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Grammatical treatment and specific language impairment: Neighbourhood density & third person singular –s

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Abstract

The purpose of this study was to test the effect of manipulating verb neighbourhood density in treatment targeting the third person singular lexical affix. Using a single-subject experimental design, 6 pre-schoolers with Specific Language Impairment (SLI) were randomly assigned to one of two conditions: 1) treatment with sparse verbs or 2) treatment with dense verbs in 12 sessions. The third person singular lexical affix was targeted for 12 sessions of treatment in both conditions. Treatment gain and generalization were measured as the dependent variables. Third person singular % correct change from pre-treatment to post-treatment was measured using sentence production tasks with comparisons across the two treatment conditions. Treatment gain and generalization were greater for children enrolled in the sparse condition. Preliminary clinical recommendations are made and theoretical implications are discussed relative to neighbourhood density effects on lexical activation and storage in children with SLI.

Keywords

specific language impairment; language intervention; neighbourhood density; finiteness markers

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Specific Language Impairment (SLI) is a heritable condition characterized by delays in language that are not caused by hearing impairment, neurological impairment, or intellectual disability (Rice, Smith, & Gayán, 2009). Language is late to emerge for children with SLI and global linguistic deficits are henceforth observed (Zubrick, Taylor, Rice, & Slegers, 2007). Most notable are deficits in vocabulary, morphology and syntax that can persist into the teenage years (Nippold, Mansfield, Billow, & Tomblin, 2009; Rice, Hoffman, & Wexler, 2009). Despite the persistent language delay that characterizes SLI, the details of how treatment effectively jumpstarts the slow moving language system are still emerging (Law, Garrett, & Nye, 2004). In this preliminary treatment study, we tested the feasibility of a novel approach to language treatment for preschool children with SLI. We asked whether the phonological characteristics of words used to teach grammatical morphemes might need to be considered when planning treatment. We first describe grammatical finiteness marking as the specific grammatical skill that poses significant difficulty for SLI. We follow this with a brief review of current treatment approaches that have been evaluated for pre-schoolers

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with SLI. Next we discuss neighbourhood density as a relevant word characteristic that affects language development. We then motivate its potential facilitative role in grammatical treatment for young children with SLI.

Grammar deficit in sli

Many aspects of language are difficult for children with SLI, but for English speaking pre-schoolers, within the domain of grammar, finiteness marking is particularly challenging (for a review see Leonard, 1998). Finiteness marking is an obligatory property of main English clauses that relates to the use of tense and subject-verb agreement markers. In English, finiteness is overtly marked by: 1) lexical affixation for third person singular present tense (e.g. she run<u>s</u>) and regular past tense (e.g. she walk<u>ed</u>), 2) morpho-phonological verb stem changes for irregular past tense (e.g. she <u>ran</u>), and 3) non-lexical free standing copula verbs (e.g. she <u>is</u> happy, <u>Is</u> she happy?) or auxiliary verbs (e.g. she <u>is</u> running; <u>does</u> she run?) in statements and questions. For SLI, the emergence and mastery of these finiteness markers is significantly delayed and growth rates are slow compared to typical children. Once finiteness markers have emerged, it is common for children with SLI to continue to omit them from their speech. In fact, in children’s expressive language, omission errors can persist until 8-years while receptive errors may be observed into the teenage years (Rice, Wexler, & Cleave, 1995; Rice et al., 2009). Thus, learning that finiteness markers are obligatory in English is challenging for children with SLI compared to typically developing peers, thereby presenting a clinically significant problem.

SLI treatment studies

The majority of studies addressing grammar treatment for pre-schoolers have focused on identifying effective techniques for presenting the grammatical targets. Techniques found effective for pre-schoolers with SLI include requesting direct imitations of targeted grammatical structures (Connell, 1987; Connell & Stone, 1992) and modelling paired with evoked production and performance-based feedback (e.g. Weismer & Murray-Branch, 1989). Conversational recasting, or imitating a child’s incorrect utterance while correcting errors, has also been shown to facilitate generalization of target grammatical structures to spontaneous speech (e.g. Camarata, Nelson, & Camarata, 1994; Fey, Cleave, Long, & Hughes, 1993; Fey, Cleave, & Long, 1997; Hassink & Leonard, 2010; Proctor-Williams & Fey, 2007). Moreover, implicit instruction appears to be more effective for grammar treatment with pre-schoolers than explicitly stating usage rules for grammatical targets (Swisher, Restrepo, Plante, & Lowell, 1995, but see Finestack & Fey, 2009 for older children). Following the child’s lead and current focus of attention has also been identified as effective for preschool children (Yoder, Molfese, & Gardner, 2011). Finally, treatment targeting expressive language using a combination of the aforementioned techniques facilitates receptive generalization (Camarata, Nelson, Gillum, & Camarata, 2009) and is useful for teaching finiteness markers to preschool children with SLI (Leonard, Camarata, Brown, & Camarata, 2004; Leonard, Camarata, Pawlowska, Brown, & Camarata, 2006)

In the context of treatment research for SLI, one topic that hasn’t been considered is whether the characteristics of the words used to elicit grammatical targets might also influence treatment outcomes. As a starting point for considering this type of approach, we focused on the neighbourhood density for verbs paired with a targeted finiteness marker during treatment. Neighbourhood density is a word form characteristic that relates to the phonological component of a word form as an integrated whole (Storkel, 2009). One common way to measure neighbourhood density is to count the number of words, or ‘neighbours’ created when one sound in any word position (i.e. initial, medial, final) is changed via substitution, addition, or deletion (Luce & Pisoni, 1998). A word, like ‘bat’ that has many neighbours (i.e. 34 total including neighbours like ‘cat’, boat’, ‘bag’) is by definition ‘dense’, whereas words like ‘dog’ that have fewer neighbours (i.e. 7 total including neighbours like ‘log’, ‘dig’, ‘dot’) are considered ‘sparse’.

Neighbourhood density and grammar treatment

Children do not process dense and sparse words similarly. In typical development, the age of acquisition for dense and sparse words differs (Storkel, 2004a; e.g., Storkel, 2009). In addition, accuracy of children’s responses differ for dense and sparse words on tasks measuring word repetition, fast mapping, word recognition, phonological awareness, nonword repetition, and sentence imitation (De Cara & Goswami, 2003; Garlock, Walley, & Metsala, 2001; Hogan, 2010; Hoover, Storkel, & Rice, 2012; Hoover, Storkel, & Hogan, 2010; Munson, Swenson, & Manthei, 2005; Storkel & Lee, 2011). The direction of neighbourhood density effects (i.e. dense vs. sparse advantage) is not consistent across studies because effects appear to be driven by task, development, and/or language abilities of the child (Werker & Curtin, 2005). Nevertheless, neighbourhood density effects on lexical processing are robust in development (Stoel-Gammon, 2011). Given this observation, we hypothesized that neighbourhood density effects could be relevant for grammatical treatment of lexical affixes like the third person singular because expressive use of a lexical affix necessarily involves retrieving and producing a word (e.g. retrieve and produce ‘run’ + ‘affix *s*’ in the third person singular context). Thus, it is possible that words with different neighbourhood density characteristics could prompt differential learning effects in SLI. While this type of treatment manipulation hasn’t been considered for SLI, neighbourhood density effects in treatment are documented for preschool children with phonological delays (Gierut & Morrisette, 2012; Morrisette & Gierut, 2002) further motivating consideration in treatment of other clinical populations.

As a preliminary step in this direction, a single-subject experimental treatment design was used herein to test the hypothesis that verbs differing in neighbourhood density have noticeable and differential effects on grammatical treatment of SLI. Accordingly, we compared treatment gain and generalization for two groups of children with SLI who participated in grammatical treatment of the third person singular finiteness marker (i.e. ‘The woman kicks the ball’). We choose the third person singular finiteness marker as the starting point because growth of this structure is slightly slower relative to the other markers in English, thus ensuring that most preschool children with SLI would have emerging knowledge, but would not have achieved mastery (Ionin & Wexler, 2002; Paradis, Rice, Crago, & Marquis, 2008; Rice, Wexler, & Hershberger, 1998). While holding third person singular constant, we manipulated dense verbs for one treatment group and sparse verbs for the other treatment group. We predicted that the groups would differ in the amount of treatment gain and also, generalization. The results that emerged are intended to serve as first documentation to motivate the clinical selection of verbs based on neighbourhood density for grammatical treatment of lexical affixes in SLI.

Methodology

Participants

Six children with SLI, two girls and four boys, were recruited from the surrounding areas of Lawrence and Kansas City, Kansas to participate. All were monolingual native speakers of Standard American English ranging in age from 4;0 to 5;9 ($M = 4;5$). The presence of SLI was determined by 1) prior identification of language impairment by a speech-language pathologist and 2) expressive grammatical performance below age expectations. The primary inclusionary criterion for entry into the study was optional use of finiteness markers, including the treated third person singular structure. Optional use for finiteness markers in SLI, in the age ranges herein, is defined elsewhere as accuracy between 20% and 80% on production measures (e.g. Hoover et al., 2012; Rice et al., 1998). Using this range as a guideline, we confirmed optional use of third person singular using the Rice/Wexler Test of Early Grammatical Impairment (TEGI: Rice & Wexler, 2001) and spontaneous language samples. According to these measures, all children were optional in their use of finiteness markers, including the treated third person singular structures. Additionally, all children had to demonstrate correct production of word-final /s/ and /z/ in monomorphemic words (e.g. noise, horse) because production is crucial for assessing third person singular marking in English. Mean Length of Utterance (MLU), receptive vocabulary and articulation were left free to vary across the participants. As assessed by parent report, none of the children were concurrently working on the third person singular structure, or any other grammar goal, in treatment that was not associated with the current study. Table 1 summarizes the participant characteristics.

Experimental treatment design

We used a staggered multiple baseline (MBL) across subjects experimental design (for a description of the design see McReynolds & Kearns, 1983). The premise of this design is to assess the effect of a treatment manipulation on a given behaviour. One advantage of the MBL design, over other single subject designs, is that it allows the examiner to assess treatment gains and generalization effects. In the MBL design, experimental control is established when behavioural changes within a participant are observed with the instatement of treatment and when treatment effects are replicated across participants. Treatment effects are considered meaningful when 1) similar patterns are observed across multiple children in the same condition and 2) post-treatment patterns differ from baseline patterns (McReynolds & Kearns, 1983). The MBL design involves a no-treatment baseline phase followed by treatment. McReynolds & Kearns (1983) recommend a minimum of 3 baseline sessions that are incremented as each subsequent child is enrolled in the study. For example, in a study where each condition has three participants, the first participant in a condition completes 3 baseline sessions, the second completes 4 and a third participant would complete 5 sessions. The delay in treatment onset by 1 additional session for each enrolled participant provides the opportunity to assess the range of baseline performance across children. The MBL design, as applied herein, included the following elements: 1) random assignment to a treatment condition, 2) an incremented baseline phase with the first participant receiving 3 sessions and 3) replication of treatment effects across children within a treatment condition. Participant pseudonyms correspond to the child's assigned treatment condition and the number of baseline sessions he/she completed. For example, participant Sparse 3 was assigned to the sparse treatment condition and completed three baseline sessions prior to treatment.

The independent variable and treatment manipulation in the current study was neighbourhood density. The dependent variable was the third person singular % correct change from baseline to post-treatment. The effect of neighbourhood density on third person singular change was assessed by randomly assigning children to one of the two treatment conditions (i.e. sparse or dense), corresponding to the neighbourhood density of the verbs used to elicit the third person singular structure. All children were taught the third person singular structure, but three children received treatment with sparse verbs while three others received treatment with dense verbs.

Stimuli

Treatment stimuli—The treatment stimuli included 12 real English verbs selected on the basis of neighbourhood density. Half the verbs had few neighbours and were assigned to the sparse treatment condition, while the other half had many neighbours and were assigned to the dense treatment condition. Following the procedures of Storkel (2004b), a word-length-sensitive calculation for neighbourhood density was obtained from an online calculator drawing from child corpora (Storkel & Hoover, 2010). The word length-sensitive calculation is used because there is an inherent negative correlation between word length and neighbourhood density such that longer words have fewer neighbours. A median split based on the pool of words available for a given word length was used to dichotomize each word as 'sparse' or 'dense'. Words within a given length with neighbourhood densities above the median were classified as 'dense' and words with neighbourhood densities below the median within a given length were classified as 'sparse'. The number of neighbours for sparse and dense words did not overlap within a given word length. For words that were three phonemes long, the 'Sparse' verbs had a mean of 7 neighbours (Range = 3 – 11) whereas the 'Dense' verbs had a mean of 18 neighbours (Range = 17 – 20). For words that were four phonemes long, 'Sparse' verbs had a mean of 4 neighbours (Range = 3 – 5) and 'Dense' verbs had a mean of 7 neighbours (Range = 6 – 8). Neighbourhood density values were calculated on the bare stem of the verb (e.g. 'run' as opposed to 'runs'). Phonotactic probability, $t(10) = .97$, $p = .456$, and word frequency, $t(10) = -.684$, $p = .522$, values did not differ across sparse and dense conditions. Moreover, syllable structure, verb argument structure, and final allomorph resulting from the third person singular morpheme were balanced across the sparse and dense conditions. The treatment stimuli are shown in Appendix I.

Generalization stimuli—A second set of 30 real verb stimuli (i.e. 15 sparse and 15 dense), also selected on the basis of neighbourhood density, was used to assess generalization. These verbs were never presented in the context of the treatment sessions. Like the treatment verbs described above, a word-length-sensitive calculation of neighbourhood density was obtained for the generalization stimuli by following the same procedures of Storkel (2004b) and using the online calculator drawing upon child corpora (Storkel & Hoover, 2010). Likewise, a median split based on the pool of words available for a given word length was used to dichotomize each word as 'sparse' or 'dense'. For words that were three phonemes long, the 'Sparse' verbs had a mean of 10 neighbours (Range = 5 – 12) whereas the 'Dense' verbs had a mean of 19 neighbours (Range = 14 – 26). For words that were four phonemes long, 'Sparse' verbs had a mean of 4 neighbours (Range = 1 – 5) and 'Dense' verbs had a mean of 10 neighbours (Range = 7 – 12). Phonotactic probability and word frequency values did not differ across the sparse and dense conditions, t values < 1.0, p values > .45. Syllable structure, verb argument structure, and final allomorph resulting from the third person singular morpheme were also balanced across the sparse and dense conditions. The generalization stimuli are shown in Appendix II.

Prior to the first no-treatment baseline session, all children demonstrated receptive knowledge of the treatment and generalization verbs by passing a receptive probe with at least 80% accuracy of picture identification. The probe pictured the target verb alongside a semantic and phonological foil; the child was instructed to point to the target verb. Table 2 reports receptive knowledge of the treatment and generalization verbs for each child. For the treatment verbs, % correct is reported for either sparse or dense verbs, depending on the child's treatment condition assignment. For the generalization verbs, % correct is reported separately for sparse versus dense verbs.

Pre- and post-treatment measures

Using the treatment and generalization stimuli, third person singular % correct was measured at each baseline session and at a post-treatment session to allow for computation of the dependent variable: third person singular % correct change accrued from baseline to post-treatment. The amount of change from baseline to post-treatment was of primary interest as a reflection of the differential effects of verb treatment varied by neighbourhood density effects.

Treatment gain—At each baseline session and at the post-treatment session, third person singular sentences containing the treated dense or treated sparse verbs were elicited via direct imitation and spontaneous elicitation. Sentences containing the treated verb stimuli were presented to assess treatment gain, or the amount of change for third person singular % correct on the verb items presented during the treatment sessions, but in sentence contexts that were never used during the day-to-day treatment sessions. The same test sentence items were used to elicit third person singular via direct imitation and spontaneous elicitation at each baseline session and at the post-treatment session. Productions from each baseline session and post-treatment were scored for accuracy and % correct values were derived. For each child in each condition, change was calculated by subtracting the average third person singular % correct of baseline sessions from the % correct at the post-treatment administration of the third person singular sentences. The amount of change for all three participants per treatment condition was then averaged and compared across conditions using visual analysis.

Generalization—Also at each baseline session and at the post-treatment session, third person singular sentences containing the generalization verbs were elicited via direct imitation and spontaneous elicitation to consider the amount of third person singular change on a set of verbs that were never presented during treatment in sentences that were never used during treatment. The same test sentence items were used to elicit third person singular via direct imitation and spontaneous elicitation at each baseline session and at the post-treatment session. In the same manner as the treated verbs, productions from each baseline session and post-treatment were scored for accuracy and % correct values were derived. The dependent variable, third person singular change, was then calculated by subtracting the average % correct at baseline from % correct at the post-treatment administration of the third person singular sentences. Likewise, the amount of third person singular change with the generalization verbs for all three participants per treatment condition was averaged and compared across conditions using visual analysis.

Reliability—Scoring reliability was calculated for 20% of each child's data used to compute the dependent variables. Two independent judges, blind to the treatment assignment, completed the reliability. Agreement in scoring was 91% (*SD* = 2%) for the dense condition and 91% (*SD* = 5%) for the sparse condition. In the case of disagreements, the original scoring was retained.

Treatment procedures

Treatment sessions were conducted on a fixed-time criterion where each child completed two 30-minute sessions a week for 6 weeks, totalling 12 treatment sessions per child. We used a time-based criterion because this afforded all children the same opportunity for learning. As this study was the first to manipulate neighbourhood density in treatment with SLI, a time-based criterion was thought to be a more conservative and controlled approach compared to alternate performance-driven treatment delivery.

Each treatment session began with the examiner reading a short story with corresponding illustrations that presented either sparse or dense target verbs in a meaningful context based on the child's experimental assignment. Even though the verbs for the sparse and dense stories differed, the same story illustrations were used for both treatment conditions (see Appendix I for a sample). The story presented each verb 4 times with the target structure and twice as a bare verb stem, for a total of 6 verb presentations per story.

After reading the story, the examiner elicited 36 productions of the target structure in a sentence context per session (i.e. 6 productions per verb). Productions were elicited through a combination of direct imitation and spontaneous elicitation. In instances where a child omitted the target structure from their production the examiner did not require the child to re-attempt the structure, rather the utterance was recasted with the target structure and target verb. In all, each child received 72 exposures to the target structure (i.e. 36 through examiner's auditory exposure + 36 through child productions & recasts) per treatment session with 864 cumulative exposures across the 12 sessions. The only way treatment sessions differed across the conditions was the set of six target verbs used in the stories and elicitations for productions. All other materials and procedures were identical. Appendix I shows a sample of the treatment protocol.

The day-to-day treatment data obtained from each child was the 36 elicited productions of the third person singular treatment target described above with either sparse or dense treated words. The productions were used to calculate a third person singular % correct value for each treatment session; these % correct values obtained from treatment are plotted in Appendix III for the sparse condition and Appendix IV for the dense condition. The % correct values obtained from treatment were not factored into the dependent variable because the dependent variable of interest was treatment gain and generalization using the treatment and generalization verbs in untreated sentence contexts.

Results

Results associated with treatment gains are summarized first, followed by generalization. Results from the sparse treatment condition always precede results from the dense treatment condition. In evaluation of the effects of treatment, we compared the effects associated with neighbourhood density in three ways: gains in treatment, global generalization and neighbourhood density generalization.

Treatment gain

The first comparison made across the treatment conditions was treatment gain, or % correct change from baseline to post-treatment for the treated verbs. Here, the sparse treatment emerged as optimal in that children enrolled in this condition showed greater change in treated sparse verbs. For the sparse treatment condition, the average third person singular % correct for treated sparse verbs was 31% (Range: 19% to 45%) at baseline and 76% (Range: 73% to 83%) at post-treatment. This yielded an average change of 46% (Range: 38% to 54%). Positive change was replicated across all children in the sparse condition.

In comparison, all children enrolled in dense treatment demonstrated less change in the treated dense verbs. Specifically, the average third person singular % correct for treated dense verbs was 35% (Range: 19% to 62%) at baseline and 40% (Range: −19% to 90%) at post-treatment, yielding an average change for treated dense verbs of 4% (Range: −19% to 28%). Of the two children demonstrating positive change the amount for one child was small (i.e. 4% change for participant Dense 5). Taken together, children enrolled in sparse treatment made greater gains in accurately marking third person singular on the treated verbs, with positive change replicated across all children.

Generalization

A second consideration in evaluation of treatment effects focused on generalization, which was examined in two ways. In a first evaluation, generalization was taken as a whole without attention to whether the changes that occurred were differentially distinguished for untreated sparse and dense verbs; hereafter this is referred to as global generalization. In a second evaluation, attention was given to neighbourhood density in order to examine whether the treatment manipulation resulted in differential generalization to sparse versus dense verbs; this is termed density generalization.

Global generalization—For the sparse treatment condition, the average third person singular % correct for untreated verbs was 37% (Range: 32% to 44%) at baseline and 60% (Range: 51% to 74%) at post-treatment. This yielded a 23% (Range: 10% to 42%) average change with positive change replicated across all children.

In comparison, for children enrolled in dense treatment, less global generalization was observed. Specifically, the average third person singular % correct for untreated verbs was 35% (Range: 14% to 62%) at baseline and 41% (Range: 25% to 64%) at post-treatment yielding an average change of 6% (Range: 2% to 11%). While positive change was replicated across all children, the average amount observed was less than that of the sparse treatment. Thus, similar to the findings for treatment gain, global generalization data indicated that greater generalization occurred in response to treatment of sparse verbs than treatment of dense verbs. However, it is possible that generalization could have been restricted to one type of verb (i.e. sparse or dense verbs rather than broad generalization across both types). To address this issue we considered density generalization, or generalization to untreated dense verbs separately from generalization to untreated sparse verbs.

Density generalization—Density generalization considered change separately for untreated sparse versus untreated dense verbs. For the sparse treatment condition, generalization to untreated sparse verbs was considered first. Average third person singular % correct was 37% (Range: 29% to 42%) at baseline and 57% (Range: 45% to 72%) at post-treatment yielding a 20% (Range: 3% to 43%) average change. Positive change was replicated across all children, with participant Sparse 3 as a possible exception (i.e. 4% change observed). For untreated dense verbs, the average third person singular % correct was 33% (Range: 26% to 46%) at baseline and 62% (Range: 48% to 76%) at post-treatment yielding an average change of 29% (Range: 16% to 48%) with positive change replicated across all children receiving sparse verb treatment. Taken together, 2 of 3 children who received treatment with sparse verbs demonstrated generalization of accurate use of third person singular to untreated sparse verbs. On the other hand, all 3 children generalized accurate use of third person singular to untreated dense verbs, with positive change replicated across all children. Thus, treatment of sparse verbs induced generalization to sparse and dense verbs for the majority of children.

Minimal density generalization was observed for children enrolled in dense treatment. For their untreated sparse verbs, third person singular % correct was 34% (Range: 13% to 57%) at baseline and 41% (Range: 26% to 60%) at post-treatment, yielding a 6% (Range: 3% to 13%) average change. Positive change was replicated across all children, but the gains were modest with the greatest change being 13%, for child Dense 4. For untreated dense verbs, average third person singular % correct was 36% (Range: 12% to 67%) at baseline and 42% (Range: 23% to 68%) at post-treatment yielding a 6% (Range: 1% to 11%) average change. Positive change was replicated across all children, but the gains were again modest with the greatest change being 11% for child Dense 4. Taken together, positive change was replicated across all children in the consideration of density generalization, but the amount of change was minimal, with the possible exception of child Dense 4. Thus, in general, treatment with dense verbs induced minimal density generalization for the majority of children.

In sum, the results highlight third person singular treatment with sparse verbs as potentially superior to that with dense verbs with patterns of treatment gain mirroring patterns of generalization. While some improvement was noted for children enrolled in dense treatment, the gain was noticeably greater for children enrolled in sparse treatment. Likewise, children enrolled in dense treatment showed minimal to no generalization to untreated verbs compared with children enrolled in sparse treatment.

Discussion

The goal of this study was to test whether neighbourhood density would be relevant to treatment targeting the third person singular lexical affix. The motivation was based on the premise that treatment of lexical affixes involves the lexical act of retrieving and producing the verb to be inflected. We expected neighbourhood density effects to be the by-product of this lexical component with effects documented as differences in treatment gain and generalization between two treatment conditions. The results supported our hypothesis. Children in the sparse treatment condition demonstrated greater treatment gain and generalization than children enrolled in the dense treatment condition.

Clinical implications

The results of this preliminary study might be useful to clinicians targeting the third person singular lexical affix in treatment. Based on the treatment gain and generalization data from this study, one preliminary recommendation might be that clinicians consider selecting sparse verbs for eliciting third person singular productions during treatment. Based on our initial findings, this tactic might be appropriate only if the treatment goal was to effect (1) gains from baseline to post-treatment on the third person singular structure for the words that were taught, or (2) generalization of the treated third person singular finiteness marker to untreated words. Stated alternatively, it might be recommended that clinicians avoid the selection of dense verbs for eliciting third person singular structure, given that children enrolled in this condition demonstrated noticeably less treatment gain and generalization. Given this, caution might be taken to avoid treatment of dense verbs, if the goals are to achieve gains in treatment and/or generalization.

It is important to point out that none of the children in this study achieved mastery of the third person singular structure, rather children made modest changes from baseline third person singular accuracy with those in the sparse condition showing, on average, more positive change than those in the dense condition. It will be important for future studies to replicate the observed effects of verb neighbourhood density using a larger sample of children with SLI, with longer durations of treatment than 12 sessions, and possibly using treatment protocols that employ accuracy rather than time-based criteria. Data from such studies would help to refine and qualify the clinical recommendations about the utility of neighbourhood density in treatment of SLI. The data might further shed light on the interface between treatment procedures and treatment stimuli, and could also inform the range of individual differences in learning.

Theoretical implications

Beyond the clinical implications, the present results have theoretical implications. While neighbourhood density has been shown influential for phonological treatment (Gierut & Morrisette, 2012; Morrisette & Gierut, 2002), this study provides a first look at its effects for grammar treatment with possible insights of an explanatory nature. We consider two testable accounts and consider the potential theoretical implications these accounts may have for SLI.

Lexical activation—Consider that simply thinking about or hearing a word is thought to activate other words in a listener’s lexicon (Storkel & Morrisette, 2002). In this study, a set of target words (albeit dense or sparse) was repeatedly presented across treatment sessions. Words were always introduced in the context of a meaningful story, and all third person singular production trials were directly tied to events from that story. If models of neighbourhood activation (e.g. Luce & Pisoni, 1998) are correct, this repetition of words likely activated other related words in the child's lexicon during treatment. Perhaps it is through this process of lexical activation that the opportunity for neighbourhood density to affect lexical affixation was borne out.

Consideration of why the sparse treatment condition emerged as optimal may also lend insight into neighbourhood density effects on grammar. There are at least two word-learning studies that are relevant to this question. In one novel word learning study, Storkel and Lee (2011) found that sparse words triggered learning in typically developing pre-schoolers. They attributed this result to the idea that hearing a sparse word activates few other words in the lexicon. Activation of a few words in sparse neighbourhood presumably speeds the process of detecting a mismatch between novel and known words, as opposed to activation of many competing within the alternate dense neighbourhood. This apparent difference in activation has thus been said to contribute to learning differences between dense and sparse words in development.

A similar argument was outlined in a second developmental word learning study. McKean, Letts and Howard (2013) again found advantages for learning sparse words, but their focus was on the phonological distinctiveness of sparse words. They supposed that dense words, with many phonologically similar neighbours, limit a child's processing capacity. The reason is that dense words are presumably represented with a finer grained level of segmental detail. Consequently, detecting a novel from known dense word in word learning likewise requires a finer grained level of analysis and differentiation. Similar accounts have been advanced by Morrisette and Gierut (2002) in treatment of phonological disorders.

The relevance to our findings is that the phonological distinctiveness of sparse words coupled with activation of rather few words for retrieval might dually converge to thereby reduce the processing load needed to produce lexical affixes. Thus children enrolled in the sparse condition of treatment may have been afforded processing advantages to facilitate production and generalization of the third person singular lexical affix. By comparison, the dense treatment condition may have been more resource demanding, rendering children's use of lexical affixes more vulnerable to error. The effects of potentially resource demanding dense words can be observed by comparing the trend lines slopes of the two treatment conditions in Appendix III and IV. Here it can be seen in the trend line slopes of the treatment data that all three sparse participants had positive slopes greater than .20 (see Appendix III), whereas all three dense participants had smaller positive, or flat, slopes less than .11 (See Appendix IV). This difference in slopes supports the hypothesis that resource demanding dense words limit correct third person singular productions while sparse words facilitate correct productions. It is well established in the larger literature that resource-demanding conditions, like dense treatment, can be particularly challenging for children with SLI (e.g. Leonard et al., 2007; Miller, Kail, Leonard, & Tomblin, 2001).

Lexical storage—It is possible that there is another explanation for the sparse condition as optimal. Specifically, sparse words may be more amenable to grammatical changes as a consequence of how they are stored in a child's lexicon. Corpus analyses, for example, show that dense words are earlier acquired (e.g. Storkel, 2004a). As a consequence of earlier entry into the lexicon, the phonological form of dense words is presumed to be more robust, both in storage and in segmental specification (e.g. Walley, Metsala, & Garlock, 2003). While robust storage and specification may be advantageous under certain circumstances, the emergence of grammatical productivity requires children to be flexible in their use of word forms. Such flexibility might be realized in use of the root form in certain grammatical contexts as opposed to the inflected form in certain other contexts. Thus, even though receptive knowledge of sparse and dense generalization lexical items was roughly equivalent across participants (see table 2), flexibility of use in a *grammatical* context might be readily achievable for sparse words because the segmental status of the sparse word form may still be in flux. Flexibility of use for sparse words may also be associated with lexical storage, such that these word forms might not be as robust given the recency of their entry in the lexicon. Thus, despite equivalent performance for dense and sparse items on a receptive probe, it is possible that for children with SLI, dense forms may preclude flexible use in multiple syntactic contexts, as evidenced behaviourally by limited progress in treatment. Again, looking at the trend line slopes of the treatment data (Appendix III for sparse and IV for dense) strengthens the hypothesis that children with SLI do not equally extend their use of dense and sparse words to multiple syntactic contexts. While plausible, a resistance hypothesis of this sort has not been tested for language treatment. This notwithstanding, corpus analyses have shown that robust word forms are highly resistant to analogical changes and also, the regularization of irregular verbs (Bybee, 2007). For the future, it will be necessary to replicate the effects in treatment as a further test of this hypothesis. Examining longitudinal changes in grammar relative to neighbourhood density via spontaneous language samples would inform whether a resistance hypothesis is specific to treatment or a general characteristic of grammatical acquisition.

Implications for sli—The hypothesized effects of lexical storage and activation on the treatment gain/generalization observed here could have broader implications for understanding the language profile of SLI. One characteristic of SLI is late onset of first words with subsequent deficits in word learning and reduced lexical diversity (Gray, 2003; Rescorla & Achenbach, 2002; Rice, Buhr, & Nemeth, 1990; Rice, Oetting, Marquis, Bode, & Pae, 1994; Watkins, Kelly, Harbers, & Hollis, 1995). We hypothesized treatment of third person singular to involve the lexical act of retrieving and producing a verb to be inflected. Given observed deficits in areas of lexical acquisition, impairments in lexical activation and storage might also be expected for SLI. The sparse advantage observed here, however, is consistent with predictions for typical development based on models of lexical activation and storage. In other words, if lexical activation and storage were problematic for SLI, we might have expected either equivalent findings across treatment conditions, or a dense advantage, but not a sparse advantage. In fact, studies of neighbourhood density effects in lexical tasks yield converging findings across typical development and SLI with both groups showing a recognition advantage for sparse words (Mainela-Arnold, Evans, & Coady, 2008; Mainela-Arnold, Evans, & Coady, 2010). Taken together, the results of our preliminary treatment study point toward intact lexical activation and storage for SLI that can be harnessed in the treatment of grammatical finiteness markers.

Limitations and future directions

While this study suggests a first step in the clinical and theoretical utility of word properties like neighbourhood density for grammar treatment, there are several limitations that will need to be addressed to advance the line of inquiry. As a group, children with SLI are heterogeneous in their language skills and the participants of the present study were no exception. Variability was observed in children's phonological skills and pre-treatment accuracy on the experimental sentence production measure. This can be seen in table 1, where all three children in the dense treatment condition had greater phonological errors on a standardized articulation test than those in the sparse condition. It is important to note, however, that all children had /s/ and /z/ in their segmental inventory, so it is unlikely that the density effects in affix production would be traceable to differences in the inventory.

Nonetheless, while inventory composition did not differ across children of this study, the number of errors did, suggesting some level of phonological heterogeneity.

Another point of difference in the population of study was the pre-treatment third person singular accuracy on the sentence production tasks, which was more variable for children in the dense condition. There was no a priori reason to suppose that pre-treatment accuracy on the experimental tasks would yield differential treatment gain or generalization; the dependent variable took pre-treatment accuracy into account in the computation of gain and generalization. Moreover, all participants had comparable elicited grammar composite scores on the pre-treatment Test of Early Grammatical Impairment (Rice & Wexler, 2001) with this norm-referenced measure as perhaps a more valid measure of baseline grammatical skills. Thus, future studies might aim for a more homogenous sampling of the population, by restricting the inclusionary criteria to include only those who are homogenous in their overall linguistic profile, including both the phonological system and the grammatical system. This will be relevant to ensuring the validity of any clinical recommendations to emerge from manipulation of word properties in grammatical treatment.

Related to the experimental design, one limitation is the single post-treatment follow-up session. It will be important for future studies testing the clinical use of verb neighbourhood density to collect multiple post-treatment measures to ensure the reliability of effects and determine whether greater gains made by the sparse treatment condition can be maintained over time. Other types of single subject designs, like the alternating treatment design, where participants are exposed to both neighbourhood density conditions may also be necessary to understand the precise day-to-day treatment effects of presenting dense vs. sparse verbs. In fact, the alternating treatment design would allow us to see whether the slow growth rate in treatment of dense words would accelerate with the introduction of sparse verbs. Likewise, if dense words hinder treatment acceleration, a deceleration in learning rate should be observed with the removal of sparse words and the introduction of dense items.

Despite limitations, this work has the potential to motivate broader lines of research that explore other grammatical finiteness markers clustering with the third person singular structure in development and known to be challenging for children with SLI. For example, it might be feasible to extend neighbourhood density manipulations to the regular past tense finiteness marker. Similarly, treatment of finiteness marking through morpho-phonological stem changes (i.e. irregular past tense) or non-lexical copula and auxiliary verbs might also be tested with respect to neighbourhood density. Research along these lines will help to establish the robustness and clinical utility of the neighbourhood density effects as they apply to the more general grammatical construct of finiteness, while addressing some of the inherent limitations of the present study.

Likewise, future studies might test the effects of other phonological properties and contexts on treatment beyond manipulations of neighbourhood density. Other word form characteristics like age of word acquisition or word frequency might further clarify other ways in which words forms presented as the input during treatment might be involved in jumpstarting change in finiteness markers. In all, research along the lines suggested would help to fully discern the ways in which phonological and lexical characteristics converge with neighbourhood density to optimally support grammatical growth for children with SLI enrolled in clinical treatment.

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Appendix I. Sample Illustration from ‘Snow Day’ Story Used for Both Conditions

Vignette for Target Sparse Verb ‘Fix’ (5 neighbours) and Target Dense Verb ‘Make’ (20 neighbours)

Examiner reads: ‘It’s almost time to go inside, but first Zoe and Max want **to fix/to make** a snowman. Zoe **fixes/makes** the snowman’s body. Max **fixes/makes** the snowman’s head. Zoe and Max want **to fix/to make** the face for the snowman. Zoe **fixes/makes** the snowman’s eyes and nose while Max **fixes/makes** the snowman’s mouth. The snowman is going to look so great when Zoe and Max are done’!

Direct Imitation of Target Structure with Target Sparse or Dense Verb

Examiner: Say Zoe **fixes/makes** the snowman’s body.

Target child response: Zoe **fixes/makes** the snowman’s body

Examiner Feedback for incorrect third person singular use: ‘Remember, Zoe **fixes/makes** the snowman’s body’

Spontaneously Elicited Production of Target Structure with Target Sparse or Dense Verb

Examiner: Max is going to **fix/make** the snowman’s head. Now it’s your turn to tell me what Max does.

Target Response: Max **fixes/makes** the snowman’s head.

Examiner Feedback for incorrect third person singular use: ‘Remember, Max **fixes/makes** the snowman’s head’

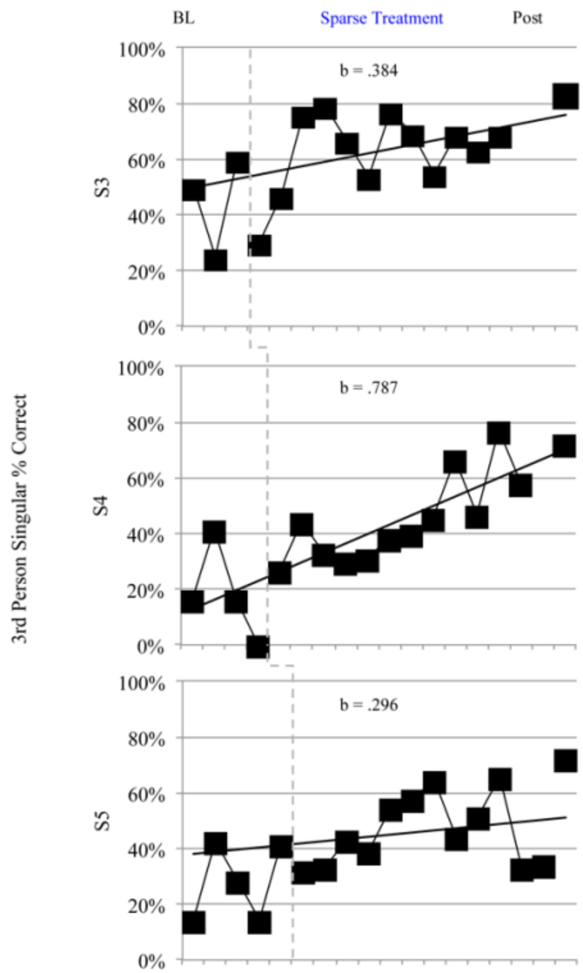
Appendix II

Verbs & Sentences Used to Assess Generalization

Dense Generalization Verbs & Sentences	Sparse Generalization Verbs & Sentences
The woman <u>pokes</u> the bubble	The woman <u>moves</u> the ball
The boy <u>hides</u> behind the tree	The boy <u>walks</u> to the park
The boy <u>bites</u> the cookie	The man <u>wipes</u> the floor
The girl <u>rides</u> the horse	The man <u>digs</u> a hole
The woman <u>kicks</u> the ball	The woman <u>cooks</u> the food
The teacher <u>reads</u> a story	The teacher <u>knocks</u> on the door
The girl <u>hugs</u> the doll	The girl <u>hops</u> on the couch
The boy <u>shakes</u> the bottle	The boy <u>climbs</u> up the tree
The dog <u>sleeps</u> under the bed	The dog <u>crawls</u> under the bed
The man <u>breaks</u> the dish	The girl <u>drops</u> the doll
The man <u>slides</u> on the floor	The woman <u>swims</u> in the water
The man <u>spills</u> the water	The teacher <u>cleans</u> the dish
The teacher <u>slips</u> in the hole	The boy <u>scoops</u> the snow
The girl <u>stacks</u> the box	The man <u>builds</u> a house
The woman <u>holds</u> the food	The girl <u>tastes</u> the cookie

Appendix III

Third person singular % correct for sparse treatment words at baseline sessions, treatment sessions and post-treatment session with linear trend lines for the sparse treatment condition. Standardized beta coefficients (b) are included to indicate treatment data slopes. Standardized beta coefficients and trend lines are based only on treatment data points.



Appendix IV

Third person singular % correct on dense treatment words at baseline sessions, treatment sessions and post-treatment session with linear trend lines for the dense treatment condition. Standardized beta coefficients (b) are included to indicate treatment data slopes. Standardized beta coefficients and trend lines are based only on treatment data points.

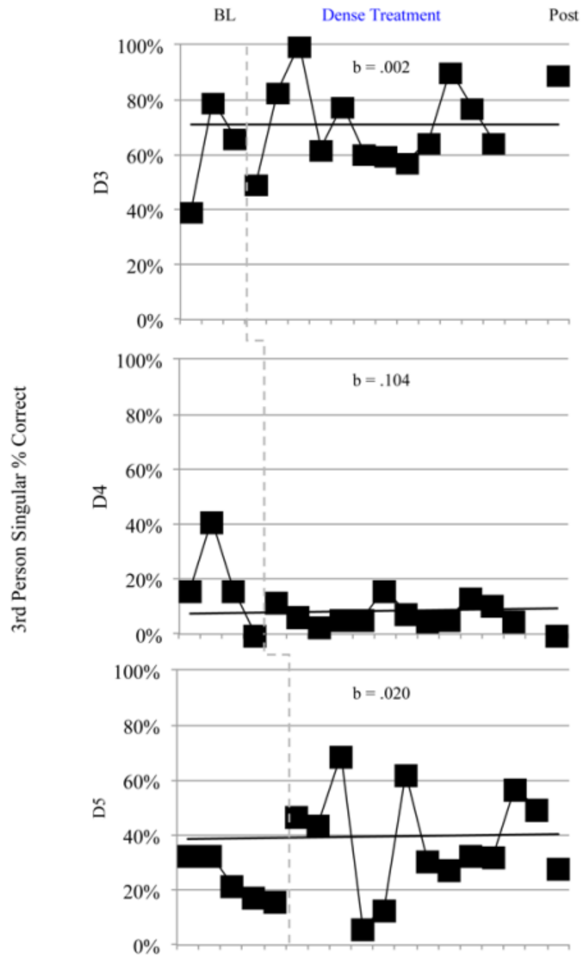

BL
Dense Treatment
Post
3rd Person Singular % Correct
D3
b = .002
D4
b = .104
D5
b = .020
100%
80%
60%
40%
20%
0%

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Table 1

Individual Participant Characteristics and Averages by Condition.

Condition	Participant[1]	Age[2]	Sex	TEGI[3] EGS %	TEGI[4] 3S	Spont.[5] 3S	PPVT[6] SS	PPVT[7] %ile	GFTA[8] SS	GFTA[9] %ile	MLU- Words[10]
Sparse	Sparse 3	4;0	M	23	25	45	90	25	110	71	3.70
	Sparse 4	4;7	M	15	30	37	108	70	95	33	3.66
	Sparse 5	4;4	M	12	0	25	99	47	100	43	3.97
	Mean	**4;3**	**NA**	**17**	**20**	**36**	**NA**	**NA**	**NA**	**NA**	**3.78**
	Median	**NA**	**NA**	**NA**	**NA**	**NA**	**99**	**47**	**100**	**43**	**NA**
Dense	Dense 3	4;1	F	26	53	25	94	34	86	21	1.84
	Dense 4	5;9	M	16	12	23	103	58	74	9	3.88
	Dense 5	4;2	F	19	11	15	84	14	84	17	3.28
	Mean	**4;7**	**NA**	**20**	**29**	**21**	**NA**	**NA**	**NA**	**NA**	**3.0**
	Median	**NA**	**NA**	**NA**	**NA**	**NA**	**94**	**34**	**84**	**17**	**NA**

Notes.

[1] Subject pseudonyms correspond to child's assigned treatment condition (sparse or dense) and number of baseline sessions completed (3, 4 or 5 sessions).

[2] Chronological age in years; months.

[3] Elicited Grammar Composite of the Test of Early Grammatical Impairment: Scores represent average % correct for third person singular, regular/irregular past tense, Copula BE and Auxiliary BE and DO.

[4] TEGI third person singular probe: Score represents % correct for third person singular.

[5] % correct third person singular during a spontaneous language sample.

[6] Standard scores on the Peabody Picture Vocabulary Test 4th Edition (M = 100; SD = 15).

[7] Percentile ranks on the Peabody Picture Vocabulary Test 4th Edition.

[8] Standard scores on the Goldman Fristoe Test of Articulation 2nd Edition (M = 100; SD = 15).

[9] Percentile ranks on the Goldman Fristoe Test of Articulation 2nd Edition.

[10] MLU in words calculated from a 30-minute spontaneous language sample.

Table 2

Pre-Treatment % Correct Receptive Knowledge of Treatment and Generalization Verbs.

Condition	Participant	Treatment Probe Items %	Generalization Probe Dense %	Generalization Probe Sparse %
	Sparse 3	100	87	87
Sparse	Sparse 4	80	93	93
	Sparse 5	100	100	93
	Mean	**93**	**93**	**91**
	Dense 3	83	93	93
Dense	Dense 4	100	93	93
	Dense 5	80	80	87
	Mean	**88**	**89**	**91**