Phonological Constraints on Children's Production of English Third Person Singular –*s*

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Purpose: Children variably produce grammatical morphemes at early stages of development, often omitting inflectional morphemes in obligatory contexts. This has typically been attributed to immature syntactic or semantic representations. In this study, the authors investigated the hypothesis that children's variable production of the 3rd person singular morpheme –*s* interacts with the phonological complexity of the verb stem to which it is attached.

Method: To explore this possibility, the authors examined longitudinal data from the spontaneous speech of 6 English-speaking children between ages 1;3 and 3;6 (years; months) and elicited imitations from a cross-sectional study of 23 two-year-olds (mean age of 2;2).

Results: The results showed that children produced third person singular morphemes more accurately in phonologically simple coda contexts (e.g., *sees*) as compared with complex coda contexts (e.g., *needs*). In addition, children produced –*s* more accurately in utterance-final position as compared with utterance-medial position.

Conclusions: The results provide strong support for the role of phonological complexity in explaining some of the variability in children's production of third person singular –*s*. This finding suggests that future research will need to consider multiple factors, including phonological and positional effects, in constructing a comprehensive developmental theory of both grammatical competence and processes of speech planning and production.

KEY WORDS: phonology, coda complexity, grammatical morphemes

It has long been observed that grammatical morphemes are variably produced in early speech (Bloom, 1970; Brown, 1973). Compare the variable production of the third person singular morpheme –*s* in examples (1a, b), both produced by the same child on the same day.

Example 1
Naima (2;2.11) (years;months.days) (1)
a. Mommy tries (to) do. (1a)
['mami 'traɪz du]

b. Mommy need(s) to go to the hospital. (1b)
['mami nid təgo tədə 'haspɪtəl]

Determiners, complementizers, subject–verb agreement, and auxiliaries are all considered to be grammatical function (as opposed to content) categories, each with its own syntactic structure (Abney, 1987; Chomsky, 1989). The fact that early stages of language acquisition exhibit variable use of such items has led some researchers to suggest that children's early grammars are syntactically impoverished, fluctuating between syntactic representations or consisting of a bare verb phrase (Lebeaux, 1988). Others propose that certain types of syntactic knowledge become available only as a child biologically matures (e.g., Radford, 1990). In particular, Wexler (1994) argues that children go through an "optional infinitive" stage of development, where they variably use infinitival, uninflected forms of verbs in contexts where the finite, inflected verb form is required. For instance, a child might say, *"This goes in there"* and at the same time, *"Patsy need a screw"* (Harris & Wexler, 1996, p. 11). According to the maturation hypothesis, the occasional use of grammatical morphemes is considered to be syntactically nonproductive. Rather, syntactic competence is considered to be achieved only once the child shows stable use of grammatical morphemes, signaling that the relevant grammatical principle has matured.

A few researchers have tried to determine why children's production of grammatical morphemes might be so variable. Some have taken a semantic approach, noting that the past tense morpheme tends to be produced earlier with accomplishment verbs (e.g., *dropped*) than with activity verbs (e.g., *played*; e.g., Bloom, Lifter, & Hafitz, 1980; Johnson & Morris, 2007). Drawing on cross-linguistic data, Hyams (2007) further suggests that children's use of grammatical markings on verbs is sensitive to aspectual distinctions. Thus, it may take children some time to learn how to appropriately mark the semantics of different types of events, and this may account for some of the variable production of inflectional morphemes in children's early speech. Thus, some of the variable production of early grammatical function morphemes might be due to semantic factors.

Other researchers have found that children variably produce grammatical morphemes in different phonological or prosodic contexts (e.g., Gerken, 1996). This would indicate that the locus of some of the variability in morpheme production is due to limitations on children's phonological representation or phonological competence rather than due to a lack of syntactic competence. If this is true, it would suggest that children's knowledge of syntax may be more advanced than typically assumed. It would also suggest that our measures of syntactic competence should take phonological factors into consideration.

In this article, we investigate whether phonological constraints can be used to predict the contexts in which children are likely to produce or omit third person singular morphemes. Researchers have long noted that children with specific language impairment (SLI) who have problems with phonology also have problems with the accurate production of grammatical morphemes. For example, Bortolini and Leonard (2000) found that English SLI children were less accurate than mean length of utterance (MLU)-matched controls at producing initial unfooted syllables and word-final coda consonants in monomorphemic words (e.g., *banana, fast*). These same children were also more likely to omit grammatical morphemes involving the use of related phonological structures (e.g., *the car, climbed*). In addition, children with delayed expressive phonological abilities but average receptive vocabulary scores are more likely to omit grammatical morphemes than would otherwise be expected (Rvachew, Gaines, Blanchet, & Cloutier, 2005). These studies indicate a close connection between phonological and morphological development in language-delayed populations. Thus, it seems promising to explore a phonological explanation for some of the variability found in typically developing children's production of grammatical morphemes.

A Phonological Approach

A number of findings in the literature support the position that children's phonological limitations contribute to some of the early variability in the production of grammatical morphemes. These results come from cross-linguistic studies of both typically developing children and those with SLI. These studies involve two types of constraints on phonological representations: (a) those often referred to as *rhythmic* or *metrical constraints* and (b) those involving issues of syllable structure complexity. Because both of these occur at a level of phonological structure above that of individual phonemes, we refer to both types of phonological limitations as *prosodic constraints*. In particular, we propose that children do not randomly omit grammatical morphemes. Rather, we hypothesize that, all else being equal, children will be more likely to produce grammatical morphemes in phonologically (or prosodically) unmarked, or simple, contexts. This is called the *prosodic licensing hypothesis* (Demuth & McCullough, 2009). This allows us to make testable predictions about the contexts in which grammatical morphemes will be most likely to appear, both in English and across languages. In this article, we discuss some of the literature that provides support for the prosodic licensing hypothesis. We first discuss some of the metrical findings (i.e., phrase-level constraints) and then focus on the syllable structure findings (i.e., syllable- or word-level constraints), providing a reference point for our study of third person singular *–s*.

Phrase-level constraints on the production of grammatical morphemes. Researchers have previously noted that until around age 2;6, children learning the southern Bantu language known as Sesotho tend to omit noun class prefixes, which are grammatical morphemes indicating the class/gender of a noun (Connelly, 1984). However, prefixes with monosyllabic stems are consistently produced. Demuth (1992, 1994) proposed that some of the variable production of these grammatical morphemes could be explained in terms of phonological constraints. Specifically, she proposed that noun class prefixes were more likely to be produced when they formed part of a disyllabic foot (e.g., $[\underline{mo}\text{-}tho]_{Ft}$ "person") but tended to be omitted when they were unfooted—that is, when the nominal stem already had two syllables (e.g., $(\underline{mo})\text{-}[sa.di]_{Ft}$ "woman"). Recent research has shown that this stage of development lasts until around age 2;3–2;6 (Demuth & Ellis, 2009).

Similarly, Gerken and colleagues (Gerken, 1991, 1994, 1996; Gerken & McIntosh, 1993) showed that the variable production of English pronominal subjects and articles is partially explained by the different metrical or rhythmic contexts in which these appear. As in Sesotho, English articles are more likely to be produced when they can be prosodified as part of a trochaic foot. In contrast, articles are more often omitted when they appear in unfooted contexts. Gerken (1996) claimed that this helps explain why 2-year-olds tend to produce footed object articles such as that in Example 2a more frequently than unfooted articles such as that in Example 2b.

Example 2 (2)

a. He kicks the piggy. (2a)

$[S \quad \underline{w}]_{Ft}\ [S\ w]_{Ft}$

b. He catches (the) piggy. (2b)

$[S \quad w]_{Ft}\ \underline{w}\ \ [S\ w]_{Ft}$

More recently, Demuth and McCullough (2009) examined the emergence of articles in five English-speaking 1- to 2-year-olds by looking at longitudinal, spontaneous speech data. They confirmed Gerken's (1996) findings from elicited imitation tasks, showing that children were more likely to produce articles when these occurred as part of a trochaic foot than when they appeared in an unfooted context.

Similar findings have also been reported in a longitudinal study of 2 children learning French, where foot structure is iambic rather than trochaic (Demuth & Tremblay, 2008). In all cases, the limiting factor was shown to be children's lack of prosodic organization at the level of the phonological phrase (for reviews, see Demuth & Tremblay, 2008; Gerken, 1996). Taken together, the findings from these metrically different languages show that some of the variability in children's early production of grammatical morphemes may be explained in terms of rhythmic constraints.

Sensitivity to rhythmic constraints may also explain why Italian-speaking children with SLI exhibit an extended period of variable production of articles (Leonard, Bortolini, Caselli, & Sabbadini, 1993). Given that there are few monosyllabic words in Italian, most articles are unfooted. The prosodic licensing hypothesis would therefore predict that Italian articles are especially vulnerable to omission until children develop competence with more complex, higher-level prosodic structures. Similar issues appear to be relevant for understanding the variable production of articles in Spanish and German (Demuth, 2001; Lleó, 2001; Lleó & Demuth, 1999). We now turn to a discussion of findings on syllable-structure constraints and implications for the acquisition of inflectional morphemes.

Syllable-level constraints on the production of grammatical morphemes. Besides being affected by rhythmic constraints, children's productions of grammatical morphemes are also affected by syllable-level constraints. For example, before typically developing children can reliably produce inflectional morphemes such as the plural morpheme *–s* in a word such as *cats,* it is necessary that these children have the ability to produce word-final /ts/ (Bernhardt & Stemberger, 1998). Thus, children's phonological grammars need to be able to handle certain types of coda consonant clusters before they begin to produce inflectional morphemes.

Johnson and Morris (2007) and Oetting and Horohov (1997) found that young children with and without language impairment were more likely to inflect past tense verbs ending in a nonobstruent consonant (e.g., *rolled*) than verbs ending in an obstruent consonant (e.g., *walked*). Thus, the sonority of the stem-final coda consonant or the sonority hierarchy of coda consonant clusters may also have an impact on the production of inflectional morphemes.

Furthermore, in one of the early studies investigating children's knowledge of inflectional morphology, Berko (1958) found that children were more likely to produce the past tense morpheme in verbs that ended in a noncoronal consonant (e.g., *kicked*) than in those that ended in coronal consonants /t, d/, where syllabic *–ed* is required (e.g., *wanted*). Thus, adding another syllable to the inflected word is apparently more difficult than having a consonant cluster (see similar findings by Marchman, Wulfeck, & Weismer, 1999).

Most relevant to the present study is an investigation of 9- to16-year-old grammatical-SLI children, where Marshall and van der Lely (2007) investigated the impact of the number of consonants at the end of the inflected verb on the production of past tense inflections. Using an elicited production task, participants were found to have increasing difficulty producing past tense morphemes as word-final consonant complexity increased from one to three consonants (e.g., *sewed* /soʊd/, *yelled* /jɛld/, *danced* /dænst/). Thus, the number of consonants at the end of the word—that is, an increase in coda consonant complexity—helps to explain some of the variable production of the past tense morpheme in grammatical-SLI children.

Other factors affecting the production of grammatical morphemes. Besides constraints on rhythm and syllable shape, children's production of grammatical morphemes is also likely to be affected by frequency of occurrence, position in the utterance, and length of the utterance. There is evidence that the frequency of inflected plurals in the input that children hear is a good predictor of their likelihood of producing plural *–s* (Zapf, 2004). Further attesting to the role of input statistics, several studies have shown that typically developing children (Edwards & Beckman, 2008; Edwards, Beckman, & Munson, 2004; Munson, 2001; Storkel, 2001; Zamuner, Gerken, & Hammond, 2004) as well as those with SLI (Munson, Edwards, & Beckman, 2005; Munson, Kurtz, and Windsor, 2005) repeat novel words with high-probability phoneme sequences more accurately than they repeat those with low-probability sequences. In addition, many of these studies indicate that children with smaller vocabularies are more likely to be affected by input statistics than children with larger vocabularies. Given these findings, it is possible to predict that frequency (or the phonotactic probability) of the inflected form might account for some of the variable production of inflectional morphemes.

Still others have found that the prosodic characteristics of words in different positions within the utterance may influence children's abilities to both perceive and produce grammatical inflections. For instance, using a sentence imitation task, Dalal and Loeb (2005) found that 5-year-olds with SLI were more likely to produce the past tense *–ed* morpheme in utterance-final as opposed to utterance-medial position. The authors suggested that the higher perceptual salience of words or morphemes in utterance-final position due to final lengthening facilitates morpheme processing and production in imitation tasks. In addition, Kirk and Demuth (2006) showed that coda consonants are more reliably produced in syllables with longer duration. Thus, there may be more time to complete the full articulation of coda consonants in longer syllables, such as those at the end of an utterance.

Of particular interest in this study is the unique distribution of third person singular *–s* in parental speech. Leonard and colleagues (e.g., Leonard & Bortolini, 1998) have raised the possibility that inflectional morphemes might be especially vulnerable and are likely to be omitted because they are composed of phonetically short elements that might be difficult to perceive. This problem is exacerbated in the case of English verbs, as these tend to occur utterance-medially in parental speech, whereas plural nouns tend to occur utterance-finally (Hsieh, Leonard, & Swanson, 1999). Hsieh et al. (1999) report that, as a consequence of this difference in distribution, third person singular *–s* is much shorter in duration compared with plural *–s,* perhaps reducing the perceptional salience of the third person singular morpheme. These authors suggest that this distributional difference may help explain some of the differences in the rate of acquisition of plural *–s* versus third person singular *–s*.

Finally, some researchers suggest that processing factors may account for some of the variability in the production of grammatical morphemes. Specifically, longer utterances require greater processing load—in their planning as well as their articulation. An increase in processing load, in turn, may lead to less efficiency in producing speech. A speaker is thus more likely to make speech errors in longer utterances, often omitting some linguistic constituents as a way to reduce processing demands (Bloom, 1990; Valian, 1991). For example, Valian (1991) found that English-speaking children between ages of 1;10 and 2;8 were more likely to omit grammatical morphemes such as pronominal subjects in longer utterances. This suggests that the increased length of an utterance, which may also include greater grammatical complexity, can have a detrimental effect on morpheme production.

Predictions for children's *acquisition of third person singular –s.* Despite its high variability in children's early speech and its importance in recent work on the locus of grammatical problems in children with SLI (e.g., Rice & Wexler, 1996), there has been little research examining possible phonological constraints on the acquisition of third person singular *–s*. Children typically acquire third person singular morphemes relatively late (Brown, 1973), showing variable production of this morpheme until around the age of 3–4 years, and longer in children with SLI. The goal of this study was, therefore, to better understand why the third person singular morpheme *–s* is so variable in children's early speech and if phonological complexity at the level of the syllable might account for some of this variability.

Following Clements and Keyser's (1983) work on syllable structure[1], we refer to final consonant+s coda clusters (e.g., *needs*) as phonologically "more complex" than singleton *–s* codas (e.g., *sees*). It is generally assumed that linguistically more complex forms are more challenging for children to acquire or produce (Bloom, 1970; Brown & Hanlon, 1970; Kamhi, Catts, & Davis, 1984). In particular, researchers have noted that words with simple syllable structures appear earlier in development, with

[1]According to some accounts of syllable structure, liquids and nasals followed by *–s* can be syllabified as part of a branching coda, whereas obstruent+s clusters, which violate the sonority sequencing principle, must be syllabified as a singleton coda consonant plus an *–s* appendix at the higher level of the syllable (Selkirk, 1982; see Kirk & Demuth, 2005, for discussion). However, in a cross-sectional study using a picture identification task, Kirk and Demuth (2005) found that 2-year-olds produced nasal+s and obstruent+s clusters equally well. Thus, both types of consonant+s clusters appear to be acquired at similar developmental periods, regardless of their structural realization within the syllable. For simplicity, we refer to both types of consonant clusters as *codas* in the present study.

singleton –*s* codas (CVC) being acquired earlier than consonant cluster codas (CVCC; e.g., Levelt, Schiller, & Levelt, 2000). Thus, we predict that children will show better performance in the production of third person singular morphemes when these occur as part of a phonologically simple (singleton–C) coda than a phonologically more complex (cluster–CC) coda. That is, we expect to find that children who exhibit variability in their production of third person –*s* will be more likely to produce this morpheme in words such as *sees* than in words such as *needs*.

To address this issue, we first examined longitudinal data from 6 English-speaking children's spontaneous productions from age 1;3 to 3;6. We then confirmed and elaborated on our findings in a more controlled, cross-sectional, elicited imitation study with 23 two-year-olds (aged 1;10–2;4).

Experiment 1: Longitudinal Study

Brown (1973) reports that many grammatical morphemes are acquired between the ages of 1 and 3 years. However, it is often difficult to test children below the age of 2 years in elicited imitation tasks. Therefore, examining longitudinal, spontaneous production data can be particularly useful when investigating children's early use of grammatical morphemes. Furthermore, looking at spontaneous data provides a rich source of information about how children typically produce grammatical morphemes in a natural environment. In this longitudinal study, we provide information about individual patterns of third person singular morpheme development in children between ages 1;3 and 3;6, paying particular attention to the role of coda complexity. In this study, we also examined the contribution of phonological constraints relative to the role of the morpheme's position within the utterance (medial vs. final), utterance length (in words), MLU (in morphemes), and frequency of the inflected form of the verb in child-directed speech.

Method

Database and participants. The data examined in this study were drawn from the Providence Corpus (Demuth, Culbertson, & Alter, 2006), a longitudinal corpus consisting of spontaneous speech interactions between 6 mother–child dyads from the southern New England region of the United States (for further information and access to the corpus, see the Child Language Data Exchange System (CHILDES; see http://childes.psy.cmu.edu/). The profiles of the 6 children are shown in Table 1, along with their gender, age range studied, and MLU in morphemes. All 6 children were typically developing, monolingual speakers of American English. The parents of 2 children (Alex, Violet) spoke a dialect typical of southern New England, which is often characterized by the omission of postvocalic /ɹ/. The parental input for the other 4 children more closely resembled Standard American English.

Table 1. Gender, age and MLU profiles of participants.

Participants	Gender	Age at first recording (years;months)	Age range studied (years;months)	MLU range
Alex	Male	1;4.28	2;5.9–3;5.16	2.18–3.15
Ethan	Male	0;11.4	1;3.15–2;6.25	1.52–3.65
Lily	Female	1;1.2	1;9.12–2;7.1	1.84–3.99
Naima	Female	0;11.28	1;5.11–2;5.29	2.34–4.37
Violet	Female	1;2.0	1;9.25–3;6.21	1.59–3.65
William	Male	1;4.10	1;10.10–3;4.15	1.56–3.32

Note. MLU = mean length of utterance.

Digital audio and video recordings were collected in the children's homes for approximately 1 hr every 2 weeks for 2 years, from the onset of first words. The digital audio and video data were downloaded onto a computer, and both mother and child speech were orthographically transcribed using Codes for the Human Analysis of Transcripts (CHAT) conventions (MacWhinney, 2000). The child utterances were also transcribed by trained coders using International Phonetic Alphabet (IPA) transcription showing the phonemic representations of words and the position of stressed syllables. Ten percent of the child data from each recording session were re-transcribed by a second coder. Percent segmental agreement between the two transcribers ranged from 85% to 95%. Most of the disagreements were in vowel quality, although some involved place/manner of consonant articulation. Differences in voicing were not counted because young children's voicing is not stable enough to accurately transcribe (Stoel-Gammon & Buder, 1999). Two-year-olds' production of coda consonants has been shown to be affected by the position of a coda within the word, word length, and stress (Kirk & Demuth, 2006). We therefore limited our investigation to children's production of third person singular morphemes in monosyllabic words.

Procedure. Using discourse context as well as phonological cues (Vihman & McCune, 1994), we first extracted from the Providence Corpus all child target third person singular monosyllabic verbs where the stem had either no coda consonant (e.g., *sees*) or one coda consonant (e.g., *needs*). Thus, third person singular –*s* appeared in either simple (C) or more complex (CC) coda contexts. Verbs ending in CCC were few and were, therefore, not considered in this study. To avoid issues of *r*-less dialect and a tendency to vocalize word-final /ɹ/

and /l/, words ending in a liquid were excluded from the analysis (25 tokens).

Then, we further excluded all target words that were followed by vowel-initial words (207 tokens; e.g., *It goes in there* [ɪ ˈgozɪn ˈdeɪɛ]). We did this to avoid possible issues of re-syllabification, where a coda consonant becomes the onset of a following syllable. In general, such re-syllabification is known to occur only when the following syllable begins with a vowel, suggesting that this might be a strategy to use when trying to avoid onsetless syllables (Kenstowicz, 1994). Because it is unlikely that the word-final *–s* is re-syllabified as an onset of the following consonant-initial word, only target words followed by consonant-initial words were analyzed.

We also excluded immediate repetitions, which are target words followed by a word beginning with *s–* (five tokens; e.g., *But he looks small to me* [bə ɪˈlʊk ˈsmatə ˈmi]), and the few cases where it was impossible to distinguish between words in the production (two tokens; e.g., *He needs to go to the office* [inigələtudə ˈafɪ]). Items with poor acoustic quality were also excluded (seven tokens).

Data analysis began for each child from the point when they targeted the first third person singular verb. Data analysis terminated at age 2;6 or as soon as third person singular *–s* was successfully produced at least 80% percent of the time in simple C contexts across two consecutive sessions (3 children). In cases where this criterion was not reached (3 children), analysis continued until the end of data collection (around 3;6).

The resulting data set included 323 verb tokens (11 verb types) in simple C contexts and 284 verb tokens (40 verb types) in complex CC contexts (see Appendix A and B, respectively). Among the 323 tokens in simple C contexts, 225 tokens (70%) occurred in utterance-medial position and 98 tokens (30%) occurred in utterance-final position. As for the 284 tokens in complex CC contexts, 211 tokens (74%) and 73 tokens (26%) occurred in utterance-medial position and utterance-final position, respectively.

These items were then coded either as *–s produced* or *–s missing,* depending on whether the third person singular morpheme *–s* was present or not (see Table 2). For words ending with a singleton *–s* (simple C context), *–s missing* indicated that the target morpheme was either missing or substituted with another consonant (e.g., *goes* [go], [gop]). However, substitution of /s, z/ with /ʃ/, /θ/ or /ʒ/ was counted as *–s produced* because studies have shown that these consonants are often interchangeable with /s/ and /z/ in early speech (Bernhardt & Stemberger, 1998). Verbs ending with consonant clusters (complex CC context) were coded as *–s produced* if final /s, z/ was present, regardless of whether the consonant of the verb stem was present, reduced, or substituted (e.g., *looks* [lʊks], [lʊs], or [lʊts]). The few tokens with consonant epenthesis were also coded as *–s produced* (e.g., *looks* [lʊksk]). In contrast, a verb was coded as *–s missing* if a cluster was deleted (e.g., *looks* [lʊ]) or if *–s* was missing (e.g., *looks* [lʊk], [lʊp]).

Results

Chi-Square: Group and Individual Results

Overall, the 6 children produced third person singular *–s* more often in simple C contexts as compared with complex CC contexts (75% vs. 54%). The result from a χ^2 test indicated that this difference was highly significant, $\chi^2(1, N = 607) = 29.47$, $p < .001$. This supports our hypothesis that word-final morpheme production is affected by coda consonant complexity.

Further analysis of individual children's performance showed that 4 of the 6 children were more likely to produce third person singular morphemes in the phonologically simple C contexts than in complex CC contexts: Alex, $\chi^2(1, N = 107) = 5.65, p = .017$; Ethan, $\chi^2(1, N = 86) = 15.02,$

Table 2. Number of tokens coded as "–*s* produced" versus "–*s* missing" in C and CC contexts.

	C context (e.g., goes [goz])			CC context (e.g., looks [lʊks])						
	–*s* produced	–*s* missing		–*s* produced				–*s* missing		
Participant	[goz]	[go]	[gop]	[lʊs]	[lʊks]	[lʊts]	[luksk] [lukps]	[lʊk]	[lʊp]	[lʊ]
Alex	59	25	–	7	3			8		5
Ethan	18	6	–	3	15			29	1	14
Lily	56	12	–	2	42		1	10		1
Naima	53	7	1	5	29		1	17		1
Violet	45	20	–	4	22	2		17	1	9
William	12	9	–	2	14	2		9	2	6
Total	243	79	1	23	125	4	2	90	4	36

$p < .001$; Naima: $\chi^2(1, N = 114) = 7.00$, $p = .008$; Violet: $\chi^2(1, N = 120) = 4.20$, $p = .040$). Two children showed no difference in performance between the two contexts: Lily, $\chi^2(1, N = 124) = .08$, $p = .776$; William, $\chi^2(1, N = 56) = .17$, $p = .678$. Lily was at ceiling, showing high accuracy on the production of third person singular *–s* in both simple and complex contexts (C: 82% vs. CC: 80%). In contrast, William showed overall poor performance on the production of third person singular morphemes (C: 57% vs. CC: 51%).

Table 3 provides a longitudinal picture of how individual children produced third person singular morphemes in each phonological context. The data are grouped into 4-month intervals. Here, as well, it can be seen that the 4 children who showed a complexity effect exhibited a gradual increase in morpheme production accuracy over time, generally becoming more accurate in simple C contexts first. In contrast, Lily showed high levels of accuracy from the onset of her first verbs. William's development of third person singular was slower than that of other children. He also produced very few target third person singular verbs overall.

Thus, the children in the longitudinal study were less accurate at producing third person singular *–s* when the morpheme was part of a complex coda cluster. These results indicate that the production of the third person singular morpheme in typically developing children is subject to coda complexity effects similar to those reported for older grammatical-SLI children's production of past tense morphemes (Marshall & van der Lely, 2007).

Logistic Regression: Group Results

To explore the relative contributions of phonological, processing, and lexical factors, we conducted a stepwise logistic regression analysis. Logistic regression is ideal when some continuous and some categorical factors are used as predictors of a dependent variable that is binary. Six hundred and seven third person singular verb tokens (C: 323, CC: 284) from 6 children were used as individual data points in a logistic regression analysis. The dependent variable was either *–s produced* or *–s missing*. Nine independent variables were examined: (a) two categorical factors—coda complexity and position of the verb within the utterance; (b) three continuous factors—utterance length (in words), frequency of the inflected verb, and the child's MLU (in morphemes); (c) and four interactions—Complexity × Length, Complexity × Frequency, Complexity × Position, Position × Length.

In stepwise logistic regression, analysis begins with a model with no factors, including just a constant (Step 0). At each step, the most significant term is added to the model until none of the factors left out of the model would have a statistically significant contribution if they were added to the model (Step 5). The results are shown in Table 4 and are discussed in the sections that follow.

Table 3. Number (percent) of children's production of third person singular *–s* in C and CC contexts over time.

	Alex		Ethan		Lily	
Age	C	CC	C	CC	C	CC
1;3–1;6	–	–	4/6 (67%)	0/9 (0%)	–	–
1;7–1;10	–	–	6/8 (75%)	3/23 (13%)	–	0/1 (0%)
1;11–2;2	–	–	4/5 (80%)	8/20 (40%)	16/22 (73%)	13/23 (57%)
2;3–2;6	1/16 (6%)	–	4/5 (80%)	7/10 (70%)	35/41 (85%)	31/31 (100%)
2;7–2;10	3/9 (33%)	3/9 (33%)	–	–	5/5 (100%)	1/1 (100%)
2;11–3;2	51/52 (98%)	7/12 (58%)	–	–	–	–
3;3–3;6	4/7 (57%)	0/2 (0%)	–	–	–	–
Total	59/84 (70%)	10/23 (43%)	18/24 (75%)	18/62 (29%)	56/68 (82%)	45/56 (80%)
	Naima		**Violet**		**William**	
Age	C	CC	C	CC	C	CC
1;3–1;6	5/5 (100%)	–	–	–	–	–
1;7–1;10	26/30 (87%)	12/20 (60%)	5/7 (71%)	0/4 (0%)	0/2 (0%)	1/1 (100%)
1;11– 2;2	8/8 (100%)	8/14 (57%)	8/13 (62%)	3/6 (50%)	–	4/5 (80%)
2;3–2;6	14/18 (78%)	15/19 (79%)	21/29 (72%)	12/18 (67%)	1/1 (100%)	1/1 (100%)
2;7–2;10	–	–	8/13 (62%)	5/10 (50%)	3/4 (75%)	5/9 (56%)
2;11–3;2	–	–	1/1 (100%)	2/3 (67%)	6/11 (55%)	3/9 (33%)
3;3–3;6	–	–	2/2 (100%)	6/14 (43%)	2/3 (67%)	4/10 (40%)
Total	53/61 (87%)	35/53 (66%)	45/65 (69%)	28/55 (51%)	12/21 (57%)	18/35 (51%)

Table 4. Relative contribution of individual factors in explaining the production patterns of third person singular –*s* using logistic regression.

Factor	Coefficient *B*	*SE B*	Wald	Exp(*B*)	*p*
Step 1					
Complexity (C, CC)	−0.942	0.176	28.786	2.564	<.001
Step 2					
Complexity (C, CC)	−1.046	0.182	33.189	0.351	<.001
MLU	0.853	0.178	23.080	2.348	<.001
Step 3					
Complexity (C, CC)	−1.014	0.183	30.784	0.363	<.001
MLU	1.027	0.190	29.145	2.792	<.001
Utterance Length	−0.101	0.036	7.914	0.904	.005
Step 4					
Complexity (C, CC)	−1.018	0.184	30.699	0.361	<.001
MLU	1.089	0.194	31.576	2.972	<.001
Utterance Length	−0.080	0.037	4.677	0.923	.031
Position (final, medial)	−0.483	0.220	4.822	0.617	.028
Step 5					
Complexity (C, CC)	−1.038	0.185	31.543	0.354	<.001
MLU	1.145	0.198	33.565	3.143	<.001
Utterance Length	−0.153	0.052	8.735	0.858	.003
Position (final, medial)	−1.223	0.436	7.875	0.294	.005
Utterance Length × Position	0.199	0.099	4.020	1.221	.045

Note. Negelkerke's R^2 was .07 for Step 1, .12 for Step 2, .13 for Step 3, .14 for Step 4, and .15 for Step 5. Only significant (p <.05) contributors are included at every step. SE = standard error; Exp(B) = estimated odds ratio.

Together, these factors were able to correctly predict 67.9% of third person singular –*s* productions by the 6 children.

Coda complexity. As shown in Table 4, coda complexity was the first factor entered into the model, indicating that of all the factors, coda complexity was most effective in predicting the contexts where third person singular –*s* was produced correctly. The negative sign on the coefficient *B* confirms that with increasing coda complexity, children's ability to produce third person singular –*s* decreased. This result is consistent with the χ^2 test, which examined coda complexity as a single independent variable. Thus, coda complexity appears to play an important role in the production of third person singular morphemes, even when the effects of other factors are taken into consideration. This provides additional support for our hypothesis that phonological complexity accounts for some of the variability in children's early production of this morpheme.

Position within the utterance. In addition to coda complexity, we examined whether the position of the third person singular morpheme within the utterance influenced children's production of third person singular –*s*. In subject-verb-object languages such as English, children hear third person singular verbs more often in utterance-medial position than in utterance-final position (Hsieh et al., 1999). Similarly, we found that 72% of the children's attempted third person singular verbs in this study occurred in utterance-medial position. Of these 436 tokens, about half were verbs with simple C structure (225 tokens) and half were verbs with more complex CC structure (211 tokens). Thus, although children's early utterances often consisted of only a few words, most of their attempted third person singular verbs occurred in utterance-medial position, and this was balanced across complexity.

Given the high frequency of utterance-medial third person singular verbs in parental speech (Hsieh et al., 1999), we might have expected children to accurately produce third person singular –*s* in utterance-medial position. As shown in Table 4, morpheme production was significantly influenced by position: However, the coefficient indicates that children produced fewer correct third person singular morphemes in utterance-medial position. Thus, similar to Dalal and Loeb's (2005) findings of past tense –*ed* morpheme production by 5-year-old children with SLI, the typically developing children in this study were also more likely to produce third person singular –*s* utterance-finally. Not surprisingly, the effects of position were also greater with increased utterance length, as confirmed by a significant interaction. Thus, children had greater difficulty producing utterance-medial third person singular –*s* in longer sentences.

As discussed in the introduction, the poorer performance in medial position could be due to the fact that phrase-medial words in English are typically shorter in duration than those in phrase-final position (Hsieh et al., 1999). Children begin to exhibit phrase-final lengthening similar to adult speakers around the time that they begin to combine words (Snow, 1994, 1998). Therefore, it is likely that the increased duration in phrase-final position provides more time for children to produce segments at the end of a word, facilitating final consonant (and morpheme) production. Similarly, Kirk and Demuth (2006), in a study of tautomorphemic word-internal and word-final coda consonants, found that these were most likely to be produced by children in word-final syllables or word-medial stressed syllables. They suggest that this may be due to the increased duration in both types of syllables, perhaps providing more time for young speakers to produce the coda consonant.

Utterance length. Third person singular morphemes are relatively late acquired compared with other grammatical morphemes (Brown, 1973). Therefore, it is likely that these morphemes are used in syntactically complex structures in longer utterances. This might increase the overall processing and planning load, leading to morpheme omission in longer utterances (e.g., Valian, 1991).

To investigate the possible effects of processing load on children's production of third person singular *–s,* we counted the number of words in each utterance and examined whether *–s* was more likely to be omitted with increasing utterance length. The length of these children's utterances ranged from 1 word to 21 words, with a mean length of 4.58 words (SD = 2.65). The results in Table 4 confirmed that the children's production of third person singular morphemes was adversely affected by utterance length, with children producing third person singular *–s* less frequently in longer utterances.

Inflected frequency. Lexical frequency factors might also help explain why children were good at producing third person singular morphemes only in some tokens. Young language learners are known to be sensitive to the frequency of various linguistic structures. For example, Zapf (2004) found that typically developing 2-year-olds produced plural nouns more accurately when the inflected form was frequent in the input (e.g., *books, shoes, dogs*). Oetting and Rice (1993) reported similar findings for children with SLI. That is, nouns that are frequently pluralized in everyday speech (e.g., *dogs, doors*) were more readily inflected than nouns that are infrequently pluralized (e.g., *stoves, clocks*).

Therefore, we examined whether children's production of third person singular *–s* may have been affected by inflected frequency in the input. To determine inflected frequency, we consulted the CHILDES database (MacWhinney, 2000). The CHILDES Parental Corpus contains around 2.6 million word tokens and 24,000 word types used in child-directed speech. If input frequency accounts for some of the variability in the production of third person singular morphemes, children should be more accurate at producing third person singular *–s* for verbs that are frequently inflected in parental input. However, the results of the logistic regression indicated no advantage for frequent third person singular verbs. There was no significant contribution of inflected frequency, nor was there a significant contribution of the Complexity × Inflected Frequency interaction.

Further investigation would be needed to explain why children's production of third person singular morphemes might not benefit from an increase in lexical frequency. Hsieh et al. (1999) showed that third person singular morphemes in utterance-medial position are likely to have short durations, even in mothers' speech. If third person singular morphemes are less perceptually salient in the speech input to children, perhaps they are less likely to benefit from the high frequency of the morpheme. In contrast, it might be easier for children to take advantage of the frequency of morphemes such as plural *–s* because these often occur in utterance-final position, where they are typically lengthened. Alternatively, it is possible that the aggregate inflected frequencies presented in the CHILDES database are not a good estimate of the frequency with which these particular children heard these words.

MLU. The last factor that we examined was MLU, calculated by averaging the number of morphemes over the whole utterances produced by each child. Because MLU is a common measure of linguistic ability in children, we predicted that a child who had low MLU would also show poor performance in producing third person singular morphemes. The results in Table 4 confirmed this prediction: Children's increasing ability to produce third person singular *–s* was significantly correlated with increasing MLU. This indicates that there is a strong correlation between children's general language abilities and their production of third person singular morphemes.

Discussion

In sum, the logistic regression showed that the production of third person singular *–s* was influenced by coda complexity, position within the utterance, utterance length, the Position × Utterance Length interaction, and MLU. Frequency of inflected form, however, failed to explain children's production pattern for third person singular *–s*.

The patterns found in children's production of third person singular *–s* could be also explained by factors other than those considered in the model. Here, we discuss some of the possible factors. Because there was a larger type inventory for the verbs in CC contexts than in C contexts (see Appendixes A and B), it is likely that children produced the same verbs in the C contexts repeatedly. If so, the reduced number of errors in C contexts may be due to practice effects. To investigate this possibility, we divided the verbs in the simple C context into high token frequency verbs (>80 occurrences; e.g., *goes, says*) and low token frequency verbs (<10 occurrences; e.g., *sees, tries*) in children's own production. Surprisingly, children accurately produced only 74% of the high token frequency verbs, whereas they produced 87% of low token frequency verbs. Thus, we think it is unlikely that simple practice effects can account for children's greater accuracy in simple C compared with complex CC context.

Another factor to be considered is the phonological context of the word following third person singular –*s* in utterance-medial position. For instance, one might wonder whether third person singular morphemes are more accurately produced when they are followed by function words than content words, given that function words are often unstressed and can perhaps re-syllabify with the preceding syllable. However, function words in the current study occurred with comparable frequency following utterance-medial third person singular –*s* in simple C (36%) and complex CC (29%) contexts.

Finally, because third person singular verbs were always followed by consonant-initial words, the utterance-medial position in the present study can also be seen as a context with greater phonological complexity. If utterance position is the primary factor mediating phonological complexity, we might expect an equally accurate production of third person singular –*s* in utterance-medial simple C contexts (e.g., *sees him*) and utterance-final complex CC contexts (e.g., *needs*), as both induce CC phonological contexts. However, our results suggest that the effect of coda complexity overrides that of phrasal complexity—that is, children produced the third person singular morphemes more accurately in utterance-medial simple C contexts (72%) even compared with utterance-final complex CC contexts (58%). This difference was significant, $\chi^2(1, N = 298) = 5.71, p = .02$. At the same time, as shown by the logistic regression analysis, children's production of third person singular –*s* was also affected by utterance position. We expect that further acoustic analysis of utterance-medial third person singular verbs, in both child and parent speech, will provide a more comprehensive understanding of why children's production of third person singular –*s* is adversely affected in utterance-medial position.

Summary: Longitudinal Study

The longitudinal study examined the possible effects of coda complexity on the variable production of third person singular morphemes in children's spontaneous speech. Chi-square analyses of the data from individual participants showed that 4 of 6 children were significantly better at producing third person singular morphemes in simple C compared with complex CC contexts. Among the 2 children who showed no effects of complexity, William was still at the early stages of acquiring third person singular morphemes; he showed overall low performance and attempted few third person singular verbs. In contrast, Lily was highly accurate at producing third person singular morphemes in both simple C and complex CC contexts, showing little variability. The logistic regression analysis showed that the variability in children's early production of word-final grammatical morphemes can be explained by multiple factors, with coda complexity significantly influencing children's production of third person singular –*s*.

The results of the longitudinal study highlight the role of phonological constraints in understanding children's variable production of English inflectional morphology. The results also suggest that children's grammatical knowledge of the third person singular may be better than often assumed. That is, if children can produce third person singular –*s* more reliably in phonologically simple contexts, this would indicate that some of the variable production of this morpheme may be due to phonological rather than syntactic limitations. The fact that this morpheme was also less reliably produced in utterance-medial compared with utterance-final position also suggests that perceptual salience and/or prosodic aspects of utterance position will need to be considered in assessing children's grammatical competence.

To explore these issues further, with more children, we designed the following cross-sectional elicited imitation study, where sentence length and lexical frequency were controlled. Because verbs in English tend to occur in utterance-medial position, another goal of the cross-sectional study was to further explore the effects of utterance position on the production of third person singular –*s*.

Experiment 2: Cross-Sectional Study

The goal of the cross-sectional study was to determine the robustness of the coda consonant complexity effect on children's production of third person singular –*s*. We also wanted to further investigate the effect of the position of third person singular –*s* within the utterance. From Table 3, it is evident that by age 2;0, most children have started producing third person singular –*s* in some but not all contexts. Thus, children around this age were expected to show variability in their production of third person singular –*s*. Therefore, in the cross-sectional study, we tested 2-year-olds using an elicited imitation task similar to that used in Gerken (1996).

Consistent with the longitudinal study, target third person singular verbs in the cross-sectional study were monosyllabic. The target verbs varied in coda complexity (simple C vs. complex CC) and in the position within an utterance (utterance-medial vs. utterance-final). Sentence length and lexical frequency were controlled: All sentences were three words (and three syllables) long, and the inflected verbs were selected to be highly frequent, both in the input children typically hear and in child productions.

On the basis of the results from the longitudinal study, we predicted that 2-year-olds would produce third person singular *–s* more often in simple C contexts than in complex CC contexts. We also predicted that children would produce third person singular *–s* more often when target verbs occurred in utterance-final compared with utterance-medial position.

Method

Participants. Participants were 23 full-term, monolingual English-learning 2-year-olds (12 girls, 11 boys). The children ranged in age from 1;9.30 to 2;4.16, with a mean age of 2;2. According to parental report, the children had normal hearing and vision and good health; none of the children had a cold or an ear infection on the day of testing. An additional 21 children were tested but were excluded from analysis either because they did not attempt any sentences (n = 19) or they attempted fewer than 8 of 16 target sentences (n = 2). The attrition rate, although high, was quite consistent with previous literature; depending on the nature of the elicited imitation task, attrition rates often range between 25% and 50% (e.g., Gerken, 1996). Furthermore, all of the children in the cross-sectional study had previously performed a comprehension/looking task for another experiment (Sundara, Demuth, & Kuhl, 2009). This task was easy, requiring only that the child listen and look. In contrast, the elicited imitation task that followed required the children to actively produce sentences. The preamble to production tasks typically involves looking at a picture book with the experimenter, where the child is encouraged to identify objects. In such cases, the child has already begun to talk before the elicited production task begins. In the present study, however, the picture book warm-up task was omitted in an effort to keep total test time to a minimum, and we suspect that this resulted in a higher attrition rate than might otherwise have been expected. Because we were interested in the factors that might account for the variability in production of third person singular *–s,* 7 children who were either at ceiling or floor (i.e., above 90% or below 10% correct) were excluded from the analysis.

Stimuli. Twenty target sentences were used in an elicited imitation task to examine children's production of third person singular morphemes in various contexts. Of the 20 sentences, 4 were fillers with a plural third person subject (e.g., *There they play*), where the use of third person singular *–s* would be ungrammatical. Because the participants made no errors of commission—that is, overgeneralization of third person singular *–s* on the plural filler sentences (e.g., *There they plays*)—the fillers are not discussed further.

The remaining 16 target sentences contained high-frequency pictureable action verbs containing either a simple C coda (*blows, cries, flies, throws*) or a complex CC coda (*drives, eats, runs, sleeps*). The target verbs were embedded either in medial or final position in three-syllable, three-word sentences with a third person singular subject (e.g., *He cries now, There he cries*). These sentence frames were constructed to contain intransitive verbs with a pronominal subject, followed by a consonant-initial adjective. These particular verbs were also selected to ensure that the children in our study would be likely to comprehend, and therefore produce, the inflected forms. Verb familiarity was determined, in part, by examining children's MacArthur Communicative Development Inventories (CDI; Fenson et al., 2000) comprehension scores of each target verb at 16 months (age 1;4) and production scores at 16 and 24 months (ages 1;4 and 2;0; Dale & Fenson, 1996) but primarily using information from the CHILDES database regarding inflected (and noninflected) verb frequency in child-directed speech (Li & Shirai, 2000; MacWhinney, 2000). In particular, we selected pictureable activity verbs with comparable inflected frequency in the input that the children were likely to comprehend and produce. This information is presented in Table 5.

To determine whether there were systematic differences in input frequency of target verbs with simple and complex codas, the effect of coda complexity (simple, complex) on inflected and noninflected frequency from the CHILDES database was tested with two separate t tests. There was no significant effect of complexity on either inflected frequency, $t(6) = -1.88$, $p = .11$, or noninflected frequency, $t(6) = -1.07$, $p = .33$, indicating that simple C and complex CC verb stimuli were matched for input frequency. Thus, despite the fact that the verbs *eat* and *eats* appear to have a higher frequency than other verbs in comprehension, production, and input, this provided no overall frequency advantage for the verbs ending in a complex CC coda.

A 36-year-old, female native speaker of American English who is also a trained musician read the 16 target and 4 filler sentences in an animated voice. Sentences were recorded in a soundproof booth using a Shure SM81 tabletop microphone (Shure Incorporated, Niles, IL). All

Table 5. Characteristics of the target verbs used in the cross-sectional study.

Target verb	Proportion of children from CDI database: Comprehending at 16 months	Producing at 16 months	Producing at 24 months	Frequency from CHILDES database: Inflected	Noninflected
blow	58.3	9.7	54.2	24	545
cry	63.9	19.4	67.3	38	296
fly	Missing entry from CDI			39	305
throw	77.8	9.7	48.6	24	858
drive	36.1	4.2	54.2	39	292
eat	84.7	19.4	79.4	135	3,960
run	50	5.6	56.1	59	618
sleep	61.1	15.3	61.7	56	822

Note. CDI = Child Development Inventory; CHILDES = Child Language Data Exchange System.

sentences were digitized at a sampling frequency of 44.1 KHz and 16-bit quantization and were excised using PRAAT (Boersma & Weenink, 2005). Target sentences had an average duration of 1.85 s (range: 1.41–2.6) and a mean F_0 of 229 Hz (range: 191–263). Each stimulus sentence was then paired with an animated cartoon of a person performing the action (e.g., crying, running). The cartoons were screened for good action-verb association by both adults and 2-year-olds, ensuring that the elicited imitations would have a referential context.

To examine the acoustic cues signaling third person singular morphemes in target sentences, the onset and offset of *–s* and the onset and offset of the preceding vowel were identified using a waveform supplemented by a spectrographic display in PRAAT. Following Munson (2004), the *onset* of *–s* was defined as the onset of high-frequency aperiodic noise; the *offset* was defined to be the end of the aperiodic noise. The onset and offset of the vowel was visually identified as the onset and offset of abrupt change in the spectrogram and amplitude of the waveform.

The duration of third person singular *–s* and the preceding vowel in each target test sentence is provided in Table 6. To probe for systematic acoustic differences among the four sets of sentences, a two-way repeated-measures analysis of variance (ANOVA) was carried out with coda complexity (simple, complex) and sentence position (medial, final) as the independent variables and duration of *–s* as the dependent variable. Only the main effect of sentence position was significant, $F(1, 3) = 40$, $p = .008$. Specifically, sentence-final *–s* (202.4 ms) was longer than sentence-medial *–s* (125.1 ms). The main effect of complexity was not significant, $F(1, 3) = 5.4, p = .11$; the Complexity × Position interaction was not significant either, $F(1, 3) = 0.58, p = 0.5$.

Similarly, another two-way repeated-measures ANOVA was carried out with coda complexity (simple, complex) and sentence position (medial, final) as the independent variables and duration of preceding vowel is the dependent variable. There was a significant main effect of complexity, $F(1, 3) = 23.8, p = .02$, and sentence position, $F(1, 3) = 63.9$, $p = .004$. The Complexity × Position interaction was also marginally significant, $F(1, 3) = 11.1, p = .045$. In post hoc tests, four pair-wise comparisons were made, and following Bonferroni's correction, the α level was adjusted to .012 (.05/4). In simple C context, the average duration of the preceding vowel was significantly shorter sentence-medially (M = 372; SD = 88) compared with sentence-finally (M = 642; SD = 163), $t(3) = -5.7, p = .011$. Similarly, in complex CC

Table 6. Duration of third person singular *–s* and the preceding vowel in target sentences (in ms).

Coda complexity	Position	Sentence	Durations (ms): Third person singular *–s*	Preceding vowel
Simple	Medial	He blows now.	99	445
		He cries now.	97	368
		He flies fast.	121	426
		He throws fast.	134	249
	Final	Here he blows.	205	706
		There he cries.	200	570
		Here he flies.	170	831
		There he throws.	228	459
Complex	Medial	She drives fast.	169	312
		She eats now.	117	179
		He runs fast.	118	197
		He sleeps now.	146	144
	Final	Here she drives.	175	446
		Here she eats.	234	250
		There he runs.	192	264
		There he sleeps.	215	238

context, the average preceding vowel duration was significantly shorter sentence-medially (M = 208; SD = 73) compared with sentence-finally (M = 300; SD = 98), $t(3) = -6$, p = .009. Finally, in sentence-medial position, the preceding vowel duration was significantly shorter in complex CC verbs than in simple C verbs, $t(3) = -5.8$, p = .01. In contrast, in sentence-final position, there was no significant difference in vowel duration in simple C and complex CC verbs, $t(3) = 4.4$, p = .02.

To summarize, the vowel duration of verbs in C contexts was overall longer than those in CC contexts, which is probably due to the fact that vowels in *blows, cries, flies,* and *throws* are followed by a voiced coda *–z*. Those vowels also have either a diphthong or long/tense vowel. Alternatively, the vowels in three of the CC target words are either followed by a voiceless coda (*eats, sleeps*) or have a short/lax vowel (*runs*). But most pertinently, the duration of the third person singular *–s* was comparable in C and CC contexts; and the duration of the third person singular *–s* as well as preceding vowel duration were shorter sentence-medially compared with sentence-finally.

Procedure. Children participated in two tasks—a perception task (10 min) followed by the production task (30 min). The results from the perception task are reported elsewhere (Sundara, Demuth, & Kuhl, 2009). For the production task, children were invited into a soundproof test room with the experimenter and were asked to put on a child-sized backpack with an Azden 31LT FM wireless microphone (Azden Corporation, Franklin Square, NY) clipped to it. This was done to ensure good acoustic quality of the recording. In the few cases where the child refused to wear the backpack, it was placed on the table and the microphone was clipped to the child's collar. The children were then invited to sit in the child-sized chair at the table and watch animated cartoons on the computer monitor. The parent sat next to the child, and the experimenter sat across the table from the child, advancing the cartoons one at a time from a laptop computer.

The target sentences were randomized and presented at a comfortable listening level over loudspeakers placed on the table. The child was then asked to listen and repeat what they heard. The first two sentences were "warm-up" sentences (repeated if necessary) to ensure that they understood the task. Each child was then given a maximum of four chances to repeat a given target sentence. If the child failed to attempt the target sentence, the experimenter moved on to the next sentence. The experimenter encouraged the child's performance with praise and stickers for both correct and incorrect productions. Finally, parents were given the MacArthur CDI short form (Vocabulary Checklist: Level II, Form A) to obtain a quick measure of the child's vocabulary size (Fenson et al., 2000).

Coding of children's productions was identical to that used in the longitudinal study, as either *–s missing* or *–s produced*. A trained coder listened to the children's utterances over headphones and transcribed them phonetically. A second coder re-transcribed data from 3 of the children, resulting in 90% agreement regarding the presence of third person singular *–s*. Items containing an epenthetic vowel (5 tokens; e.g., *He flies fast* [hi flaɪzə̲ fæst]) or inserted vowel-initial word following the verb (4 tokens; e.g., *He throws fast* [hi θɹoʊz ɪ̲t̲ fæst]) were excluded from the analysis to avoid issues of possible resyllabification. This was primarily an issue for Participant 7 (see Table 7), where all eight medial forms were produced with an epenthetic vowel or inserted vowel-initial word. Some children occasionally deleted the final word in a medial target sentence, producing a two-word utterance with the verb in final position (e.g., *He sleeps now* [hi slips]). These were also excluded from the analysis (17 tokens). The resulting dataset included 147 tokens in simple C contexts and 158 tokens in complex CC contexts. The number of third person singular morphemes produced out of the total attempted sentences for each participant is summarized in Table 7.

Results

Figure 1 shows the average percent correct production of third person singular morphemes as a function of both phonological complexity and position within the utterance. Overall, in utterance-medial position, children produced third person singular *–s* more often in simple C (M = 60.1%, SE = 8.5) compared with complex CC context (M = 51.4%, SE = 8.7); similarly, in utterance-final position, children produced third person singular *–s* more often in simple C (M = 75.7%, SE = 4.7) compared with complex CC context (M = 63.8%, SE = 7.7).

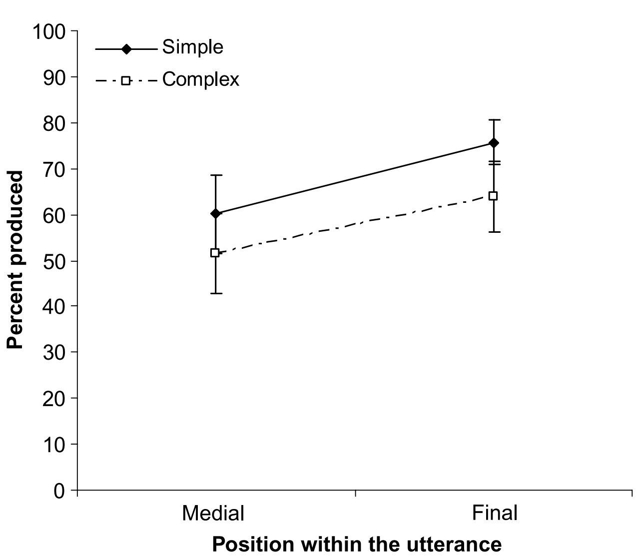
To test for the effects of complexity and position, we performed a repeated-measures ANOVA with coda complexity (simple, complex) and utterance position (medial, final) as the within-subjects variables and with percent *–s produced* as the dependent variable. Because we were testing the significance of a priori, directional predictions about the effects of complexity and position, one-tailed tests were more appropriate than the more typical, two-tailed tests. The main effect of complexity was significant, $F(1, 22) = 3.3$, p = .04, η_p^2= .13; and the main effect of position was also significant, $F(1, 22) = 3.07$, p = .04, η_p^2= .15 . The Complexity × Position interaction was not significant, $F(1, 22) = 0.11$, p = .37, η_p^2= .01. Thus, consistent with our predictions, children produced third person singular *–s* more often in simple C than in complex CC context. Children also produced *–s* more often utterance-finally compared with utterance-medially. This

Table 7. Number of tokens with -s produced out of total attempted tokens at each coda complexity and utterance position. Children with 0 correct productions and children at ceiling are excluded from the table.

Participant number	Age (year;month:days)	CDI item scores	Simple medial position	Simple final position	Complex medial position	Complex final position	Total
1	1;9:30	100	0/0	4/4	0/3	2/4	6/11
2	1;10:8	71	2/4	3/3	1/4	4/4	10/15
3	1;10:15	41	0/1	2/4	0/2	0/1	2/8
4	1;10:10	44	2/3	2/4	1/4	1/4	6/15
5	1;10:9	51	3/3	4/4	2/4	3/4	12/15
6	1;9:20	58	3/3	2/4	3/4	3/3	11/14
7	2;4:16	82	0/0	2/4	0/0	2/4	4/8
8	2;4:0	83	3/3	4/4	2/3	2/3	11/13
9	2;3:26	96	3/3	3/3	2/4	2/4	10/14
10	2;3:15	75	0/4	4/4	0/4	3/4	7/16
11	2;3:20	76	2/4	1/3	2/4	3/4	8/15
12	2;4:00	97	4/4	2/4	4/4	4/4	14/16
13	2;3:16	71	0/3	3/4	4/4	4/4	11/15
14	2;3:11	86	1/2	4/4	3/4	3/4	11/14
15	2;3:18	67	2/2	3/4	2/3	3/4	10/13
16	2;3:12	62	2/3	2/3	2/2	0/2	6/10
17	2;3:21	99	4/4	3/4	4/4	3/4	14/16
18	2;3:25	88	3/3	2/4	4/4	3/4	12/15
19	2;3:25	84	3/4	3/4	0/3	3/4	9/15
20	2;3:13	43	1/2	3/4	1/2	2/4	7/12
21	2;3:27	66	2/2	2/3	1/2	0/3	5/10
22	2;3:15	99	0/0	3/3	1/2	3/4	7/9
23	2;3:15	81	3/4	4/4	2/4	4/4	13/16
Total	—	—	43/61	65/86	41/74	57/84	206/305

replicates the findings of the longitudinal study, where the effects of coda complexity and utterance position on the production of third person singular morpheme production were found to be independent.

Figure 1. Percent production (±*SE*) for simple and complex codas in utterance-medial and final positions by 2-year-olds (n = 23).



Further analysis showed that, unsurprisingly, these children's CDI scores (see Table 7) were positively correlated with their production accuracy of the third person singular morpheme, r = .5, p = .02. In typically developing children, it is quite possible that the correlation between vocabulary and production accuracy is mediated by age. In other words, perhaps both CDI scores and production accuracy correlate with age and, thus, are correlated with each other. However, this was not the case. Specifically, although age (in days) was significantly correlated with CDI scores, r = .46, p = .03, there was no significant correlation between age and production accuracy, r = .28, p = .20. Finally, we partialed out the effect of age and re-calculated the correlation between CDI scores and production accuracy. The partial correlation between CDI scores and production accuracy, controlling for age, was still significant, r = .44, p = .04. Thus, even older children with small vocabularies showed poor grammatical performance.

Together with the results on MLU in the longitudinal study, these significant partial correlations provide evidence for a strong link between children's overall morphological/lexical development and their production of the third person singular morpheme. These findings are also broadly in accordance with studies showing that children's vocabulary size mediates the frequency effects on their production accuracy (Edwards et al., 2004; Munson, Kurtz, & Windsor, 2005). In conclusion, the results from both the longitudinal study and the cross-sectional study show that young children are more likely to produce third person singular morphemes in phonologically simple, or unmarked, contexts, especially in utterance-final position.

General Discussion

The goal of the present study was to determine if some of the variability in typically developing English-speaking children's production of third person singular *–s* could be explained by phonological factors. If so, it would provide a principled explanation for some of the variable production of this morpheme, indicating that it was phonologically conditioned and not simply random. It would also indicate that children's syntactic competence might be more robust than often assumed.

In the longitudinal study, we demonstrated that children produced third person singular *–s* more accurately in phonologically simple C coda contexts than in complex CC coda contexts. There was also an effect of position within the utterance, with worse performance in utterance-medial position. Utterance-medial syllables are typically shorter in duration, rendering less time for children to produce segments. The findings in the longitudinal study also showed that the utterance length and the child's MLU significantly contributed to explaining the early production of third person singular *–s*.

We confirmed these findings in the cross-sectional study with 2-year-olds, where utterance length and inflected frequency were held constant. Thus, our findings provide strong support for the role of phonological constraints at the level of both the syllable and the utterance in explaining some of the variability in young children's production of third person singular *–s*. That is, at early stages of acquisition, children are more likely produce third person singular *–s* in phonologically simple contexts. This is consistent with the prosodic licensing hypothesis, which states that young children will first produce grammatical morphemes in phonologically (or prosodically) simple, unmarked contexts (Demuth & McCullough, 2009).

The fact that children show better command of third person singular morphemes in phonologically simple contexts also suggests that they may have access to some of the syntax and semantics of these constructions earlier than is often assumed. Further support for this position comes from perception/comprehension experiments showing that children have an awareness of several grammatical morphemes well before they can reliably produce them. Early in the second year of life, children are sensitive to grammatical morphemes, as evidenced by 13-month-olds' detection of phonetic changes that convert function words into nonsense words (Shi, Werker, & Cutler, 2006). Gerken and McIntosh (1993) also noted that children younger than age 2 years who do not yet produce articles notice when the article *the* is changed to a nonce word. Particularly relevant to this study, Soderstrom, Wexler, and Jusczyk (2002) reported that 19-month-olds prefer to listen to grammatical passages with third person singular *–s* over ungrammatical passages without it (e.g., *At the bakery, a team bakes bread* vs. **At the bakery, a team bake bread*), demonstrating their sensitivity to the grammatical distribution of the third person singular morpheme (see also Soderstrom, White, Conwell, & Morgan, 2007). Preliminary findings from the perception experiment with the participants in the present cross-sectional study indicate that children as young as 22 months are sensitive to grammatical/ungrammatical contrasts with third person singular *–s* in a referential task (Sundara et al., 2009). Together, these findings indicate that children have some early awareness of grammatical agreement, raising the possibility that the grammatical representations of at least person and number, if not "tense," are emerging quite early in development.

In addition to coda complexity effects, the longitudinal and cross-sectional studies also showed that children are more likely to produce third person singular *–s* in utterance-final compared with utterance-medial position. Morphemes such as the third person singular are lengthened at the ends of utterances in the parental input that children hear (Hsieh et al., 1999), making it more likely that children will detect them in this position. Snow (1994, 1998) further shows that children's own productions begin to exhibit longer duration at phrasal boundaries around the time they begin to produce word combinations. Thus, it is likely that children have more time to produce coda consonants and morphemes phrase-finally as compared with phrase-medially. From an articulatory/planning perspective, third person singular *–s* might also be more challenging in utterance-medial position due to the fact that another word follows, necessitating the planning of additional articulatory gestures. In contrast, at the end of an utterance, especially in slower child speech, no additional gestural planning is immediately required. Finally, the ends of utterances have the advantage of being the most recent in memory, perhaps facilitating production in elicited imitation tasks. Further acoustic investigation of children's speech timing and realization of third person singular *–s* in these different phrasal contexts would provide some insight into which of the previously mentioned factors is most important for explaining these behavioral findings.

Aside from the effects of syllable complexity and utterance position, MLU and utterance length also had the expected effect on production accuracy. Children with larger MLUs were more likely to accurately produce third person singular *–s,* especially in shorter utterances. Children in the cross-sectional study with larger vocabularies (measured by CDI scores) also produced the third person singular morpheme more accurately, suggesting a close connection between lexical and morphological development. Surprisingly, however, the inflected frequency of the verb was not correlated with production variability in the longitudinal study, contrary to findings on the production of plural morphemes (Zapf, 2004). It is possible that the frequency statistics reported for the inflected frequency of third person singular verbs in the CHILDES database did not constitute an appropriate model of inflected frequency for the individual children in the longitudinal study. Alternatively, it is possible that some other measure of frequency, such as phonotactic probability of consonant clusters, would better account for some of the variability in third person singular morpheme production (e.g., Maekawa & Storkel, 2006; Munson, 2001; Storkel, 2001).

One might wonder if all inflectional morphemes are susceptible to coda complexity to the same extent. We assessed the spontaneous production of 3 of the children in the longitudinal study (Ethan, Naima, and William) for complexity effects on the production of plural *–s*. The results showed no effects of coda complexity, indicating that these children can produce plural *–s* equally well in both simple and complex codas. However, many of these pluralized nouns occurred phrase-finally in short utterances (e.g., *Two cats!*). The plural nouns in general, and those with complex codas (e.g., *books, dogs, cars*), were also much more frequent compared with third person singular verbs. This suggests that a combination of plural token frequency and complexity, as well as a tendency for plurals to occur finally in short utterances, may reduce the effects of phonological complexity on children's production of plural *–s,* facilitating earlier production. On the other hand, third person singular *–s* might be more likely to be affected by coda complexity, as they tend to occur utterance-medially and are overall less frequent than plural *–s* (Hsieh et al., 1999).

The results from this study raise many other questions about the phonology of children's early third person singular morphemes. For example, little is known about the acoustics of this morpheme in either child or parental speech. If third person singular *–s* exhibits shorter duration in utterance-medial position in child-directed speech, perhaps young children also produce it with short duration, rendering it inaudible to the adult transcriber (Scobbie, Gibbon, Hardcastle, & Fletcher, 2000). It would therefore be interesting to investigate the possibility of covert phonetic contrasts on children's apparent omission of third person singular *–s*. This suggests that further acoustic analysis, both of the input children hear (cf. Newman, Clouse, & Burnham, 2001) and of child productions, would provide further evidence of this morpheme in children's underlying phonological representations.

Further acoustic analysis could also address possible issues of re-syllabification across word boundaries. In a preliminary analysis, we found that 2 of the children in the longitudinal study appeared to preserve third person singular *–s* at higher rates when the verb was followed by a word beginning with a vowel. However, it is not clear if this is most likely when the following word is an unstressed grammatical morpheme (e.g., *in, up*) or if this is a more general process that occurs even with a word that begins with a sonorant onset (e.g., *needs led* > *need sled*). There are other phonological environments, including the segmental and sonority content of the stem (cf. Johnson & Morris, 2007; Oetting & Horohov, 1997), that might also facilitate the production of third person singular morphemes, and this could be investigated using acoustic analysis as well.

Finally, researchers have found a close connection between the semantics of the verb (e.g., accomplishment vs. activity, punctual vs. durative) and children's use of the past tense morpheme (e.g., Bloom et al., 1980; Johnson & Morris, 2007). Studies have also shown that semantic complexity is a factor affecting speech processing (Gennari & Poeppel, 2003). Therefore, it would be interesting to explore the possible contribution of semantics to understanding some of the variable production of third person singular *–s* (cf. Hyams, 2007).

The findings from this study point to the fact that phonological factors account for much of the variability in children's early production of third person singular *–s*. Children are more likely to produce this morpheme in phonologically simple contexts—that is, in simple codas utterance-finally. In contrast, they are more likely to omit this morpheme in phonologically more complex contexts—that is, in complex coda clusters utterance-medially. These findings hold important methodological and theoretical implications for the field of language acquisition. First, they point to the need for syntactic and semantic experiments to control for issues of phonological complexity; only then can we better understand the true nature of children's morphological or syntactic competence. Second, they suggest that children's syntactic representations may emerge much earlier than typically assumed. If children can produce third person morphemes in prosodically (or phonologically) licensed (simple, unmarked) contexts, this suggests that they have some of the requisite knowledge of grammar. Future research will be required to develop a more complete developmental model of planning and production, where the contributions of phonological complexity, as well as the other issues outlined in this article, all play a role in our understanding of how and why children's early utterances take the variable form that they do.

Conclusion

The goal of this study was to examine the effects of phonology on young children's variable production of English third person singular *–s*. To do this, we examined the possible effects of both coda complexity and position of the third person singular verb within the utterance. We first investigated the development of third person singular morphemes in longitudinal speech data from 6 children between the ages of 1;3 and 3;6. We then addressed the same issue by testing 23 two-year-olds in a cross-sectional, elicited imitation experiment. The results from both studies showed that children were better at producing third person singular *–s* in simple coda contexts compared with complex consonant cluster codas and in utterance-final as compared with utterance-medial position, thereby providing further support for the hypothesis that children's early grammatical morphemes are prosodically licensed. This suggests that future research on morphological development will need to consider phonological complexity and positional effects in constructing a comprehensive theory of how and when grammatical morphemes are acquired.

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Appendix A. Types and tokens analyzed for each child in simple C contexts.

Context	Alex		Ethan		Lily		Naima		Violet		William	
C	*cries*	1	*flies*	1	*blows*	1	*cries*	1	*goes*	38	*blows*	1
	goes	71	*glows*	5	*flies*	1	*goes*	34	*grows*	1	*goes*	15
	says	12	*goes*	8	*goes*	41	*knows*	3	*plays*	2	*plays*	1
			grows	2	*plays*	1	*plays*	1	*says*	24	*says*	3
			knows	2	*says*	22	*says*	21			*sees*	1
			plays	1	*sees*	2	*tries*	1				
			says	4								
			sees	1								
Total		84		24		68		61		65		21

Appendix B. Types and tokens analyzed for each child in complex CC context.

Context	Alex		Ethan		Lily		Naima		Violet		William	
CC	*comes*	3	*clacks*	1	*comes*	5	*comes*	3	*comes*	2	*bites*	2
	drives	2	*comes*	2	*dings*	1	*eats*	8	*fits*	4	*breaks*	1
	eats	1	*cuts*	2	*eats*	1	*fits*	1	*gets*	1	*comes*	12
	fits	2	*digs*	2	*gets*	1	*gets*	1	*hops*	1	*eats*	1
	gets	1	*eats*	4	*likes*	2	*looks*	6	*likes*	6	*fits*	1
	looks	4	*gets*	1	*lives*	3	*makes*	1	*looks*	24	*gets*	1
	means	2	*hooks*	1	*looks*	11	*needs*	21	*loves*	2	*hates*	1
	needs	4	*keeps*	1	*loves*	4	*sings*	3	*makes*	1	*hits*	2
	sings	1	*likes*	1	*makes*	3	*sits*	1	*means*	1	*likes*	1
	sits	1	*looks*	30	*means*	6	*sounds*	2	*moves*	1	*looks*	1
	sleeps	1	*makes*	3	*needs*	9	*stands*	4	*needs*	4	*needs*	1
	sounds	1	*means*	3	*rocks*	1	*tucks*	1	*sticks*	2	*rings*	3
			needs	4	*sings*	3	*walks*	1	*stops*	1	*runs*	2
			rides	5	*sits*	1			*walks*	6	*scoops*	2
			sleeps	1	*sleeps*	2					*sounds*	4
			sounds	1	*sounds*	1						
					sticks	1						
					swims	1						
Total		23		62		56		53		55		35