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Third Person Singular -s in Typical Development and Specific Language Impairment: Input and Neighbourhood Density

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Abstract

The purpose of this study was to examine factors promoting the use of third person singular -s by 23 children with specific language impairment (SLI) and 21 children with typical development (TD). Relative proportions of third person singular -s forms in the input (input proportion) were calculated for 25 verbs based on data from an American English corpus of child-directed speech. Neighbourhood density values were also collected for these verbs. With previously collected probes of third person singular -s use for each of these verbs, we found with logistic regression that input proportion was positively associated with the likelihood of third person singular -s use for both groups. For neighborhood density, we found that children with SLI were more likely to inflect sparse verbs than dense verbs; density was not significantly related to inflection use for TD children. We argue that as a result of their verbs' poorly encoded phonological representations, children with SLI were less able to inflect dense verbs than sparse verbs. We recommend that clinicians be aware of the effects of input proportion and neighbourhood density to ensure that assessments are representative and that treatment success is optimal.

Keywords

specific language impairment; developmental language disorders; tense/agreement morphology; third person singular -s; input; neighbourhood density

Introduction

One of the hallmarks of specific language impairment (SLI) in children learning English is a protracted period of using tense and agreement morphemes inconsistently. At five years of age, children with SLI lag behind not only their same-age peers but also much younger typically developing children in their use of these morphemes. The latter difference occurs even when the two groups are matched for mean length of utterance or number of verbs in their expressive vocabulary (e.g. Hoover, Storkel, & Rice, 2012; Leonard, Miller, & Gerber, 1999; Rice & Wexler, 1996).

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Declaration of Interest

The authors report no conflicts of interest.

The most prominent account of this protracted use of tense and agreement forms is the Extended Optional Infinitive account of Rice and her colleagues (Rice, Wexler, & Cleave, 1995; Rice, Wexler, & Hershberger, 1998; Wexler, Schütze, & Rice, 1998). According to this account, a biologically-based maturation principle is slow to emerge in children with SLI. Until this principle is in place, tense and agreement morphemes are treated as optional. During this optional period, these morphemes are either produced correctly, or tense/agreement is not expressed, replaced instead by a nonfinite form. Thus, during the same language sample, a five-year-old English-speaking child with SLI might produce *Mommy like asparagus* as well as *Daddy likes ice cream*, and *The doggy barking* as well as *The kitty is purring*.

Although the basic idea of the Extended Optional Infinitive account is consistent with much of the evidence in English, it does not rule out other factors. In particular, the progression from emergence to mastery of tense/agreement morphemes in children with SLI is slow but ever changing. Instead of showing, say, 35% use for an extended period of time and then rapidly reaching 90% use in a matter of a few weeks, children with SLI show a gradual but steady increase from approximately 35% to 90% use over the course of about three years (Rice et al., 1998). Even if maturation is the dominant force, with such a gradual change in degree of use, other factors might well be shaping the trajectory of growth in this usage. The present study examines two such factors. Specifically, we ask whether the input might affect the likelihood that children omit tense/agreement morphemes during the optional period, and whether the phonological composition of the verbs to be produced can slow children's progression toward tense/agreement mastery.

There seem to be three ways in which input can affect the degree to which children use, or fail to use, tense/agreement morphology. Each applies to both typically developing children as well as children with SLI, though perhaps in different ways. First, languages differ in the degree to which they have overt marking of tense/agreement. Legate and Yang (2007) found that the degree to which a language has overt tense/agreement marking is related to the duration of the optional infinitive period in children learning the language. English has a relatively sparse morphology with many bare verb stems, including those that are considered finite (e.g. *run* in *I/you/we/they run fast*). Not coincidentally, English-speaking children go through a longer optional infinitive period than children learning French or Spanish – languages with a higher degree of overt marking of tense/agreement.

Input also seems to influence the degree of tense/agreement use even within a language. Hadley, Rispoli, Fitzgerald, and Bahnsen (2011) studied the input provided by English-speaking parents interacting with their young typically developing children. They found that the degree to which the parents' input contained overt markers of tense/agreement served as a predictor of their children's growth of tense/agreement morphology. This provides more evidence that the process of acquiring tense/agreement morphology is not strictly based on maturation.

Input also appears to play a role at the level of individual verbs. In recent years, investigators have reported ways in which verbs differ in how readily children are able to use tense/agreement morphemes with them. For example, Theakston, Lieven, and Tomasello (2003)

presented novel verbs to young typically developing children in strictly third singular contexts (e.g. *Look, it mibs*), strictly bare stem contexts (e.g. *Will it keef?*), or in contexts where both versions of the novel verb were heard (e.g. *Look, it tams; Will it tam?*). When required to produce the novel verbs in third person singular -s contexts, the children were most likely to use this inflection if the novel verb always contained the inflection in the input and were least likely to use this inflection if the novel verb always appeared in the input as a bare stem. Leonard, Fey, Deevy, and Bredin-Oja (2015) used a similar method and found that children with SLI were even more influenced by the input than were younger typically developing children matched for MLU when verbs were always presented in third person singular form in the input but probed in contexts obligating their bare form.

The role of input has also been observed as a result of more naturalistic communication, as is seen in the work of Räsänen, Ambridge, and Pine (2014). These investigators examined verb use in British English and found that verbs that most frequently appear as bare stems in the input are those that are more likely to lack tense/agreement use in the speech of young typically developing children in contexts requiring third person singular -s, a phenomenon they termed *defaulting*. This finding suggests that children's selection of a bare stem in third person singular -s contexts during the optional infinitive period may have been less a matter of chance than previously assumed. That is, verbs more frequently heard in third person singular -s form may have been more likely to be produced in that form, perhaps because this form constituted a stronger competing form. This opens up the possibility that bare-stem productions in third person singular -s contexts may be as much a selection of a default form as a selection of a nonfinite form.

This possibility seems especially plausible considering that in languages with a rich inflectional morphology, young children often go through a period during which they use a verb inflected for third person singular not only in appropriate contexts but also in contexts requiring a different tense/agreement inflection (Bedore & Leonard, 2001; Bortolini, Caselli, & Leonard, 1997; Grinstead, Baron, Vega-Mendoza, De la Mora, Cantú-Sánchez, & Flores, 2013). In such languages (e.g. Italian, Spanish), an overt infinitive inflection exists but when errors occur in finite contexts, it is the third person singular, not the infinitive that is most likely to be used as a substitute. Indeed, Räsänen, Ambridge, and Pine (2016) found that when children make tense/agreement errors in Finnish, they tend to replace lower-frequency tense/agreement morphemes with higher-frequency morphemes. It is probably not a coincidence that these substitute forms are frequently occurring in these languages – much like bare stems in English.

In addition to being frequent, these substitute forms also tend to be phonologically simple. The effects of the phonological characteristics of a verb on the likelihood that it will display tense/agreement morphology have also been studied. For example, the phonotactic probability of a verb (Marshall & van der Lely, 2006) and its phonological complexity at the site of inflection (Song, Sundara, & Demuth, 2009) can play a role in the speech of children with SLI and younger typically developing children. In addition, some studies have also implicated neighbourhood density, a measure of the number of words that differ from a target word by one added, deleted, or substituted phoneme. Hoover et al. (2012) found that typically developing children were more likely to produce third person singular -s on dense

verbs than on sparse verbs whereas children with SLI were equally likely to inflect sparse and dense verbs. In contrast, Hoover and Storkel's (2013) smaller treatment study found that when children with SLI were engaged in therapy targeting third person singular *-s* inflection with sparse verbs only, there was more generalization to both sparse and dense untreated verbs than when treatment involved dense verbs only. This finding suggests that children with SLI may respond differently to sparse and dense verbs when producing third person singular *-s* forms.

In the present study, we ask whether children's productions of verbs in third person singular *-s* form in finite contexts vary as a function of the relative proportion with which these verbs appear in third person singular *-s* form in the input. We also ask whether this relationship is the same for children with SLI as it is for children with typical language development, given the much slower development of tense/agreement use in this clinical population. We also examine the role of neighbourhood density in children's use of third person singular *-s*. The available evidence suggests that this factor may operate differently in children with SLI and their typically developing peers.

Method

Participants

Participants were the children with specific language impairment (SLI) and younger typically developing (TD) children reported by Leonard, Deevy, Miller, Charest, Kurtz, and Rauf (2003) and Leonard et al. (2015). We included in the analysis only those children whose data were collected at Purdue. In total, there were 61 children, 30 from Leonard et al. (2003) and 31 from Leonard et al. (2015). Thirty-one of these children met the criteria for SLI, while 30 were typically developing children matched for MLU. Both studies used similar criteria to identify children as exhibiting SLI or typical development. Children in both groups passed a hearing screening and demonstrated no history of seizures or evidence of neurological impairment. Importantly, they were also able to produce the consonants /s/ and /z/ in word-final position during a picture naming task, suggesting that attempts to produce third person singular *-s* inflected forms would be intelligible. In addition, all children were speakers of Standard American English.

The children with SLI had been participating in language intervention at the time of the original studies. They ranged in age from 3;9 (years; months) to 6;7 ($M = 5;1$, $SD = 9.24$ months), with 13 being female and 18 male. All of these children passed an oral-motor screening. These children all had standard scores above 85 on the Columbia Mental Maturity Scale (CMMS; Burgemeister, Blum, & Lorge, 1972). The children with SLI from Leonard et al. (2003) scored at least 1.5 SDs below the mean on the Structured Photographic Expressive Language Test-II (SPELT-II; Werner & Kresheck, 1983) and the finite verb morphology composite (FVM; Leonard, Miller & Gerber, 1999). In Leonard et al. (2015), all but two children scored below 87 on the Structured Photographic Expressive Language Test – Preschool 2 (SPELT-P2; Dawson, Eyer, & Fonkalsrud, 2005). Previous work had shown that 87 served as an appropriate cutoff score, providing high sensitivity and specificity (Greenslade, Plante, & Vance, 2009). The remaining two children scored below the 10th

percentile on the Developmental Sentence Scoring (Lee, 1974). Across both studies, these children had a mean MLU in words of 4.08 ($SD = 0.68$).

The TD children ranged in age from 2;5 to 4;11 ($M = 3;2$, $SD = 7.57$ months). Ten were male and 20 were female. To establish that these children showed age-appropriate nonverbal intelligence, the seven children 3;6 and younger were assessed using the Leiter International Performance Scale – Revised (LIPS; Roid & Miller, 1997) and the other 23 were assessed using the CMMS; standard scores on these assessments were above 85 for all children. These children also received age-appropriate scores on the Reynell Developmental Language Scales (Reynell & Gruber, 1990), a measure of general language ability. These children had a mean MLU in words of 4.12 ($SD = 0.63$), statistically similar to the values for the group with SLI, $t(59) = 0.25$, $p = 0.800$, $d = 0.07$.

Procedure

Third person singular -s probes.—The outcome measure of interest for this present study was the presence or absence of the third person singular -s inflection on a variety of verbs in contexts where the inflection was obligatory. Both Leonard et al. (2003) and Leonard et al. (2015) used the same child-friendly task to elicit third person singular -s. In this sentence completion task, the child was presented with a Shy Turtle character who withdrew into his shell as another character performed and described an action. The child was then encouraged to tell the Shy Turtle what the other character did with a probe item that provided an obligatory context for third person singular -s. An example item from the probes used in Leonard et al. (2015) is provided below:

BOY: I love to feed my dog. Do you? I feed my dog every morning.

TURTLE: Oh-oh, I didn't see. What does the boy do every morning? The boy...

CHILD: Feeds his dog.

Probe items were coded for the presence or absence of the inflection. Across the two studies, 28 different verbs were probed. Leonard et al. (2003) used the following verbs: *bark, climb, comb, count, cry, drink, drive, eat, hide, laugh, read, ride, run, swim, take (a nap)*, and *yell*. Leonard et al. (2015) probed the following: *bark, bite, call, comb, cook, count, feed, help, hide, play, put (on), rake, slide, sweep, swim, swing, take (a nap)*, and *wear*. Verbs were included in the present analysis based on their use in the input corpus (see below), yielding a list of 25 different verbs: *bite, call, climb, comb, cook, count, cry, drink, eat, feed, help, hide, laugh, play, put (on), rake, read, ride, run, slide, sweep, swim, swing, take (a nap)*, and *wear*. Productions of non-targeted verbs were exempted from scoring.

We then calculated for each child the percentage of third person singular -s use for all scored items. However, some children showed no inconsistency, scoring either 0% or 100%. Only those children showing inconsistency were included in the analysis, given that one of the goals of this study was to characterise the response patterns of children who were in the process of learning third person singular -s forms. This resulted in a final sample of 21 children in the TD group (seven male and 14 female) and 23 children in the group with SLI (13 male and 10 female). The mean age of the group with SLI was 5;1 ($SD = 10.11$ months) and 2;11 for the TD group ($SD = 3.83$ months). The MLU in words for the group with SLI

was 4.08 ($SD = 0.74$) and 4.03 ($SD = 0.64$) for the TD group. As before, both groups were well-matched for MLU in words, $t(42) = -0.22$, $p = 0.820$, $d = -0.07$. Table 1 provides the percentages of the TD and SLI groups' third person singular *-s* use for each verb.

To ensure that we could pool the data from the Leonard et al. (2003) and Leonard et al. (2015) studies, we completed separate Fisher's exact tests by group to examine the association between study year (i.e. Leonard et al., 2003 or Leonard et al., 2015) and the presence or absence of third person singular *-s* on each of selected verbs that were shared between studies – *comb*, *count*, *hide*, *swim*, and *take*. None of these tests were significant, $p = 0.373$. These findings suggest that each of the shared verbs yielded scores that were highly similar across the two studies. This proved true for both the TD and SLI groups.

Input proportions.—In addition to group, an important independent variable was the proportion of third person singular *-s* forms in the child-directed input for each of the probed verbs. We used input proportion rather than raw frequency of third person singular *-s* in the input based on findings reported by Ambridge, Kidd, Rowland, and Theakston (2015) that the relative rather than absolute frequency of inflected forms in the input seems to be the operative factor in children's subsequent use. Note that input proportion was the measure used by Räsänen, Ambridge, and Pine (2014) in their study of input effects on British English-speaking children's use of third person singular *-s*.

As the participants in our study were children speaking American dialects of English, the Providence corpus of parent-child interaction was selected as the source of the input data (Demuth, Culbertson, & Alter, 2006). This morphologically tagged corpus is available as part of the CHILDES project (MacWhinney, 2000). The corpus is a longitudinal collection of spontaneous language samples from six children interacting with their parents at home across ages 0;11 to 4;0. The overall corpus contains 364 hours of speech distributed across 44 to 88 sessions of varying length per child. The parents and children spoke either Standard American English or a non-rhotic dialect of English present in southern New England. Only verbs from adult speakers were included in the input measure; children and inanimate object speakers like toys were excluded.

For each verb reflected in our probes, we identified all bare stems and third person singular *-s* inflected forms in the child-directed adult speech from the Providence corpus. Bare stems were defined as verbs appearing in the input without any inflection, regardless of context (e.g. *they hide*, *they can hide*). A proportion was then calculated using the formula: Number of third person singular *-s* forms / (Number of third person singular *-s* forms + Number of bare forms). Table 1 shows the input proportions for each verb.

Verbs were initially included in our analysis if they appeared at least 10 times in the input corpus in order to ensure that the calculated proportions reflected the patterns of these verbs' use in a variety of contexts. The verbs *bark* and *yell* did not meet this cutoff, appearing only eight and seven times in the corpus, respectively. In addition to the 25 verbs identified above, this criterion also included the verb *drive*, which appeared in the input in its third person singular *-s* form 34% of the time. This percentage of third person singular *-s* use was five SDs above the mean percentage use for all other verbs. In addition, this percentage differed

from the corresponding value in the Manchester corpus (used in Räsänen, Ambridge, & Pine, 2014) far more than any of the other 25 verbs. A closer inspection of the utterances containing *drives* in the Providence corpus revealed that the speech directed at just two of the six children accounted for nearly three quarters of the total number of times that *drives* appeared in the corpus, suggesting that contextual factors or interests particular to these children may have contributed to the high rate of third person singular *-s* forms for *drive*. For these reasons, the verb *drive* was excluded from the results.

Some verbs appeared more often in the corpus than others; when a verb appeared relatively more often in the corpus, we were more confident that the observed proportion of third singular *-s* use for this verb reflected its underlying tendency to appear in this form than when a verb was relatively scarcer. In order to take into account our confidence about the observed third person singular *-s* proportion for our verbs, we devised a frequency-adjusted input proportion measure that worked to adjust the difference between a verb's observed proportion and the overall proportion for all the verbs in the corpus. The degree of adjustment was determined using a measure of our confidence about this difference. First, we calculated the overall proportion for third person singular *-s* forms relative to bare stems for all of the verbs in the corpus, including verbs that did not appear on the child probes, by counting all of the third person singular *-s* forms and all of the bare forms. Only verbs that appeared at least 200 times in the corpus were included – an arbitrary cutoff but one that was designed to ensure that the corpus average would not be unduly affected by outliers or verbs with very low frequencies of occurrence. The overall corpus third person singular *-s* proportion was 7.2%. We then conducted multiple Fisher's exact tests for each of the verbs in our study, comparing the observed number of third person singular *-s* and bare forms to the number of forms observed across all of the corpus verbs. This yielded a series of *p*-values that served as a measure of our confidence concerning the difference between the observed third person singular *-s* proportion for a verb and the proportion across the entire corpus.

We then computed a frequency-adjusted third person singular *-s* proportion for each verb using the following formula: $(1 - \text{Fisher's exact test } p\text{-value}) * (\text{observed third person singular } -s \text{ proportion} - \text{corpus average third person singular } -s \text{ proportion}) + \text{corpus average third person singular } -s \text{ proportion}$. This formula combines a measure of confidence with the difference between the observed proportion for a verb and the corpus average, rescaling the result so that it lies above zero. The correlation between the observed third person singular *-s* proportion and the frequency-adjusted proportion was high, $r = .98$, $p < 0.001$. Table 1 shows the observed and frequency-adjusted proportions for each verb.

Neighbourhood density.—In our final model, we included neighbourhood density as another independent variable. We collected values for neighbourhood density for our verbs using the online calculator developed by Storkel and Hoover (2010), deriving these numbers from their child corpus. Neighbourhood density z-scores were calculated for each verb, normalised according to the mean and SD of the number of neighbours at each word length. These z-scores were used in the following regression procedures; these values ranged from -1.19 to 2.23 . Nine of the verbs were sparser than average (i.e., had negative z-scores), with 16 being denser than average. Biphone frequency average and positional segment average

(based on Storkel & Hoover, 2010) were not significantly associated with ND z-score, $r = 0.07$, $p = 0.727$, nor was log frequency, $r = -0.07$, $p = 0.740$. Frequency-adjusted input proportion was also not significantly associated with ND z-score, $r = 0.35$, $p = 0.086$, suggesting that neighbourhood density was relatively independent of these other variables.

Results

There were 577 responses to probe items, distributed across 25 verbs. Children in the TD group used the third person singular -s inflection on 63% of opportunities ($SD = 28\%$, Range: 12% – 93%) whereas children with SLI used the inflection 43% of the time ($SD = 22\%$, Range: 6% – 87%). Mixed-effects logistic regression was used to model the influence of group and input on children's use of third person singular -s forms. The dependent variable was the presence or absence of the third person singular -s inflection on the probed verbs. The independent variables were group (with TD being the reference value) and the frequency-adjusted proportion of third person singular -s forms in the input for the probed verbs (input proportion). Random effects for participant and verb were also included. The model as a whole was significant, $\chi^2(2) = 11.36$, $p < 0.0036$, as were the effects of group, $\beta = -1.07$, $SE = 0.38$, $p < 0.005$, and frequency-adjusted input proportion, $\beta = 4.81$, $SE = 2.41$, $p = 0.046$. Table 2 provides details of the model.

The model indicated that the odds that a child with SLI would use the third person singular – s inflection were 2.87 times lower than the odds for a TD child. In addition, a verb having 20% input proportion – a percentage of use close to that of the verb *swing*, which had the highest input percentage in this study – had 2.46 times greater odds than a verb with 0% input proportion to be inflected by children across both groups. Figure 1 displays the predicted probability of third person singular -s use in each group as a function of the percentage of third person singular -s forms in the input.

One of our aims was to determine whether the SLI and TD groups demonstrated different responses to the input. As such, we considered a separate logistic regression model that included an interaction term between group and input proportion, in addition to the previous independent variables. Based on likelihood ratio χ^2 and BIC values, this model was not significantly better than the model without the interaction term, $\chi^2(1) = 0.02$, $p = 0.881$, BIC = 6.34. This suggests that the association between input proportion and children's production of third person singular –s was similar for SLI and TD groups.

In order to examine the influence of neighbourhood density, we again used mixed-effects logistic regression, continuing with the same dependent variable as in previous models (i.e. the use of a third person singular -s form). The independent variables were group, frequency-adjusted input proportion, neighbourhood density z-score, and an interaction between neighbourhood density and group. The model was significant, $\chi^2(4) = 28.90$, $p < 0.0001$, and a better fit for the data than the model without neighbourhood density, $\chi^2(2) = 19.79$, $p < 0.001$, BIC = -7.07. Frequency-adjusted input proportion continued to have a positive association with the likelihood of third person singular -s use by children with and without SLI, $\beta = 6.21$, $SE = 2.64$, $p = 0.019$. For TD children, neighbourhood density z-score was not associated with third person singular -s use, $\beta = 0.30$, $SE = 0.20$, $p = 0.135$,

whereas for children with SLI, neighborhood density z-score was negatively associated with third person singular -s use (Group x ND interaction: $\beta = -0.98$, $SE = 0.25$, $p < 0.001$). Details of this model are provided in table 3.

Largely in agreement with the previous model, the results for the current model indicated that the odds that children in the TD group would produce third person singular -s forms were on average 2.87 times larger than those for children with SLI. All children were more likely to produce inflected forms when the input proportion was higher; the odds of inflecting were 3.04 times larger with verbs appearing as third person singular -s forms in the input 20% of the time compared to those verbs never appearing as inflected forms. The effects of neighbourhood density, however, differed between groups. For the TD group, sparse verbs were no more likely to be inflected than dense verbs. In contrast, for children with SLI, the odds that they would use an inflected form were 3.79 times larger with sparse verbs having ND z-scores of -1 compared to dense verbs having ND z-scores of 1. See figure 2 for a display of the predicted probability of third person singular -s use by children with and without SLI across a range of ND z-scores representative of the verbs in our study.

Surprisingly, children with SLI produced third person singular -s forms with sparse verbs at rates similar to their TD peers. The odds that TD children would use a third person singular -s form on dense verbs were 4.58 times larger than those for children with SLI, as one would expect given the difficulties children with SLI characteristically demonstrate with third person singular -s. However, for sparse verbs, the odds that children with SLI would use third person singular -s were in fact numerically higher than those for TD children ($OR = 1.50$), though this difference was not statistically significant. This indicates that the two groups' use of third person singular -s was similar for sparse verbs, a conclusion supported by a test comparing the predicted probability that the TD and SLI groups would use third person singular -s with sparse verbs having a ND z-score of -1, $\chi^2(1) = 0.58$, $p = 0.447$.

A model that included interaction terms between group, neighbourhood density, and input proportion, $\chi^2(7) = 34.80$, $p < 0.0001$, was not significantly better than the model without the interaction terms, $\chi^2(3) = 7.62$, $p = 0.055$, $BIC = 11.45$, suggesting that the effects of neighbourhood density and input proportion were relatively independent for each group.

Discussion

The results of this study show that the proportion of third person singular -s forms in the input has a similar effect on children with SLI and children with typical language development; verbs with higher input proportion were associated with greater third person singular -s use. Based on an American English corpus with speakers of American English, our results are consistent with those in Räsänen et al. (2014), which used a British English corpus with TD children from the UK.

Current theoretical frameworks differ in the degree to which input is assumed to play a role during the period of development when children are highly inconsistent in their use of tense/agreement morphology. According to the Optional Infinitive framework of Wexler (1994, 1998) and the Extended Optional Infinitive account of Rice and Wexler (1996), input serves

only a triggering function, to dispose children to acquire certain types of language features rather than others. During the period of tense/agreement inconsistency, it is assumed that a maturational principle has not yet emerged, and, until it does, children's grammars license both inflected and bare forms in contexts where adults would use inflected forms only. More recently, others holding the maturational view have presented data indicating that input can play a more important role in acquiring tense/agreement morphology. These scholars have noted that input containing a larger proportion of overt tense/agreement morphemes is associated with larger gains in tense/agreement use in children (Hadley et al., 2011; Legate & Yang, 2007). However, even this more recent approach does not address the verb-specific findings of the present study, namely, that children will be more likely to inflect a particular verb with third person singular *-s* if that verb has a higher proportion of appearing with the third person singular *-s* inflection in the input. These findings do not rule out maturational factors as an important component in children's development of tense/agreement morphology, but they do argue for a provision that permits children to be influenced not only by overt tense/agreement in the input in general but also by the way individual verbs appear in the input.

The verb-specific effects of input observed here seem compatible with assumptions of the usage-based approach (Tomasello, 2003). In fact, investigators working within this framework have demonstrated strong verb-specific effects by systematically manipulating how verbs are presented to children. For example, Finneran and Leonard (2010) applied the novel verb learning procedure of Theakston et al. (2003) to children age 30 to 36 months who averaged 55% use of tense/agreement morphology in obligatory contexts with familiar verbs. After hearing novel verbs presented exclusively in third person singular *-s* form (e.g., *The bear meps*), the children used the same inflection correctly with these verbs in over 90% of the contexts requiring this inflection. In contrast, after hearing novel verbs exclusively in bare stem form (e.g., *Will the horse pim?*) the children used third person singular *-s* in only 35% of obligatory contexts. Because the children showed an ability to occasionally apply the inflection to verbs that they never heard in inflected form (as in *pim* in the above example), these findings illustrate the strong role that the input can play at the level of specific verbs even when children have already begun to show some level of productivity in their tense/agreement use.

To our knowledge, the present study is the first to examine the effects of natural child-directed speech on third person singular *-s* use in children with SLI. Consistent with other studies, children with SLI produced third person singular *-s* less often than children with TD, though the boost to third person singular *-s* use from verbs with a higher degree of inflection use in the input was similar in the two groups – as the frequency-adjusted input proportion increased from 0% to 20%, the change in percentage use of third person singular *-s* was 23% for the group with SLI and 22% for the TD group. The similarity between the SLI and TD groups suggests that despite their other weaknesses, children with SLI seem to be able to take advantage of the input at the level of individual word forms.

Because the effects of the proportion of third person singular *-s* in the present study were no greater on the third person singular *-s* use of the children with SLI than that of their younger typically developing peers, it does not appear that this type of measure can account for the

overall weaker use of this morpheme by the SLI group. However, the input effects reported here have a certain degree of imprecision because input proportion was based on an independent corpus rather than the specific input received by each child. In contrast, experimental studies applying the novel verb method of Theakston et al. (2003) to children with SLI have reported even stronger input effects on these children than for typically developing peers. These effects have been seen not only for third person singular –s use (Leonard et al., 2015) but for the use of other tense/agreement morphemes as well (Leonard & Deevy, 2011). A clearer picture of the influence of input on these children’s extraordinary weaknesses with tense/agreement morphology might require detailed study of each child’s individual input history.

A second major finding of the present study was that neighbourhood density exerted different effects on the two groups of children. The children with SLI were more likely to inflect sparse verbs than dense verbs, but density did not prove to be a significant factor in the productions of the TD children. This interaction produced an unexpected between-group finding – the two groups inflected sparse verbs at similar rates. If we understand the effect of input proportion to be the result of the retrieval of more familiar inflected forms, then because neighbourhood density and input proportion did not interact for either group, it appears that neighbourhood density affected the productive use of third person singular -s in a manner apart from input effects. If neighbourhood density had significantly affected the retrieval of familiar inflected forms only, then we would have expected to observe an interaction between neighbourhood density and input proportion for at least one of the groups.

Our finding that neighbourhood density and input did not interact does not mean that they are necessarily unrelated to each other. Although we studied frequency-adjusted proportions of third person singular –s use in the input, other frequency measures have been found to be related to neighbourhood density (see Walley, 1993). In fact, Vitevich, Storkel, Francisco, Evans, and Goldstein (2014) found that two novel words each with a single phonological neighbor were learned at different rates as a function of the frequency of occurrence of the neighbor. Because our neighbourhood density measure did not include the frequency of occurrence of each neighbor, this factor, as well as others might have played a subtle role in our findings.

The differential effect of competition among word forms may explain some of the contrast between the TD and SLI groups. Children with SLI differ from typically developing peers in having much greater difficulty learning a word’s form than its meaning due to these children’s significant weakness in phonological encoding (Gray, 2004; McGregor, Licando et al., 2013). This type of weakness causes the underlying phonological representations of words for children with SLI to be less well-defined (Gray, Pittman, & Weinhold, 2014). This later may cause children with SLI to have difficulty inflecting verbs from dense neighbourhoods as a result of competition among many poorly-defined forms.

Walley (1993) raised a similar possibility regarding the learning of (presumably uninflected) words, by noting that words from sparse neighborhoods might be acquired more easily because children can rely on “developmentally primary, holistic procedures” without the

demand of distinguishing the word from others in finer segmental detail. In contrast, words from dense neighborhoods might require much more segmental detail, requiring more capacity resources (pp. 332–333). Applied to the present study, accessing a verb from a dense neighborhood, especially in the face of weaknesses in phonological encoding, may tax capacity resources, rendering the use of the inflection with that verb especially vulnerable.

Alternatively, it may be the case that for bare forms with high neighbourhood density, their high resemblance to other bare forms causes the production of these bare forms to become entrenched. That is, because these children will have remained at a point of using bare-stem forms in third person singular *-s* contexts for a protracted period (see Rice et al., 1998), verbs resembling these perpetual bare-stem forms may, themselves, be produced in the same manner. However, for verbs in sparse neighbourhoods, their resemblance to other verbs is lessened, increasing the likelihood that these children can apply their marginal productive inflection ability.

The performance of TD children in this study did not match the pattern displayed in Hoover et al. (2012), where dense verbs were more likely to be inflected than sparse verbs. As can be seen in Figure 2, the TD children in the present study showed a trend of greater use of third person singular *-s* with dense verbs, but this use did not differ significantly from their use of the inflection with sparse verbs. The two studies also differed in our finding that sparse verbs were more likely than dense verbs to be inflected by the children with SLI, whereas no such difference was observed by Hoover et al. One key difference between the neighbourhood density measures in the two studies was our use of *z*-scores reflecting a continuum rather than a division of verbs into discrete sparse-dense categories as was done by Hoover et al.

Our findings are compatible with the findings of Hoover and Storkel (2013). These investigators found that for children with SLI, third person singular *-s* treatment with sparse verbs tended to result in more generalization to untreated verbs than treatment with dense verbs. An inspection of the verbs used in the two studies reveals that the neighbourhood density values of the verbs in Hoover and Storkel (2013) were more similar to those in the present study. This similarity provides converging evidence for the idea that highly sparse verbs may be advantageous for children with SLI.

Should the findings reported here be replicated, the results will have important clinical implications. The effect of input on children's use of third person singular *-s* suggests that the clinician's choice of verbs to include on an assessment probe will affect the degree to which children will use the inflection. Rather different clinical conclusions might be drawn depending on the choices made. The interpretation of a child's performance should be qualified to the degree to which the verbs selected appear more or less often in the input with third person singular *-s*. Clinicians basing their assessment on children's use of third person singular *-s* in spontaneous speech will also need to be cautious. The verbs used by children in play or conversational contexts might be those that are especially likely to be used as bare stems in the input or, conversely, those that are least likely to be used in the input as bare stems. In treatment, clinicians often seek contexts in which children will have early success. It is possible that, other factors being equal (e.g. phonological complexity, grammatical

aspect), children with SLI will be most successful in using third person singular *-s* with verbs that have high third person singular *-s* frequencies in the child-directed input.

These results also indicate that neighbourhood density should be considered by clinicians as they assess and design intervention for children with SLI. Assessing third person singular *-s* using dense verbs might underestimate performance for children with SLI while using sparse verbs could overestimate it. In addition, given that dense words tend to be learned earlier than sparse words (Storkel, 2009), it is probable that verbs used in play with young children also tend to be dense. By carefully considering which verbs to probe and which play to pursue when planning assessments, clinicians might be able to ensure that the children use a balanced distribution of verbs. Such a distribution might give clinicians a more accurate impression of a child's range of third person singular *-s* use. These findings also provide indirect support for Hoover and Storkel's (2013) recommendation that clinicians target sparse verbs during treatment for third person singular *-s*.

Children with SLI demonstrate an enduring period of inconsistency in producing tense/agreement morphology. Our results show that with certain verbs, children with SLI can produce third person singular *-s* at rates nearing those of their TD peers. If learning conditions can be manipulated to help children with SLI take advantage of the properties of these verbs, then it may be possible to shorten the period of inconsistency in tense/agreement morphology and improve communicative and academic outcomes.

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Figure 1.

Model predictions of third person singular *-s* use by frequency-adjusted percentage of third person singular *-s* forms in the input for each group (Model 1). Error bars represent 95% confidence intervals.

Figure 2.
Model predictions of third person singular *-s* use by neighbourhood density z-score for each group (Model 2). Error bars represent 95% confidence intervals.

Table 1

Third Person Singular -s in Probes and Corpus

Verb	% of 3s -s use		Providence corpus			
	TD	SLI	# of 3s -s forms	# of bare forms	% of 3s -s forms ^a	% of 3s -s forms ^b
Bite	80 (12/15)	46 (6/13)	7	39	15.2	15.0
Call	70 (7/10)	36 (4/11)	53	451	10.5	10.5
Climb [*]	67 (2/3)	88 (7/8)	12	127	8.6	8.1
Comb [*]	56 (5/9)	50 (7/14)	5	27	15.6	15.1
Cook [*]	57 (8/14)	64 (7/11)	6	72	7.7	7.4
Count [*]	60 (9/15)	60 (12/20)	5	178	2.7	2.8
Cry [*]	60 (3/5)	89 (8/9)	6	59	9.2	8.3
Drink	83 (5/6)	30 (3/10)	17	134	11.3	11.1
Eat	71 (5/7)	22 (2/9)	83	1781	4.5	4.5
Feed	75 (9/12)	50 (6/12)	4	79	4.8	6.4
Help	50 (6/12)	31 (4/13)	31	959	3.1	3.1
Hide	71 (12/17)	20 (3/15)	4	81	4.7	6.4
Laugh [*]	50 (2/4)	67 (6/9)	2	14	12.5	10.9
Play [*]	36 (5/14)	38 (5/13)	29	1058	2.7	2.7
Put [*]	31 (4/13)	18 (2/11)	41	5084	0.8	0.8
Rake	54 (7/13)	11 (1/9)	1	18	5.3	7.2
Read	100 (5/5)	11 (1/9)	9	1513	0.5	0.6
Ride	67 (4/6)	33 (3/9)	21	115	15.4	15.4
Run	67 (4/6)	60 (6/10)	22	124	15.1	15.1
Slide	71 (10/14)	57 (8/14)	3	39	7.1	7.2
Sweep [*]	67 (10/15)	42 (5/12)	0	16	0.0	4.5
Swim	71 (15/21)	47 (9/19)	3	44	6.4	7.2
Swing	60 (9/15)	42 (5/12)	8	38	17.4	17.3
Take	71 (10/14)	31 (5/16)	122	1876	6.1	6.4
Wear	50 (6/12)	33 (4/12)	58	465	11.1	11.1

Note. The percentage of third person singular -s inflection is followed by data in parentheses providing the number of children who produced the inflection relative to the total number of scorable responses for each verb. Verbs marked with

^{*} are from sparse neighborhoods.

^a Observed proportion.

^b Frequency-adjusted proportion.

Table 2

Logistic Regression Model for Third Person Singular -s Use: Group and Input (Model 1)

Variable	<i>B</i> [95% CI]	<i>SE</i>	<i>z</i>	<i>p</i>	<i>OR</i>
(Intercept)	0.33 [-0.33, 0.99]	0.34	0.99	0.324	1.39
Group	-1.07 [-1.81, -0.32]	0.38	-2.80	0.005	0.34
Input	4.81 [0.08, 9.54]	2.41	1.99	0.046	2.46

Note. Group reference value is TD. The odds ratio displayed for Input is for the change from 0% to 20% frequency-adjusted third person singular -s forms in the input. Input = frequency-adjusted proportion of third person singular -s forms in the input; OR = odds ratio; CI = confidence interval.

Model log-likelihood = -355.77. Model $\chi^2(2) = 11.36$, $p = 0.0034$. Random effects: Participant ($Var = 1.14$, $SE = 0.37$), Verb ($Var = 0.07$, $SE = 0.09$).

Table 3

Logistic Regression Model for Third Person Singular -s Use: Group, Input, and Neighbourhood Density (Model 2)

Variable	<i>B</i> [95% CI]	<i>SE</i>	<i>z</i>	<i>p</i>	<i>OR</i>
(Intercept)	0.06 [−0.63, 0.75]	0.35	0.17	0.862	1.06
Group	−0.57 [−1.38, 0.24]	0.41	−1.37	0.170	0.57
Input	6.21 [1.04, 11.39]	2.64	2.35	0.019	3.04
ND	0.30 [−0.09, 0.70]	0.20	1.50	0.135	1.35
Group × ND	−0.98 [−1.47, −0.50]	0.25	−3.98	<0.001	0.37

Note. Group reference value is TD. The odds ratio displayed for Input is for the change from 0% to 20% frequency-adjusted third person singular -s forms in the input. Input = frequency-adjusted proportion of third person singular -s forms in the input; ND = neighbourhood density z-score; OR = odds ratio; CI = confidence interval. Model log-likelihood = −345.87. Model $\chi^2(4) = 28.90$, $p < 0.0001$. Random effects: Participant (*Var* = 1.20, *SE* = 0.38), Verb (*Var* = 0.05, *SE* = 0.08).