Effects of Word Position and Stress on Onset Cluster Production: Evidence from Typical Development, Specific Language Impairment, and Dyslexia

Chloe R. Marshall, Heather K. J. van der Lely

Language, Volume 85, Number 1, March 2009, pp. 39-57 (Article)

Published by Linguistic Society of America
DOI: *https://doi.org/10.1353/lan.0.0081*

For additional information about this article
https://muse.jhu.edu/article/262978

Access provided at 25 Aug 2019 08:24 GMT with no institutional affiliation

EFFECTS OF WORD POSITION AND STRESS ON ONSET CLUSTER PRODUCTION: EVIDENCE FROM TYPICAL DEVELOPMENT, SPECIFIC LANGUAGE IMPAIRMENT, AND DYSLEXIA

Chloe R. Marshall
University College London

Heather K. J. van der Lely
University College London

Children with specific language impairment (SLI) and dyslexia have phonological deficits that are claimed to cause their language and literacy impairments and to be responsible for the overlap between the two disorders. Little is known, however, about the phonological grammar of children with SLI and dyslexia, and indeed whether they show differences in phonological development. We designed a nonword repetition task to investigate the impact of word position and stress on the production accuracy of onset clusters. We compared the performance of children with SLI and dyslexia, SLI only, and dyslexia only (mean age eleven), and three groups of typically developing children (aged five, seven, and nine). Analysis of cluster production accuracy revealed that all three clinical groups made significantly more errors on word-medial clusters compared to word-initial clusters. Unstressed clusters were more difficult than stressed clusters for the two dyslexic groups but not the SLI-only group. None of the groups of typically developing children showed an effect of word position or stress on cluster accuracy. All groups, however, created new clusters significantly more frequently in initial than medial positions. These results indicate a difference in phonological grammar in children with SLI and dyslexia that could potentially shed light on the relationship between the two disorders. Furthermore, they indicate that structural position and stress are developmentally independent elements in phonological representations.*

Keywords: specific language impairment, dyslexia, phonology, language development, positional markedness

1. Introduction. Developmental disorders of language and of skills that rely on language, such as literacy, have an important role to play in our understanding of language development. Studying disordered language development gives researchers the opportunity to tease apart aspects of language that typically develop in concert. Characterizing the range of possible language phenotypes and the phenotypic overlap between different developmental disorders is particularly relevant in this regard. Such knowledge not only provides insight into developmentally independent aspects of the language system, but, given that language disorders have a genetic basis (Stromswold 2001, Fisher 2007), is starting to contribute to uncovering the genetic origins of language.

Morphology and syntax have been comprehensively investigated in children with developmental language disorders within a range of theoretical linguistic frameworks (Rice & Wexler 1996, van der Lely & Battell 2003, Ring & Clahsen 2005). Such approaches have enabled researchers to characterize impairments with precision and make predictions as to the locus of the underlying deficit. Phonology, however, has not benefited from such a systematic approach, and has been investigated more from a processing perspective, using measures of speech perception, phonological awareness, and phonological working memory. Valuable though these studies are, we believe that studying phonological deficits within a linguistically informed perspective, using the tools of linguistic theory and analysis, can also be illuminating.

* We thank Sally Harcourt-Brown, Sophie Tang, and Angela Pozzuto for their help with the data collection for this study, and Franck Ramus, Stuart Rosen, John Harris, Jill Beckman, and Yvan Rose for discussions. We are extremely grateful to all the schools, children, and parents that we work with, for giving up their time and making us so welcome. We also gratefully acknowledge the advice of editors Brian Joseph and Joe Pater, and the anonymous referees, whose detailed comments have greatly improved the article. This study was funded by an Economic and Social Research Council Grant, RES-000-23-0575, awarded to Heather van der Lely.

One of the most striking characteristics of children with developmental language disorders is that they perform poorly on tasks where they have to repeat nonsense words, even when compared to younger children matched on general language abilities. There has been much debate over whether this is due to impoverished phonological working-memory capacity, or whether it reflects difficulties in creating and retrieving phonological representations (Gathercole & Baddeley 1990, Snowling et al. 1991, van der Lely & Howard 1993). Nonword repetition stimuli are typically manipulated for length, and a well-replicated finding is that the repetition accuracy of children with developmental language disorders tails off more sharply than that of their peers as the number of syllables increases to three and beyond. However, a group of recent studies, using a set of nonword stimuli whereby the phonological complexity of the nonwords is manipulated (van der Lely & Harris 1999), demonstrates that it is not just the amount of phonological material that impacts children's accuracy, but also the way that material is structured. Children with developmental language disorders are considerably worse at repeating stimuli with consonant clusters (despite having no obvious articulation difficulty) and are particularly likely to make errors with nonwords that contain unfooted syllables—even when nonwords are only two syllables long (Marshall et al. 2002, Marshall 2004, Gallon et al. 2007).

These findings suggest that the locus of the disorder is not in limited working-memory capacity, but rather in structuring linguistic material so that it can be held effectively in working memory. They therefore support claims that the underlying deficit is in processes specific to language, and not in domain-general processing capacity or speed of processing. The goal of our study is to characterize that representational deficit with greater precision in two developmental disorders that have been the subject of particular focus in the language-acquisition research literature: SPECIFIC LANGUAGE IMPAIRMENT (SLI) and DYSLEXIA.

1.1. SPECIFIC LANGUAGE IMPAIRMENT AND DYSLEXIA. Children with SLI have an impairment in acquiring language despite appearing to have all the necessary precursors in place, such as normal intellectual functioning and an adequate learning environment (Leonard 1998). Children with dyslexia have a significant difficulty in learning to read alongside similar exclusionary criteria (Snowling 2000). There is a substantial overlap between the two populations: around 50% of children diagnosed with SLI are also dyslexic, and vice versa (McArthur et al. 2000). The reasons for this overlap, and therefore the nature of the relationship between SLI and dyslexia, are still unclear, but there is a growing support for the view that phonological deficits underlie both disorders (Joanisse et al. 2000, McArthur et al. 2000, Bishop & Snowling 2004). Children with SLI are reported to have impairments in tasks involving nonword repetition and the categorical perception of speech sounds (for a review, see Leonard 1998). The same phonological deficits, plus difficulties accessing lexical phonological representations and manipulating phonological representations, have also been implicated in dyslexia (Snowling 2000). More recently, a deficit affecting the perception of rhythmic timing has been proposed for both dyslexic children (Goswami et al. 2002) and children with SLI (Corriveau et al. 2007).

While researchers of SLI and dyslexia have investigated certain phonological skills extensively, particularly speech perception, phonological working memory, rapid access to lexical phonological representations, and the overt phonological manipulation of phonological representations, they have been less thorough in exploring phonological grammar, that is, the implicit rules or constraints that govern how sounds are assembled into words. Therefore, we do not yet know whether children with SLI and dyslexia have identical deficits in phonological grammar, or whether they differ in their phonological grammar compared to typically developing children. This issue is important because genetic studies of SLI and dyslexia have identified several loci associated with each disorder, but none that is associated with both (Galaburda et al. 2006, Monaco & the SLI Consortium 2007). Teasing apart complex pathways from gene to behavior relies on good descriptions of cognitive phenotypes, and the phonological phenotype of both SLI and dyslexia remains to be specified.

Previous studies have indicated that multisyllabic words with marked stress patterns (e.g. initial unfooted syllables) and consonant clusters would be a good place to start investigating phonological grammar (Bishop et al. 1996, Marshall 2004, de Bree 2007, Gallon et al. 2007). In this study, therefore, we investigate the effect of word position and stress on the accuracy of onset cluster production, an interaction that has not been systematically studied in either typical or atypical development. First, however, we review the current state of knowledge of positional effects on segmental and cluster development.

1.2. Effects of word position and stress on phonological representations. Different positions in a word are not equal with respect to the phonological contrasts that can appear there (Trubetskoy 1939). Some positions license a large number of contrasts and resist reduction, and are termed ‘strong’, while others license a smaller number of contrasts and yield to reduction, and so are termed ‘weak’. For example, laryngeal feature contrasts involving voice, aspiration, and glottalization are realized in syllable onsets but neutralized in codas (Steriade 1997). Of direct relevance to our study are findings that initial syllables are strong and noninitial syllables are weak (Beckman 1998, Casali 1998), while stressed syllables are strong and unstressed syllables are weak (Alderete 1995, Beckman 1998). Whether the contrast between strong and weak positions is due to perception and/or production, or is strictly grammatical, is subject to debate (Smith 2004).

Although word-initial and stressed positions are both strong, it is possible that they gain their strength for different reasons. Word-initial positions are psycholinguistically important because they play a critical role in lexical access (Beckman 1998). The temporal structure of spoken input means that acoustic-phonetic information unfolds over time. Numerous studies have shown that earlier parts of the word are more important for word recognition than later parts of the word (Cole & Jakimik 1980, Marslen-Wilson & Zwisterlood 1989, Benki 2003). This is a central assumption of the cohort model, in which speech input at the beginning of the word activates all lexical items that share the same initial sequence. This initial set of candidates is termed the word-initial cohort, and progressively fewer candidates remain activated as more acoustic-phonetic information is perceived. The subsequent process of word recognition proceeds linearly from the onset to the end of the word (Marslen-Wilson & Welsh 1978, Marslen-Wilson 1987). It is therefore crucial that all contrasts are maintained in the onset because of its important role in lexical access.

In English, stress is associated with increased pitch, duration, and volume relative to neighboring syllables, and full vowel quality. Stressed syllables are used to locate word boundaries for the purposes of word recognition, even by infants (Jusczyk et al. 1999), but the presence or absence of stress on a given syllable is not relevant in early-stage word recognition (Cutler 1986). Stressed positions, unlike word-initial positions, are prominent only phonetically. It has therefore been argued that strong positions should be divided into two—psycholinguistically strong positions and phonetically strong positions (Smith 2004). Initial syllables are classified as psycholinguistically strong, whereas stressed syllables are phonetically strong. This distinction is important because it raises the possibility that children might respond differently to word position and stress during development.

1.3. Effects of word position and stress during development. Previous studies of positional asymmetries have tended to focus on segmental contrasts and their reduction in weak positions. Schwartz and Goffman (1995) asked twenty-two-to-twenty-eight-month-olds to repeat CVCV nonwords that had either iambic or trochaic stress. Few children omitted consonants, but when consonants were omitted they were almost invariably initial. Other errors, such as assimilation, were not significantly affected by either word position or stress. Kirk and Demuth (2006) compared two-year-olds' nonword repetition of coda stop and nasal production in stressed and unstressed syllables, and in medial versus final position. In both medial position and final position, coda consonants were more accurately produced in stressed than in unstressed syllables.

With regard to clusters, word-final clusters are acquired before onset clusters, with the exception of *s* + stop clusters (Kirk & Demuth 2005). Chambless (2004) compared eighteen-to-thirty-eight-month-olds' repetition of nonwords containing clusters in either word-initial or word-medial position. Accuracy was greater medially than initially, but there was an interaction with cluster type: *s* + stop clusters were produced less accurately in initial position than stop + liquid clusters. When considering just stop + liquid clusters, there appeared to be no significant difference between initial and medial position (Chambless 2004).

There is some evidence that stress affects the acquisition of onset clusters. In a longitudinal study of two Québécois-French children, aged between one and four years old, Rose found that stop + liquid onset clusters in real words were realized in stressed syllables before unstressed syllables (Rose 2002). There are also instances of stress effects on onset clusters in adult language: for example, in south-eastern Brazilian Portuguese, underlying clusters surface in stressed syllables but not in unstressed ones (Harris 1997).

Word position affects how accurately children with SLI repeat clusters in nonwords: they are less accurate at correctly repeating consonant clusters that follow an initial weak syllable (Marshall 2004, Gallon et al. 2007). For example, they are less accurate with the cluster in a nonword like *fəklɛtə* than the cluster in *klɛtələ*. The nonword repetition test used in those studies, the test of phonological structure (van der Lely & Harris 1999), however, did not contain the stimuli needed to distinguish whether this was an effect of word position or had to do with the presence of an initial weak syllable. Nor was cluster accuracy tested in unstressed syllables. In a related study, Marshall and colleagues (2003) found that children with SLI created new clusters in nonwords that lacked them, or added clusters to nonwords that already contained one. Dyslexic children have not, to the best of our knowledge, been tested on stimuli that manipulate the word position and stress of clusters.

1.4. Aims of this study. In this study we use a nonword repetition paradigm to manipulate the phonological environment of onset clusters in multisyllabic nonwords with respect to word position (initial, medial) and stress (stressed, unstressed), in order to determine which word-level factors affect onset-cluster accuracy during typical and atypical development (SLI, dyslexia). Our main goal is to determine whether doing so would reveal any differences between SLI and dyslexic children, and whether either disorder differs from the typical pattern of development at age 4;6 and above. A secondary aim is to determine whether word position and stress are developmentally independent elements of the phonological representation.

2. Method.

2.1. Participants. Six groups of children participated: three clinical groups (SLI + dyslexia, SLI-only, and dyslexia-only) and three groups of younger, typically developing children. Children for the clinical groups were recruited twelve months prior to the running of the experiment that we report here. We selected children aged between 8;00 and 12;11 years old, according to several criteria. First, all children had to achieve a minimum score of 80 on each of two tests of nonverbal cognition, and an average combined standard score of at least 85 (i.e. −1 SD below the mean or higher). The nonverbal tests used were the Raven's Standard Progressive Matrices (Raven 1998) and the block design subtest of the British Ability Scales-2 (Elliott 1996).

For inclusion in the SLI group, children had to have a formal diagnosis of SLI but no additional diagnosis of attention deficit and hyperactivity disorder (ADHD), autistic spectrum disorder (ASD), or dyspraxia, attendance at a special school/unit for children with SLI, and a standard score of 78 or below (i.e. seventh percentile) on one or more of the following language tests: (i) Test for Reception of Grammar-2 (TROG; Bishop 2003)—a test of sentence comprehension; (ii) British Picture Vocabulary Scales-2 (BPVS; Dunn et al. 1997)—a test of single-word comprehension; (iii) Clinical Evaluation of Language Fundamentals-3 (CELF, sentence repetition subtest; Semel et al. 1995)—a test of sentence production; and (iv) Test of Word-Finding-2 (TWF; German 2000)—a test of single-word production.

For inclusion in the dyslexia group, children had to have a formal diagnosis of dyslexia but no additional diagnosis of ADHD, ASD, or dyspraxia, attendance at a special school/unit for children with dyslexia,[1] and a standard score of 78 or below (i.e. seventh percentile) on the reading subtest of the Wechsler objective reading dimensions (WORD; Wechsler 1990). This is a single-word reading test comprising phonologically regular and irregular words.

Many children fulfilled both sets of criteria with regard to standardized test scores, although they may have had a diagnosis of just one. This did not surprise us—a substantial overlap between dyslexia and SLI has been widely reported (e.g. around 50%; McArthur et al. 2000), and this overlap is likely to be particularly high when children are selected from special educational settings, as ours were. Children who fulfilled our criteria for both SLI and dyslexia were allocated to an SLI + dyslexia group. In all, we recruited thirty SLI + dyslexic, thirteen SLI-only, and twenty-one dyslexia-only children. By the time of testing, two children from the dyslexia-only group had moved away and were unavailable for testing.

To be included in the control groups, children had to achieve a standard score of 85 or above on each of the language and literacy tasks used to select participants for the SLI and dyslexic groups, and have no history of a speech or language delay or any other special educational need. We recruited sixty-five control children aged between 5;00 and 12;11 years old. However, it became clear during the course of this study that the older control children (10;6 plus) were making no nonword repetition errors, whereas the clinical groups were performing below the level of our younger controls, then aged 6;00. We therefore decided to recruit some younger children, aged 4;06 to 6;00. Because of time constraints, we did not administer the full battery of tests to these children. However, we administered the TROG and BPVS, and to be included, these younger children had to perform within normal limits on those two tests. In addition, they had to have no history of a speech or language delay, or any other special educational need. When it came to dividing up our control children into groups for this

[1] With the exception of one child, who is in mainstream school.

study, we selected all of our control children aged 4;06 to 10;06, split into three age bands of two years each. In this way we could investigate how cluster accuracy develops with age within typically developing children. This is justified because we are not interested in the overall levels of performance—it is well documented that children with SLI and dyslexia perform worse than their language-matched controls on nonword repetition tests (Gathercole & Baddeley 1990, Bishop et al. 1996, Gallon et al. 2007). Rather, we are interested in whether children with SLI and dyslexia respond in the same way as typically developing children to the phonological variables manipulated in the test. For this reason, rather than labeling our typically developing groups as 'controls', we term them 'TD' for 'typically developing' and label them by mean age: TD5, TD7, and TD9.

Because children in the TD7 and TD9 groups were recruited at the same time as the SLI and dyslexic children, we can report on group comparisons for three tests: TROG, BPVS, and the WORD single-word reading subtest. Participant details are shown in Table 1, and where groups share subscripts, this indicates that on post hoc testing they do not differ at the $p < 0.05$ level. Particularly relevant is the comparison of BPVS scores, given the links between phonology and vocabulary development (Storkel & Morisette 2002).

	SLI + DYSLEXIA	SLI-ONLY	DYSLEXIA-ONLY
N	30	13	19
age mean (SD)	11.72 (1.15)	11.49 (1.57)	11.32 (1.18)
age range	9.25 – 14.00	9.25 – 14.08	9.58 – 13.08
TROG, raw	11.18_a (3.24)	13.46_a (2.47)	16.26_b (2.05)
TROG, z-score	−1.53 (0.91)	−0.87 (0.82)	0.08 (0.71)
BPVS, raw	79.75_a (16.62)	86.00_b (12.01)	98.89_b (12.81)
BPVS, z-score	−1.20 (0.78)	−0.73 (0.80)	0.11 (0.66)
WORD, raw	18.79 (7.03)	35.31_a (8.89)	19.89 (5.38)
WORD, z-score	−2.04 (0.47)	−0.42 (0.84)	−1.81 (0.33)
	TD5	TD7	TD9
N	22	23	18
age mean (SD)	5.84 (0.48)	7.54 (0.48)	9.40 (0.52)
age range	4.50 – 6.50	6.58 – 8.50	8.58 – 10.50
TROG, raw	—	13.43_a (3.00)	16.22_b (2.01)
TROG, z-score	—	0.71 (0.90)	0.50 (0.59)
BPVS, raw	—	72.57_a (13.25)	93.00_b (9.12)
BPVS, z-score	—	0.56 (0.72)	0.61 (0.60)
WORD, raw	—	26.61 (9.71)	39.39_a (7.12)
WORD, z-score	—	1.36 (0.91)	1.09 (0.86)

TABLE 1. Participant details.

Key
TROG: Test for Reception of Grammar, 2nd edn. (Bishop 2003)
BPVS: British Picture Vocabulary Scales, 2nd edn. (Dunn et al. 1997)
WORD: Wechsler Objective Reading Dimensions (Wechsler 1990)

2.2. STIMULI. Four basic nonword items, all three syllables in length and containing an onset cluster, were subjected to a 2 (word position: initial, final) × 2 (stress: stressed, unstressed) manipulation of the cluster. This resulted in the creation of a total of sixteen stimuli that, importantly, ensured that segmental content and working-memory load were balanced across conditions.

We also included eighteen one-syllable stimuli with an onset cluster in order to check that children could produce clusters in this the most basic of word forms. Even though the onset clusters in our three-syllable nonwords were all of the form obstruent + liquid, we included in our one-syllable stimuli examples of all three onset cluster types found in English: obstruent + liquid, *s* + stop, and *s* + sonorant, in order to obtain a thorough picture of performance. The complete list of one- and three-syllable stimuli is given in the appendix.

Stimuli were recorded in an anechoic chamber by the first author, who has a southern British English accent. Individual sound files were created and edited using Audition software (Microsoft Corporation).

2.3. PROCEDURE. We presented the stimuli on a laptop using DMDX software (developed by Jonathan Forster, University of Arizona). DMDX allows sound files to be both played and recorded, and creates individual sound files for each response, which can then be analyzed visually. 3.5 seconds were allowed for a response, as pilot testing showed this was more than adequate, even for the youngest children. Children heard the stimuli through Sony Dynamic Stereo MDR-7509 headphones, and gave their response into a Samson C01U USB Studio Condenser Microphone. One-syllable and three-syllable nonwords were mixed together and items were presented to all children in the same pseudo-randomized order (i.e. ensuring that no two nonwords from the same condition occurred one after the other).

2.4. TRANSCRIPTION. Nonwords were broadly transcribed live by the experimenter (who was the first author or a research assistant), and then retranscribed from the recording by the same experimenter. We did not count a substitution of [w] for /r/ as incorrect, as this is a common feature of young children's clusters (Smit 1993). Intertranscriber reliability, calculated on 10 to 15% of data within each group, and across the whole word, was as follows: SLI + dyslexia: 97.9%, SLI-only: 100%, dyslexia-only: 100%, controls: 99.0%. Areas of disagreement were resolved by discussion, and if consensus could not be reached then the first author made the final decision.

2.5. PREDICTIONS. Our predictions are as follows: given that initial syllables and stressed syllables are strong positions while noninitial and unstressed syllables are weak, if there is an effect of position and stress, then cluster accuracy will be higher in initial syllables and in stressed syllables. However, the question of WHETHER there will be effects of word position and stress in all six groups is an open one. It is also an open question as to whether all six groups will produce the same types of errors at the same relative frequencies.

3. RESULTS. Although we transcribed the entirety of the nonwords, we were interested in two particular measures: cluster accuracy and the formation of new clusters in nontarget position, as these are the two measures that inform us about the relationship between clusters, word position, and stress. We therefore ignored other segmental errors, for example, the repetition of *fəklɛtə* as *təklɛtə*, or *snɪd* as *snɪp*.

First, we report the results for cluster accuracy in the one-syllable nonwords. One child from the SLI + dyslexia group could produce no clusters word-initially, and another from that group produced only one cluster out of eighteen—this despite being able to produce clusters in real words. Neither of these two children was able to produce any clusters in the three-syllable nonwords, so we did not analyze their data any further: the group means reported in Table 2 exclude those two children. Because the scores were so close to ceiling, and therefore not normally distributed, we used a nonparametric test, the Kruskal-Wallis analysis of variance by ranks, using the number of clusters repeated correctly as the dependent variable. This revealed no significant group differences in accuracy on one-syllable nonwords that contain an initial consonant cluster ($\chi^2 = 7.718$, $p = 0.172$).

Before we present our analyses of the three-syllable nonwords, it is worth saying a few words about initial-weak-syllable omission. Although younger SLI children and young

	SLI + DYSLEXIA	SLI-ONLY	DYSLEXIA-ONLY	TD5	TD7	TD9
total score	94.84 (12.37)	98.72 (2.44)	97.37 (4.67)	94.19 (6.52)	98.07 (3.97)	98.77 (3.05)

TABLE 2. Mean scores (SD) for cluster accuracy in one-syllable nonwords, expressed as a percentage.

typically developing children are reported to omit initial weak syllables (Allen & Hawkins 1978, Bortolini & Leonard 2000), this particular error is not a feature of our data nor that of other studies of older SLI children (Marshall 2004). Among the twenty-eight children in the SLI + dyslexia group, only four omitted an initial weak syllable from just one nonword item, and no child made this error more than once. From the SLI-only and dyslexia-only groups, no child omitted an initial weak syllable. In the TD5 group, only one child omitted one, and no child in the older control groups did. Therefore, initial-weak-syllable omission is not a confound in the analyses that we present.

3.1. CLUSTER ACCURACY. The mean scores for cluster accuracy are reported in Table 3 as percentages correct for ease of exposition, but the dependent variable in the analysis is the number of clusters correct. Because the TD9 group performed so close to ceiling, with little variation in scores, we carry out statistical analysis on only the TD5 and TD7 groups, and the three clinical groups.

	SLI + DYSLEXIA	SLI-ONLY	DYSLEXIA-ONLY
total score	66.99 (19.68)	75.96 (26.50)	84.87 (15.77)
initial cluster, stressed	84.82 (20.79)	84.62 (26.10)	94.74 (13.38)
initial cluster, unstressed	64.29 (33.63)	84.62 (26.10)	84.21 (23.88)
medial cluster, stressed	68.79 (22.18)	67.31 (25.79)	85.53 (24.03)
medial cluster, unstressed	50.00 (29.66)	67.31 (34.44)	75.00 (26.35)
	TD5	TD7	TD9
total score	81.53 (17.2)	91.85 (8.31)	97.22 (4.90)
initial cluster, stressed	87.50 (18.50)	94.57 (12.96)	100.00 (0.00)
initial cluster, unstressed	77.27 (25.48)	93.48 (13.52)	95.83 (9.59)
medial cluster, stressed	77.27 (23.03)	89.13 (14.74)	98.61 (5.89)
medial cluster, unstressed	84.09 (27.33)	90.22 (14.58)	94.44 (10.69)

TABLE 3. Mean scores (SD) for cluster accuracy in three-syllable nonwords, expressed as a percentage.

A 2 (word position: initial, medial) × 2 (stress: stressed, unstressed) × 5 (group) ANOVA revealed that the main effects of word position, stress, and group were all significant: $F(1,100) = 29.40$, $p < 0.001$, $\eta^2 = 0.227$; $F(1,100) = 12.30$, $p < 0.001$, $\eta^2 = 0.110$; and $F(4,100) = 6.94$, $p < 0.001$, $\eta^2 = 0.217$ respectively. There was no significant third-order interaction: $F(4,100) = 0.87$, $p = 0.485$, $\eta^2 = 0.034$, and no significant word position × stress interaction: $F(1,100) = 1.36$, $p = 0.247$, $\eta^2 = 0.013$. There were, however, significant interactions between word position and group: $F(4,100) = 2.98$, $p = 0.023$, $\eta^2 = 0.106$, and between stress and group: $F(4,100) = 5.44$, $p < 0.001$, $\eta^2 = 0.179$. Accuracy was higher for word-initial clusters than word-medial clusters, and for clusters in stressed syllables compared to those in unstressed syllables. Post hoc testing for group differences (using the Games-Howell procedure to account for unequal variances and group sizes) revealed that the SLI + dyslexia group performed worse than the dyslexia-only and TD7 groups, $p = 0.010$ and $p < 0.001$ respectively, and marginally worse than the TD5 group, $p = 0.059$. No other group differences were significant.

We analyze the word position × group interaction first (see Figure 1). A series of paired-samples two-tailed *t*-tests within each group revealed significantly more correct repetitions of clusters in word-initial compared to word-medial position for the SLI + dyslexia, SLI-only, and dyslexia-only groups: $t(27) = 4.15$, $p < 0.001$; $t(12) = 5.20$,

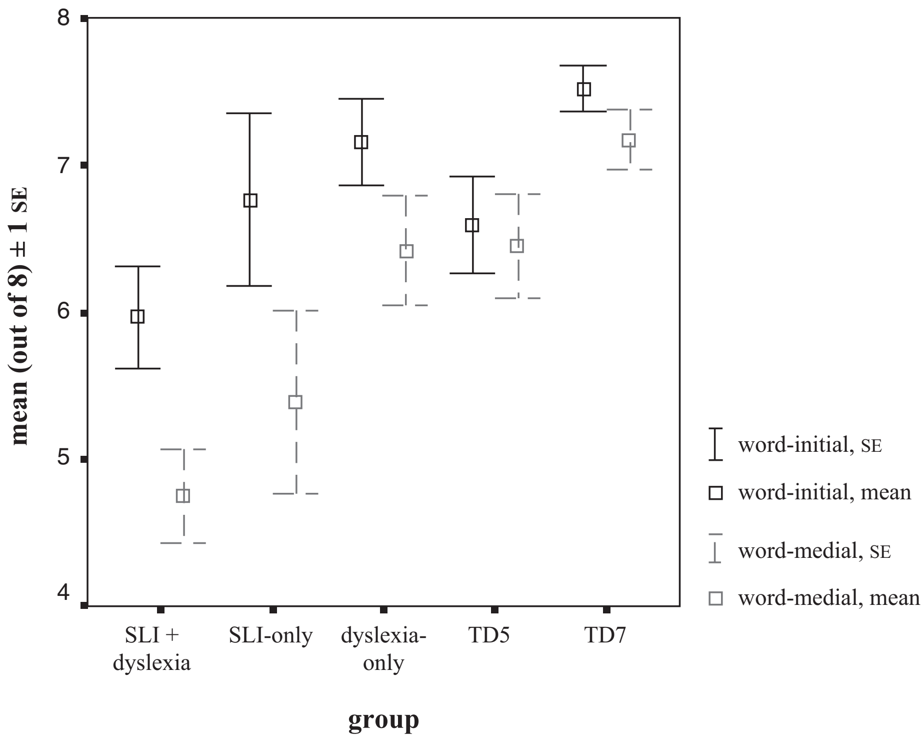

FIGURE 1. The interaction between word position and group for cluster accuracy.

$p < 0.001$; and $t(18) = 2.16$, $p = 0.044$ respectively, but not for the TD5 group: $t(21) = 0.40$, $p = 0.690$, or the TD7 group: $t(22) = 1.50$, $p = 0.148$.

One-way ANOVAs to investigate the effect of group within the initial and medial conditions revealed the following. A one-way ANOVA within the word-initial conditions revealed a significant group effect: $F(4,100) = 3.66$, $p = 0.008$. Post hoc testing using Games-Howell correction revealed that the only significant group difference was between the SLI + dyslexia and TD7 groups, $p = 0.002$. A one-way ANOVA within the word-medial conditions also revealed a significant group effect: $F(4,100) = 8.43$, $p < 0.001$. This time there were a greater number of group differences. The SLI + dyslexia group scored significantly worse than the dyslexia-only, TD5, and TD7 groups, $p = 0.012$, $p = 0.007$, and $p < 0.001$ respectively. No other group differences reached significance.

Next we analyze the stress × group interaction (see Figure 2). A series of paired-samples *t*-tests within each group revealed a significant advantage for clusters in stressed compared to unstressed positions for the SLI + dyslexia and dyslexia-only groups: $t(27) = 4.30$, $p < 0.001$; and $t(18) = 2.58$, $p = 0.019$, respectively, but not for the SLI-only ($t(12) = 0.00$, $p = 1.000$), TD5 ($t(21) = 0.44$, $p = 0.665$), or TD7 ($t(22) = 0.00$, $p = 1.000$) groups.

A one-way ANOVA within the stressed conditions showed a significant group effect: $F(4,100) = 4.06$, $p = 0.004$. Post hoc testing using Games-Howell correction revealed that the only significant group difference was between the SLI + dyslexia and TD7 groups, $p = 0.002$. A one-way ANOVA within the unstressed conditions also revealed a significant group effect: $F(4,100) = 8.01$, $p < 0.001$. The SLI + dyslexia group

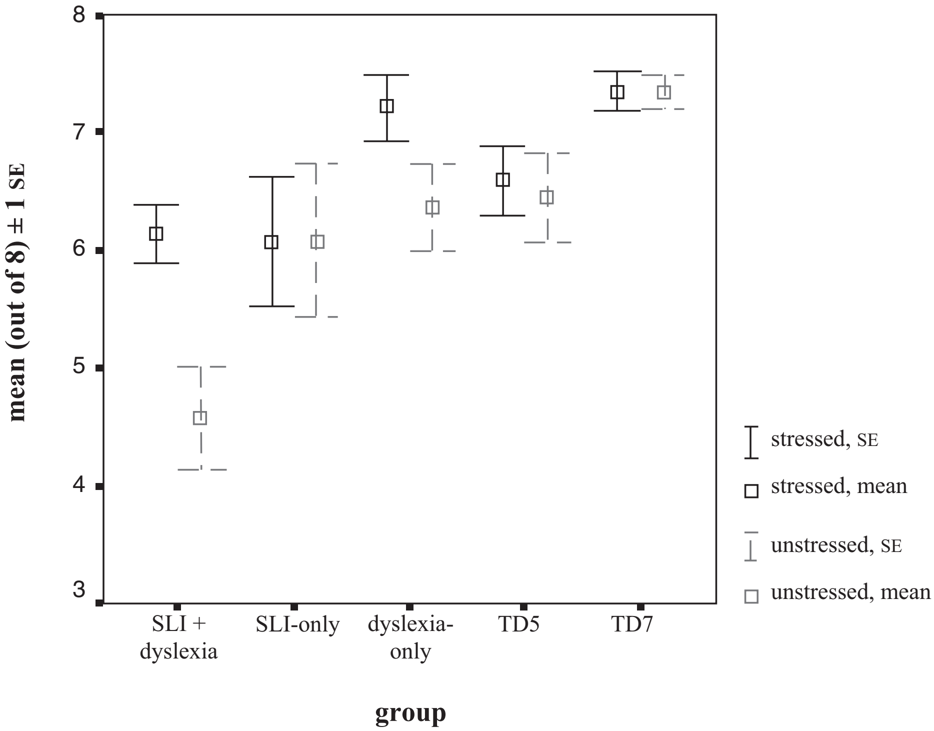

FIGURE 2. The interaction between stress and group for cluster accuracy.

scored significantly worse than the dyslexia-only, TD5, and TD7 groups, $p = 0.022$, $p = 0.014$, and $p < 0.001$ respectively. No other group differences reached significance.

3.2. ERRORS. We analyze two types of errors: errors on the target cluster itself, and errors whereby a new cluster was created (this latter type occurred even when the target cluster was realized accurately, so we analyze this error type separately).

ERRORS IN CLUSTER PRODUCTION. Here we consider the different types of errors that the groups make on clusters. Five different error types were coded. Examples of each of these types are given in 1.

(1)	C1 deleted:	fləkɛtə – ləkɛtə
	C2 deleted:	tʌprəfə – tʌpəfə
	C1 substituted:	fəklɛtə – fəglɛtə
	C2 substituted:	ləfræpə – ləflæpə
	Other error:	prəfʌtə – bəfʌtə

Note that for the two types of substitution errors, clusterhood is preserved, but the segmental content is not accurate and these are therefore counted as errors.

The different error types made by each group, collapsed across conditions, are shown in Table 4. Although Table 4 shows the percentage of errors, the analysis was carried out with the raw number of errors produced as the dependent variable.

Because the TD9 group made so few errors, we once again exclude them from the statistical analysis. The data from the remaining five groups violate the assumption of sphericity, so we use Greenhouse-Geisser corrections in reporting the results of the

	SLI + DYSLEXIA	SLI-ONLY	DYSLEXIA-ONLY	TD5	TD7	TD9
C1 deleted	1.12 (3.82)	0.00 (0.00)	0.99 (3.13)	0.85 (2.92)	0.54 (1.80)	0.00 (0.00)
C1 substituted	2.01 (2.97)	3.85 (5.44)	0.99 (2.34)	5.97 (6.53)	1.90 (3.97)	0.69 (2.02)
C2 deleted	18.30 (14.43)	12.98 (15.82)	7.90 (10.38)	5.68 (6.37)	3.53 (4.92)	1.39 (3.43)
C2 substituted	1.79 (3.34)	1.44 (3.74)	0.33 (1.43)	1.70 (3.94)	0.82 (2.15)	0.35 (1.47)
Other error	9.38 (9.84)	5.77 (9.36)	4.93 (6.10)	3.98 (6.83)	1.36 (3.24)	0.35 (1.47)

TABLE 4. Mean scores (SD) for different error types on clusters in three-syllable nonwords, expressed as a percentage across all conditions.

ANOVA,[2] and nonparametric signed-ranks tests in exploring the error types within each group. A 5 (error type) × 5 (group) ANOVA revealed significant main effects of error type and group: $F(2.3, 229) = 34.83$, $p < 0.001$, $\eta^2 = 0.258$; and $F(4,100) = 6.79$, $p < 0.001$, $\eta^2 = 0.214$ respectively, and a significant interaction between error type and group: $F(9.2, 229) = 5.11$, $p < 0.001$, $\eta^2 = 0.170$.

In order to explore the interaction, we carried out a series of Wilcoxon signed-rank tests within each group, setting the alpha value to 0.005 to account for multiple comparisons. For the SLI + dyslexia group, C2-deletion errors were significantly more common than C1-deletion, C1-substitution, and C2-substitution errors, Z = −4.20, Z = −4.03, and Z = −4.49 respectively, $p < 0.001$ for each. 'Other' errors were also significantly more common than C1-deletion, C1-substitution, and C2-substitution errors, Z = −4.03, Z = −3.66, and Z = −3.53, $p < 0.001$ for each. The difference between C2-deletion and 'other' errors was not significant, however. For the SLI-only group, the only significant comparison was a greater number of C2-deletion compared to C1-deletion errors, Z = −2.84, $p = 0.005$. For the dyslexia-only group, C2-deletion errors significantly outnumbered C1-deletion errors and C2-substitution errors, Z = −2.98 and Z = −2.96 respectively, $p = 0.003$ for both. No comparisons reached significance for either of the control groups.

A series of one-way ANOVAs revealed significant group differences for C1-substitution, C2-deletion, and 'other' errors. Post hoc testing using Games-Howell correction revealed that for C1-substitution errors, the only significant difference was between the TD5 group and the dyslexia-only group, $p = 0.019$. The SLI + dyslexia group made significantly more C2-deletion errors than the dyslexia-only, TD5, and TD7 groups, $p = 0.046$, $p = 0.002$, and $p < 0.001$ respectively. For 'other' errors, the SLI + dyslexia group made significantly more errors than the TD7 group. No other differences reached significance.

CREATION OF NEW CLUSTERS. A different type of error from those analyzed in the previous section occurred when participants created new onset clusters in nontarget positions, by inserting /l/ or /r/ after an obstruent consonant. On occasion, they created clusters in nonwords even when they repeated the existing cluster correctly, for example, *fɛklətə – flɛklətə*. This error type is therefore independent from the error responses analyzed in the previous section. Examples of where errors were created are given in 2.

(2) word-initial stressed syllable: **f**ɛklətə – **fl**ɛkətə
word-initial unstressed syllable: **t**əprʌfə – **tr**əpʌfə
word-medial stressed syllable: frə**p**ælə – fə**pl**ælə
word-medial unstressed syllable: drɛ**p**əkə – drɛ**pl**əkə

[2] Sphericity is an assumption of an ANOVA with a repeated-measures factor. Sphericity requires that the variances of the differences between levels of the repeated-measures factor are equal. Thus, results from ANOVAs violating this assumption cannot be trusted, and we have corrected for this violation using the Greenhouse-Geisser correction.

We calculated the percentage of times a cluster was created where context would allow it for each condition (see Table 5). There were some nonwords where a cluster could not be created in each context. For example, consider the creation of clusters in a word-initial stressed syllable, that is, in the stimuli *fɛklətə*, *tʌprəfə*, *kɛdrəpə*, and *læfrəpə*. Of those four, a cluster cannot be created in *læfrəpə*. Similarly, consider the word-medial stressed position, *klətɛfə*, *prəfʌtə*, *drəpɛkə*, and *frəpælə*—assuming the cluster is created with the same C2 that is in the target cluster, a new cluster cannot be created in *klətɛfə* (**tl*).[3] We therefore calculated the percentage over the number of contexts that would support creation of a cluster. Note that each condition contained the same number of contexts that were able to support cluster creation.

	SLI + DYSLEXIA	SLI-ONLY	DYSLEXIA-ONLY
initial cluster, stressed	19.05 (21.14)	25.64 (30.89)	5.26 (12.49)
initial cluster, unstressed	10.71 (18.27)	20.51 (25.60)	10.53 (15.92)
medial cluster, stressed	4.76 (11.88)	2.56 (9.25)	1.75 (7.65)
medial cluster, unstressed	1.19 (6.30)	0.00 (0.00)	0.00 (0.00)
	TD5	TD7	TD9
initial cluster, stressed	7.58 (14.30)	7.25 (14.06)	1.85 (7.86)
initial cluster, unstressed	13.64 (26.55)	8.70 (14.97)	1.85 (7.86)
medial cluster, stressed	4.55 (11.71)	0.00 (0.00)	0.00 (0.00)
medial cluster, unstressed	0.00 (0.00)	0.00 (0.00)	1.85 (7.86)

TABLE 5. Mean scores (SD) for creation of new clusters in three-syllable nonwords, according to where the cluster was created and expressed as a percentage.

In this analysis, percentage of clusters created was used as the dependent variable. A 2 (word position: initial, medial) × 2 (stress: stressed, unstressed) × 5 (group) ANOVA revealed significant main effects of word position and group: $F(1,100) = 58.77$, $p < 0.001$, $\eta^2 = 0.370$ and $F(4,100) = 2.83$, $p = 0.028$, $\eta^2 = 0.102$ respectively, but no main effect of stress: $F(1,100) = 0.80$, $p = 0.374$, $\eta^2 = 0.008$. There was no significant third-order interaction: $F(4,100) = 1.55$, $p = 0.194$, $\eta^2 = 0.058$; word position × stress interaction: $F(1,100) = 0.92$, $p = 0.340$, $\eta^2 = 0.009$; or stress × group interaction: $F(4,100) = 1.24$, $p = 0.299$, $\eta^2 = 0.047$. There was, however, a significant interaction between word position and group: $F(4,100) = 2.52$, $p = 0.046$, $\eta^2 = 0.092$.

We explored the word position × group interaction (see Figure 3). A series of paired-samples two-tailed *t*-tests comparing performance on word-initial and word-medial conditions for each group revealed that all groups created significantly more clusters word-initially than word-medially: SLI + dyslexia: $t(27) = 4.95$, $p < 0.001$; SLI-only: $t(12) = 3.16$, $p = 0.008$; dyslexia-only: $t(18) = 2.65$, $p = 0.016$; TD5: $t(21) = 2.73$, $p = 0.013$; TD7: $t(22) = 3.14$, $p = 0.005$. A one-way ANOVA revealed a significant main effect of group for the word-initial conditions: $F(4,100) = 2.83$, $p = 0.028$. On post hoc testing using Games-Howell correction, the only significant difference was between the SLI-only group and the TD7 group, $p = 0.046$. A one-way ANOVA revealed no significant main effect of group for the word-medial conditions: $F(4,100) = 1.40$, $p = 0.240$.

3.4. SUMMARY. Word-medial clusters were repeated less accurately by all three clinical groups, while clusters in unstressed syllables were problematic for the two dyslexic groups but not the SLI-only group. The SLI + dyslexia group was least accurate

[3] A referee questioned whether this assumption was correct, given that there are instances in our data where the cluster was created with a different C2 from that of the target cluster. Across our whole data set, an overwhelming 87% of clusters were created with the same C2 as in the target cluster.

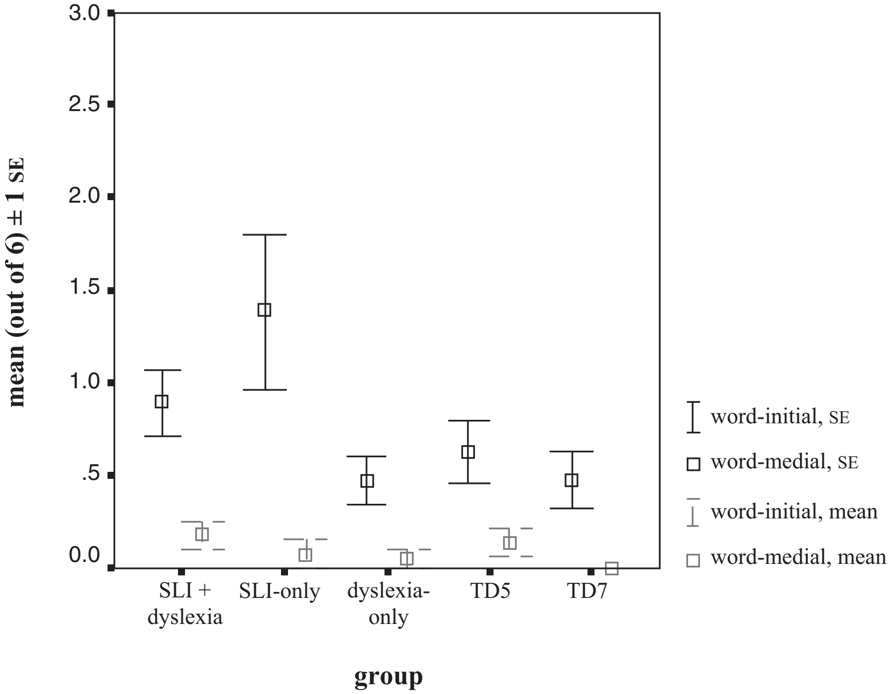

FIGURE 3. The interaction between word position and group for newly created clusters.

overall, with its most frequent errors consisting of the deletion of the second consonant in the cluster (/r/ or /l/) and 'other' errors that were not readily classifiable. None of the typically developing groups showed an effect of word position or stress in cluster repetition. However, ALL groups created clusters significantly more often in initial than in medial positions, and the creation of initial clusters was particularly high within the SLI-only group.

4. DISCUSSION. In this study we set out to investigate a little-studied area of phonological grammar—the accuracy of onset cluster production in different word positions and in stressed and unstressed syllables. Our main aim was to determine whether doing so would reveal any differences between SLI and dyslexic children, and whether either disorder differs from the typical pattern of development at age 4;6 and above. A secondary aim was to determine whether word position and stress are developmentally independent elements of the phonological representation.

Crosslinguistically, word-initial and stressed positions resist reduction. Although they are both strong positions, it has been argued that they gain their strength for different reasons, with initial positions being psycholinguistically strong and stressed positions being phonetically strong (Beckman 1998, Smith 2004). Our study provides evidence that word position and stress are also developmentally independent. We found that word position affected cluster accuracy only in children with SLI and dyslexia, whereas typically developing children showed no effect of word position. Stress affected cluster accuracy only in dyslexic children: this is a rare instance of children with dyslexia and children with SLI responding differently on a phonological task. Again, the typically developing children showed no effect of stress. Despite the most common error being the deletion of the second consonant in the cluster (/r/ or /l/), all groups created clusters in nontarget positions within the nonword. Such clusters were created overwhelmingly in word-initial positions, and this was the case not only for the three clinical groups but also for the three typically developing groups. This suggests that word-position factors are important for cluster formation in typically developing children too, even though by the age of four and a half they are equally accurate in repeating existing onset clusters whatever their position in the word.

An important issue in the study of developmental disorders is whether clinical participants show patterns of performance that are qualitatively different from those of typically developing children. The pattern of new-cluster creation reveals word-position effects in typically developing children too. In contrast, our study provides no evidence for stress impacting on typical development of clusters. Of course, we could have tested a group of even younger children, but younger children have higher levels of initial-weak-syllable deletion and difficulties with the articulation of /r/ and /l/, so positional effects on clusters might not emerge. The difference between SLI and dyslexia in terms of the effects of stress on cluster accuracy, however, has potentially important ramifications for models of the two disorders.

Dyslexic children's difficulty in repeating clusters accurately in unstressed syllables indicates a deficit in constructing accurate phonological representations when, presumably, perceptual cues to segmental identity are weak (given that unstressed syllables are shorter and not as loud compared to stressed syllables; Ashby & Maidment 2005). There is evidence from other sources that dyslexic children are impaired in the perception of stress itself. For example, they have difficulty identifying PERCEPTUAL-CENTERS, the mid-spectral energy burst at the onset of the nucleus, and this is claimed to explain their problems identifying onset and rhyme (Goswami et al. 2002). Although it is not immediately obvious what the link between problems with P-center identification and our finding of cluster reduction in weak syllables would be, these two phenomena might be related. More recent research findings from Goswami's lab indicate, however, that a majority of children with SLI also have difficulty identifying P-centers, suggesting that children with SLI and children with dyslexia share the same phonological deficit (Corriveau et al. 2007). Similarly, some accounts of SLI claim that children with SLI have a speech-perception deficit that is of the same kind but more severe than that of children with dyslexia (Kamhi & Catts 1986, Tallal 2003). In our data, the lack of a stress effect on SLI children's onset realization is incompatible with both of these views. Instead, it suggests that the underlying nature of SLI and dyslexic children's impairments is at least partially qualitatively different. Research into the ability of children with SLI and dyslexia to perceive clusters in different word and stress positions would be a valuable next step in examining this issue.

It could be, of course, that the dyslexic children's difficulty with stress is not in perception but in production. Kirk and Demuth (2006), in their study of coda consonant production in typically developing children, interpreted lower accuracy for coda production in medial unstressed syllables as due to there being less time available for articulating the coda compared to stressed syllables. Children with SLI have been shown to produce articulatory movements that are more variable in spatiotemporal organization than those of their typically developing age-matched peers (Goffman 2004). Whether this is also the case for dyslexic children is not clear from the current research evidence.

Our results are in line with those reported in Gallon et al. 2007, a nonword repetition study of children with grammatical-SLI,[4] but they challenge the interpretations pre-

[4] Children with grammatical-SLI have been argued to exhibit a relatively pure, domain-specific, grammatical impairment, and are hence a subgroup within the SLI population. See van der Lely & Battell 2003 for further details.

sented there. Like Gallon and colleagues, we found that onset clusters are repeated less accurately when they follow an initial unstressed syllable than when they are word-initial in a stressed syllable. Gallon and colleagues took this to be due to an interaction between marked syllable structure (i.e. the presence of a cluster) and marked metrical structure (the presence of an initial unstressed syllable). Neither their SLI children nor ours omitted initial weak syllables. Their nonword repetition stimuli, however, contained only two conditions with onset clusters: in either word-initial stressed position or word-medial stressed position. Therefore, it is possible that errors occurred on clusters that followed the weak syllable not because of the weak syllable per se, but because the onset cluster was not word-initial. We can tease apart the effects of word position and stress in our data because we have two conditions with initial weak syllables (word-initial unstressed, word-medial stressed) and two without (word-initial stressed, word-medial unstressed). For our SLI + dyslexia group, cluster accuracy in weak-strong contexts was 66.54% and in strong-weak contexts was 67.41%. For our SLI-only group, cluster accuracy in weak-strong contexts was 75.97% and in strong-weak contexts was also 75.97%. Therefore the overall metrical structure of the word has no effect on cluster accuracy.

In line with many previous studies, we have found that SLI and dyslexic children perform worse on nonword repetition tasks than even much younger children (Gathercole & Baddeley 1990, Dollaghan & Campbell 1998, Gallon et al. 2007). There has been much debate over why this is the case, and what factors may affect nonword repetition accuracy (Archibald & Gathercole 2006, van der Lely & Gallon 2006, Graf Estes et al. 2007). In light of this debate, it is important to note that we designed all of our experimental stimuli to have exactly the same number of syllables (three) and phonemes (nine). We manipulated the arrangement of those phonemes in terms of their higher-level organization in the prosodic hierarchy, but not the total amount of phonological material to be retained in short-term memory. Clusters have already been identified as one factor that children find difficult—now we have extended that by showing that the location of the cluster within the word is significant. There are probably many other phonological variables affecting performance in nonword repetition tests that are yet to be examined. Our results therefore challenge the notion that nonword repetition tests measure only phonological short-term-memory capacity. We have demonstrated that the nature of the phonological representation that the child has to create, store, and retrieve is also relevant. Importantly, the structure of the phonological representation is affected in both SLI and dyslexia. In order to disentangle how phonological representations in SLI and dyslexia DIFFER, we hope researchers will follow our approach in taking detailed language and literacy measures when they study one or both of these populations, so that the phonological characteristics of each disorder can be determined more precisely.

Finally, our data potentially contribute toward testing different theoretical accounts of positional asymmetries. In an optimality-theoretic framework there are two major approaches that account for positional asymmetries: POSITIONAL MARKEDNESS (PM) and POSITIONAL FAITHFULNESS (PF). Both accounts make use of markedness and faithfulness constraints, but differ in how they state positional effects. PM accounts propose that certain marked structures either must or cannot occur in certain positions. PM faithfulness constraints are context-independent, while their markedness constraints directly prohibit marked structure in weak positions (Steriade 1997, Zoll 2003). PF accounts, by contrast, have context-independent markedness constraints and faithfulness constraints that are restricted to particular contexts (Alderete 1995, Beckman 1998, Casali 1998).

In many instances, the two approaches make the same predictions for the data, and so are difficult to tease apart. For example, our accuracy data do not help in this regard: the finding that SLI and dyslexic children reduce clusters more frequently in word-medial positions and retain them more frequently in word-initial positions is predicted by both accounts. The accounts differ, however, in their predictions for instances where marked structure is created in the output. Because PF constraints prohibit change in strong positions, they not only prevent reduction in underlying marked structures in these positions, but also prevent phonological augmentation from taking place there. PF predicts that when marked structure is created, it will be drawn to weak positions. Our data reveal that children create clusters more frequently word-initially than word-medially, and therefore created marked structure in strong positions, contrary to the PF account. The anticipatory production of clusters has been long known from the speech-error literature (Cohen 1973), and therefore the position of this error that we see in all groups of children may indicate no more than imprecise speech planning. Our results, however, are consistent with the predictions of the PM account, which can deal straightforwardly with phonological augmentation in strong positions, because these are precisely the positions where marked structure is favored.[5]

5. Conclusions. In this study we investigated one aspect of phonological grammar: the impact of word position and stress on the accuracy of onset cluster production in children who are acquiring English. Word-medial clusters were more difficult than initial clusters for children with SLI and dyslexia to repeat. Unstressed clusters were realized less accurately than stressed clusters by only the dyslexic children. To our knowledge, these are the first data showing qualitative differences in phonology between SLI and dyslexic children, and they highlight the insight that linguistic theory can bring to bear on clinical investigations of language. We argue that these data challenge models of SLI and dyslexia whereby the phonological deficits underlying these two disorders are identical. Furthermore, our findings indicate that structural position and stress are developmentally independent elements in phonological representations.

Appendix: List of stimuli

THREE-SYLLABLE NONWORDS

WORD-INITIAL STRESSED	WORD-INITIAL UNSTRESSED	WORD-MEDIAL STRESSED	WORD-MEDIAL UNSTRESSED
klɛtəfə	klətɛfə	fəklɛtə	fɛklətə
prʌfətə	prəfʌtə	təprʌfə	tʌprəfə
drɛpəkə	drəpɛkə	kədrɛpə	kɛdrəpə
fræpələ	frəpælə	ləfræpə	læfrəpə

ONE-SYLLABLE NONWORDS

OBSTRUENT + LIQUID	*s* + STOP	*s* + SONORANT
drɔn	stɔn	slɔn
klʌf	spʌf	smʌf
glɛp	skɛp	snɛp
plɪd	spɪd	snɪd
brʌp	stʌp	swʌp
græv	skæv	slæv

[5] Similarly, Zoll (2003) shows that PF makes the wrong predictions for several phonological phenomena, including mimetic palatalization in Japanese and vowel-length distribution in Guugu Yimidhirr, cases where marked structure arises through augmentation of the input.

REFERENCES

ALDERETE, JOHN. 1995. Faithfulness to prosodic heads. Amherst: University of Massachusetts, Amherst, MS.

ALLEN, GEORGE, and SARAH HAWKINS. 1978. The development of phonological rhythm. *Syllables and segments*, ed. by Alan Bell and Joan B. Hooper, 173–85. New York: Elsevier.

ARCHIBALD, LISA, and SUSAN GATHERCOLE. 2006. Nonword repetition: A comparison of tests. *Journal of Speech, Language and Hearing Research* 49.970–83.

ASHBY, MICHAEL, and JOHN MAIDMENT. 2005. *Introducing phonetic sciences*. Cambridge: Cambridge University Press.

BECKMAN, JILL. 1998. *Positional faithfulness*. Amherst: University of Massachusetts, Amherst dissertation.

BENKI, JOSÉ. 2003. Quantitative evaluation of lexical status, word frequency and neighborhood density as context effects in spoken word recognition. *Journal of the Acoustical Society of America* 113.1689–705.

BISHOP, DOROTHY. 2003. *Test for reception of grammar*. 2nd edn. London: Harcourt Assessment, Psychological Corporation.

BISHOP, DOROTHY; TONY NORTH; and CHRIS DONLAN. 1996. Nonword repetition as a behavioral marker for inherited language impairment: Evidence from a twin study. *Journal of Child Psychology and Psychiatry* 37.391–403.

BISHOP, DOROTHY, and MAGGIE SNOWLING. 2004. Developmental dyslexia and specific language impairment. *Psychological Bulletin* 130.858–86.

BORTOLINI, UMBERTA, and LAURENCE LEONARD. 2000. Phonology and children with specific language impairment: Status of structural constraints in two languages. *Journal of Communication Disorders* 33.131–50.

CASALI, RODERIC. 1998. *Resolving hiatus*. New York: Garland.

CHAMBLESS, DELLA. 2004. Asymmetries in initial and medial cluster acquisition. *Proceedings of the 28th annual Boston University Conference on Language Development (BUCLD)*, ed. by Alejna Brugos, Linnea Micciula, and Christine Smith, 86–97. Somerville, MA: Cascadilla.

COHEN, ANTHONY. 1973. Errors of speech and their implication for understanding the strategy of language users. *Speech errors as linguistic evidence*, ed. by Victoria Fromkin, 88–92. New York: Walter de Gruyter.

COLE, RONALD, and JOLA JAKIMIK. 1980. How are syllables used to recognize words? *Journal of the Acoustical Society of America* 67.965–70.

CORRIVEAU, KATHLEEN; ELIZABETH PASQUINI; and USHA GOSWAMI. 2007. Basic auditory processing skills and specific language impairment: A new look at an old hypothesis. *Journal of Speech, Language and Hearing Research* 50.647–66.

CUTLER, ANNE. 1986. *Forbear* is a homophone: Lexical stress does not constrain lexical access. *Language and Speech* 29.201–20.

DE BREE, ELISE. 2007. *Dyslexia and phonology: A study of the phonological abilities of Dutch children at-risk of dyslexia*. Utrecht: University of Utrecht dissertation.

DOLLAGHAN, CHRIS, and THOMAS CAMPBELL. 1998. Nonword repetition and child language impairment. *Journal of Speech, Language and Hearing Research* 41.1136–46.

DUNN, LLOYD; LEOTA DUNN; CHRIS WHETTON; and JULIET BURLEY. 1997. *British picture vocabulary scales*. 2nd edn. Windsor: NFER Nelson.

ELLIOTT, COLLIN. 1996. *British ability scales*. 2nd edn. Windsor: NFER Nelson.

FISHER, SIMON. 2007. Molecular windows into speech and language disorders. *Folia Phoniatrica et Logopaedia* 59.130–40.

GALABURDA, ALBERT; JOSEPH LOTURCO; FRANCK RAMUS; R. HOLLY FITCH; and GLENN ROSEN. 2006. From genes to behavior in developmental dyslexia. *Nature Neuroscience* 9.1213–17.

GALLON, NICHOLA; JOHN HARRIS; and HEATHER VAN DER LELY. 2007. Nonword repetition: An investigation of phonological complexity in children with grammatical-SLI. *Clinical Linguistics and Phonetics* 21.435–55.

GATHERCOLE, SUSAN, and ALAN BADDELEY. 1990. Phonological memory deficits in language-disordered children. *Journal of Memory and Language* 29.336–60.

GERMAN, DIANE. 2000. *Test of word finding*. 2nd edn. Austin: Pro-ed.

Goffman, Lisa. 2004. Kinematic differentiation of prosodic categories in normal and disordered language development. *Journal of Speech, Language and Hearing Research* 47.1088–102.

Goswami, Usha; Jennifer Thomson; Ulla Richardson; Rhona Stainthorp; Diana Hughes; Stuart Rosen; and Sophie Scott. 2002. Amplitude envelope onsets and developmental dyslexia: A new hypothesis. *Proceedings of the National Academy of Sciences* 99.10911–16.

Graf Estes, Katherine; Julia Evans; and Nicole Else-Quest. 2007. Differences in nonword repetition performance of children with and without specific language impairment: A meta-analysis. *Journal of Speech, Language and Hearing Research* 50.177–95.

Harris, John. 1997. Licensing inheritance: An integrated theory of neutralization. *Phonology* 14.315–70.

Joanisse, Marc; Franklin Manis; Patricia Keating; and Mark Seidenberg. 2000. Language deficits in dyslexic children: Speech perception, phonology and morphology. *Journal of Experimental Child Psychology* 77.30–60.

Jusczyk, Peter; Derek Houston; and Mary Newsome. 1999. The beginnings of word segmentation in English-learning infants. *Cognitive Psychology* 39.159–207.

Kamhi, Alan, and Hugh Catts. 1986. Toward an understanding of developmental language and reading disorders. *Journal of Speech, Language and Hearing Research* 51.337–47.

Kirk, Cecilia, and Katherine Demuth. 2005. Asymmetries in the acquisition of word-initial and word-final consonant clusters. *Journal of Child Language* 32.709–34.

Kirk, Cecilia, and Katherine Demuth. 2006. Accounting for variability in 2-year olds' production of coda consonants. *Language Learning and Development* 2.97–118.

Leonard, Laurence. 1998. *Children with specific language impairment*. Cambridge, MA: MIT Press.

Marshall, Chloe R. 2004. *The morpho-phonological interface in specific language impairment*. London: University of London dissertation.

Marshall, Chloe R.; John Harris; and Heather K. J. 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.

Marshall, Chloe R.; John Harris; and Heather K. J. van der Lely. 2003. The nature of phonological representations in children with grammatical specific language impairment. *Proceedings of the University of Cambridge First Postgraduate Conference in Language Research*, ed. by Damien Hall, Theodore Markopoulos, Angeliki Salamoura, and Sophia Skoufaki, 511–17. Cambridge: Cambridge Institute of Language Research.

Marslen-Wilson, William. 1987. Functional parallelism in spoken word recognition. *Cognition* 25.71–102.

Marslen-Wilson, William, and Alan Welsh. 1978. Processing interactions and lexical access during word recognition in continuous speech. *Cognitive Psychology* 10.29–63.

Marslen-Wilson, William, and Pienie Zwisterlood. 1989. Accessing spoken words: The importance of word onsets. *Journal of Experimental Psychology: Human Perception and Performance* 15.576–85.

McArthur, Genevieve; John Hogben; V. Edwards; Steven Heath; and Elise Mengler. 2000. On the 'specifics' of specific reading disability and specific language impairment. *Journal of Child Psychology and Psychiatry* 41.869–74.

Monaco, Anthony, and the SLI Consortium. 2007. Multivariate linkage analysis of specific language impairment (SLI). *Annals of Human Genetics* 71.660–73.

Raven, John. 1998. *Raven's progressive matrices*. Oxford: Oxford Psychologists Press.

Rice, Mabel, and Kenneth Wexler. 1996. Towards tense as a clinical marker of specific language impairment in English-speaking children. *Journal of Speech and Hearing Research* 39.1239–57.

Ring, Melanie, and Harald Clahsen. 2005. Distinct patterns of language impairment in Down's syndrome and Williams syndrome: The case of syntactic chains. *Journal of Neurolinguistics* 18.479–501.

Rose, Yvan. 2002. Relations between segmental and prosodic structures in first language acquisition. *Annual review of language acquisition*, vol. 2, ed. by Lynn Santelmann, Maaike Verrips, and Frank Wijnen, 117–55. Amsterdam: John Benjamins.

Schwartz, Richard, and Lisa Goffman. 1995. Metrical patterns of words and production accuracy. *Journal of Speech and Hearing Research* 38.876–88.

Semel, Eleanor; Elisabeth Wiig; and Wayne Secord. 1995. *Clinical evaluation of language fundamentals*. San Antonio: Psychological Corporation.

Smit, Ann. 1993. Phonologic error distributions in the Iowa-Nebraska articulation norms project: Word-initial consonant clusters. *Journal of Speech and Hearing Research* 36.931–47.

Smith, Jennifer. 2004. *Phonological augmentation in prominent positions*. New York: Routledge.

Snowling, Maggie. 2000. *Dyslexia*. 2nd edn. Oxford: Blackwell.

Snowling, Maggie; Shula Chiat; and Charles Hulme. 1991. Words, nonwords and phonological processes: Some comments on Gathercole, Willis, Elmslie and Baddeley. *Applied Psycholinguistics* 12.369–73.

Steriade, Donca. 1997. Phonetics in phonology: The case of laryngeal neutralization. Los Angeles: University of California, Los Angeles, ms.

Storkel, Holly, and Michele Morrisette. 2002. The lexicon and phonology: Interactions in language acquisition. *Language, Speech and Hearing Services in Schools* 33.24–37.

Stromswold, Karin. 2001. The heritability of language: A review and metaanalysis of twin, adoption and linkage studies. *Language* 77.647–723.

Tallal, Paula. 2003. Language learning disabilities: Integrating research approaches. *Current Directions in Psychological Science* 12.206–11.

Trubetskoy, Nikolay. 1939. *Grundzüge der Phonologie* [Principles of phonology]. Prague: Travaux du cercle linguistique de Prague.

van der Lely, Heather K. J., and Jackie Battell. 2003. Wh-movement in children with grammatical-SLI: A test of the RDDR hypothesis. *Language* 79.153–81.

van der Lely, Heather K. J., and Nichola Gallon. 2006. Exploring the impact of higher level linguistic representations on nonword repetition performance. *Applied Psycholinguistics* 27.591–94.

van der Lely, Heather K. J., and John Harris. 1999. Test of phonological structure. Available from the authors at the Centre for Developmental Language Disorders and Cognitive Neuroscience, London, UK.

van der Lely, Heather K. J., and David Howard. 1993. Specifically language impaired children: Linguistic impairment or short term memory deficit? *Journal of Speech and Hearing Research* 37.1193–207.

Wechsler, David. 1990. *Wechsler objective reading dimensions*. London: Psychological Corporation.

Zoll, Cheryl. 2003. Positional asymmetries and licensing. *Optimality theory in phonology: A reader*, ed. by John McCarthy, 365–78. Oxford: Blackwell.

UCL Centre for Developmental Language Disorders
and Cognitive Neuroscience
Psychology and Language Sciences Division
University College London
Chandler House
2 Wakefield St.
London WC1N 1PF
United Kingdom
[h.vanderlely@ucl.ac.uk]

[Chloe.Marshall.1@city.ac.uk]

[Received 13 February 2008;
accepted 10 August 2008]