The nature of phonological representations in children with Grammatical-Specific Language Impairment (G-SLI)*

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In this paper we present a model of abstract phonological representations in children with Grammatical-Specific Language Impairment (G-SLI). We report results from a new non-word repetition test, the Test Of Phonological Structure (TOPhS, van der Lely & Harris, 1999), which systematically varies syllabic complexity. G-SLI children have difficulty repeating non-words containing consonant clusters. Several patterns in the data lead us to hypothesise that G-SLI children have an abstract syllabic template no more complex than CV. When faced with a word containing a cluster, they are forced to rely on memorising only partially-structured sound sequences.

1 Introduction

Children with Specific Language Impairment (SLI) have significantly impaired language acquisition despite the absence of any obvious language-independent cause, such as hearing loss, low non-verbal IQ, motor difficulties or neurological damage (Leonard, 1998). Within the SLI population as a whole, deficits have been diagnosed with syntax, morphology and phonology, and, to a lesser extent, the lexicon (Leonard, 1998). The picture is complex, though, because the range of impairments and their level of severity vary greatly between individuals.

SLI is recognised as a valuable testing ground for theories of linguistic and cognitive development (Pinker, 1991; van der Lely, Rosen & McClelland, 1998), because it enables researchers to tease apart the relative contributions of domain-general and domain-specific cognitive mechanisms, and to test modularity within the language system. However, the heterogeneity of SLI makes it difficult to test linguistic models of the disorder. One way out of this impasse is to identify subgroups of SLI children whose members share a common profile of linguistic strengths and weaknesses. One such group, termed Grammatical (G)-SLI, has been identified by van der Lely and her colleagues. G-SLI children's difficulties with language are confined to the core aspects of grammar – syntax, morphology and phonology (van der Lely *et al*, 1998; van der Lely, in press). The aim of this paper is to investigate the phonological abilities of G-SLI children with the aim of proposing a model of phonological representations in this sub-group, a model which may or may not be generalisable to other sub-groups of SLI.

The phonological abilities of children with SLI have been investigated using non-word repetition tasks, and a consistent finding is that SLI children's performance deteriorates as syllable number increases (Gathercole & Baddeley, 1990; Bishop, North & Donlan, 1996; Dollaghan & Campbell, 1998). Gathercole & Baddeley (1990) propose that the task taps into

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children's phonological short-term memory abilities. They claim that SLI children perform poorly on the task because they have limited capacity in their phonological store, and/ or an unusually rapid decay rate for items held there. However, the design of currently available non-word repetition tests does not allow a fine-grained investigation of which phonological structures cause errors. It is possible that the claim that a deficit in phonological short-term memory causes non-word repetition difficulties is unjustified. The difficulty could be in forming correct phonological representations in the first place rather than in retaining them (Edwards & Lahey, 1998).

Consonant complexity has been recognised as having a possible influence on non-word repetition, although the data are sparse and contradictory. Gathercole & Baddeley (1990) found that non-words with consonant clusters were harder for children to repeat, although the effect was similar for both typically developing and language impaired participants. They interpreted this difficulty with clusters as being related to articulation problems. In contrast, Bishop *et al*'s (1996) study found that while consonant clusters affected repetition accuracy in both groups, the effect was significantly greater for the SLI group. They too interpreted this as revealing a difficulty with articulatory complexity.

2 THE TEST OF PHONOLOGICAL STRUCTURE

The Test of Phonological Structure (TOPhS, van der Lely & Harris, 1999) sets out to test the impact of prosodic complexity on non-word repetition performance. Stimuli are varied along a series of parameters controlling metrical structure and syllable-internal constituency. The relative complexity of a given prosodic structure can be understood in terms of how marked it is, as revealed by universal preferences in cross-linguistic distribution and language acquisition. For example, all languages have words with unmarked parameter settings, but only some have words with marked settings. In acquisition, unmarked parameter settings are acquired first.

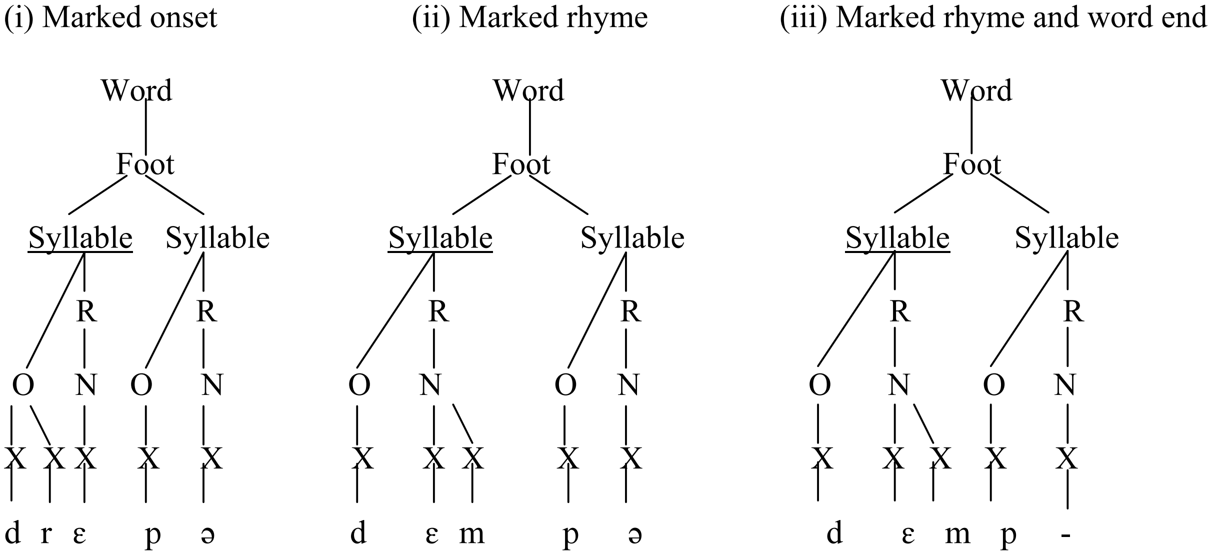
The non-word stimuli used in TOPhS are constructed on the basis of three binary parameters that regulate the complexity of syllabic constituency, with English allowing the marked setting in every case: simplex versus complex onsets; open versus closed syllables; vowel versus consonant at the word end (syllable structure follows Harris, 1994). The three syllabic parameters are set out in Table 1, together with real-word models and examples drawn from the non-word data set. In each of the examples, the segment string illustrating the relevant parameter is underlined.

Table 1. Syllabic parameters used in the TOPhS

SYLLABIC PARAMETER	SETTINGS		REAL WORD	NON-WORD
Onset	Unmarked	Simplex	**pawn**	*pɪf*
	Marked	Complex	**prawn**	*prɪf*
Rhyme	Unmarked	Open	**city**	*pɪfi*
	Marked	Closed	**filter**	*pɪlfi*
Word end	Unmarked	V-final	**city**	*pɪfi*
	Marked	C-final	**sit**	*pɪf*

Marked and unmarked syllabic structures are compared only in the stressed syllable. Non-words are also varied along two metrical parameters, but these are not the focus of the present paper (see Marshall, Ebbels, Harris & van der Lely, 2002). Twenty-four permutations of parameter values and four basic non-words were used to create a stimulus set comprising 96 non-words. All non-words conform to the phonotactic constraints of English and are intended to be applicable to all dialects of English. Three further examples of non-words, and their prosodic structure, are illustrated in Figure 1.

Figure 1. Examples of non-words used in the TOPhS



10 children with G-SLI aged 9;04 – 16;08 participated in this study, plus 10 typically developing children aged 4;10 – 9;07 individually matched to the G-SLI group on a measure of receptive grammar (Test for the Reception of Grammar, TROG, Bishop, 1989), and 10 children aged 4;05 – 9;10 individually matched on a measure of receptive vocabulary (British Picture Vocabulary Scales, BPVS, Dunn *et al*, 1997). Because there were no significant differences between the two control groups in either age ($t = -0.091$, $p = 0.929$) or TOPhS score ($t = -0.308$, $p = 0.761$), they are treated as one group in this analysis (termed 'Typically Developing Language', TDL). Non-words were transcribed broadly for the purposes of phonological analysis and scored as either correct or incorrect for statistical analysis. Voicing errors were not scored as incorrect, and nor was replacement of 'r' by 'w' in clusters.

3 RESULTS

The scores in Table 2 reveal that the ability of the G-SLI group as a whole to repeat non-words is significantly worse than their language ability would lead us to expect.

Table 2. Participants' scores

	G-SLI	TDL
Mean score (SD)	59.1 (21.98)	80.1 (10.62)
Range of scores	32-84	53-94

In sections 3.1 – 3.4 we discuss four types of evidence which we argue, when taken together, enable us to propose a model of phonological representations in children with G-SLI. Since syllabic markedness generally results in the formation of clusters, much of this evidence comes from the behaviour of clusters.

3.1 The relationship between cluster number and syllable number

A 2 (Group: G-SLI, Language TDL) x 4 (Syllable number:1,2,3,4) x 3 (Cluster number: 0,1,2) ANOVA reveals main effects for Group ($F(1,288) = 89.666$, $p < 0.001$), Syllable number ($F(3,288) = 17.548$, $p < 0.001$) and Cluster number ($F(2,288) = 11.004$, $p < 0.001$. However, none of the interactions were significant. This means that syllable and cluster number affect the G-SLI and TDL groups in the same way, although the G-SLI group has significantly lower rates of accuracy.

The impact of syllable number on repetition accuracy for both groups is illustrated in Figure 2 below, while the impact of cluster number is illustrated in Figure 3.

Figure 2. Accuracy according to syllable number

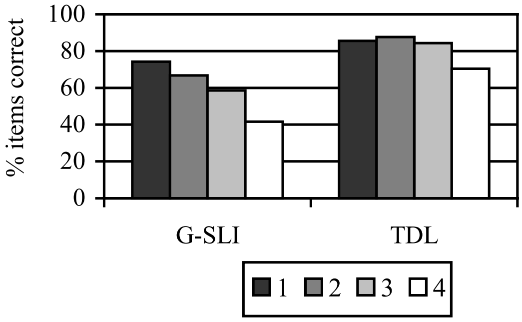
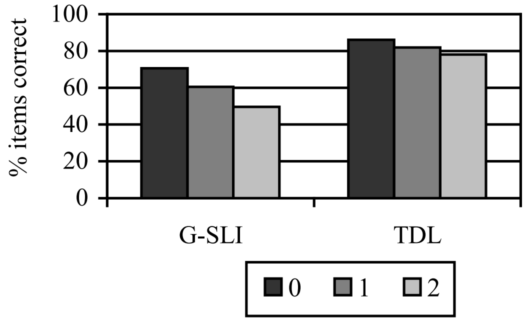


Figure 3. Accuracy according to cluster number



The effects of syllable and cluster number are a 'double whammy' on performance. The data in (1) and (2) illustrate the relationship between syllable number and cluster accuracy.

(1) *Child GD* drɛp → √ drɛmp → √ drɛpə → √
drɛpəri → dɛpəri bədrɛpə → dəpɪpə bədrɛmpəri → dəpɛmpfə

(2) *Child SM* klɛt → √ klɛst → √ klɛtə → √
klɛtələ → kɛtələ klɛstələ → kɛsələ fəklɛstələ → kəkɛsələ

GD and SM repeat the underlined cluster correctly when it occurs in a one or two syllable non-word, but reduce it when the non-word is longer. Working memory limitations could explain this type of error – clusters do not cause many errors in short non-words because short non-words do not place a strain on short-term memory, but as syllable number increases working memory is too limited to contain an accurate representation of the non-word.

The data in (3) and (4) illustrate that working memory limitations cannot be the whole answer, because here the non-words are matched for syllable number but differ in whether or not they contain clusters. In these examples, non-words that lack clusters are repeated correctly, while those that contain clusters are not. The most common error is for clusters to be reduced, although vowel epenthesis between two consonants is also attested, as in GD's data.

(3) *Child QC* fəkɛtələ → √ fəklɛstələ → fəkɛstələ

(4) *Child GD* fɪpələ → √ fɪmpələ → fɪmɪpələ frɪpələ → fəpɪfə

We interpret these results discussed in this section as indicating that syllable number cannot be the only factor influencing non-word repetition. Clusters also play a role, and we suggest that the phonological representation of clusters is difficult for children with G-SLI, a theme which we develop in the remainder of this paper.

3.2 The misattachment of C_2 of a complex onset and rhymal consonants

The data in (5) and (6) reveal that G-SLI children make errors on the attachment of the C_2 of a complex onset, attaching it to the wrong onset. Rhymal misattachment, as in (7), is also attested, although it is rarer. Misattachment errors are more common in children with scores in the higher range; those with low scores tend to reduce clusters completely by deleting C_2.

(5) *Child LJ* fəklɛt → fləkɛt fəklɛtə → fləkɛtə fəklɛstələ → flølkɛstələ
(6) *Child CT* bədrɛp → brədrɛt bədrɛpə → brədrɛpə
(7) *Child GS* fəklɛstə → fəzkɛstə

This type of error occurs in approximately 3.75% of non-words that already contain a cluster. We interpret it as revealing a difficulty in joining up the additional consonant to the prosodic hierarchy. The child knows that this consonant has to go somewhere in the word, but cannot remember where. It is also noteworthy that G-SLI children create clusters in non-words that previously lacked them (as in (8)), as though they were carrying over C_2s and rhymal consonants from previous non-words.

(8) *Child GS* dɪfɪpl → dɪfrɪpl pɪfɪtə → prɪfɪtə dɛpəri → dɛmpəri

A conservative estimate (excluding non-words that become more complex in the process of lexicalisation, see section 3.3) is that this type of addition has an incidence of approximately 3.70%. Such errors, which result in an increase rather than a decrease in complexity, have also been noted by Ellis Weismer & Hesketh (1996) when teaching SLI children novel words. They concluded, as we do, that syllabic errors reflect more than just a tendency to reduce the form to one that is articulatorily easier (c.f. Bishop *et al*, 1996).

3.3 Replacement of non-words by real words ('lexicalisation')

Data in (9) and (10) show that children with G-SLI can convert non-words into real words.

(9) *Child SM* drɛmpə → ***jumper*** klɛsti → ***crusty*** fɪpɪlə → ***flipper***
(10) *Child GS* klɛt → ***collect*** bədɛp → ***protect*** kɛst → ***kissed***

Note that the target non-word and its real word replacement share properties, such as the majority of segments and metrical structure (on most occasions, but not all: when changes in metrical structure do occur, the output frequently has trochaic foot structure). TDL children make the occasional lexicalisation but their errors only involve minor changes. fəkɛt → ***forget*** and kɛst → ***kissed*** are the most common in TDL children, and fɪmpl → ***simple*** and pɪlf → ***pill*** are also attested.

Lexicalisation has been noted in previous studies of non-word repetition (e.g. Stackhouse, 1993; Dollaghan, Biber & Campbell, 1995, Ellis Weismer & Hesketh, 1996) We suggest that real words are well-rehearsed sound sequences, and therefore pose less of a load on the memory (Marshall *et al*, 2002).

3.4 Optionality

The data in (11), (12) and (13) reveal that children's errors are inconsistent. In (11) all three words are matched for metrical and syllabic structure, but in one the word-final consonant is omitted. (12) shows that this optionality occurs even within the same cluster. (13) shows that it occurs even within the same non-word.

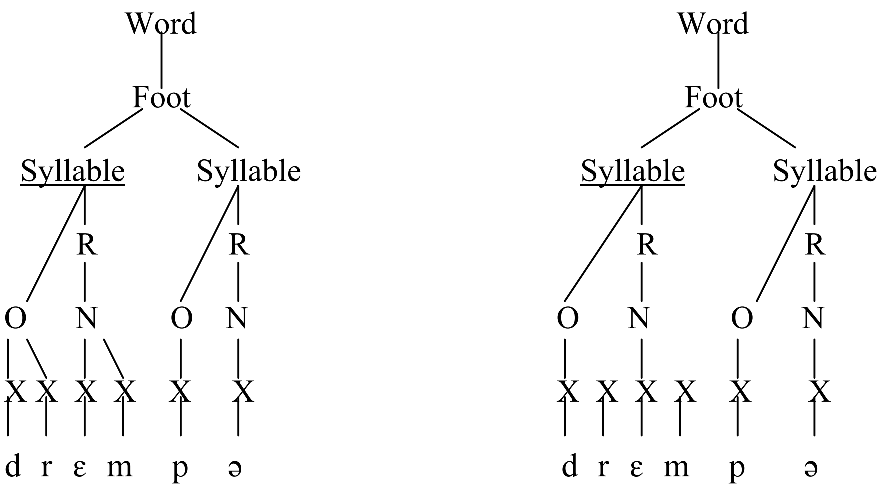
(11) *Child CT*	sɪprɪlf → √	fəklɛst → √	bədrɛmp → bədrɛm
(12) *Child SA*	dɛmp → √	fɪmp → fɪm	
(13) *Child QC*	pɪlfɪte → prɪlfɪtə	prɪlfɪtə → prɪpɪtə	

We will return to an explanation of optionality once we have proposed our model of phonological representations in G-SLI.

4 Model of phonological representations in G-SLI

We propose an interpretation of the data whereby children with G-SLI have only unmarked parameter values available to them, meaning that they have just a CV template. There is no room on this template for additional consonants. For example, Figure 4 (i) shows that for typically developing children the additional /r/ and /m/ can be joined to prosodic hierarchy. Figure 4 (ii) shows that for G-SLI children these additional consonants cannot be joined to the prosodic hierarchy because the constituents in question do not branch.

Figure 4. Representations of syllabic complexity in:
(i) The typically developing child (ii) The G-SLI child



Consequently, syllables containing clusters have to be remembered as partially unstructured sequences of segments, without the full structure being available as an *aide-memoire*. Sometimes children remember the partially unstructured sequences correctly and sometimes they don't, hence the optionality in their production. In contrast to previous work on SLI (Gathercole & Baddeley, 1990; Bishop *et al*, 1996), we have shown that for G-SLI children errors with clusters are not just in the direction of simplification. The finding that clusters are created as well as reduced reveals that the difficulty is one of representation.

We can now explain why G-SLI children do badly on longer words in non-word repetition tests. It is *not* that they have limited capacity in their phonological store compared to other children. Remembering words with underspecified phonological representations places a *strain* on their memory capacity. The causal arrow is reversed.

REFERENCES

Bishop, D.V.M. (1989) *Test for Reception of Grammar*, 2nd Edition. Age and Cognitive Performance Research Centre, University of Manchester, M13 9PL.

Bishop, D.V.M., T. North, and C. Donlan (1996) 'Nonword repetition as a behavioural marker for inherited language impairment: evidence from a twin study.' *Journal of Child Psychology and Psychiatry* 37: 391-403.

Dollaghan, C., M. Biber, and T. Campbell (1995) 'Lexical influences on non-word repetition.' *Applied Psycholinguistics* 16:211-222.

Dollaghan, C. and T. Campbell (1998) 'Nonword repetition and child language impairment.' *Journal of Speech, Language and Hearing Research* 41:1136-1146.

Dunn, L.M., L.M. Dunn, and C. Whetton (1997) *British Picture Vocabulary Scales*, 2nd Edition. Windsor, UK: NFER Nelson.

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

Ellis Weismer, S. and L.J. Hesketh (1996) 'Lexical learning by children with Specific Language Impairment: Effects of linguistic input presented at varying speaking rates.' *Journal of Speech and Hearing Research* 39:177-190.

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

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

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

Marshall, C., S. Ebbels, J. Harris, and H. van der Lely (2002) 'Investigating the impact of prosodic complexity on the speech of children with Specific Language Impairment.' *UCL Working Papers in Linguistics* 14:43-68.

Pinker, S. (1991) 'Rules of Language.' *Science* 253:530-535.

Stackhouse, J. (1993) 'Phonological disorder and lexical development: two case studies.' *Child Language Teaching and Therapy* 9:230-241.

van der Lely, H.K.J. (in press) 'Evidence for and implications of a domain-specific grammatical deficit.' Chapter forthcoming in L. Jenkins (ed.) *The genetics of language: Linguistic Variations series*. Series editors J. Rooryck and P. Pica. Oxford: Elsevier.

van der Lely, H.K.J. and J. Harris (1999) 'Test of Phonological Structure (TOPhS).' unpublished test, available from the authors.

van der Lely, H.K.J., S. Rosen, and A. McClelland (1998) 'Evidence for a grammar-specific deficit in children.' *Current Biology* 8(23):1253-1258.

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