A profile of expressive inflectional morphology in early school-age children with Developmental Language Disorder

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Previous research has established that children with Developmental Language Disorder (DLD) have difficulties producing inflectional morphology, in particular, finiteness marking. However, other categories of inflectional morphology, such as possessive *'s* nominal inflection remain relatively unexplored. Analyses of the characteristics for marking inflection, such as allomorphic categories, may increase our understanding of patterns within disordered grammar to inform the design of interventions and target selection. Data from n = 30 early school-aged children (M = 75 months, SD = 3.38, range = 69-81 months) with DLD were analysed to develop a profile of inflectional morphology skills. Morphological categories included expressive regular past tense, third person singular, and possessive 's. Skills were profiled using an elicitation task. The relationships between expressive morphosyntax, and phonological short term memory and working memory were also explored. Children demonstrated low accuracy in performance across all inflectional categories, including possessive *'s*. There were no significant differences between productions of different morphemes, but syllabic allomorphs ([əd]; [əz]) were produced with significantly lower accuracy than segmental allomorphs ([d], [t]; [z], [s]) across all morphological categories. All correlations between expressive morphosyntax and measures of memory were non-significant. Children with DLD show broad deficits in the ability to mark for inflection, including possessive *'s*; this has implications for theories explaining DLD. Findings may contribute to the design of urgently needed interventions for this clinical population.

Keywords: developmental language disorder; morphosyntax; verbal inflection; nominal inflection

Introduction

Developmental Language Disorder (DLD) is a neurodevelopmental condition which results in a slower pace of language development compared to typically developing (TD) peers in the absence of other known biomedical conditions (Bishop et al., 2017). Previous research has established that children with DLD present with particular difficulties using inflectional morphology. Within the study of English grammar, inflectional morphology refers to marking of lexical items with affixation (e.g., *walk + ed* or change of vowel *run* → *ran* to denote past tense) to distinguish items from other grammatical categories. In typical development, inflectional morphemic development in the early years is proposed to follow a predictable order of acquisition: plural (*-s*), possessive (*'s*), regular past tense (*-ed*), then third person singular *(3s*) (Brown, 1973).

Children with DLD demonstrate weakness in the ability to use and understand finiteness marking. An example of inflectional morphology, finiteness refers to marking verbs in subject-verb contexts to indicate the obligatory syntactic relationship for tense and agreement. For example, *The man jogg**ed*** for *–ed,* or *The woman run**s*** for *3s*. Nominal inflection refers to marking nouns rather than finiteness, such as plural –s in *The two boy**s*** or to indicate possession, as in *The boy'**s** ball*. Most research into the grammatical difficulties in DLD has focussed on finiteness marking (see Leonard, 2014 for a comprehensive review).

Inflectional morphology development in children with and without DLD

Extended Optional Infinitive account of DLD

Several theories attempt to account for the morphosyntactic development of inflectional

morphology in TD children compared to children with DLD[1]. For example, a seminal linguistic theory rooted in nativist accounts of linguistic development, suggests that children with DLD experience delays with finiteness marking due to an 'Extended Optional Infinitive' stage in morphosyntactic development (Rice & Wexler, 1996). This suggests that once children with DLD activate hypothesised obligatory movement constraints necessary for finiteness marking in English, morphological acquisition occurs at a similar rate to TD children; however, this activation is delayed. Deficits or delays in finiteness marking are clearly useful clinical markers in the identification of children with DLD (Redmond et al., 2019; Rice et al., 1998).

However, Leonard (2014) reviewed cross-linguistic evidence extensively and concluded there is no universal feature of grammar (including finiteness) that characterises morphological development in children with DLD. For example, English-speaking children with DLD produce possessive *'s* less consistently than younger TD children matched for mean length of utterance (Leonard, 1995), which suggests nominal inflection, as well as finite inflection may be affected in children with DLD. Alternative theories draw upon the interplay of morphophonological properties of inflectional morphology to explain the patterns of development in children with and without DLD.

Processing accounts

Leonard and colleagues suggested accounts of processing difficulties, which posit a

[1] It is acknowledged that previous research has used various terms to describe childhood language disorder in the absence of other biomedical conditions, such as specific language impairment. The term Developmental Language Disorder (DLD) is used throughout this paper, in line with recommendations from a recent international consensus study (Bishop et al., 2017).

processing-capacity limitation in children's ability to learn morphemes as a result of their low perceptual salience as a phonological unit of meaning (e.g., Leonard, 1989; Leonard et al., 2003). In contrast to the Extended Optional Infinitive account, "the surface account assumes that children with SLI [*aka DLD*] have no fundamental gaps in their grammatical knowledge apart from the deficiencies that arise because of their slow intake of relevant data due to processing limitations" (Leonard et al., 2003, p. 44). This then has implications for hypothesising the morphemes' function (e.g., inflection) (Leonard & Bortolini, 1998; Leonard et al., 1997). For example, children with DLD performed significantly below their TD counterparts matched for mean-length-of-utterance in their use of *–ed* inflection to mark tense and passive participles (e.g., *The boy was push**ed** by the girl*) (Leonard et al., 2003). This suggests that the use of such morphemes may be subject to the phonetic properties of the marker, as opposed to the grammatical function, as proposed by the Extended Optional Infinitive account.

Low perceptual salience of inflectional morphology plausibly interacts with proposed deficits in non-linguistic cognitive systems for children with DLD. Baddeley's (2012) application of the Working Memory Model (Baddeley & Hitch, 1974) suggests that children with DLD experience grammar difficulties due to an issue with phonological short-term memory (PSTM) (Jackson et al., 2016). That is, children cannot temporarily store novel phonological information (such as verbal and nominal inflection) to ultimately create long-term phonological representations of the information for later retrieval and use in expressive language. Archibald (2017) presented evidence that argues for symbiosis between working memory and long-term storage of linguistic representations and operations required for sentence-processing and word learning. Montgomery et al. (2016) present a working memory-based view to account for sentence comprehension deficits in children with DLD. However, few

studies have linked working memory deficits to expressive morphosyntax skills. Therefore, it is of interest to consider the measurement of such cognitive functions, such as PSTM and working memory, when considering a profile of inflectional morphology for children with DLD. If such a relationship between working memory and expressive morphosyntax does exist, perhaps the perceptual salience of certain morphemes may then explain an advantage to learning.

A body of work has indicated that acquisition of the plural *–s* morpheme is driven by perceptual salience in typical development, with segmental allomorphs [s] and [z] perceived earlier than the syllabic [ez] allomorph in early childhood (Davies et al., 2017, 2020). Perhaps salience driving the order of acquisition of *–s* allomorphs ([s], [z], [əz]) for the respective morphemes (plural *-s, 's*, *3s*) is also applicable to morphological development in children with DLD. Notably, plural *–s* has been considered a relatively spared feature in the grammar of children with DLD (e.g., Crystal et al., 1989). Given plural *–s* shares the same phonological surface form as the markedly affected *3s* morpheme, this somewhat undermines the simple view of processing deficits. However, it has been argued that the effect of utterance position on perceptual salience accounts for this finding, as *3s* usually occurs in utterance medial position, leading to shorter durations (Leonard et al. 1997). The argument for perceptual salience for both surface processing and working memory theories would suggest that there should be an advantage to learning morphemes that are perceptually more salient, such as the syllabic [əd] *–ed* allomorph, as in *tast**ed*** (Leonard et al., 1997). However, it appears that even for TD children acquiring *-ed,* allomorph [əd] is latest to develop.

A recent body of work has demonstrated an effect of syllabicity across the production of verbal (*-ed, 3s*) and nominal (*'s*) inflection for preschool children with DLD as well as TD children. Thirty children with DLD aged 4;6 to 5;11 years were

tested on expressive measures of morphosyntax and produced syllabic morphemes (i.e., [əd] and [əz]) with significantly lower accuracy than segmental morphemes (i.e., [d], [t] and [z], [s]) suggesting a robust effect of syllabicity across all inflectional categories (Tomas et al., 2015).The effect of syllabicity on the production of morphological inflection in children with DLD was further supported in a comparison study of 13 five-year-olds with DLD and 19 TD age-matched controls (Tomas et al., 2017). Both groups showed more difficulty producing syllabic allomorphs than segmental allomorphs for novel verbal inflection, with poorer performance in the DLD group overall (Tomas et al., 2017).

The effect of syllabicity across morphological categories suggests that even for TD children, the pattern of development of inflectional morphology cannot be solely accounted for by linguistic theories suggesting a general delay in morphosyntactic acquisition in children with DLD (e.g., Rice & Wexler, 1996). Further, the later acquisition of the syllabic [əd] allomorph challenges the notion of processing theories and associated perceptual salience effects for *-ed*. That is, processing theories would suggest the perceptual salience of an added syllable should aid morphological acquisition for children with DLD.

Domain-general theories

Domain-general theories suggest difficulties with morphological inflections in children with DLD may be explained by a deficit in the ability to implicitly detect statistical regularities in their ambient linguistic environment (Plante & Gomez, 2018; Ullman & Pierpoint, 2005). There is evidence to suggest that the probabilistic nature of grammar is better suited to implicit learning (Evans et al., 2009), and that grammatical abilities are correlated with implicit learning in TD children (Lum et al., 2012). Therefore, the difficulties in DLD may arise in the learning and use of rule-governed computations of

morphological sequencing (e.g., *walk* → *walk**ed***; *walk* → *walk**s***; *boy* → *boy**'s***), likely to be influenced by morphophonological effects, such as phonological complexity and lower relative frequencies of lexical items and specific allomorphs occurring through language input.

Statistical learning principles place emphasis on combinatorial characteristics of particular morphemes in morphosyntactic sequences (e.g., von Koss Torkildsen et al., 2013), suggesting more complex sequences are more difficult to learn. Several studies have evaluated the effects of phonological complexity on performance of inflectional morphology for children with and without DLD. For example, *3s* inflections with consonant + s coda (e.g., *nee**ds***) are more phonologically complex than those with a singleton -s coda (e.g., *see**s***) and this seems to affect production by TD 2-year-olds (Song et al., 2009); however, phonological complexity does not appear to affect their production of possessive *'s* morphemes (Mealings & Demuth, 2014). Importantly, these data are not currently available for children with DLD.

In relation to *–ed* inflection, inflected forms without monomorphemic counterparts (e.g., voiced obstruent + /d/: *ro**bbed***, *hu**gged***, *ju**dged***), are produced with lower accuracy by children with DLD compared to TD children (Marshall & van der Lely, 2006). Segmental *–ed* allomorphs inflected as consonant + [d]/[t] codas (e.g., *squee**zed***, *ho**pped***, *jum**ped***) are also produced with lower accuracy than the less phonologically complex singleton + [d]/[t] codas (e.g., *cr**ied***, *st**irred***, *pl**ayed***) (Oetting & Horohov, 1999; Tomas et al., 2015). Notably, many previous analyses appear not to acknowledge the effect of syllabic allomorphs on phonological complexity. For example, Owen Van Horne and Green-Fager (2015) found words ending in obstruents and alveolars were less likely to be produced accurately by both children with and without DLD; however, words that facilitated [ed] marking (e.g., *wai**ted***) were not considered independently

from other alveolar items (e.g., *kissed*). Therefore, it is not clear whether phonological complexity can explain the effect of syllabicity observed in the development of inflectional morphology in children with and without DLD.

Domain-general accounts suggest morphosyntactic deficits in DLD may reflect a failure to identify statistical patterns through linguistic input resulting in difficulty in the ability to discern the difference between grammatical and ungrammatical rules (Leonard & Deevy, 2017). This may explain the partial learning of *–ed* inflection, where verbs with segmental allomorphs are learned correctly (e.g., *kissed*, *played*), but uninflected forms that would otherwise require syllabic allomorphs (e.g., *taste*, *add*) are incorrectly interpreted as correct in the same morphosyntactic contexts.

To further investigate the effect of syllabicity across categories of inflectional morphology, Tomas et al. (2015) reported on a corpus analysis which indicated across *–ed*, *3s*, and *'s* morphemes, syllabic allomorphs occurred with lower frequency compared to segmental allomorphs, suggesting frequency effects may explain lower accuracy in production of syllabic allomorphs. For children with DLD, it has been suggested that difficulties producing *3s* compared to plural *–s* are due to the higher relative frequency of lexical items marked for nominal inflection, especially in utterance final position (Leonard, 1989; Leonard & Bortolini, 1998). In relation to *–ed* inflection, children with DLD appear to produce low frequency verbs with lower accuracy than high frequency verbs; however, this frequency effect was not observed with TD children (Ullman & van der Lely, 2001). Owen Van Horne and Green-Fager (2015) suggest lexical frequency, phonological complexity, and lexical aspect all influence *–ed* acquisition in both DLD and TD populations. Specifically, for both TD children and children with DLD, verbs that are frequently marked for *–ed* (e.g., *played*), phonologically simple (e.g., *cried*), and highly telic (e.g., *closed*) are likely to be produced with greater

accuracy than verbs that are infrequently marked for *–ed* (e.g., *fish**ed***), phonologically complex (e.g., *jump**ed***), and atelic (e.g., *walk**ed***).

Summary

Overall, it appears many factors may influence or explain the inflectional morphology difficulties of children with DLD. Most research has focussed on finiteness marking as a primary area of deficit, whereas other categories of inflectional morphology, such as possessive *'s* nominal inflection remain relatively unexplored (Leonard, 2019). Recent evidence indicates that there are widespread effects of syllabicity across categories of inflectional morphology. This has implications for processing accounts in which perceptual salience is a driving factor for explaining inflectional morphology development in children with DLD. Many studies have identified frequency effects, which may indicate the delay in acquisition of syllabic allomorphs for both TD children and children with DLD may be the result of infrequent exposure to items within their ambient linguistic environment.

Morphological inflection and intervention effectiveness for children with DLD

Results from intervention studies add value to theoretical accounts of DLD and inform which treatment targets should be prioritised. For example, studies of *–ed* intervention suggest targeting verbs that are frequently marked for *–ed* as determined by corpus analysis appears to provide an advantage to production accuracy (Marchman et al., 1999; Oetting & Horohov, 1997). Conversely, results from a recent randomised control trial suggest that targeting low frequency, phonologically complex, and atelic verbs results in more rapid and generalised intervention effects when compared to targeting high frequency, phonologically simple, and telic verbs (Owen van Horne et al., 2017).

There appears to be very little generalisation following intervention to grammatical categories which are untreated, yet linguistically similar (Eidsvåg et al., 2019; Leonard

et al., 2004). For example, in a series of intervention studies where *–ed* was targeted, there appeared to be little transference to *3s* as a related morphosyntactic structure despite *3s* structures being used to prime production of *-ed*, e.g., *The frog flips. What did it do?* (Calder et al., 2020, 2021). This suggests increased input may be insufficient to improve outcomes, and intervention must be highly targeted to optimise effectiveness.

Finally, nominal inflection is relatively unexplored in intervention research. In Ebbels' (2014) review of the literature, only two included studies specifically targeted nominal inflection (Smith-Lock et al., 2013a, 2013b). Interestingly, in an intervention study where *-ed*, *3s* and *'s* were targeted, Smith-Lock et al. (2015) found that inflectional category did not moderate intervention outcomes. That is, one way to mark inflection is not harder to learn with intervention than another. As such, further research is needed to determine which morphosyntactic targets should be prioritised through interventions.

Research questions

Since predictions of theories and empirical findings are equivocal regarding the predicted morphosyntactic deficits experienced by children with DLD, it is pertinent to develop profiles of inflectional morphology skills. This study draws upon pre-intervention data collected as part of a series of intervention studies to treat morphosyntax difficulties for children with DLD. The research questions were as follows. For children with DLD:

1. Is there a significant difference in accuracy of inflectional production across morphological categories (i.e., *-ed*, *3s*, *'s*)
2. Is there a significant difference in accuracy of inflectional production across allomorphic categories (i.e., syllabic allomorphs: [əd], [əz]; segmental voiced:

[d], [z], and; segmental voiceless: [t], [s])?

In addition, as part of the program of research evaluating the efficacy of a grammar intervention, pre-intervention measures of cognitive functioning, such as phonological short term memory and working memory, were collected. We present two exploratory research questions:

3. Is there a relationship between expressive inflectional morphology and phonological short term memory as measured by performance on a non-word repetition test?
4. Is there a relationship between expressive inflectional morphology and measures of working memory?

Methods and materials

Ethical approval was obtained from the Curtin University Human Research Ethics Committee (Approval number: **HRE2017-0835**) and the Western Australian Department of Education (Approval number: **D190018955)**.

Participants

Data analysed for the current study were collected as part of a programme of research evaluating grammar intervention efficacy. Demographic information is presented in Table 1. Participants were *n* = 30 children diagnosed with DLD (mean age = 75 months, SD = 3.38, range = 69-81 months; 66.67% male, 23.33% female), who all attended a specialised educational programme. Enrolment to the programme requires that children

Table 1. Demographic information and means, standard deviations and ranges of variables of interest.

Demographics and variables	Mean	Standard deviation	Range
Age (months)	75	3.38	69 – 81
Sex	23 Male (76.67%)/7 Female (23.33%)	-	-
SPELT-3	72.43	16.04	40 – 105
GET Total Time 1 (/90)	7.60	6.26	0 – 24
GET Total Time 2 (/90)	9.02	8.08	0 – 28
NRT	73.19	9.47	42 – 94.80
WMTB-C (VSS)	86.20	22.14	55 – 129
WMTB-C (PL)	78.10	12.90	56 – 113
WMTB-C (CE)	78.83	13.09	57 – 105

Notes. GET = Grammar Elicitation Test; NRT= Nonword Repetition Test; SPELT-3 = Structured Photographic Expressive Language Test 3rd Edition; WMTB-C = Working Memory Test Battery for Children; VSS = Visuospatial Sketchpad; PL = Phonological Loop; CE = Central Executive. Standard scores are reported for all standardised assessments

meet criteria for DLD as reported by Bishop et al. (2016), including language skills below that expected given their age based on an extensive assessment process; the absence of other biomedical and developmental disorders, such as autism spectrum disorder or intellectual disability, and; no history of hearing loss. Therefore, participants met diagnostic criteria for DLD prior to study recruitment.

Participants were recruited on the basis of inclusion in an intervention study targeting expressive morphosyntax. Therefore, this sample may not be entirely representative of the DLD population at large. This is considered a limitation. Notably, although participants were in receipt of specialised classroom support, no participant had or was receiving targeted intervention for morphosyntax prior to involvement in the studies.

Measures

Baseline measures included a hearing screen, testing acuity at 20 dB HL for each ear at 500, 1000, 2000, and 4000 Hz for each ear. The Phonological Probe from the Test of Early Grammatical Impairment (Rice & Wexler, 2001) was administered to ensure each participant could articulate the phonemes necessary to produce inflectional morphology markers.

Mean scores of relevant dependent variables are presented in Table 1. Overall, there was considerable variability in scores across all measures for the current sample, which was not unexpected given the heterogeneity of presentation of skills in the DLD population (Bishop et al., 2016). The Structured Photographic Expressive Language Test 3rd Edition (SPELT-3) (Dawson et al. 2003) was administered as a standardised expressive grammar measure. The test was normed on 1580 children aged four to 10 years and measures expressive morphosyntax using 54 items across a range of structures. Test-retest reliability is strong (0.94), and construct validity is appropriate.

The discriminant validity of the SPELT-3 was evaluated by Perona et al. (2005), where at 90% sensitivity and 100% specificity, a scaled cutoff score of 95 (i.e., -0.33 standard deviation below the mean) is recommended to identify language disorder. The mean scaled score on the SPELT-3 indicate the participants presented with expressive grammar difficulties. Of the 30 participants, three scored above the 95 cut-off; however, these participants were included in the study on the basis of an existing DLD diagnosis, and evidence that they demonstrated difficulty with expressive morphosyntax (as measured on the Grammar Elicitation Test detailed below), which is shown to be a reliable indicator of DLD (Redmond et al., 2019).

Expressive morphosyntax

The Grammar Elicitation Test (GET) was administered to measure expressive inflectional morphology skills. The criterion-referenced assessment is reported in detail by (Smith-Lock et al., 2013a), and was designed to identify areas of difficulty and measure change following intervention. The past tense (*-ed*), third person singular (*3s*), and possessive 's (*'s*) subtests of the GET were administered. Each subtest includes 30 items, totalling 90. Within each morphological category, all possible allomorphs are distributed equally. That is, for the *–ed* subtest, there are 10 items for the voiced [d] allomorph (as in *crawl**ed***), 10 for the voiceless [t] allomorph (as is in *lick**ed***), and 10 for the syllabic [əd] allomorph (as in *land**ed***). For the *3s* subtest, there are 10 items for each of the voiced [z] (as in *smil**es***), the voiceless [s] (as is in *skip**s***), and the syllabic [əz] allomorph (as in *kiss**es***). Finally, for the *'s* subtest, there are 10 items for each of the voiced [z] (as in *dog'**s***), the voiceless [s] (as is in *sheep'**s***), and the syllabic [əz] allomorph (as in *horse'**s***). The test was administered at initial assessment, and immediately prior to intervention following a baseline phase of five weeks. The second testing point was included in this study to evaluate test-retest reliability of the GET.

Dichotomous scoring was used, where participants' responses were scored as 'correct' if they produced the appropriate allomorph for the target, whereas omissions and overgeneralisations were scored as 'incorrect'.

Validity and reliability of the GET. Given the experimental nature of the test, we report on analyses of the validity and reliability of the GET as a measure of expressive inflectional morphology. Concurrent validity was assessed using a bivariate Pearson's (r) product-movement correlation. The relationship between the GET and raw scores on the SPELT-3 was positive and strong, $r(30) = 0.61$, $p < 0.001$, with 37.7% of the variability in the participants' GET scores accounted for by variability in their SPELT-3 scores.

Cronbach's alpha assessing the internal consistency of the GET across the morphosyntax structures (*-ed*, *3s,* and *'s*), was 0.70, which is considered acceptable. Further calculations assessed the internal consistency of allomorphs within the structures. Cronbach's alpha for allomorphs within the *–ed* structure ([d], [t], [əd]) was 0.69, indicating borderline acceptable consistency. The mean score of [əd] production was lower than that of [d] and [t]. For *3s*, Cronbach's alpha was 0.84, and for *'s,* 0.83, suggesting good internal consistency amongst allomorphic categories within these structures. The internal consistency of the GET as a measure of expressive morphosyntax was supported.

To assess the test-retest reliability of the GET, a Pearson's *r* was calculated using the scores from the two pre-intervention testing points. Data from $n = 6$ participants were excluded from this analysis as they had baselines of differing lengths compared to the remaining $n = 24$ (Calder et al., 2020). The bivariate correlation between two testing points that was positive and strong, $r(24) = 0.66$, $p < 0.001$. r^2 indicated 43.6% of the variability in participants' scores at the second testing point was accounted for

variability at the initial testing point.

Memory measures

Phonological short term memory. The Nonword Repetition Task (NRT) (Dollaghan & Campbell, 1998) requires participants to repeat 16 nonwords with four items of each syllable length, ranging from one to four syllables. The nonwords were recorded prior to administration and delivered via laptop to ensure consistency of the verbal stimuli. Responses were audio recorded and scored for total phonemes correct and percentage phonemes correct (PPC) as per guidelines outlined by Dollaghan and Campbell (1998).

Working memory. Three subtests of the Working Memory Test Battery for Children (WMTB-C) (Pickering & Gathercole, 2001) were administered. The Block Recall subtest was used to measure participants' visuo-spatial sketchpad (VSS). This subtest uses a corsi-block test where the administrator points to a series of blocks in sequences that gradually increase, and the participant then points to the series in turn. The Digit Recall subtest requires participants to repeat strings of digits which increase in length, to measure participants' phonological loop (PL). The Backward Digits Recall subtest was used to measure the participants' central executive (CE), requiring participants to repeat a string of digits back to the administrator in reverse order which also increases in length. It is thought that the VSS, PL and CE contribute to the working memory system as separate components within the one cognitive system (see Baddeley, 2012).

Results

Research questions: 1. Is there a significant difference in accuracy of inflectional production across morphological categories, 2. Is there a significant difference in inflectional production across allomorphic categories?

The mean correct production of each allomorph within each category of morphological inflection is presented in Figure 1. Visual inspection suggests that syllabic allomorphs

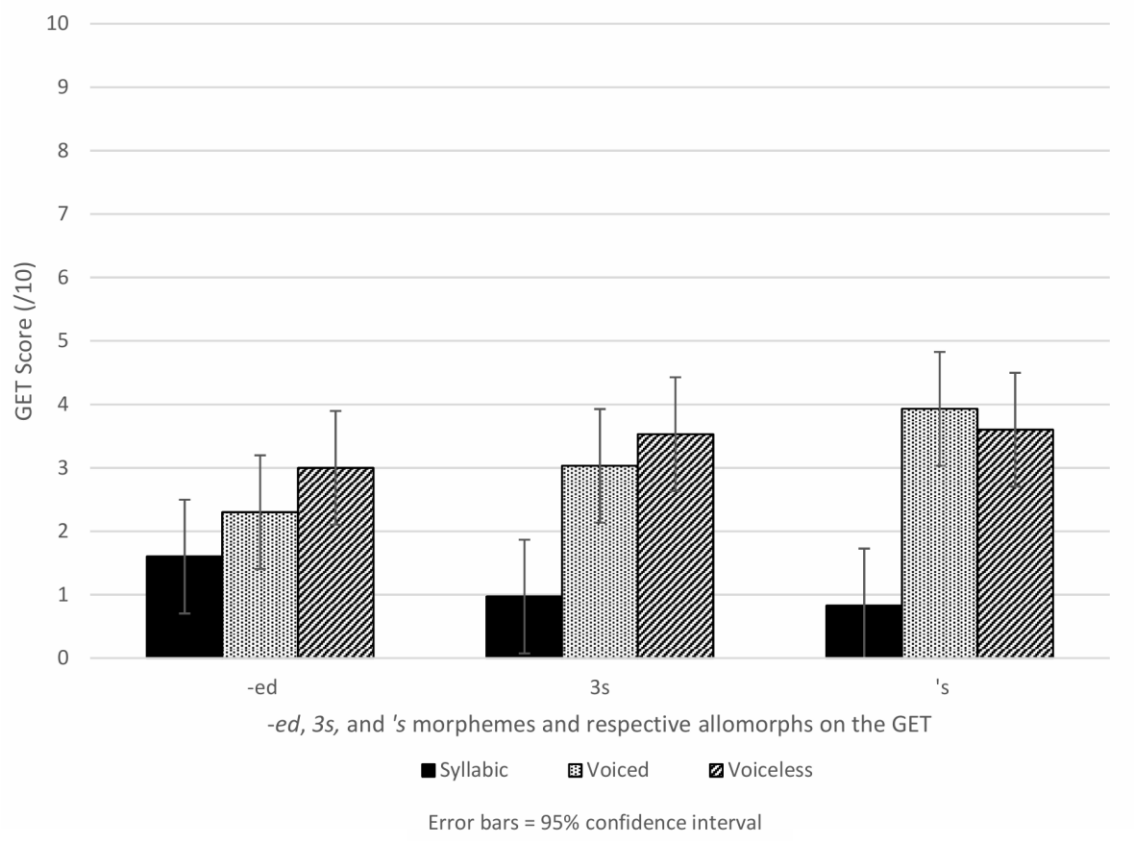

Figure 1. Mean items correct on the GET past tense (*-ed*), third person (*3s*) and possessive (*'s*) subtests across the three allomorphs within each inflectional category.

were produced with lower accuracy across the three categories. A 3x3 factorial analysis of variance (ANOVA) was used to test for differences in production of inflectional morphology across 30 children at initial assessment (GET Total Time 1). Responses were grouped into morphemic categories (*-ed*, *3s*, *'s*) and allomorphic categories within morphemic categories (syllabic [əd], segmental voiced [d], and voiceless [t] for *–ed*; syllabic [əz], segmental voiced [z] and voiceless [s] for *3s* and *'s*). All necessary post hoc pairwise comparisons included Bonferroni adjustments for α-values.

The main effect of morpheme was non-significant, $F(2, 261) = 0.870$, $p = 0.420$, $\eta^2 = 0.007$, indicating no differences in the mean production between *–ed*, *3s*, or *'s* (see Figure 1). There was a main effect for allomorphic categories, $F(2, 261) = 21.56$, $p <$

0.001, η^2 = 0.142, where pairwise comparisons revealed syllabic allomorphs (*M* = 1.13, *SD* = 1.81) were produced with less accuracy than voiced (*M* = 3.09, *SD* = 2.73) and voiceless (*M* = 3.38, *SD* = 2.86) segmental allomorphs (all *p*s < 0.001, *d*s < 0.80). There was no significant difference between voiced and voiceless segmental allomorphs (*p* = 1.0, *d* = 0.10). The interaction between morphemic category and allomorphic category was not significant, $F(2, 261) = 1.844$, $p = 0.121$, $\eta^2 = 0.027$.

Lexical frequency analysis

Given there was no effect of morpheme, but a main effect of allomorph, we were interested in exploring whether lexical frequency of items on the GET may explain this effect. Using the free-to-access online SUBTLEX corpus (hiip://www lexique org/shiny/openlexicon/), we determined the lexical frequency of individual *–ed* and *3s* items (as marked for inflection) using the Lg10CD value for each item (Brysbaert & New, 2009) (see Figure 2). Frequencies could not be determined for *'s* items, as the corpus search function is not sensitive to punctuation. A 2x3 factorial ANOVA was used to test differences in lexical frequency between verbal morphemes and allomorphs. Items were grouped into morphemic categories (*-ed*, *3s*) allomorphic categories within morphemic categories (syllabic [əd], segmental voiced [d], and voiceless [t] for *–ed*; syllabic [əz], segmental voiced [z] and voiceless [s] for *3s*).

The main effect of morpheme was non-significant, $F(1, 54) = 0.595$, $p = 0.444$, $\eta^2 = 0.011$, indicating no differences in the mean lexical frequency of *–ed* versus *3s*. The main effect of allomorph was also non-significant, $F(2, 53) = 2.111$, $p = 0.131$, $\eta^2 = 0.073$. However, there was a significant interaction between morpheme and allomorph, $F(2, 54) = 12.330$, $p < 0.001$, $\eta^2 = 0.313$.

To further explore the interaction, separate one-way between groups ANOVAs were run for both *–ed* and *3s* morphemes to compare mean frequencies of allomorphs within

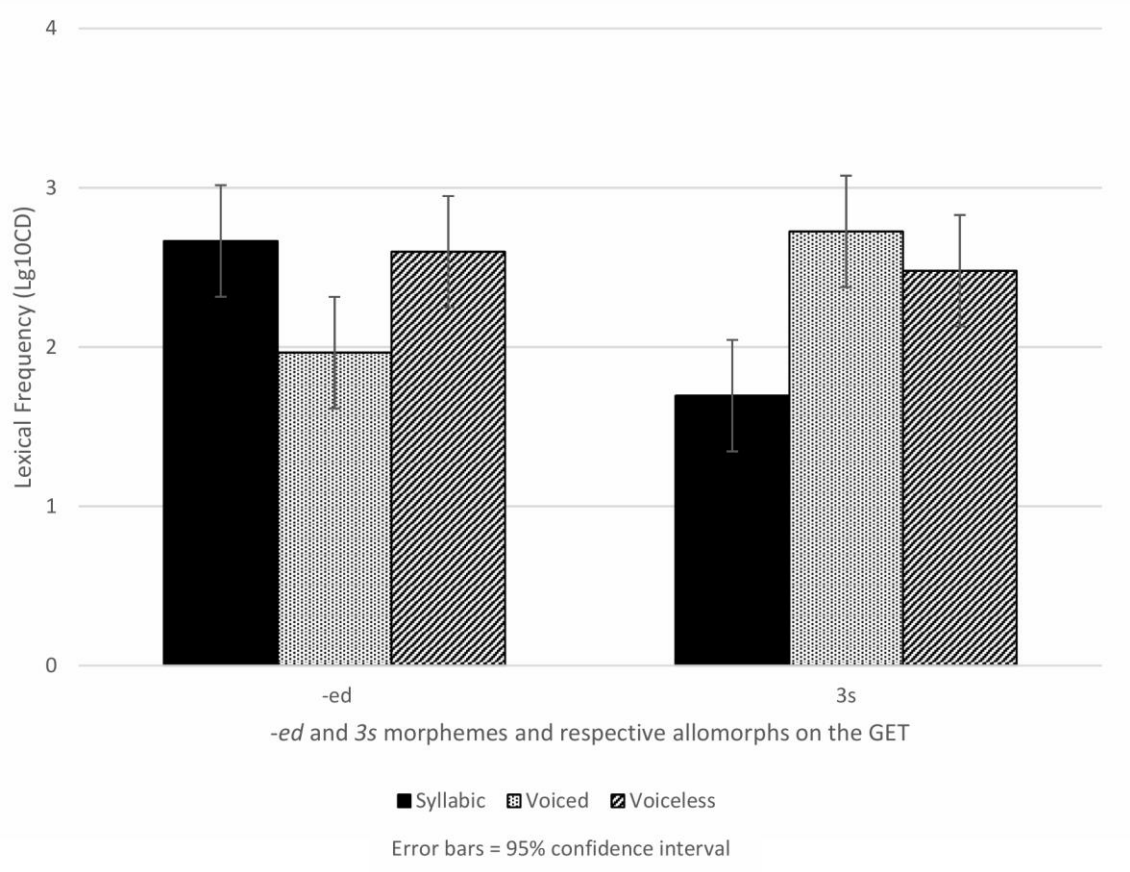

Figure 2. Mean lexical frequency of the items on GET past tense (*-ed*) and third person (*3s*) subtests across the three allomorphs within each inflectional category.

each morphological category. The *–ed* ANOVA revealed a significant effect of allomorph on lexical frequency, $F(2, 29) = 5.380$, $p = 0.011$. Post hoc tests indicated that syllabic [əd] allomorphs ($M = 2.67$, $SD = 0.40$) had significantly higher lexical frequency than voiced segmental [d] allomorphs ($M = 1.97$, $SD = 0.52$), $p = 0.016$, $d = 1.51$. All other comparisons were non-significant.

The effect of allomorph was also significant for *3s*, $F(2, 29) = 8.767$, $p = 0.001$. Post hoc tests indicated that syllabic [əz] allomorphs ($M = 1.70$, $SD = 0.75$) had significantly lower lexical frequency than voiced [z] ($M = 2.73$, $SD = 0.51$), $p = 0.001$, $d = 1.61$, and voiceless [s] ($M = 2.48$, $SD = 0.41$), $p = 0.014$, $d = 1.29$, segmental allomorphs. There was no significant difference between voiced and voiceless segmental allomorphs.

Exploratory research questions

Research questions 3 and 4: Is there a relationship between expressive inflectional morphology and phonological short term memory as measured with a non-word repetition test, and/or working memory?

A total of four bivariate correlations were run to explore the relationship between inflectional morphology and measures of memory. Since the GET showed overall acceptable/good internal consistency, the GET Total score (i.e., *-ed*, *3s* and *'s* combined) was considered an appropriate overall measure of inflectional morphosyntax to explore potential relationships. Correlations between the GET Total score, and NRT (r = 0.19) and WMTB-C CE (r = -0.06), PL (r = 0.23) and VSS (r = 0.01) raw scores were non-significant.

Discussion

Children with DLD show broad deficits in their ability to mark inflection, especially finite verbs. However, whether other aspects of inflectional morphology, such as possessive *'s* nominal marking, are also implicated for children with DLD remains relatively unexplored. Broader deficits in inflectional morphology marking beyond finiteness marking have implications for existing theories explaining DLD and identifying targets to prioritise through intervention.

In this study, we found no significant differences in performance between production of *–ed*, *3s*, or *'s*. This suggests that, prior to intervention, these inflectional morphemes may be equally affected in early school-age (69 – 81 months) children with DLD. This finding somewhat challenges the notion that children with DLD are characterised by a period of protracted use of morphological non-finiteness compared to TD peers (Tomas et al., 2017). Alternative theories suggest morphemes may/may not be perceived adequately depending on their phonetic properties due to a processing deficit

(e.g., Leonard et al., 2003). Similar to findings of TD children (Davies et al., 2017), processing theories suggest perceptual salience of morphemes drives learning for children with DLD. This could also be considered in the context of exploring the relationship between PSTM and working memory, and expressive morphology. However, in the current sample of children with DLD, there was no apparent advantage to learning the more perceptually salient syllabic [əd] allomorph for *–ed*, (indeed we found a disadvantage). Further, there were no relationships between PSTM and working memory, and expressive morphology. Therefore, although working memory appears to play a role in word learning, sentence-processing and sentence comprehension deficits in children with DLD (Archibald, 2017; Montgomery et al., 2016), we did not find evidence of such an effect for expressive morphosyntax.

The concept of phonological complexity suggests segmental allomorphs, especially those preceded with obstruent codas (e.g., Marshall & van der Lely, 2006) are more difficult to produce than phonologically simple allomorphs. However, many previous analyses did not account for syllabic allomorphs. Although overall production across allomorphs was low for participants in the current study, there was a clear effect of syllabicity. This may be explained by the low frequency of syllabic allomorphs compared to segmental allomorphs that occur in children's linguistic input (Tomas et al., 2015).

To explore this observation in more detail, we determined the lexical frequency of GET items targeting verbal inflection using the SUBTLEX corpus. Results for *3s* mirrored findings from Tomas et al. (2015), suggesting that the effect of syllabicity may be accounted for by the relative lower frequency of *3s* verbs marked with the [əz] allomorph. Interestingly, however, *-ed* items marked with the syllabic [əd] allomorph were more frequent than items marked with voiced segmental allomorphs, yet these

items were produced in error significantly more than the segmental allomorphs by the children with DLD. Perhaps then, frequency effects are a more relevant estimate of linguistic input, as for TD children (Davies et al., 2017). Further, accurate production of allomorphy seems to be dependent on the morphophonological properties of the lexical item (i.e., syllabic allomorphs are produced with lower accuracy) rather than the morphosyntatic function of the lexical item (i.e., there are no differences between verbal and nominal inflection). And although items for syllabic –ed allomorphs had higher overall frequency compared to items for syllabic 3s allomorphs, syllabic allomorphs for both –ed and 3s are less frequent than the respective segmental allomorphs (Tomas et al., 2015). This may then provide evidence of a difficulty in the children's ability to detect inflectional allomorphs (especially syllabic allomorphs) as meaningful units of information. This aligns with domain-general accounts of DLD (Plante & Gomez, 2018; Ullman & Pierpont, 2005), which suggest a difficulty implicitly detecting statistical regularities in the ambient linguistic environment.

For the current sample, the effect of syllabicity was greater than that of inflectional category. This finding mirrors important contributions to the evidence-base (Tomas et al., 2015, 2017) with a different group of children with DLD using different methodology, further challenging theories explaining DLD as simply a delay in development of inflectional morphology. Given the generally low performance across measures of morphosyntax, the effect of syllabicity may be characterised by a complex interplay between morphology, allomorphy, and frequency.

Morphological inflection and intervention effectiveness in children with DLD

It is well established that intervention treating morphosyntax must be highly targeted, and generalisation across inflectional class is not typically observed (Calder et al., 2020, 2021; Eisdvåg et al., 2019; Leonard et al., 2004). However, recent intervention studies

targeting *–ed* marking have demonstrated explicit rule instruction using metalinguistic training and visual support results in generalised improvement to non-taught lexical items within the same inflectional class (Calder et al., 2020, 2021). This may suggest that children with DLD may not learn how to correctly apply inflectional morphemes (especially syllabic allomorphs) through exposure alone, but explicit intervention helps activate rule awareness (e.g., verbs ending in alveolar obstruents are marked with [əd] for *–ed*), and then subsequent application of the rule.

Further, it has also been observed that the selection of targets from an inflectional class, whether verbal or nominal, may have little effect on treatment outcomes. That is, the type of intervention, not the target, may influence outcomes when treating inflectional morphology (e.g., Smith-Lock et al., 2015). Findings from the current study indicate no differences in pre-intervention performance on measures of *-ed*, *3s* or *'s*, which is similar to existing studies (e.g., Tomas et al., 2015). So, if lexical items occuring with lower frequency in terms of morphophonology are less likely to be learned through ambient linguistic environments, they should perhaps be considered priorities for intervention targets.

Findings also highlight a gap in the literature exploring interventions to target *'s* inflection for children with DLD (Ebbels, 2014). Given the recent demonstrated efficacy of an explicit approach to treat *–ed* production (Calder et al., 2020, 2021), and the benefit of selecting of complex verbs (Owen Van Horne et al., 2017), perhaps these principles could be applied to interventions to improve *'s* for children with DLD.

Limitations and future directions

The current sample of children was recruited for intervention studies, so there is risk of ascertainment bias. Future research should profile expressive inflectional morphology skills through random recruitment with large samples (e.g., Redmond et al., 2019).

Further, although the GET was piloted on 30 TD five-year-old children who reached ceiling (reported in Smith-Lock et al., 2013a), there has never been a direct comparison of TD children and children with DLD on GET across a range of ages to determine its discriminant validity. Strong correlations with the SPELT-3 are reassuring, however, a direct comparison of randomly sampled TD and DLD populations on the GET would be truly illustrative of the inflectional morphology profile of these developing populations. Given the current findings challenge pre-established theories of DLD, it may also be pertinent to include measures of nominal plural marking in future studies (cf. Crystal et al., 1989: Leonard et al., 1997) as similar effects of allomorphy and frequency may be uncovered (Davies et al., 2020).

Despite a non-significant interaction between morpheme and allomorph from the statistical analysis, results may still indicate a complex interplay between morphology, allomorphy, and frequency as discussed. Perhaps for higher-frequency segmental allomorphs (Tomas et al., 2015), verbal inflection is indeed more affected for children with DLD than nominal inflection, but this effect was negated by poor performance on the more complex syllabic allomorph items across GET subtests. The interaction could be further investigated using higher powered study with an increased sample size. Nonetheless, findings from the current study contribute to the evidence-base suggesting children with DLD experience broad deficits in inflectional morphology, especially syllabic allomorphs within morphological categories. This shows clearly that nominal, as well as verbal inflectional morphemes, especially those that are syllabic should be considered priorities for intervention research.

Conclusions

For the current sample of children with DLD, production of nominal inflection (i.e., *'s*) appears to be an area of difficulty as well as verbal inflection (i.e.,*-ed, 3s*). Further, there

appeared to be no relationship between expressive inflectional morphology skills, and PSTM and working memory, suggesting processing accounts may not explain difficulties with morphosyntax for all children with DLD. More research is needed to unpack the difficulties with morphosyntax experienced by children with DLD, such as the ability to detect probabilistic regularities in linguistic input. Nonetheless, findings from this study highlight the need to consider nominal inflection as an area of deficit in children with DLD, and to look beyond verbal inflection as a priority for intervention.

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Conflict of Interest Statement

The authors declare there are no relevant conflicts of interest.

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References

Archibald, L. M. D. (2017). Working memory and language learning: A review. *Child Language Teaching and Therapy, 33*(1), 5-17. hiip://dx.doi.org/10.1177/0265659016654206

Baddeley, A. (2012). Working memory: theories, models, and controversies. *Annual Review of Psychology, 63,* 1-29. hiips://doi.org/10.1146/annurev-psych-120710-100422

Baddeley, A. D., & Hitch, G. (1974). Working Memory. In G. H. Bower (Ed.), *Psychology of Learning and Motivation* (Vol. 8, pp. 47-89): Academic Press.

Bishop, D. V. M. (2014). Problems with tense marking in children with specific language impairment: not how but when. *Philosophical Transactions of the Royal Society B: Biological Sciences, 369*(1634). doi:10.1098/rstb.2012.0401

Bishop, D. V. M., Snowling, M. J., Thompson, P. A., & Greenhalgh, T. (2017). Phase 2 of CATALISE: a multinational and multidisciplinary Delphi consensus study of problems with language development: Terminology. *Journal of Child Psychology and Psychiatry*, *58*(10), 1068-1080. hiip://dx.doi.org/10.1111/jcpp.12721

Bishop, D. V. M., Snowling, M. J., Thompson, P. A., Greenhalgh, T., & CATALISE consortium. (2016). CATALISE: A multinational and multidisciplinary delphi consensus study. Identifying language impairments in children. *PLoS ONE, 11*(7), e0158753. hiips://doi.org/10.1371/journal.pone.0158753

Brown, R., (1973). *A First Language: The Early Stages* (Cambridge, MA: Harvard University Press).

Brysbaert, M., & New, B. (2009). Moving beyond Kučera and Francis: A critical evaluation of current word frequency norms and the introduction of a new and

improved word frequency measure for American English. *Behavior Research Methods*, *41*(4), 977-990. hiips://doi.org/10.3758/BRM.41.4.977

Calder, S. D., Claessen, M., Ebbels, S., & Leitão, S. (2021). The efficacy of an explicit intervention approach to improve past tense marking for early school-aged children with Developmental Language Disorder. *Journal of Speech, Language, & Hearing Research, 64*(1), 91-104. hiips://doi.org/10.1044/2020_JSLHR-20-00132

Calder, S. D., Claessen, M., Ebbels, S., & Leitão, S. (2020). Explicit grammar intervention in young school-aged children with developmental language disorder: An efficacy study using single case experimental design. *Language, Speech, & Hearing Services in Schools*, *51*(2), 298-316. hiips://doi.org/10.1044/2019_LSHSS-19-00060

Crystal, D., Fletcher, P., & Garman, M. (1989). *Grammatical Analysis of Language Disability* (2nd ed.). London: Cole and Whurr.

Davies, B., Xu Rattanasone, N., & Demuth, K. (2020). Acquiring the last plural: Morphophonological effects on the comprehension of / əz/. *Language Learning and Development, 16*, 161-179. hiips://doi.org/10.1080/15475441.2020.1717956

Davies, B., Rattanasone, N. X., & Demuth, K. (2017). Two-year-olds' sensitivity to inflectional plural morphology: Allomorphic effects. *Language Learning and Development, 13*(1), 38-53. doi:10.1080/15475441.2016.1219257

Dawson, J. I., Stout, C. E., & Eyer, J. A. (2003). *Structured Photographic Expressive Language Test—Third Edition (SPELT-3).* DeKalb, IL: Janelle Publications.

Dollaghan, C., & Campbell, T. F. (1998). Nonword repetition and child language impairment. *Journal of Speech, Language, & Hearing Research, 41*(5), 1136-1146. hiips://doi.org/10.1044/jslhr.4105.1136

Ebbels, S. (2014). Effectiveness of intervention for grammar in school-aged children with primary language impairments: A review of the evidence. *Child Language Teaching and Therapy, 30*(1), 7-40. hiip://dx.doi.org/10.1177/0265659013512321

Eidsvåg, S. S., Plante, E., Oglivie, T., Privette, C., & Mailend, M. L. (2019). Individual versus small group treatment of morphological errors for children with Developmental Language Disorder. *Language, Speech, & Hearing Services in Schools, 50*(2), 237-252. hiips://doi.org/10.1044/2018_lshss-18-0033

Evans, J. L., Saffran, J. R., & Robe-Torres, K. (2009). Statistical learning in children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 52*(2), 321-335. hiips://doi.org/10.1044/1092-4388(2009/07-0189)

Jackson, E., Leitao, S., & Claessen, M. (2016). The relationship between phonological short-term memory, receptive vocabulary, and fast mapping in children with specific language impairment. *International Journal of Language & Communication Disorders, 51*(1), 61-73. hiips://doi.org/10.1111/1460-6984.12185

Leonard, L. B. (2019). Reciprocal relations between syntax and tense/agreement morphology in children's interpretation of input: A look at children with specific language impairment. *First Language, 39*(1), 96-110. hiips://doi.org/10.1177/0142723717729094

Leonard, L. B. (2014). *Children with Specific Language Impairment*. Cambridge, MA: MIT Press.

Leonard, L. B. (1995). Functional categories in the grammars of children with specific language impairment. *Journal of Speech, Language, & Hearing Research, 38*(6), 1270-1283. hiips://doi.org/10.1044/jshr.3806.1270

Leonard, L. B. (1989). Language learnability and specific language impairment in children. *Applied Psycholinguistics, 10*(2), 179-202. hiip://dx.doi.org/10.1017/S0142716400008511

Leonard, L. B., & Bortolini, U. (1998). Grammatical morphology and the role of weak syllables in the speech of Italian-speaking children with specific language impairment. *Journal of Speech Language and Hearing Research, 41*(6), 1363-1374. hiips://doi.org/10.1044/jslhr.4106.1363

Leonard, L. B., & Deevy, P. (2017). The changing view of input in the treatment of children with grammatical deficits. *American Journal of Speech-Language Pathology, 26*(3), 1030–1041. hiips:// doi.or/10.1044/2017_AJSLP-16-0095

Leonard, L. B., Deevy, P., Miller, C. A., Rauf, L., Charest, M., & Kurtz, R. (2003). Surface forms and grammatical functions: past tense and passive participle use by children with specific language impairment. *Journal of Speech, Language, Hearing Research, 46*(1), 43-55. hiips://doi.org/10.1044/1092-4388(2003/004)

Leonard, L. B., Camarata, S. M., Brown, B., & Camarata, M. N. (2004). Tense and agreement in the speech of children with specific language impairment: patterns of generalization through intervention. *Journal of Speech, Language, & Hearing Research, 47*(6), 1363-1379. hiips://doi.org/10.1044/1092-4388(2004/102)

Leonard, L. B., Deevy, P., Miller, C. A., Rauf, L., Charest, M., & Kurtz, R. (2003). Surface Forms and Grammatical Functions: Past Tense and Passive Participle Use by Children With Specific Language Impairment. *Journal of Speech, Language & Hearing Research*, *46*(1). 43-55. hiips://doi.org/10.1044/1092-4388(2003/004)

Leonard, L. B., Eyer, J. A., Bedore, L. M., & Grela, B. G. (1997). Three accounts of the grammatical morpheme difficulties of English-speaking children with specific language impairment. *Journal of Speech, Language, and Hearing Research, 40*(4), 741-753. hiip://dx.doi.org/10.1044/jslhr.4004.741

Lum, J. A., Conti-Ramsden, G., Page, D., & Ullman, M. T. (2012). Working, declarative and procedural memory in specific language impairment. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior, 48*(9), 1138-1154. hiip://dx.doi.org/10.1016/j.cortex.2011.06.001

Marchman, V. A., Wulfeck, B., & Weismer, S. E. (1999). Morphological productivity in children with normal language and SLI: A study of the English past tense. *Journal of Speech, Language, and Hearing Research, 42*(1), 206-219. hiips://doi.org/10.1044/jslhr.4201.206

Marshall, C. R., & van der Lely, H. K. J. (2006). A challenge to current models of past tense inflection: The impact of phonotactics. *Cognition, 100*(2), 302-320. hiips://doi.org/10.1016/j.cognition.2005.06.001

Mealings, K. T., & Demuth, K. (2014). Cluster reduction and compensatory lengthening in the acquisition of possessive-s. *Journal of Child Language, 41*(3), 690-704. hiips://doi.org/10.1017/S0305000913000093

Montgomery, J. W., Gillam, R. B., & Evans, J. L. (2016). Syntactic versus memory accounts of the sentence comprehension deficits of Specific Language Impairment: looking back, looking ahead. *Journal of Speech, Language, and Hearing Research, 59*(6), 1491-1504. hiip://dx.doi.org/10.1044/2016_JSLHR-L-15-0325

Oetting, J. B., & Horohov, J. E. (1997). Past-tense marking by children with and without specific language impairment. *Journal of Speech, Language, and Hearing Research, 40*(1), 62-74. hiips://doi.org/10.1044/jslhr.4001.62

Owen van Horne, A. J. O., Fey, M., & Curran, M. (2017). Do the hard things first: A randomized controlled trial testing the effects of exemplar selection on generalization following therapy for grammatical morphology. *Journal of Speech Language, & Hearing Research, 60*(9), 2569-2588. hiips://doi.org/10.1044/2017_jslhr-l-17-0001

Owen Van Horne, A. J., & Green Fager, M. (2015). Quantifying the relative contributions of lexical and phonological factors to regular past tense accuracy. *International Journal of Speechlanguage Pathology, 17*(6), 605-616. hiips://doi.org/10.3109/17549507.2015.1034174

Perona, K., Plante, E., & Vance, R. (2005). Diagnostic accuracy of the structured photographic expressive language test: third edition (SPELT-3). *Language, Speech, & Hearing Services the Schools, 36*(2), 103-115. hiips://doi.org/10.1044/0161-1461(2005/010)

Pickering, S., & Gathercole, S. E. (2001). *Working Memory Test Battery for Children (WMTB-C)*: Psychological Corporation.

Plante, E., & Gomez, R. L. (2018). Learning without trying: The clinical relevance of statistical learning. *Language, Speech, & Hearing Services in Schools, 49*(3s), 710-722. hiips://doi.org/10.1044/2018_lshss-stlt1-17-0131

Redmond, S. M., Ash, A. C., Christopulos, T. T., & Pfaff, T. (2019). Diagnostic accuracy of sentence recall and past tense measures for identifying children's language impairments. *Journal of Speech Language, & Hearing Research, 62*(7), 2438-2454. hiips://doi.org/10.1044/2019_jslhr-l-18-0388

Rice, M. L., & Wexler, K. (1996). Toward tense as a clinical marker of specific language impairment in English-speaking children. *Journal of Speech & Hearing Research, 39*(6), 1239-1257. doi:10.1044/jshr.3906.1239

Rice, M. L., Wexler, K., & Hershberger, S. (1998). Tense over time: the longitudinal course of tense acquisition in children with specific language impairment. *Journal of Speech Language, & Hearing Research, 41*(6), 1412-1431. hiips://doi.org/10.1044/jslhr.4106.1412

Rice, M., & Wexler, K. (2001). *Test of Early Grammatical Impairment.* San Antonio, TX: The Psychological Corporation.

Smith-Lock, K. M., Leitao, S., Lambert, L., & Nickels, L. (2013a). Effective intervention for expressive grammar in children with specific language impairment. *International Journal of Language & Communication Disorders, 48*(3), 265-282. hiips://doi.org/10.1111/1460-6984.12003

Smith-Lock, K. M., Leitão, S., Prior, P., & Nickels, L. (2015). The effectiveness of two grammar treatment procedures for children with SLI: A randomized clinical trial. *Language, Speech, & Hearing Services in Schools, 46*(4), 312-324. hiips://doi.org/10.1044/2015_LSHSS-14-0041

Smith-Lock, K., Leitão, S., Lambert, L., Prior, P., Dunn, A., Cronje, J., Newhouse, S., & Nickels, L. (2013b). Daily or weekly? The role of treatment frequency in the effectiveness of grammar treatment for children with specific language impairment. International *Journal of Speech-Language Pathology, 15*(3), 255-267. hiip://dx.doi.org/10.3109/17549507.2013.777851

Song, J. Y., Sundara, M., & Demuth, K. (2009). Phonological constraints on children's production of English third person singular -s. *Journal of Speech Language and Hearing Research, 52*(3), 623-642. doi:10.1044/1092-4388(2008/07-0258)

Tomas, E., Demuth, K., & Petocz, P. (2017). The Role of frequency in learning morphophonological alternations: Implications for children with specific language impairment. *Journal of Speech Language, & Hearing Research, 60*(5), 1316-1329. hiips://doi.org/10.1044/2016_jslhr-l-16-0138

Tomas, E., Demuth, K., Smith-Lock, K. M., & Petocz, P. (2015). Phonological and morphophonological effects on grammatical development in children with specific language impairment. *International Journal of Language & Communication Disorders, 50*(4), 516-528. hiips://doi.org/10.1111/1460-6984.12152

Ullman, M. T., & Pierpont, E. I. (2005). Specific language impairment is not specific to language: the procedural deficit hypothesis. *Cortex, 41*(3), 399-433. hiips://doi.org/10.1016/S0010-9452(08)70276-4

van der Lely, H. K.J., & Ullman, M. T. (2001). Past tense morphology in specifically language impaired and normally developing children. *Language and Cognitive Processes, 16*(2-3), 177–217. hiips://doi.org/10.1080/01690960042000076

von Koss Torkildsen, J., Dailey, N. S., Aguilar, J. M., Gómez, R., & Plante, E. (2013). Exemplar variability facilitates rapid learning of an otherwise unlearnable grammar by individuals with language-based learning disability. *Journal of Speech, Language, and Hearing Research, 56*(2), 618–629. hiips://doi.org/10.1044/1092-4388(2012/11-0125)