact.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Specific Language Impairment and the G-SLI subgroup

The behavioural and genetic heterogeneity of SLI (The SLI Consortium, 2002; Marcus & Fisher, 2003, van der Lely, 2005) makes its difficult to construct a general profile of the phenomenon that would fit any given child. One way to address this potential problem is to study selected subgroups of children with SLI who share similar linguistic and cognitive profiles. Van der Lely and colleagues identified one such group, the "Grammatical SLI" (G-SLI) subgroup, who are characterized by a relatively discrete, persisting core deficit in grammar (syntax, morphology and, potentially, phonology), yet their speech is clear and they do not suffer from any articulation problems (van der Lely, 2005). This group represents between 10–20% of those children with persisting SLI (over 9 years) whose non-verbal IQ falls within normal limits (van der Lely & Stollwerck, 1996; Bishop, Bright, James, & van der Lely, 2000). Studies of Greek- and Hebrew-speaking children with G-SLI have provided further evidence of the morpho-syntactic characteristics of this subgroup (Stavrakaki, 2001, 2002; Friedmann & Novogrodsky, 2004).

This paper investigates phonological abilities in a group of English-speaking children and teenagers (hereafter referred to as children) presenting with G-SLI. Previous findings from morpho-syntactic investigations of the G-SLI subgroup have been replicated in other SLI subgroups, although some of these children also suffer from co-occurring non-verbal deficits and/or non morpho-syntactic language deficits (O'Hara & Johnson, 1997; Bishop et al., 2000; Norbury et al., 2002). Whether the findings of the present investigation into the phonology of the G-SLI subgroup also generalize to other SLI subgroups is an empirical issue that merits further study, since it can further elucidate the manner in which different language components develop relative to one another.

Prosodic phonology

The present study investigates the phonology of children with G-SLI by means of a non-word repetition task that tests the effect of prosodic complexity on performance. The prosodic structure of a word has two aspects. One governs how individual consonants and

RIGHTSLINK

vowels are grouped into syllables (syllabic structure). The other governs relations of stress prominence between neighbouring syllables (metrical structure).

A single word can consist of one syllable (e.g. *pay*), two (e.g. *pen.cil*), three (e.g. *ba.na.na*), or more (a point indicates a syllable division). The syllable itself is composed of an onset and a rhyme. The onset contains any consonants at the beginning of the syllable. It can be empty (e.g. *eye*), or it can contain one consonant (e.g. ***p**ay*) or a cluster of consonants (e.g. ***pl**ay*). The rhyme is composed of an obligatorily present nucleus and an optionally present coda. The nucleus is typically a vowel (as in both syllables of *city*) or sometimes a syllabic consonant (as in the second syllable of *button*). The coda consists of any consonant following the vowel in the same syllable (as in the *n* of *win.ter*).

The organization of syllables into metrical structure is reflected in the location of stresses within a word. A stressed syllable is stronger or more prominent than a weak, unstressed syllable (as in the strong-weak pattern of *cíty*, where the accent indicates a stress). The basic unit of metrical organization is the stress foot. This consists of either a strong syllable on its own (as in *pay*) or a strong-weak (trochaic) combination (as in *cíty*). A word minimally contains one foot (as in the *pay* and *cíty* examples just given). In words of more than one foot, one is more prominent than the other(s), identifiable on the basis of its bearing the primary stress of the word. For example, (*Cìnde*)(*réllla*) contains two feet (parenthesized), with a primary stress on the penultimate syllable and a subsidiary stress on the first. Within a word, certain unstressed syllables fall outside foot structure. In English, unfooted syllables of this type can be adjoined to the beginning or end of a word. For example, an unfooted syllable is left-adjoined to *ba*(*nána*) and right-adjoined to (*fánta*)*sy*.

The syllabic and metrical structure of a phonological word forms a prosodic hierarchy (Selkirk, 1980, 1982; McCarthy & Prince, 1995). As shown in Figure 1, a word contains at least one foot; each foot contains at least one syllable; each syllable contains an onset and a rhyme, which in turn linked to individual phonemes. Unfooted syllables are joined directly to the phonological word.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

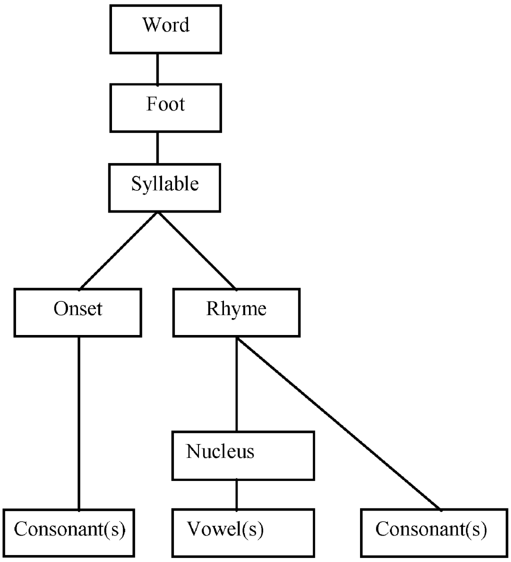

Figure 1. The Prosodic hierarchy.

The prosodic hierarchy provides us with a structure into which words can be analysed at different levels, including syllabic and metrical. Prosodic analysis elucidates the relationship between syllabic and metrical complexity and helps pinpoint any phonological problems that children with SLI may have.

The phonology of children with SLI

The phonological abilities of children with SLI are similar to those of younger, typically developing children. Findings from various studies indicate that children with SLI have difficulties with complex prosodic structure. For example, consonant cluster reduction, word-final consonant deletion and word-initial weak syllable deletion—each symptomatic of some prosodic deficit—occur with relatively high frequency in 2-year-old children. Cluster reduction persists for some time. These processes are also prevalent in the speech of children with SLI aged between 3- and 9-years-old (Gathercole & Baddeley, 1990; Bishop, North, & Donlan, 1996; Goffman, 1999; Sahlen, Reuterskioeld-Wagner, Nettelbladt, & Radeborg, 1999; Bortolini & Leonard, 2000; Orsolini, Sechi, Maronato, Bonvino, & Corcelli, 2001).

Consonant cluster reduction, final consonant deletion and weak syllable deletion all have the effect of simplifying the prosodic structure of a word. Children with SLI have been observed to omit weak syllables, especially when they precede strong syllables, as in *nanə banana* (Ingram, 1981). In a study of a group of Swedish children with SLI, Sahlen et al. (1999) found that unstressed syllables were omitted from words and non-words six times more often in pre-stressed than in post-stressed position. Similarly, Bortolini and Leonard (2000) found that English-speaking children with SLI omitted word-initial weak syllables on approximately 90% of occasions.

Some researchers have attributed weak-syllable deletion to the reduced perceptibility of unstressed syllables; compared to stressed syllables, they are shorter in duration, have less extreme fundamental frequency contours and are, therefore, less perceptually salient (see for example Echols & Newport, 1992; Echols, 1993). Others have argued that unstressed syllables are more difficult to produce (see for example Gerken, 1996). To the extent that these explanations might be correct, they can only be part of the story, because weak syllables are not deleted across the board. In both normally developing and impaired phonology, weak-syllable deletion is well established in word-initial position but is much less common after a stressed syllable. Hence, *banana* is more likely to be rendered as *nanə* rather than *bəna*. This is consistent with the fact that children's early utterances tend to be organized into strong-weak bisyllables. In other words, weak syllable deletion appears to be driven primarily by the prosodic structuring of syllables into trochaic feet.

Children with SLI have difficulty with the metrical structure of words, finding it difficult to produce and repeat polysyllables (Gathercole & Baddeley, 1990; Montgomery, 1995; Bishop et al., 1996; Botting & Conti-Ramsden, 2001). Using a non-word repetition procedure, Gathercole and Baddeley (1990) found striking deficits in children with SLI for non-words with three or more syllables compared with language-matched controls. These findings were replicated by Montgomery (1995) and Bishop et al. (1996). This has led to the suggestion that a core deficit in SLI lies in phonological short-term memory. Gathercole and Baddeley's Children's Test of Non-word Repetition (CNRep; Gathercole & Baddeley, 1996), is widely used as a diagnostic test of language and reading deficits, is designed to detect what is thought to be a primary memory deficit: either the capacity of the phonological store is unusually small (for example, limited to one or two syllables) or its contents decay unusually rapidly.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

An alternative view is that poor non-word repetition performance involves not just phonological memory but a range of phonological processing skills (Snowling, Chiat, & Hulme, 1991; van der Lely & Howard 1993). Snowling et al. (1991) argue that non-word repetition is a complex psycholinguistic task. They point out that previous work failed to separate the phonological memory component (i.e. maintaining a phonological representation in the phonological loop) from the phonological processing components involved in constructing the phonological representation of an input non-word and reconstructing it in speech output. Indeed, van der Lely and Howard (1993) found that not all children with SLI have short-term memory problems. When the phonological structure of the to-be-remembered non-words was simple, children were able to remember as many words as their language-matched peers. This raises the possibility that it is the prosodic structure of certain words renders them difficult.

More recently Roy and Chiat (2004), recognizing the importance of prosodic factors, designed a repetition task aimed at 2–4-year-olds in which they systematically manipulated the syllable length and prosodic structure of both words and non-words. They found the effect of prosodic structure to be significant among the typically developing children they studied. Their results are similar to those of Sahlen et al. (1999): whole-syllable errors were almost exclusively restricted to unstressed syllables, with those preceding stress being most vulnerable.

Examination of the range of non-words used in the CNRep reveals that the prosodic complexity of the different conditions (defined in terms of syllable number) is not controlled. For example, although *ballop* and *glistow* both contain two syllables, their syllable-internal structure is different. *Ba.llop* contains two simplex onsets, an open rhyme (the first, which ends in a vowel), and a word-final consonant. On the other hand, *glis.tow* has one complex and one simplex onset, one closed rhyme (the first, which ends in a consonant), and a word-final vowel. Amongst polysyllabic words used in CNRep, there are uncontrolled-for differences in metrical structure. For example, the five-syllable word *detratapillic* could be stressed as either *dètratapíllic* or *detràtapíllic*, in both cases with two feet and one unfooted weak syllable. In one instance, the unfooted syllable occurs in the middle of the word: (*dètra*)***ta***(*píllic*). In the other, it occurs at the beginning: ***de***(*tràta*)(*píllic*). Compare this with *voltularity*, with the same number of syllables and feet: here the unfooted syllable is adjoined to the end of the word: (*vòltu*)(*lári*)***ty***. These two words also differ in their syllable-internal structure: the former has one complex onset and no closed internal rhymes, while the latter has no complex onsets and one closed rhyme. In short, CNRep fails to take account of the fact that prosodic factors other than raw syllable count can potentially impact on the accuracy with which children with SLI to repeat non-words.

Test of Phonological Structure (TOPhS)

In this study, we investigate the syllabic and metrical dimensions of prosodic structure to determine the nature of any phonological deficit that might be evident in children with G-SLI. The initial hypothesis was that children with G-SLI have difficulty in constructing words with complex prosodic structures. We use a non-word repetition procedure, the Test of Phonological Structure (TOPhS) (van der Lely & Harris, 1999). What is novel about this procedure is its basic prosodic design: it allows us to examine phonological abilities by systematically varying the syllabic and metrical complexity of non-words. The procedure consists of 96 non-words that have been constructed using five binary phonological

Table I. Syllabic and metrical parameters used in TOPhS.

Parameter		Setting	Description	Real word	Non-word
Syllabic	Onset	Unmarked	No consonant cluster	**c**i.ty	**p**ɪ̱.fi
		Marked	Consonant cluster	**pr**e.tty	**pr**ɪ̱.fi
	Rhyme	Unmarked	Open syllable	c**i**.ty	p**ɪ̱**.fi
		Marked	Closed syllable	f**il**ter	p**ɪ̱l**.fi
	Word-end	Unmarked	Vowel-final	ci.t**y**	pɪ̱.f**i**
		Marked	Consonant-final	si**t**	pɪ**f**
Metrical	Left adjunction	Unmarked	No initial unfooted syllable	ci.ty	kɛ̱.tə
		Marked	Initial unfooted syllable	**ba**.na.na	**fə.**kɛ̱.tə
	Right adjunction	Unmarked	No initial unfooted syllable	ci.ty	kɛ̱.tə
		Marked	Final unfooted syllable	Ca.na.**da**	kɛ̱.tə.**lə**

parameters, chosen because they establish the major typological outlines of syllable and metrical structure in English.

The five selected parameters are set out in Table I, where they are illustrated by real-word examples and TOPhS non-word examples. In each of the examples, the segment string illustrating the relevant parameter is in bold.

Three of the parameters control aspects of syllabic structure (see Table I). One establishes whether an onset contains one consonant (the simplex option) or more than one consonant (complex). Another determines whether a rhyme is open (simplex, i.e. ending in a vowel) or is closed (complex, i.e. ending in a consonant). A third establishes whether a word ends in a vowel (simple) or a consonant (complex). In each of these cases, the simplex option is less "marked" than the complex. The relative markedness of a given structure is initially determined on the basis of observed asymmetries in its occurrence across different languages and in phonological acquisition. A less marked structure occurs in all languages and appears early in the acquisition process. A more marked structure occurs only in a subset of languages and is acquired relatively late.

The other two parameters selected for TOPhS are metrical (again see Table-I). One establishes whether a word contains an unfooted syllable adjoined to the beginning of a word (left adjunction), the other whether an unfooted syllable is adjoined to the end of a word (right adjunction). In both cases, adjunction adds to the metrical complexity of a word and constitutes the marked option.

The combination of settings on the different prosodic parameters was systematically varied to produce 24 sets of non-words containing between zero and four marked structures.[2] By way of illustration, consider the phonological structure of the non-words in

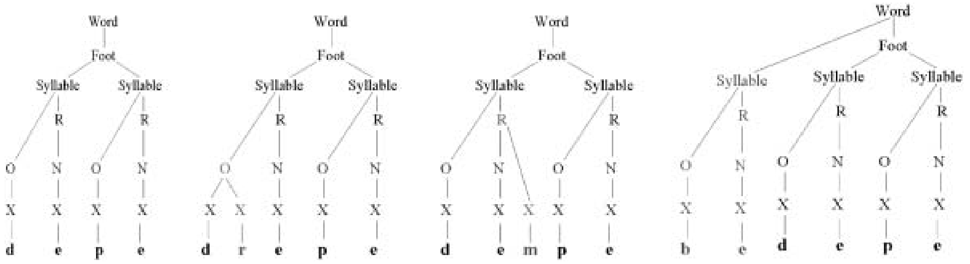

Figure 2. Prosodic structural complexity of non-words: examples from TOPhS.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Table II. Syllabic and metrical structures in disyllabic non-words.

Parameter		*Disyllabic examples*				
	Non-word Real word	*dɛ̱pə* city	*drɛ̱pə* pretty	*drɛ̱əmpə* plenty	*bədrɛ̱p* suppress	*bədrɛ̱mp* deflect
Syllabic	Onset	0	1	1	1	1
	Rime	0	0	1	0	1
	Word end	0	0	0	1	1
Metrical	Left adjunction	0	0	0	1	1
	Right adjunction	0	0	0	0	0

Figure 2. The non-word *dɛ́pə* is unmarked with respect to all five of the selected parameters: like the real word *city*, it contains no complex onsets, no closed syllables, no final consonant and no metrically adjoined syllables. Each of the other non-words in Figure 2 differs minimally from *dɛ́pə* in containing one marked structure: a complex onset in the case of *drɛ́pə*, a closed rhyme in *dɛ́mpə*, and a left-adjoined syllable in *bədɛ́pə*.

The strength of the TOPhS procedure is that the prosodic complexity of words can be manipulated independently of the number of phonemes or syllables they contain. We can thereby see whether the number and type of marked structures have any effect on the accuracy of repetition performance. For example, a bisyllabic TOPhS form such as *dɛ́pə* (with no marked structures) is prosodically less complex than monosyllabic *dɛ́p* (with one marked structure, namely final C), even though it contains one more phoneme. To take another example, we can see from table II that bisyllabic TOPhS non-words can contain anything from zero to four marked structures. The marked content of a bisyllabic non-word can be exclusively syllabic (e.g. *drɛ́.pə*, *drɛ́m.pə*) or both syllabic and metrical (e.g. *bə.drɛ́p*, *bə.drɛ́mp*).

Preliminary investigations using the TOPhS procedure employed a case-study design of children with SLI. For the child she studied, Peiris (2000) found difficulties caused by onset clusters, closed rhymes and right adjunction. Marshall, Ebbels, Harris, and van der Lely (2002) found that, in the four children they studied, most errors occurred in non-words with adjoined syllables.

The present study extends the use of TOPhS to a comparison of three groups of children, matched according to language ability rather than chronological age—a group with G-SLI and two with typically developing language. By matching children with G-SLI to younger, typically developing children, we control for both the effects of vocabulary and grammatical abilities. In addition, we can assess whether phonological complexity, defined in terms of prosodic markedness, differentially affects the performance of G-SLI children in comparison to typically developing children.

Method

Participants

A total of 37 children participated in this study, one group of children with G-SLI and two control groups matched for language ability (LA1 and LA2). The G-SLI group included 11 boys and 2 girls. Their mean chronological age at the time of this experiment was 15;8, ranging from 12;7 to 19;10. The selection criteria for these participants are reported in van der Lely, Rosen, and Adlard (2004) and they were originally selected from a larger group who had already been diagnosed by speech and language therapists as falling within the definition of SLI: that is, they all displayed a mismatch between verbal and non-verbal intelligence. They showed a significant impairment (<-1.5 SD) on one or more standardized language tests, and their non-verbal abilities were >85, as measured on standard non-verbal IQ tests (British Ability Scales (BAS); Elliott, Murray, & Pearson, 1978; Raven's Progressive Matrices; Raven, Court, & Raven, 1978). Children with any deficits in neurological, motor, hearing, articulation abilities (e.g. dyspraxia) or psycho-social skills (e.g. pragmatic impairment or attention deficits) were excluded.

From this group of children, the G-SLI group was selected on the basis of a battery of standardized language assessment tests. These were: the British Picture Vocabulary Scale (BPVS; Dunn, Dunn, Whetton, & Pintilie, 1982), a test of receptive vocabulary; the Test for Reception of Grammar (TROG; Bishop, 1983), a test of sentence understanding; and the Illinois Test of Psycholinguistic Abilities (GC-ITPA; Kirk, McCarthy, & Kirk, 1968), a test of expressive morphology. In addition, a further three tests tailored to identify G-SLI were also administered, testing those aspects of grammar thought to be core to the computational grammar system. These were: the Verb Agreement and Tense Test (VATT; van der Lely, 2000), a test of agreement and tense marking in expressive language; the Test of Active and Passive Sentences (TAPS; van der Lely, 1996b), a test of the assignment of theta roles in reversible active and passive sentences; and the Advanced Syntactic Test of Pronominal Reference (A-STOP; van der Lely, 1997), a test of the assignment of reference to pronouns and anaphors. Participants were included in the G-SLI group only if they made 20% or more errors on each of these tests. In contrast, normally developing children over 5 years of age rarely make errors on these tests. Thus, on these arguably core aspects of grammar these children were performing substantially below their other language abilities, such as vocabulary. The group of children participating in this study is one of several groups of children with G-SLI that van der Lely and colleagues have been studying over a number of years. The partition of participants into different groups is to ensure that the same children are not studied repeatedly, and care is taken to consider which previous experiments the children have taken part in. Over the years however, we have amassed a fairly detailed profile of these children's strengths and weaknesses. Further details of the criteria for the selection of the participants can be found in van der Lely (1996a; 2005) and van der Lely and Stollwerck (1996).

Out of the tests used by van der Lely for the initial selection of the G-SLI participants, three were used to match the G-SLI participants with control participants who had normal language skills for their chronological age. Table III provides a summary of the participants' details and their scores for the three standardized tests that were used for selecting language-matched control children. The scores for the G-SLI participants were the scores from the most recent test they had done.

It can be seen from Table III that the G-SLI participants had a mean equivalent age of 7;3 on the test of expressive morphology (GC-ITPA; Kirk et al., 1968). On the test of sentence understanding (TROG; Bishop, 1983), the children's z-score was -1.79, with an equivalent age of 8;9[3] On the BPVS test of single-word comprehension (Dunn et al., 1982), they achieved a z-score of -2.04, with an equivalent age of 8;6.

The Language Ability (LA) control groups were made up of typically developing, younger children, selected from a primary school in London. All the children had English as their first language, and only children who fell within the normal range of abilities as assessed by the BPVS, TROG and GC-ITPA tests were included in the study. These participants had taken part in other investigations undertaken by van der Lely and colleagues. The 24 children who took part in this study were divided into two subgroups.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

RIGHTSLINK

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Table III. Summary of participant details at matching: G-SLI and LA control groups.

	Participants					
	G-SLI(n=13)		*LA1 Control (n=12)*		*LA2 Control (n=12)*	
	Mean	*(SD)*	*Mean*	*(SD)*	*Mean*	*(SD)*
Chronological age	13;7	(32.22)	5;6	(10.01)	7;5	(5.22)
Range	10;3–18;0		4;6–6;9		6;10–8;2	
GC-ITPA						
Raw Score	21.77	(4.02)	20.58	(4.74)	24.91	(3.73)
Z-score	n/a	n/a	n/a	n/a	n/a	n/a
Equivalent age	7;3	(12.78)	7;1	(16.81)	8;4	(16.24)
TROG						
Raw Score	14.38	(1.66)	15.08	(2.54)	15.92	(2.15)
Z-score	−1.79	(.73)	1.20	(1.15)	.39	(.85)
Equivalent age	8;9	(31.81)	9;1	(18.16)	10;3	(15.61)
BPVS						
Raw Score	78.23	(17.49)	53.83	(12.42)	68.18	(10.49)
Z-score	−2.04	(.62)	.24	(.94)	−.10	(.71)
Equivalent age	8;6	(24.44)	5;10	(15.28)	7;3	(11.64)

Notes: GC-ITPA=Grammatical Closure subtest, Illinois Test of Psycholinguistic Abilities (Kirk et al., 1968). TROG=Test of Reception of Grammar (Bishop, 1983). BPVS=British Picture Vocabulary Scale (Dunn et al., 1982).

One control group (LA1) consisted of six boys and six girls; at the time of the experiment, their mean age was 5;6, ranging from 4;6 to 6;9. They were matched to the G-SLI participants on the basis of raw scores in the two tests that tap morpho-grammatical ability: TROG (t(23)=−.82, p=.420) and GC-ITPA (t(23)=.68, p=.506). Their raw vocabulary scores on the BPVS were significantly lower than the G-SLI participants: t(23)=3.99, p=.001.

The second group of controls (LA2) consisted of older children, five boys and seven girls. Ages at the time of the experiment ranged from 6;10 to 8;2, with a mean of 7;5. This group provides a vocabulary-matched control group, as their BPVS scores on the comprehension of single words did not differ from those of the children with G-SLI (t(19)=1.75, p=.10). Although their scores on the grammar tests were better than those of the children with G-SLI, this difference did not reach significance (TROG, t(23)=−1.87, p=.074; ITPA, t(23)=−1.88, p=.073).

Design and materials

The three participant groups (G-SLI, LA1 and LA2) constituted the between-participant variable in the experiment. The five prosodic parameters (onset, rhyme, word-end, left adjunction and right adjunction) were the within-participant variables. The non-word stimuli were 96 items drawn from ToPhS. These were constructed on four segmentally different base forms: *dɛ́.pə*, *fɪ́.pl*, *pɪ́.fi*, *kɛ́.tə*. Each of these forms was systematically varied to produce 24 sets of non-words which differ according to the particular combinations of prosodic structures they contain. For example, Set 1, comprising the base forms themselves, contains no marked structures. Each of the non-words in Set 7 is marked with respect to two syllabic structures (an onset cluster and a closed rhyme): *drɛ́m.pə*, *frɪ́m.pl*, *prɪ́l.fi*, *klɛ́s.ti*. Set 24 contains non-words with the same two marked syllabic structures as Set 7 plus two marked metrical structures (left adjunction and right adjunction): i.e. *bədrɛ́mpəri*, *dɪfrɪ́mpələ*, *sɪprɪ́lfɪtə*, *fəklɛ́stələ*. In this way each non-word is controlled for its syllabic and metrical markedness. In going beyond a gross segment or syllable count, this design enables us to investigate whether the level of syllabic and/or metrical complexity in a word has an impact on performance in repetition tasks.

The 96 non-words were produced by a female native English speaker, audio-recorded using a Bruel and Kjaer sound level meter (model 2231). The data was recorded onto a hard disk from which DAT copies were made for use in presentation. The non-words were presented once each, separated by three-second silent intervals, in an uninterrupted sequence, and in a random order.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Procedure

Each participant was tested individually in a quiet room. The equipment was laid out on a table, and the non-word stimuli presented via Sennheiser AD475 headphones through a Sony Walkman Digital audio recorder TCD-D8 set at a consistent listening level. The participants spoke into a Sony Electret condenser microphone ECM959, and responses were recorded on a Sony Walkman Digital audio recorder TCD-D8.

Participants were told they were going to hear some "made-up" words that they would not have heard before and that they would have to repeat into the microphone. They were told not to worry if they had difficulty doing this but to try their best and repeat every made-up word they heard. Four practice non-words were provided at the start of the task. Before the start of the task proper, the experimenter used the first practice item to model the procedure orally without the tape and asked the participant if they understood the procedure. In total, including the practice items, the test took approximately 5–7 minutes to administer. If a participant requested that a non-word be repeated, then the tape was stopped and the non-word in question repeated and noted as such. In the event this rarely happened (less than .1% of the time).

Coding of responses

Each participant's repetitions of non-words were transcribed using broad phonetic transcription (IPA symbols). All responses were coded as either a correct repetition (and given a score of 1) or an incorrect repetition (and given a score of 0). To evaluate the reliability of transcription, two children's responses were randomly selected and transcribed by a second judge. There was 93% agreement between the word-by-word transcriptions of the two coders. Differences on individual non-word transcriptions were settled by the two coders.

Results

Correct scores

The overall mean percentages of correct repetitions of non-words for the G-SLI, LA1 and LA2 groups are shown in Table IV.

Two control children, one in LA1 and one in LA2, were identified as outliers and so were removed from the analysis.

We found no decrements or improvements in performance over the course of the task. T-tests confirmed for each group no significant difference between performance on the first 48 non-words compared to performance on the second 48 non-words (G-SLI t(94)=−.340, p=.735; LA1 t(94)=−.577, p=.565; LA2 t(94)=1.120, p=.266).

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Table IV. Mean per cent of correct responses by number of marked structures per non-word.

Number of Marked Structures	*Group*		
	G-SLI	*LA1*	*LA2*
	Mean (SD)	*Mean (SD)*	*Mean (SD)*
0	92.3% *(21.37)*	89.6% *(12.87)*	100.0% *(.00)*
1	81.9% *(16.78)*	94.6% *(5.42)*	97.9% *(3.34)*
2	65.2% *(19.78)*	90.7% *(3.99)*	91.9% *(6.62)*
3	50.5% *(25.79)*	89.9% *(6.96)*	92.3% *(7.59)*
4	33.7% *(30.36)*	82.3% *(13.54)*	84.4% *(14.23)*
TOTAL	62.9% *(20.49)*	90.4% *(4.02)*	92.9% *(5.15)*

As a measure of relative prosodic complexity, each non-word was categorized according to the number of marked structures it contains, yielding an integer value between 0 and 4. For example, the structure of *frípl* has a complexity value of 1 (based in its marked onset cluster); *dɪ.frímpl* has a value of 3 (based on its onset cluster, closed rhyme and left-adjoined weak syllable).

It is evident from Table IV that the G-SLI group found the task significantly harder than the two control groups. The G-SLI group shows an incremental decrease in the number of correct responses as the number of marked structures increases. A 3 × 5 ANOVA (Group (G-SLI, LA1, LA2) × Structure (0, 1, 2, 3, 4)) revealed significant main effects of Group (F(1,34)=19.17, p=.000), Structure (F(2,68)=40.69, p=.000) and a significant interaction (F(4,68)=14.26, p=.000). Thus, the groups were differentially affected by the increasing complexity of the non-words.

To investigate this interaction, one-way ANOVAs for each group were carried out according to the number of marked structures. These revealed no group effect for non-words marked with 0 structures, but there was a group effect for non-words marked with 1, 2, 3 and 4 structures using the Brown-Forsythe statistic (1: F(2,16)=8.127, p=.003; 2: F(2,16)=19.311, p=.000; 3: (F(2,16)=27.539, p=.000; 4: F(2,22)=22.96, p=.000). Further post-hoc comparisons using the Games-Howell test on structures 1 to 4 revealed that the G-SLI group consistently produced significantly fewer correct responses than the LA1 group for words marked with 1 structure, p=.13, and significantly fewer correct responses than both the LA1 and LA2 groups on words marked for 2–4 structures: 2 structures (LA1 p=.001, LA2 p=.001); 3 structures (LA1 p=.000, LA2 p=.000); and 4 structures (LA1 p=.000, LA2 p=.000). In contrast, no significant difference was found between LA1 and LA2 performance on non-words marked for 1, 2, 3 and 4 structures.

Thus, the G-SLI group's correct response rate is significantly lower than the typically developing children for non-words marked for 1 or more structures but not for 0 marked structures. This indicates that prosodic complexity, measured by the number of marked structures, is affecting performance. However, for the majority of TOPhS stimuli, as the prosodic complexity of a non-word increases, so too does the number of syllables it contains.

Number of syllables per non-word

Table V shows the performance on TOPhS analysed by the number of syllables per each non-word. The performance of the children with G-SLI is seen here to deteriorate as

Table V. Mean per cent of correct responses by number of syllables per non-word.

	Group		
	G-SLI	*LA1*	*LA2*
Number of Syllables	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
1	85.1% *(7.45)*	95.3% *(6.02)*	93.8% *(7.97)*
2	69.2% *(19.46)*	93.0% *(4.65)*	95.3% *(5.24)*
3	57.5% *(28.10)*	89.3% *(6.32)*	92.7% *(6.02)*
4	39.4% *(31.91)*	82.3% *(8.35)*	87.5% *(10.31)*
TOTAL	62.9% *(20.49)*	90.4% *(4.02)*	92.9% *(5.15)*

syllable number increases. On the face of it, this is consistent with the claim that a short-term memory deficit is involved.

However, as pointed out above, the design of the TOPhS test allows us to investigate the extent to which prosodic complexity affects non-word repetition performance. If for example we look at monosyllabic non-words, which according to the phonological short-term memory account should not present too great a problem for children with G-SLI, we can see in table 6 that the G-SLI group overall produce 85.1% correct responses versus 95.3% and 93.8% for the LA1 and LA2 groups respectively. This difference in performance is significant (F(2,36)=7.37, p<.01). However, non-words with only one syllable vary within the TOPhS as to how many marked syllabic structures they have. This can vary from *dɛp* (marked for just one structure—word-end), through *dɛmp* (marked for two—rhyme and word-end), to *drɛmp* (marked for three—onset, rhyme and word-end). The correct responses for the number of marked syllable structures are reported in Table VI.

A 3 × 3 ANOVA (Group (G-SLI, LA1, LA2) × syllabic Structure per monosyllable (1, 2, 3)) revealed significant main effects of Group (F(1, 34)=6.60, p=.004), and Structure (F(2,50)=8.94, p=.001), as well as a significant interaction (F(3,50)=5.24, p=.003).

To investigate the group effect, one-way ANOVAs were carried out to investigate the difference between the groups on monosyllabic non-words marked for 1, 2 and 3 syllabic structures. These found a significant effect of Group for monosyllables marked for 2 and 3 syllabic structures—in the case of 2 marked syllabic structures, (F(2,36)=5.58, p=.008). Follow-up Bonferroni post-hoc tests, showed a significant difference in performance between the G-SLI group and both the LA1 group (p=.021) and the LA2 group (p=.021). For 3 marked syllabic structures, using the Brown-Forsythe statistic (F(2,26)=7.52, p=.003). Follow-up post-hoc tests, using the Games-Howell test, showed a significant

Table VI. Mean % of correct responses for monosyllabic non-words.

	Group		
No of Syllable Structures Marked	*G-SLI*	*LA1*	*LA2*
	Mean (SD)	*Mean (SD)*	*Mean (SD)*
1 (e.g. kɛ́t)	*100.0% (.00)*	95.8% *(14.43)*	97.9% *(7.22)*
2 (e.g. klɛ́t)	*83.7% (10.69)*	93.8% *(6.53)*	93.8% *(8.43)*
3 (e.g. klɛ́st)	*73.1% (18.99)*	97.9% *(7.22)*	89.6% *(19.82)*
TOTAL	*85.1% (7.45)*	95.3% *(6.02)*	93.8% *(7.97)*

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

difference in performance between the G-SLI group and the LA1 group (p=.001). No significant difference was found between G-SLI and LA2 or between LA1 and LA2.

One-way ANOVAs were also carried out to investigate the impact of increasing the number of marked syllabic structures. These found a significant effect for the number of marked syllabic structures for the G-SLI group (F(2,38)=15.11, p=.000). (The F-Statistic is reported here, although it fails the Homogeneity of Variance test. This is because robust tests of the equality of means cannot be reported for the reason that the G-SLI group made no errors on monosyllablic non-words marked for 1 syllabic structure.) Post-hoc tests, using the Games-Howell test, showed significant differences in performance between monosyllables marked for 1 versus 2 syllabic structures (p=.000) and 1 versus 3 structures (p=.000). In contrast, no significant difference in performance was found between the LA1 and LA2 groups for the number of syllabic structures a monosyllabic non-word was marked for.

Thus the G-SLI performance was significantly worse than that of the controls on monosyllables marked for 2 syllabic structures and from the LA1 controls on monosyllables marked for 3 syllabic structures. The G-SLI group also found monosyllables with 2 or 3 marked syllabic structures significantly more difficult than those marked for just 1 syllabic structure.

The above analysis only involved phonological complexity as measured by marked syllabic structure. If we look at non-words with two syllables, we can see whether marked metrical structure affects performance. TOPhS non-words with two syllables fall into two types: a metrically unmarked one consisting of a trochaic (strong-weak) foot (for example, *drɛ́.pə*, *drɛ́m.pə*), and a metrically marked one consisting of a weak syllable adjoined to the left of a strong syllable (yielding an iambic rhythmic pattern, for example *bə.drɛ́p*, *bə.drɛ́mp*). An account based on phonological short-term memory would not predict a difference in performance between these two bisyllabic patterns. However, as noted above, previous research has indicated that weak initial syllables cause problems for children with SLI (Ingram, 1981; Sahlen et al., 1999; Bortolini & Leonard, 2000). An approach based on prosodic complexity predicts that children with G-SLI will perform worse on a disyllabic non-words with weak-strong stress than on those with strong-weak stress. Table VII reveals just this pattern. (For consistency, only disyllabic non-words marked for 1 and 2 syllabic structures were included.)

A 3 × 2 ANOVA ((Group (G-SLI, LA1, LA2) × marked stress pattern (SW, WS)) revealed significant main effects of group (F(1, 34)=16.14, p=.000), stress pattern (F(1,34)=13.87, p=.001) and a significant interaction (F(2,34)=9.61, p=.000). Further analysis, using Brown-Forsythe statistic, revealed significant effects of group for non-words with strong-weak stress (F(2,20)=5.28, p=.015) and for those with weak-strong (F(2,18)=26.05, p=.000). Further post-hoc comparisons, using the Games-Howell test, revealed that the G-SLI group produced fewer correct responses than the LA2 group on

Table VII. Mean % of correct responses by stress pattern in disyllabic non-words.

	Group		
	G-SLI	*LA1*	*LA2*
Marked Stress Pattern	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Strong-Weak (e.g. *drɛ.pə*, *drɛm.pə*)	80.1% (21.12)	94.4% (8.21)	96.5% (8.30)
Weak-Strong (e.g. *bə.drɛp*, *drɛmp*)	59.6% (21.74)	93.1% (7.81)	95.1% (7.50)

strong-weak stress (p=.049). For the weak-strong stress the G-SLI group produced fewer correct responses than both LA1 (p=.000) and LA2 (p=.000). In contrast, no significant difference in performance was found between the LA1 and LA2 groups on either strong-weak or weak-strong stress. Further t-tests revealed that the children with G-SLI, but not the control groups, were performing significantly worse on the marked weak-strong pattern than on unmarked strong-weak (t(24)=2.44, p=.022).

The results underline the impact that prosodic complexity can have on the repetition of non-words with just one or two syllables—words that, according to accounts based on short-term memory, should not create difficulties in performance for the G-SLI children.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Error analysis

It is not within the scope or aims of this paper to undertake a full phonological analysis of the errors the children made. However, an attempt was made to ascertain whether the types of error found were similar across all the groups. Generally, there was little overlap between the performances of children in the G-SLI and control groups. The percentage of correct responses made by non-outliers within the LA1 group ranged from 84% to 98%. In the case of LA2, the range was from 83% to 100%. In contrast, correct responses produced by the majority (12/13) of the G-SLI group ranged from 31% to 85%. Only one participant in the G-SLI group scored within the control group range (98%). This participant clearly displays typical phonological ability, although his vocabulary and morpho-syntax test scores did not differ from the rest of the G-SLI group. The performance of two other G-SLI participants was on the cusp of the control range, at 82% and 85%. In contrast, three G-SLI participants found the task particularly difficult, achieving correct responses of only 31%, 36% and 41%. On the other hand, the LA group contained two outliers, one from each subgroup, scoring less than 70% correct. While one of these children's scores on the standardized tests of morpho-syntax and vocabulary were low-average, the corresponding scores for the other child were well within the normal range.

LA1 and LA2 groups. The mean percentage rate of correct responses made by the language controls was very high (90.4% for the LA1 group and 92.9% for the LA2 group) and is consistent with the developmental view that prosodic structure is largely in place by 3 years of age (Demuth, 1996). The majority of repetition errors were due to onset cluster reduction, with the overall metrical structure being maintained (e.g. *fəkέstələ* for *fəklέstələ*). Other errors involved consonant substitution (e.g. *klέtərə* for *klέtələ*), consonant insertion(e.g. *frəklέtələ* for *fəklέtələ*), vowel substitution (e.g. *bədέmpəri* for *bədrέmpəri*) and metathesis (e.g. *sɪfɪ́pɪtə* for *sɪpɪ́fɪtə*). All of the errors made by the language controls are of the type generally made by younger, typically developing children.

G-SLI group. In order to investigate whether the type of errors made by the children with G-SLI were similar to those made by the language controls, we chose to look in greater detail at the individual non-words with the lowest correct scores. These are listed in Table VIII, together with their respective numbers of syllables and marked structures.

The non-words in Table VIII have between 2 and 4 syllables and have either 3 or 4 marked structures. They are among the most prosodically complex items in TOPhS. (Their high prosodic complexity goes hand-in-hand with a high syllable count.) In addition, all of the words are characterized by being marked for onset and left adjunction. Analysis of the error rates for each of these words reveals that the majority of children with G-SLI made

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Table VIII. G-SLI: non-words with lowest correct performance.

			Marked Structures					
				Syllabic			*Metrical*	
Non-word	*Mean % Correct*	*Total No of Syllables*	*Total*	*O*	*R*	*WE*	*L Adj*	*R Adj*
dɪfrɪ́mp	23%	2	4	1	1	1	1	0
fəklɛ́st	23%	2	4	1	1	1	1	0
dɪfrɪ́mpl	23%	3	3	1	1	0	1	0
dɪfrɪ́mpələ	23%	4	4	1	1	0	1	1
fəklɛ́stələ	15%	4	4	1	1	0	1	1
fəklɛ́tələ	15%	4	3	1	0	0	1	1
dɪfrɪ́pələ	15%	4	3	1	0	0	1	1

the same type of error or errors, the most common being onset cluster reduction. Like the LA control groups, they also made errors of consonant substitution, consonant deletion, consonant insertion, vowel substitution and metathesis. Other errors made by the children with G-SLI included omitting the second of two consonants within a word-final cluster (e.g. *fəklɛ́s* for *fəklɛ́st*), various combinations of errors such as deletion of right-adjoined syllables and consonant substitution (e.g. *fəglɛ́stə* for *fəklɛ́stələ*), and consonant substitution together with onset reduction (e.g. *dɪfɪ́ntl* for *dɪfrɪ́mpl*).

The error data show that increased metrical complexity causes problems with syllabic structure. For example, on non-words marked for a combination of syllabic and metrical structures, the error is typically made on a marked onset cluster. The total number of TOPhS non-words that are marked for both onset structure and the two metrical structures is 36. In total the G-SLI group made only 19 (52%) correct responses on non-words marked for these structures, whereas LA1 and LA2 made correct responses of 31 (87%) and 32 (90%) respectively.

Within the G-SLI group, even those individuals with the highest error rates were still able to produce some non-words with complex structures. For example, onset cluster reduction was a frequent cause of incorrect repetition, but this does do not mean the children with G-SLI cannot produce complex onset clusters. Several participants were able to correctly repeat *frɪmp* (marked for all three syllabic structures), while *prɪlf* (marked for the same structures) was reduced to *pɪlf*. On the more prosodically complex words that included both of the marked metrical structures, for example, *bədrɛ́mpəri*, marked for four parameters (onset, rhyme, left and right adjunction), several participants produced *dədrɛ́mpəri*; although the word-initial onset is segmentally incorrect, this form contains the correct syllabic and metrical structures. For the same non-word, other participants produced the correct metrical structure but made errors at the segmental and/or syllabic level, e.g. *bədɛ́mpəri*, *bətɛ́mpəri*, *dərɛ́mpəri*. This would indicate that complex phonological structures are available to the G-SLI children but that phonological complexity in non-words is more likely to result in repetition errors. That is, there is optionality in their ability to repeat non-words with complex structures, something that mirrors the optionality found in the syntactic abilities of children with G-SLI (van der Lely, 2005).

Correlations

To complete the statistical analysis, group correlations were carried out to investigate whether language test scores and age were related to non-word repetition accuracy. Pearson

RIGHTSLINK

Table IX. Correlations between TOPhS accuracy and (i) language test scores (BPVS, TROG, GC-ITPA) and (ii) age.

	G-SLI *n=13*	*LA1 and LA2* *n=24*
BPVS	r=.113, p=.714	r=.167, p=.436
TROG	r=−.516, p=.071	r=−.35, p=.870
GC-ITPA	r=.204, p=.504	r=.060, p=.780
AGE	r=−.048, p=.876	r=.183, p=.392

correlations were carried for the G-SLI group and each of the LA groups, comparing raw scores on the BPVS, TROG and GC-ITPA language tests, together with the participants' ages at testing, with the number of correct repetitions of non-words on TOPhS. The results are shown in Table IX below.

No significant correlations were found for any of the groups. Thus neither language test scores nor age predicted performance (G-SLI, ($r \leqslant .204$, $p > .071$; LA, ($r \leqslant -.350$, $p > .392$). Note that the only correlation approaching significance was a negative one between TROG and TOPhS for the G-SLI group. Therefore, there does not appear to be any direct relation between these general tests of vocabulary and morpho-syntax on the one hand and typical versus atypical phonological development on the other.

Discussion

Drawing on prosodic theory, this study has investigated phonological deficits in children with G-SLI and compared the results with those of typically developing children. The results reveal that the accuracy with which the children with G-SLI repeated non-words incrementally decreased as phonological complexity increased. In comparison, the LA control groups, whose average age was at least 8 years younger than the average age of the participants with G-SLI, achieved a relatively low rate of errors on the same task; this is consistent with the claim that prosodic structure is largely established by age 3 (Demuth, 1996).

The results of the current study are consistent with previous non-word repetition studies which have found that non-word repetition accuracy deteriorates as syllable length increases (Gathercole & Baddeley, 1990; Bishop et al., 1996; Botting & Conti-Ramsden, 2001; Norbury et al., 2002). As Gathercole and colleagues suggest, short-term memory is likely to play a role in non-word repetition. Furthermore, increasing the number of syllables of a non-word typically affects its phonological complexity. However, our study goes further and provides evidence that, even when the number of syllables in a word is held constant, performance deteriorates for children with G-SLI as the number of marked prosodic structures is increased. This pattern is evident both in monosyllabic non-words, where the number of marked syllabic structures can vary, and in disyllables, where metrical structure can affect performance. Thus, our findings reveal that, in non-word repetition tasks, children with G-SLI not only have problems when the number of syllables in a non-word increases but also when the number of marked structures increases—even in one- and two-syllable non-words.

Gathercole, Willis, Emslie, and Baddeley (1991) and Dollaghan, Biber, and Campbell (1995) found that "word-likeness" (analogy of a non-word to a real word) can affect performance. For this reason, one of the criteria used in designing the non-words used in

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

the TOPhS was that they should not only adhere to the phonotactic constraints of English but also be novel in the sense that they did not contain any real words or morphemes. Thus, lexical-phonological representations of existing words in the children's vocabularies would not have assisted performance in this task. Examination of the responses made in this study revealed that only two words were repeated by what appears to be an analogy with a real word. These were *fəkɛ̱t*, which was repeated as *forget* by six children in the G-SLI group. The non-word *kɛst* was repeated as *kɪst* and *kɪs* (*kissed*, *kiss*) by two participants in the G-SLI group, and as either *kɪst*, *kɪs* or *tɛst* (*test*) by six participants in the control groups. Overall in this test, analogy with real words was not a factor in repetition accuracy.

Two other studies (Gathercole & Baddeley, 1989; Edwards & Lahey, 1998) found that accuracy in non-word repetition significantly improved with age in both SLI and typically developing children. This was not found to be the case in the present study: some of the oldest children with SLI had the highest error rates. This suggests that the children with G-SLI are not merely exhibiting delayed phonological development. The lack of age effects in the control groups can be attributed to the high level of their overall performance.

Additionally, Gathercole, Willis, Emslie, and Baddeley (1992) and Roy and Chiat (2004) found that receptive vocabulary was a significant predictor of non-word repetition accuracy for typically developing children. However, we found no significant correlation between non-word repetition accuracy and vocabulary comprehension, which is consistent with Edwards and Lahey's (1998) study. The absence of correlations with other language tests indicates that TOPhS is tapping something qualitatively different from word knowledge.

This study indicates that children with G-SLI have difficulty mapping individual vowels and consonants onto the target prosodic structure. The pattern of findings suggests that, while children with G-SLI are aware of complex prosodic words and are on occasions able to produce them, they have difficulty matching segments to slots in a target prosodic frame when this is relatively complex (see also Marshall et al., 2002). This leads to syllabic, metrical and segmental errors that are also found in typically developing children who have not yet fully acquired adult-like prosodic structure—errors such as onset cluster reduction, consonant assimilation, consonant substitution, metathesis, weak-syllable deletion, and relocation of stress. Syllabic errors (particularly onset cluster reduction) are more frequent in this study, but metrical errors (particularly deletion of left- and/or right-adjoined syllables) were also evident.

The high number of onset cluster reduction errors found in this study is consistent with Orsolini et al.'s (2001) study of Italian-speaking children with SLI. They found a much stronger tendency for their SLI group, in comparison to their control groups, to simplify a syllable containing a complex (marked) onset cluster into a simple (unmarked) onset. In typical language acquisition, unmarked onsets (e.g. ***p****ay*) are acquired before marked onsets (e.g. ***pl****ay*). However, the data reveal that children with G-SLI are occasionally able to produce marked onsets. Orsolini et al. (2001) also found that children did not systematically reduce all marked onsets: the range of errors on syllables containing just a marked onset was between 20% and 80%.

The difficulties the children with G-SLI had with disyllabic non-words with weak-strong stress (in contrast to those with strong-weak) is consistent with previous research. Both Sahlen et al. (1999) and Bortolini and Leonard (2001) found that word-initial weak syllables caused problems for their SLI group. The present study shows that our children with G-SLI also found it particularly difficult to repeat weak-strong non-words. Gerken (1996) interpreted her observation of children's weak syllable omissions as implying that the metrical foot is an important prosodic unit in their speech production. The findings from this study provide further support for this hypothesis.

Our results revealed a significant difference in the pattern of performance for children with G-SLI compared to typically developing younger children. We also found that the prosodic complexity of a word can impact performance: the greater the number of marked prosodic structures, the greater the decrease in performance. This effect was apparent even on monosyllabic and disyllabic non-words. Non-word repetition tasks are recognized as valuable screening tests for identifying children with language and/or literacy problems. In fact, six of the non-words featured in TOPhS have been incorporated into the Grammar and Phononology Screening (GAPS) Test (Gardner, Froud, McClelland, & van der Lely, 2006). This test has been standardized over 668 children aged 3;4–6;6 years of age across the UK, taking into account population distribution and social economic status. TOPhS provides the opportunity to extend our understanding of the phonological abilities of older children with SLI. Further studies of SLI are required to explore the impact of structural complexity on phonological acquisition and on non-word repetition. TOPhS goes some way towards address these issues.

Conclusion

This study has used a non-word repetition procedure to investigate the nature of the phonological abilities of a group of children with G-SLI. A widely assumed account of why children with SLI perform poorly on non-word repetition tasks is that they have impaired short-term phonological memory, which becomes overstretched as the number of segments or syllables is increased (cf. Gathercole & Baddeley, 1990). However, although short-term memory is likely to affect repetition accuracy, this cannot provide a full account of the participants' performance in the test reported on here. What is required to explain our results is a more nuanced model of phonological complexity than one that relies on a gross count of segments or syllables within a string. A purely string-based approach fails to account for the interacting effects of syllable-internal structure and metrical structure highlighted by the results reported here. Providing a measure of phonological complexity and determining how this affects the performance of children with G-SLI thus require us to take full account of prosodic structure.

The degree of prosodic complexity in a (non)-word can be gauged by identifying the number of marked syllabic and metrical structures it contains: the greater the number of marked structures, the more complex it is. As our results reveal, increasing the prosodic complexity of non-words can result in a deterioration in the accuracy with which they can be repeated. Compared to typically developing children, the performance of children with G-SLI is differentially impaired by this effect, pointing to a structure-based deficit in their phonological grammars. That is not to say that complex syllabic and metrical structures are unavailable to children with G-SLI. There is, however, a degree of optionality in their ability to process, represent and/or reproduce them.

The findings of the present study have more general implications for theories of language acquisition, particularly vocabulary acquisition. They emphasize the relative independence of different components of linguistic knowledge, such as lexical-semantic versus lexical-phonological knowledge. We cannot assume that, because a child is able to relate an object to a name, he/she has an adult-like phonological representation of this word. Moreover, the relationship between lexical and phonological development is not necessarily one of direct dependency. Account needs to be taken of the different aspects of word-specific lexical

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

knowledge - phonological, semantic and syntactic. In developmental and acquired disorders, these different types of lexical knowledge potentially dissociate.

The findings of the present study are consistent with those of previous studies showing that hierarchical complexity in linguistic structure impacts on impairments affecting the morphological and syntactic components of grammar. We now have evidence that impairments affecting the phonological component of grammars can also be sensitive to structural complexity, in this case involving the prosodic hierarchy. We thus find support for a generalized interpretation of the hypothesis that G-SLI represents a Computational Grammatical Complexity deficit (van der Lely, 2005).

The study presented here shows the importance of taking account of structural complexity when investigating language abilities and in particular of the prosodic complexity of non-words used in repetition tasks. The design of TOPhS can provide a basis for future assessments of phonological impairment as well as for studies of normal phonological development.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

Acknowledgements

We would like to thank the children who participated in this study and the speech and language therapists, teachers and parents of Moor House School (Hurst Green), Dawn House School (Nottingham) and Thornhill Primary School (London) for their help and co-operation. The research on which this study is based was carried out in partial fulfilment of an MA in Linguistics at University College London by Gallon and was supported by Wellcome Trust grants (refs: 044179/Z/95, 063713) to van der Lely, which is gratefully acknowledged. vdL is supported by the Wellcome Trust.

Notes

1. On the reasons for treating a word-internal coda as distinct from a word-final consonant, see Harris (1994).
2. Two criteria were followed in choosing the segments used to fill out the prosodic frames of individual stimuli in TOPhS. Firstly, only unmarked segments were used; for example, none of the forms contains dental fricatives. Secondly, it was of course necessary to avoid real words. This raises the issue of whether lexical neighbourhood effects in real words might influence repetition performance in non-words. This potential effect was not controlled for in the present study, although it is something that should certainly be investigated in future research employing the TOPhS design.
3. Scores on the GC-ITPA and TROG tests should be taken as a general guide to the SLI participants' grammatical knowledge, since these tests assess a range of abilities, not only those that are problematic for G-SLI participants. The tests are always supplemented with non-standardized assessments that target specific aspects of morpho-syntactic knowledge, which we see as crucial to the linguistic characterization of G-SLI.

References

Bishop, D. V. M. (1983). *Test of Reception of Grammar (TROG)*. Manchester: Manchester University.

Bishop, D. V. M. (1997). *Uncommon understanding: Comprehension in specific language impairment*. Hove: Psychology Press.

Bishop, D. V. M., Bright, P., James, C., & van der Lely, H. K. J. (2000). Grammatical SLI: A distinct subtype of developmental language impairment? *Applied Psycholinguistics*, *21*, 159–181.

Bishop, D. V. M., North, T., & Donlan, C. (1996). Non-word repetition as a behavioural marker for inherited language impairment: Evidence from a twin study. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *37*, 391–403.

Bortolini, U., & Leonard, L. B. (2000). Phonology and children with specific language impairment: Status of structural constraints in two languages. *Journal of Communication Disorders*, *33*, 131–150.

Botting, N., & Conti-Ramsden, G. (2001). Non-word repetition and language development in children with specific language impairment (SLI). *International Journal of Language and Communication Disorders*, *36*, 421–432.

Chiat, S. (2001). Mapping theories of developmental language impairment: Premises, predictions and evidence. *Language and Cognitive Processes*, *16*, 113–142.

Demuth, K. (1996). The prosodic structure of early words. In J. L. Morgan, & K. Demuth (Eds.), *Signal to Syntax* (pp. 171–184). Mahwah, NJ: Lawrence Erlbaum Associates.

Dollaghan, C. A., Biber, M. E., & Campbell, T. F. (1995). Lexical influences on non-word repetition. *Applied Psycholinguistics*, *16*, 211–222.

Dunn, L. M., Dunn, L. M., Whetton, C., & Pintilie, D. (1982). *The British Picture Vocabulary Scale*. Windsor: NFER-Nelson.

Echols, C. H. (1993). A perceptually-based model of children's earliest productions. *Cognition*, *46*, 245–296.

Echols, C. H., & Newport, E. L. (1992). The role of stress and position in determining first words. *Language Acquisition*, *2*, 189–220.

Edwards, J., & Lahey, M. (1998). Non-word repetitions of children with specific language impairment: Exploration of some explanations for their inaccuracies. *Applied Psycholinguistics*, *19*, 279–309.

Elliott, C., Murray, D., & Pearson, L. (1978). *British Ability Scales*. Windsor: NFER-Nelson.

Friedmann, N., & Novogrodsky, R. (2004). The acquisition of Relative clause comprehension in Hebrew: A study of SLI and normal development. *Journal of Child Language*, *31*, 661–681.

Gardener, H., Froud, K., McClelland, A., & van der Lely, H. K. J. (2006). The development of the Grammar and Phonology Screening (GAPS) test to assess key markers of specific language difficulties in young children. *International Journal of Language and Communication Disorders*, *41*, 513–540.

Gathercole, S. E., & Baddeley, A. D. (1989). Evaluation of the role of phonological STM in the development of vocabulary in children: A longitudinal study. *Journal of Memory and Language*, *28*, 200–213.

Gathercole, S. E., & Baddeley, A. D. (1990). Phonological memory deficits in language disordered children: Is there a causal connection? *Journal of Memory and Language*, *29*, 336–360.

Gathercole, S. E., & Baddeley, A. D. (1996). *Children's test of non-word repetition*. Oxford: The Psychological Corporation.

Gathercole, S. E., Willis, C. S., Emslie, H., & Baddeley, A. D. (1992). Phonological memory and vocabulary development during the early school years: A longitudinal study. *Developmental Psychology*, *28*, 887–898.

Gathercole, S. E., Willis, C., Emslie, H., & Baddeley, A. D. (1991). The influence of number of syllables and wordlikeness on children's repetitions of non-words. *Applied Psycholinguistics*, *12*, 349–367.

Gerken, L. (1996). Prosodic structure in young children's language production. *Language*, *72*, 683–712.

Goffman, L. (1999). Prosodic influences on speech production in children with specific language impairment and speech deficits: Kinematic, acoustic and transcription evidence. *Journal of Speech, Language and Hearing Research*, *42*, 1499–1517.

Harris, J. (1994). *English Sound Structure*. Oxford: Blackwell.

Ingram, D. (1981). *Procedures for the phonological analysis of children's language*. Baltimore, MD: University Park Press.

Joanisse, M. F., & Seidenberg, M. S. (1998). Specific language impairment: a deficit in grammar or processing? *Trends in Cognitive Sciences*, *2*(7), 240–247.

Kirk, S. A., McCarthy, J. J., & Kirk, W. D. (1968). *Illinois test of psycholinguistic abilities*. Urban, IL: University of Illinois Press.

Leonard, L. (1998). *Children with specific language impairment*. Cambridge, MA: MIT Press.

Marcus, G., & Fisher, S. E. (2003). FOXP2 in focus: What can genes tell us about speech and language? *Trends in Cognitive Sciences*, *7*(6), 257–262.

Marshall, C., Ebbels, S., Harris, J., & van der Lely, H. K. J. (2002). Investigating the impact of prosodic complexity on the speech of children with specific language impairment. *University College London Working Papers in Linguistics*, *14*, 43–66.

McCarthy, J., & Prince, A. (1995). Prosodic Morphology. In J. Goldsmith (Ed.), *The Handbook of Phonological Theory* (pp. 318–366). Oxford: Blackwell.

McClelland, J. L., & Patterson, K. (2002). Rules or connections in past-tense inflections: What does the evidence rule out? *Trends in Cognitive Sciences*, *6*(11), 465–472.

Montgomery, J. W. (1995). Examination of phonological working memory in specifically language-impaired children. *Applied Psycholinguistics*, *16*, 355–378.

Norbury, C., Bishop, D., & Briscoe, J. (2002). Does impaired grammatical comprehension provide evidence for an innate grammar module? *Applied Psycholinguistics*, *23*, 247–268.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.

O'Hara, M., & Johnson, J. (1997). Syntactic bootstrapping in children with specific language impairment. *European Journal of Disorders of Communication*, *32*, 189–205.

Orsolini, M., Sechi, E., Maronato, C., Bonvino, E., & Corcelli, A. (2001). Nature of phonological delay in children with specific language impairment. *International Journal of Language and Communication Disorders*, *36*, 63–90.

Peiris, D. (2000) The influences of prosodic complexity on segmental production in SLI: A single case study, MSc thesis, University College London, London.

Pinker, S. (1991). Rules of Language. *Science*, *253*(5019), 530–353.

Ramus, F. (2001). Talk of two theories. *Nature*, *412*(6845), 393–395.

Raven, J. C., Court, J., & Raven, J. (1978). *The Progressive Matrices*. London: Lewis.

Roy, P., & Chiat, S. (2004). A prosodically controlled word and non-word repetition task for 2- to 4-year-olds: Evidence from typically developing children. *Journal of Speech, Language, and Hearing Research*, *47*(1), 223–234.

Sahlen, B., Reuterskioeld-Wagner, C., Nettelbladt, U., & Radeborg, K. (1999). Non-word repetition in children with language impairment—pitfalls and possibilities. *International Journal of Language and Communication Disorders*, *34*, 337–352.

Selkirk, E. O. (1980). The role of prosodic categories in English word stress. *Linguistic Inquiry*, *11*, 563–605.

Selkirk, E. O. (1982). *The Syntax of Words*. Cambridge, MA: MIT Press.

Snowling, M., Chiat, S., & Hulme, C. (1991). Words, non-words and phonological processes: Some comments on Gathercole, Willis, Emslie and Baddeley. *Applied Psycholinguistics*, *12*, 369–373.

Stavrakaki, S. (2001). Comprehension of reversible relative clauses in specifically language impaired and normally developing Greek children. *Brain and Language*, *77*, 419–431.

Stavrakaki, S. (2002). Sentence comprehension in Greek SLI children. In F. Windsor, L. Kelly, & N. Hewlett (Eds.), *Investigations in Clinical Linguistics and Phonetics*, Chapter 5 (pp. 57–72). Hillsdale, NJ: Erlbaum.

Tallal, P. (2000). Experimental studies of language learning impairments: From research to remediation. In D. Bishop, & L. Leonard (Eds.), *Speech and language impairments in children: Causes, characteristics, intervention and outcome*. Hove: Psychological press.

The SLI Consortium, (2002). A Genome wide Scan Identifies Two Novel Loci Involved in SLI. *American Journal of Human Genetics*, *70*, 384–398.

van der Lely, H. K. J. (1996a). Specifically language impaired and normally developing children: Verbal passive vs. adjectival passive sentence interpretation. *Lingua*, *98*, 243–272.

van der Lely, H. K. J. (1996b). *The Test of Active and Passive Sentences (TAPS)*, Available from author, Centre for Developmental Language Disorders and Cognitive Neuroscience, University College London, London.

van der Lely, H. K. J. (1997). *Advanced Syntactic Test of Pronominal Reference (A-STOP)*, Available from author, Centre for Developmental Language Disorders and Cognitive Neuroscience, University College London, London.

van der Lely, H. K. J. (2000). *Verb Agreement and Tense Test (VATT)*, Available from author, Centre for Developmental Language Disorders and Cognitive Neuroscience, University College London, London.

van der Lely, H. K. J. (2005). Domain-specific cognitive systems: Insight from Grammatical-specific language impairment. *Trends in Cognitive Sciences*, *9*(2), 53–59.

van der Lely, H. K. J., & Harris, J. (1999). *Test of Phonological Structures (TOPhS)*, Available from authors, Centre for Developmental Language Disorders and Cognitive Neuroscience, University College London, London.

van der Lely, H. K. J., & Howard, D. (1993). Children with specific language impairment: Linguistic impairment or short-term memory deficit? *Journal of Speech and Hearing Research*, *36*, 1193–1207.

van der Lely, H. K. J., & Stollwerck, L. (1996). A grammatical specific language impairment in children: An autosomal dominant inheritance? *Brain and Language*, *52*, 484–504.

van der Lely, H. K. J., Rosen, S., & Adlard, A. (2004). Grammatical language impairment and the specificity of cognitive domains. Relations between auditory and language abilities. *Cognition*, *94*, 167–183.

Clin Linguist Phon Downloaded from informahealthcare.com by University of Washington on 02/13/13
For personal use only.