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Research Article

The Role of Utterance Length and Position in 3-Year-Olds' Production of Third Person Singular *-s*

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Purpose: Evidence from children's spontaneous speech suggests that utterance length and utterance position may help explain why children omit grammatical morphemes in some contexts but not others. This study investigated whether increased utterance length (hence, increased grammatical complexity) adversely affects children's third person singular *-s* production in more controlled experimental conditions.
Method: An elicited imitation task with 12 Australian English–speaking children ages 2;9 (years;months) to 3;2 (M_{age} = 2;11) was conducted comparing third person singular *-s* production in 3-word and 5-word utterances, both utterance medially (e.g., *He sits back*; *He sits back and swings*) and utterance finally (e.g., *There he sits*; *That's the way he sits*) using a within-subjects design. Children were shown pictorial representations of each utterance on a computer and were invited to repeat 16 pseudorandomized prerecorded utterances. Acoustic analysis determined the presence/absence and duration of the third person singular morpheme.
Results: Third person singular production was significantly lower utterance medially compared to utterance finally for the 5-word utterances and significantly lower utterance medially in the 5-word compared to 3-word utterances.
Conclusion: These results suggest that increased utterance length results in significantly lower third person singular production, but only in the more articulatorily challenging utterance-medial position. Thus, morpheme omission is greatest at the intersection of grammatical *and* phonological complexity.

Key Words: child language acquisition, speech production, acoustic phonetics, grammatical morphemes

Grammatical morpheme production has been found to be highly variable in children's early speech (Brown, 1973). Researchers taking a phonological perspective on this issue have suggested that children's morpheme omission patterns are not random (Song, Sundara, & Demuth, 2009). Rather, they show that morpheme omission interacts with phonological context, with children being more likely to produce morphemes in phonologically simple environments compared to more challenging environments. This is known as the *prosodic licensing hypothesis* (Demuth & McCullough, 2009). Two of the phonological contexts that have been found to contribute to children's variable use of inflectional morphemes are utterance position and coda complexity (Song et al., 2009; Theodore, Demuth, & Shattuck-Hufnagel, 2011). Other researchers have explained morpheme production variability in terms of either immature syntactic representations (Radford, 1990) or performance constraints (Valian, 1991). Corpus studies of children's spontaneous speech have found that children's longer utterances involved subject omission (Bloom, 1990) as well as variability in inflectional morpheme use (e.g., Song et al., 2009). However, these issues have yet to be explored in an experimental context where utterance length is manipulated or using acoustic analysis to provide a more reliable measure of morpheme realization than perceptual transcription affords (cf. Munson, Edwards, Schellinger, Beckman, & Meyer, 2010; Theodore, Demuth, & Shattuck-Hufnagel, 2012).

The aim of this study was therefore to determine if increased utterance length (hence, increased grammatical complexity) offers some insight into why children tend to omit third person singular *-s* in some contexts but not others. In order to allow for greater control and accuracy, we designed an experimental study using acoustic analysis to investigate this possibility. The third person singular *-s* morpheme was chosen for this investigation as it is acquired fairly late compared to other grammatical morphemes, and children still exhibit variable production of it between the ages of 3 and 4 years

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(Brown, 1973). In addition, fricatives such as /s/ and /z/ are difficult sounds for children to produce as they require more complex tongue and airflow control (Koenig, Lucero, & Perlman, 2008). As a result, fricatives are later acquired compared to stops (Chirlian & Sharpley, 1982; Kilminster & Laird, 1978; McLeod, 2007), with only 60% of word-final /s/ produced between the ages of 2 and 3 years (Smit, 1993). Hence, the articulatory demands for the production of third person singular *-s* are quite high.

Evidence that increased utterance length may be a factor contributing to morpheme omission has been suggested in several studies. Song et al. (2009) found that, in spontaneous speech, children had more difficulty producing third person singular morphemes in longer sentences than shorter sentences. Longer sentences often involve increased grammatical complexity, both syntactically and semantically (Valian, 1991). Using cognitive resources to process the semantic and syntactic information of language units (e.g., words, morphemes, phrases, clauses) can adversely affect the accuracy of an individual's speech performance (Charest & Johnson, 2011). Previous studies involving children have shown that increasing the complexity or length of sentences often results in the omission of sentence subjects, inflectional tense morphemes, auxiliaries, and articles (see Charest & Johnson, 2011, for a review). Marton and Schwartz (2003) found that increasing word length for a nonword repetition task decreased children's repetition accuracy. Grela and Leonard (2000) found that children were more likely to omit sentence subjects in more complex ditransitive sentences (e.g., *The girl is putting the cup on the table*) compared to simpler transitive sentences with a locative adjunct (e.g., *The girl is washing the cup at home*). These studies suggest that children meet the demands of producing longer sentences through the omission of linguistic constituents (Bloom, 1990; Valian, 1991). It is therefore expected that increased utterance length, along with the increase in grammatical complexity that this typically entails, will have an adverse effect on children's grammatical morpheme production.

There is also evidence that utterance position is a factor in children's morpheme production, from both a planning perspective and a phonological perspective. Valian (1991) showed that the production demands required by a child are higher at the beginning of an utterance in comparison to the end of the utterance. When an inflected word occurs utterance medially, the speaker still has to plan and articulate the rest of the sentence, which is not required when the inflected word occurs utterance finally (Theodore et al., 2011). We would therefore expect that children would be more likely to *omit* morphemes that occur early in the sentence due to these additional demands and would be more likely to actually *produce* morphemes that occur utterance finally. The expectation that utterance-final morphemes will be easier to produce is also supported from a phonological perspective. Words produced at the end of a phrase are typically longer in duration than words produced elsewhere in the phrase, at least in English, due to phrase-final lengthening (Oller, 1973). Phrase-final lengthening is evident in children as young as 2 years of age (Snow, 1994). Utterance-medial morphemes are therefore more difficult to produce because they are shorter in duration, which means that there is less time for the child's articulators to approximate their targets. This has been found for third person singular *-s,* which was produced more often in utterance-final position (e.g., *There he sits*) compared to utterance-medial position, even when controlling for utterance length (e.g., *He sits back*; Song et al., 2009; Sundara, Demuth, & Kuhl, 2011).

Similar findings have also been reported for plural *-s* (Theodore, Demuth, & Shattuck-Hufnagel, 2010, 2011) and syllabic plural *-es* (Mealings, Cox, & Demuth, 2013). This utterance position effect is especially important in regard to third person singular morphemes. Because English is a subject-verb-object language, third person singular verbs are much more prevalent in the utterance-medial compared to utterance-final position (Song et al., 2009). Thus, although children hear plurals in the utterance-final position 52% of the time, they only hear third person singular verbs in the utterance-final position 16% of the time (Hsieh, Leonard, & Swanson, 1999). Thus, it is likely that the third person singular morpheme is particularly difficult for children to perceive and produce (Sundara et al., 2011). These factors, in addition to syntactic and semantic issues (Radford, 1990; Valian, 1991), may contribute to the overall later acquisition of verbal inflections.

An additional phonological factor affecting morpheme production is coda complexity. Studies on consonant cluster production in Australian 2-year-olds showed that these are often not produced in an adult-like manner (McLeod, van Doorn, & Reed, 2001a, 2001b). In a longitudinal study of the spontaneous speech of six American English–speaking children ages 1;3 (years;months) to 3;6, Song et al. (2009) found that both utterance position and coda complexity influenced the likelihood that a third person singular *-s* morpheme would be produced. With respect to coda complexity, the third person singular morpheme was also more likely to be produced when the inflected verb ended in a simple coda (e.g., *cries*) compared to a complex coda cluster (e.g., *sits*). In a follow-up study using an elicited imitation task, where word and utterance length were controlled using three-word, three-syllable utterances, Song et al. showed the same results with 2-year-old children. Similar consonant cluster effects have also been reported for the plural *-s* morpheme (e.g., *keys* vs. *dogs*) (Ettlinger & Zapf, 2011; Polite, 2011) and the past tense *-ed* morpheme (e.g., *died* vs. *hugged*) in older children with specific language impairment (SLI; Marshall & van der Lely, 2007; Oetting & Horohov, 1997). Furthermore, Mealings and Demuth (2013) found that coda clusters involving the possessive *-s* morpheme often resulted in morpheme production, but at an expense with the cluster being simplified in the utterance-medial position (e.g., the target word *Doug's* was produced as *Dou's* [dɐz]). This was an interesting finding as it suggests that the morpheme rather than the coda of the lexical item was the articulatory target. Thus, it is evident that coda clusters add an additional challenge in morpheme production, and the way in which these clusters are produced can provide insight into morphological articulatory planning.

The purpose of the current study was therefore to further explore the effect of utterance length on children's production of third person singular *-s* morphemes during an elicited imitation task. In many of our previous studies (Mealings et al., 2013; Mealings & Demuth, 2013; Song et al., 2009; Sundara et al., 2011; Theodore et al., 2011), we tested children between the ages of 2;0 and 2;6 (M_{age} = 2;3), with all sentences containing three words/three syllables. In this study, we wanted to test children's ability to produce third person singular *-s* in three- and five-word sentences (three and five syllables, respectively). Because the mean length of utterance (MLU) for children ages 3;0–3;6 is reportedly 3.43 words (Rice et al., 2010), we chose to test slightly older children for the present study than those we had previously studied.

In light of the previous findings, the following hypotheses were made: First, due to the increased grammatical complexity for the longer utterances, we predicted that the children would be more likely to omit the third person singular *-s* in the longer five-word utterances compared to the shorter three-word utterances. Second, we expected lower levels of third person singular *-s* production in utterance-medial compared to utterance-final position for both the three-word and five-word utterances (Song et al., 2009; Sundara et al., 2011). Finally, we predicted that cluster reduction would occur more often in the longer five-word utterances, as well as in utterance-medial position, where there is less time to articulate all of the coda consonants.

Method

Participants

The participants were 12 typically developing children (five male, seven female) from monolingual Australian English–speaking homes in the Sydney region. All were recruited through brochures displayed at local child care centers and magazine advertisements, in compliance with ethics approval. Parents interested in having their children participate in the study contacted the researcher and were then enrolled in the study. The age range of the children was 2;9–3;2, with a mean of 2;11. This number of participants provided enough power to reveal significant results and reflects the number of participants used in previous studies of a similar nature (e.g., Song et al., 2009; Theodore et al., 2011). An additional 13 children participated in the experiment but were not included for analysis due to lack of speaking (n = 6) or ceiling performance (n = 7). This attrition rate is similar to the rate in the studies mentioned earlier, though ceiling performance was higher than expected. However, those children who reached ceiling performance were slightly older than those who showed variable morpheme production (M_{age} = 3;0), hence were likely to be too linguistically advanced for this simple imitation study.

All of the children were healthy on the day of testing and were reported by their parents to be typically developing in their speech and language skills. The children were screened by tympanometry to ensure that there was no middle ear blockage on the day of testing. After the experiment, each child's parent was asked to complete a brief demographic survey and the MacArthur Communicative Development Inventories (CDI) short form 100-word checklist (Fenson et al., 2000) as a rough measure of language ability. The raw CDI scores ranged from 53 to 100, with a mean of 93 (SD = 13), indicating a range of language skills. Even though the CDI is typically used only with children up to age 2;6, these raw scores were positively correlated with the children's third person singular morpheme production (r = .669, p < .05). This relationship was also found by Song et al. (2009), as was a correlation between MLU and third person singular morpheme production, suggesting a strong link between overall morphological/lexical development and third person singular production. In contrast, regression analysis revealed no effects of age or gender on morpheme production.

Stimuli

The goal of our study was to examine some of the factors that might contribute to a child's variable production of the third person singular morpheme. We expected that increased utterance length would result in poorer performance (due to increased grammatical complexity) than shorter utterance length, and that overall performance would be better in the utterance-final position (due to phrase final lengthening) than utterance-medial position. Therefore, in line with previous studies, a within-subjects design was used (see Mealings et al., 2013; Mealings & Demuth, 2013; Song et al., 2009; Sundara et al., 2011; Theodore et al., 2011). Four high-frequency, familiar, picturable target CVC verbs were selected for the experiment. The inflected lexical frequencies were extracted via ChildFreq from the CHILDES database, which calculated the children's frequency of saying the target verb per million words at age 3;0 (Bååth, 2010; MacWhinney, 2000). The range of the frequencies was 16–37, with a mean of 25 (see Appendix for raw frequencies). Each target verb ended with a coda cluster CVC + s. The final consonant of the stem preceding the /s/ morpheme was either an alveolar or velar voiceless stop. Each target word appeared in four present tense sentences that were structurally controlled. Critically, the same pronoun + verb sequences occurred in both the three- and five-word sentences. In the utterance-medial conditions, the verb was followed by an object or particle, with a conjoined verb in the five-word sentences. In the utterance-final condition, the pronoun + verb sequence occurred finally in the utterance. On some syntactic measures, the five-word utterance-final sentence (with an embedded clause where the complimentizer "that" has been elided) would be considered "more complex" than the five-word utterance-medial sentence with a conjoined verb, thus mediating against our expectation of better performance utterance finally. On

Table 1. Target verbs and their corresponding stimulus sentences.

Sentence	Target	IPA	Utterance-medial	Utterance-final
3-word	*sits*	/sɪts/	He sits back.	There he sits.
	bites	/bɑets/	She bites pears.	There she bites.
	talks	/toːks/	She talks back.	Now she talks.
	hits	/hɪts/	He hits balls.	Now he hits.
5-word	*sits*	/sɪts/	He sits back and swings.	That's the way he sits.
	bites	/bɑets/	She bites pears and eats.	There's the pear she bites.
	talks	/toːks/	She talks back and fights.	That's the way she talks.
	hits	/hɪts/	He hits balls and wins.	There's the ball he hits.

the other hand, because the five-word utterance-final sentence had no other content words, in some respects, it might be easier to process than the utterance-medial condition with a conjoined verb. The stimuli are shown in Table 1.[1]

To control for any articulatory influences, the target verb in the utterance-medial position was always followed by a word that began with a bilabial stop (half voiced, half voiceless) so that it was at a different place of articulation to the alveolar -*s* morpheme. This makes the phonological context more challenging and reduces the possibility of resyllabification of the -*s* morpheme with the following word (Theodore et al., 2011).

A female native speaker of Australian English was recorded producing the 16 stimulus sentences using child-directed speech. The recording took place in a sound-attenuated room using a Behringer C-2 microphone and Pro Tools LE software (Avid Technology, 2005) at a sampling rate of 44.1 K. Afterward, each sentence was segmented, and the spectrogram/waveform was acoustically coded using Praat software (Version 5.2.23; Boersma & Weenink, 2011). For each target word, stop durations were measured from the offset of the vowel (i.e., the end of high amplitude regularity in the waveform) to the end of the burst energy spike. Fricative durations were measured from the onset to offset of high-frequency aperiodic noise. The adult's average stop and fricative durations for each context are shown in Table 2. The duration of the closure and frication was on average 2.58 times longer when the target word was in the utterance-final position compared to utterance-medial position. These measurements served as a baseline for subsequent exploration of the same issues in the children's speech.

Each stimulus sentence was paired with a semantically related picture in computer display to serve as a visual prompt during the experiment. All pictures were real photos with minimal background distractions. Each of the 16 stimulus prompts were pseudorandomized into two versions and were alternated across participants to control for order effects.

Procedure

The child and parent were invited into a sound-attenuated test room containing a child-sized table and chairs, with a computer monitor and speakers on top of the table. The room was equipped with two computers (one used for the stimulus display and the other for the sound recording), Sony SRS-55 speakers, and a Behringer C-2 microphone. The microphone was placed on the table near the child in order to best capture his or her speech. After becoming familiarized with the experimenter by engaging with a picture book or toys, the child was invited to "play a language game" by looking at the pictures on the computer monitor and repeating what he or she heard. The experiment began with a brief warm-up/practice in order to familiarize the child with the task and to check the sound levels. Once the child was ready, the test items were initiated. The presentation began with the auditory prompt "Say what I say!" For each item, a pictorial representation of the target verb appeared on the monitor along with the auditory prompt. If needed, three attempts were allowed for each utterance in order to obtain an acoustically acceptable recording. The child was encouraged with praise and stickers for each trial. The entire procedure took approximately 30 min. The child was given a T-shirt and/or stickers, and the parents were given a gift card for their time.

Acoustic Coding and Analysis

Acoustic analysis was used to determine the presence or absence of the third person singular morpheme because it provides greater accuracy than simply relying on human perception (Munson et al., 2010; Scobbie, 1998). Each of the children's utterances was recorded using Pro Tools LE at a sampling rate of 44.1 kHz. Then, the samples were excised and coded by a trained coder using Praat (Boersma & Weenink, 2011). Of the 192 tokens, six were excluded due to poor acoustic quality from noise interference. The target words of the remaining 186 tokens were acoustically coded. The acoustic coding criteria were based on Stevens' (2002) feature cue–based model in which distinctive feature bundles representing speech segments are derived from the vocal tract configuration.

Each acoustic cue was identified primarily by visual inspection of the waveform and spectrogram, but also by listening to the utterance. Spectrograms allow three-dimensional speech information to be displayed on a two-dimensional graph. Acoustic events can be identified across time (represented on the horizontal axis) by the vertical frequency information and intensity shading (Clark & Yallop, 1995; Ladefoged, 1993). Figure 1 shows

[1]Because this study investigates the speech of Australian children, IPA transcriptions reflect Australian-English vowels (cf. Harrington, Cox, & Evans, 1997).

Table 2. Average stop and fricative durations by utterance length and position for the adult model.

	Average stop duration (ms)				Average fricative duration (ms)			
	Three-word		Five-word		Three-word		Five-word	
Utterance position	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Medial	90	14	64	12	70	11	67	4
Final	131	29	147	29	242	15	232	36

a representative waveform and spectrogram illustrating the acoustic cues of interest.

The acoustic cue that identified third person singular -*s* production was the presence of high-frequency aperiodic noise representing the turbulent flow of air through a narrow fricative constriction. This was typically preceded by a stop coda, or, in the case of cluster simplification where the stop was omitted, periodicity for the vowel (represented by high amplitude regularity in the waveform and a strong second formant). Stop consonant production was identified as closure representing the complete occlusion of the oral and nasal cavities, usually followed by a burst spike of energy as the air is released. Identifying this cue allowed us to examine whether the stop plus -*s* coda clusters were reduced to either /s/ only or stop only singleton codas. The durations of the target word's vowel, stop closure, and third person singular -*s* morpheme were measured for the 186 tokens so that durational utterance position effects could be compared. We used the same measurement procedure as that described earlier for the adult prompt. All of the tokens were coded by one trained coder. A second trained coder then coded 10% of the tokens. Reliability between the two coders on the presence or absence of an acoustic event was 98%.

Results

Effects of Utterance Length and Position on Third Person Singular -s Production

Recall that we expected that third person singular -*s* would be produced at lower rates in the five-word compared to three-word utterances and utterance medially compared to utterance finally. The presence or absence of word-final frication was used to determine whether or not the third person singular -*s* morpheme was produced. As there was no difference in mean -*s* morpheme production after /t/ (e.g., *sits*) compared to /k/ (e.g., *talks*), $t(11) = 1.657$, $p = .126$, $d = 0.394$, all target words were pooled together for the following analyses. To examine third person singular production as a function of utterance length and utterance position, the mean number of morpheme productions across children was submitted to a repeated measures analysis of variance (ANOVA). The factors of utterance length (three-word vs. five-word) and utterance position (medial vs. final) were used. With α set at .05, the main effect for utterance length was not significant, $F(1, 44) = 2.814$, $p = .10$, $\eta_p^2 = .060$, indicating no overall difference between production of the third person singular morpheme in three-word utterances (84%) compared to five-word utterances (73%). However, as expected, the main effect of utterance position was significant, $F(1, 44) = 22.349$, $p < .01$, $\eta_p^2 = .337$, indicating that the third person singular morpheme was produced in a greater proportion of utterance-final tokens (95%) compared to utterance-medial tokens (63%). Moreover, there was an interaction between utterance length and utterance position, $F(1, 44) = 6.721$, $p < .05$, $\eta_p^2 = .133$. A series of four paired-samples *t* tests were then conducted to determine significant differences in third person singular productions between conditions (Three-Word Utterances × Five-Word Utterances in utterance-medial position; Three-Word Utterances × Five-Word Utterances in utterance-final position; Utterance-Medial Position × Utterance-Final Position for three-word utterances; Utterance-Medial Position × Utterance-Final Position for five-word utterances). Bonferroni corrections were used to account for the multiple comparisons in order to control for Type 1 error, so an alpha level of .05 was adjusted to $\alpha = .05/4 = .0125$. The results revealed an utterance length effect in the utterance-medial position, with morpheme production significantly lower in the five-word utterances (48%) compared to the three-word utterances (85%), $t(11) = 3.023$, $p < .0125$, $d = 1.046$. Interestingly, there was no utterance length effect in the utterance-final position. The results also revealed that there was no utterance position effect for the three-word utterances. There was, however, an utterance position effect for the five-word utterances, with morpheme production significantly lower utterance medially (48%) compared to utterance finally (98%), $t(11) = -5.745$, $p < .0125$, $d = -2.462$. This is illustrated in Figure 2.

Figure 1. Representative waveform and spectrogram from an adult speaker showing acoustic landmarks for the target word *sits*.

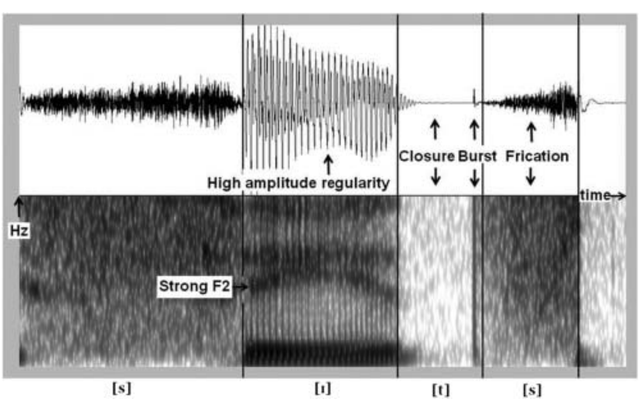
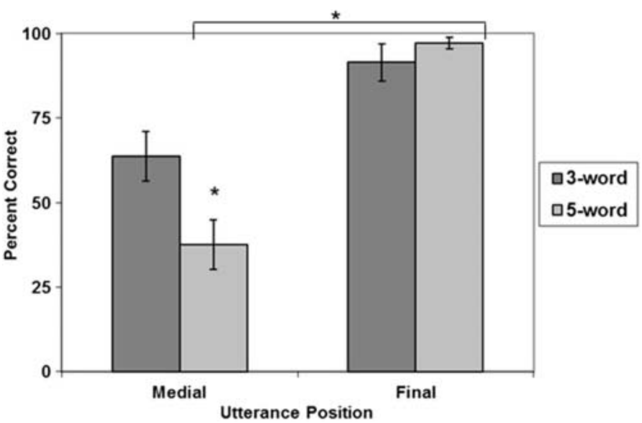


Figure 2. Mean percentage of third person singular *-s* morphemes realized for three-word and five-word utterances in medial- and final-utterance positions. Error bars indicate standard error of the mean. *$p < .0125$.



Thus, as predicted, children were overall poorer at producing the third person singular morpheme utterance medially compared to utterance finally. This is consistent with the findings of Song et al. (2009) and Theodore et al. (2010) for third person singular morphemes. However, the fact that there was no utterance position effect for the three-word utterances is surprising. We suspect this is because the 3-year-old children in our study were older than children in the aforementioned studies and therefore more linguistically and cognitively advanced, no longer showing the utterance-medial effect for these short utterances. However, when the task was made harder by increasing the number of words and syllables in the utterance to five, even the 3-year-olds exhibited problems producing the morpheme utterance medially. Thus, although the articulatory demands for the target word in the utterance-medial position were the same across the three- and five-word conditions, the overall production demands required to remember and then plan the rest of the utterance were much greater in the longer five-word condition.

Of course, it is possible that the articulatory demands in the three- and five-word sentences could have been different if the duration of the final consonants was shorter in the five-word utterances. To explore this possibility, we conducted a second acoustic analysis to examine the possible durational differences in the final consonants across conditions.

Coda Durations as a Function of Utterance Length and Position

Recall that previous studies have reported durational differences according to the position in which a word appears in a sentence, with utterance-final words typically having a longer duration than utterance-medial words due to phrase-final lengthening (Oller, 1973). It has been suggested that this effect mediates against coda and inflectional morpheme production utterance medially (Hsieh et al., 1999; Song et al., 2009). To determine if these durational effects held equally across the different utterance lengths, we submitted the mean stop closure durations (from 158 tokens) and fricative morpheme durations (from 143 tokens) across children to a repeated measures ANOVA. The factors of utterance position (medial vs. final) and utterance length (three-word vs. five-word) were used.

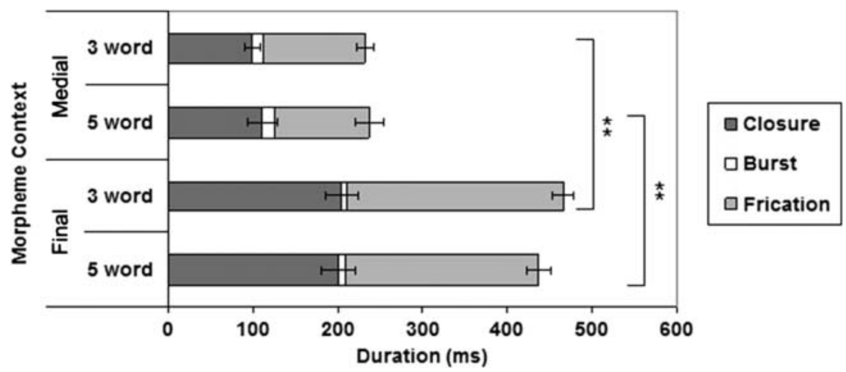
As expected, the ANOVA results showed a main effect for utterance position for both closure duration, $F(1, 44) = 39.050$, $p < .01$, $\eta_p^2 = .470$, and fricative duration, $F(1, 44) = 97.990$, $p < .01$, $\eta_p^2 = .690$, indicating that both coda consonants were significantly longer in duration when in the utterance-final position, *M*(closure) = 202 ms; *M*(fricative) = 242 ms, compared to the utterance-medial position, *M*(closure) = 87 ms; *M*(fricative) = 111 ms. It is this phrase-final lengthening that was likely to aid morpheme production in this position. Interestingly, however, the effect of utterance length was not significant for either closure duration, $F(1, 44) = 0.028$, $p = .869$, $\eta_p^2 = .001$, or fricative duration, $F(1, 44) = 2.774$, $p = .103$, $\eta_p^2 = .059$. Thus, the extent of phrase-final lengthening was the same for both three-word utterances and five-word utterances, with no difference in closure durations, *M*(three-word) = 143 ms; *M*(five-word) = 146 ms, or fricative durations, *M*(three-word) = 187 ms; *M*(five-word) = 165 ms, respectively. No interaction was found between utterance position and utterance length for closure, $F(1, 44) = 0.129$, $p = .721$, $\eta_p^2 = .003$, or frication, $F(1, 44) = 0.088$, $p = .768$, $\eta_p^2 = .002$. This suggests that the third person singular morpheme, as well as the consonant that preceded it, had the same duration regardless of utterance length. This is shown in Figure 3.

A similar analysis was conducted on the adult model to assess the extent to which children have adult-like productions. The mean stop closure durations and fricative morpheme durations for the adult were submitted to a repeated measures ANOVA. The factors of utterance position (medial vs. final) and utterance length (three-word vs. five-word) were used. As with the children, the ANOVA results for the adult model showed a main effect for utterance position for both closure duration, $F(1, 12) = 24.643$, $p < .01$, $\eta_p^2 = .673$, and fricative duration, $F(1, 12) = 267.516$, $p < .01$, $\eta_p^2 = .957$, indicating that both coda consonants were significantly longer in duration when in the utterance-final position compared to utterance-medial position (see also Table 2). Again, as with the children, the effect of utterance length for the adult was not significant for either closure duration, $F(1, 12) = 0.102$, $p = .755$, $\eta_p^2 = .008$, or fricative duration, $F(1, 12) = 0.367$, $p = .556$, $\eta_p^2 = .030$. No interaction was found between utterance position and utterance length for closure, $F(1, 12) = 2.691$, $p = .127$, $\eta_p^2 = .183$, or frication, $F(1, 12) = 0.115$, $p = .740$, $\eta_p^2 = .009$. This is shown in Figure 4. These results show that the children's productions were comparable to the adult model regarding phrase-final lengthening, though the children's durations were slightly longer overall.

Cluster Reduction

The realization of the word-final coda cluster helps provide some insight into children's processes of articulatory

Figure 3. Children's mean closure, burst release, and fricative durations for third person singular verbs in medial- and final-utterance positions for three-word and five-word utterances. Error bars indicate standard errors of the mean for closure and fricative durations. **$p < .01$.



planning in this task (e.g., Song, Demuth, Shattuck-Hufnagel, & Ménard, 2013). Previous studies have shown that some children simplify coda consonant clusters to a singleton in morphological contexts (Mealings & Demuth, 2013; Polite, 2011; Theodore et al., 2011). In light of these findings, we therefore conducted a second acoustic analysis to explore more closely the contexts in which cluster reduction was more likely to occur. We expected more cluster reduction in the longer, more complex five-word utterances, as well as in utterance-medial position, where there is less time to articulate all of the coda consonants.

Recall that for the entire coda cluster to be realized, both the final stop and the word-final fricative need to be produced. Stop production requires the acoustic cues of closure and/or a burst release, or a glottal stop burst release, to be present on the spectrogram (see Shattuck-Hufnagel, Demuth, Hanson, & Stevens, 2011; Song, Demuth, & Shattuck-Hufnagel, 2012). Fricative production requires the presence of high-amplitude aperiodic noise. Therefore, there were three types of possible coda reduction, illustrated here using the target verb *sits*: no coda (e.g., [sɪ]), stop only coda (e.g., [sɪt]), and fricative only coda (e.g., [sɪs] or [sɪz]). Figure 5 provides a breakdown of the coda cluster realizations for the three-word and five-word utterances in both the utterance-medial and utterance-final positions. As expected, cluster reduction occurred most often in the utterance-medial compared to utterance-final position (50% vs. 95%), $F(1, 44) = 30.493$, $p < 0.01$, $\eta_p^2 = .409$. In addition, paired t tests (with Bonferroni correction $\alpha = .05/2 = .025$) revealed that, in the utterance-medial position, cluster reduction occurred more often in the five-word utterances compared to the three-word utterances, $t(11) = 2.253$, $p < .025$, $d = .722$. There was, however, no difference utterance finally, $t(11) = -0.897$, $p = .19$, $d = .396$. Thus, for the utterance-medial verb in the five-word utterances, the cluster was often reduced to the stop only (as in 16 out of 48 tokens), or less frequently to the fricative only (as in 7 out of 48 tokens), or it was completely omitted (as in 7 out of 48 tokens). Full cluster realization only occurred in 18 out of 48 tokens. The type of coda reduction provides some insight into children's articulatory planning strategies. This is further explored in the Discussion.

Figure 4. Adult model's mean closure, burst release, and fricative durations for third person singular verbs in medial- and final-utterance positions for three-word and five-word utterances. Error bars indicate standard errors of the mean for closure and fricative durations. **$p < .01$.

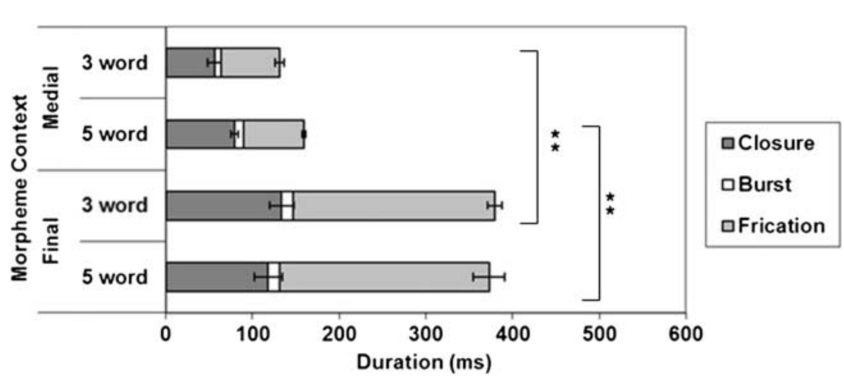
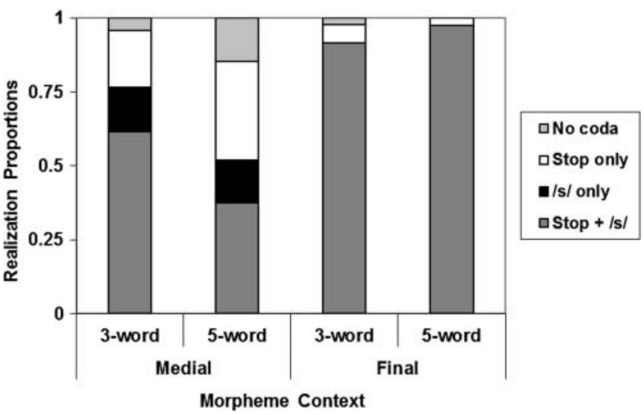


Figure 5. Coda cluster realizations for third person singular verbs in medial- and final-utterance positions for three-word and five-word utterances.



The results of this study suggest that increased utterance length and concomitant increased grammatical complexity, combined with the more phonologically challenging utterance-medial position, conspire to mediate against full coda cluster (and morpheme) production in the longer five-word utterances. As children get older and use longer utterances, the grammatical complexity increases. Because verbs in English typically occur utterance medially, verbal inflection may be at particular risk as children's overall grammatical competence and MLU increase.

Discussion

As previously noted, children's early use of grammatical morphemes is highly variable, taking several years to consistently appear for a given learner (Brown, 1973). Some of this variable use may be explained, in part, by interactions with syntax, performance limitations, and phonological context (Radford, 1990; Song et al., 2009; Valian, 1991). The goal of the present study was to investigate through acoustic analysis the possibility that increased utterance length (hence increased grammatical complexity) would have an adverse effect on children's production of third person singular *-s*.

It was expected that, due to the increased grammatical complexity, the five-word utterances would be more challenging than the three-word utterances, thereby resulting in more third person singular *-s* omissions. However, this was only observed when the morpheme occurred in the utterance-medial position, where only 48% of morphemes were produced. In the utterance-final position, morpheme production was close to ceiling. This higher level of morpheme production in the utterance-final position might be due to the diminished planning demands toward the end of the sentence (Valian, 1991). This, combined with the phonological advantage of phrase-final lengthening, could then facilitate morpheme production in the utterance-final position. In contrast, the less time available to fully articulate the third person singular morpheme in the utterance-medial position, combined with the planning demands of the early part of the sentence, presents a particularly challenging context for morpheme production for these 3-year-olds. Because most verbs occur utterance medially in English, this may explain why the third person singular morpheme is sometimes omitted as children's sentences become more complex.

In contrast to previous literature with 2-year-olds (e.g., Song et al., 2009; Sundara et al., 2011; Theodore et al., 2010), we found no evidence for the utterance-medial effect for the three-word utterances in this study. This indicates that by 3 years of age, when children's average MLU is greater than three words (Rice et al., 2010), children's omission of even the later acquired third person singular *-s* becomes less apparent in sentences of this length.

The findings of our study therefore show that increasing the utterance length from three words to five words, along with the associated increase in grammatical complexity, results in the relinquishment of what is presumably the most fragile linguistic constituent—the third person singular *-s*. This omission, however, was only evident in the utterance-medial position, suggesting that it is not increased grammatical complexity alone, but rather a combination of both the phonological context and increased utterance length, that adversely affects third person singular morpheme production. These findings therefore contribute to a growing body of literature showing a close link between phonological and morphological development (Mealings et al., 2013; Mealings & Demuth, 2013, Song et al., 2009; Sundara et al., 2011; Theodore et al., 2011).

The second analysis revealed that coda cluster production was more compromised utterance medially compared to utterance finally for both the three-word and five-word utterances. Errors included stop production with fricative omission, stop omission with fricative production, and entire cluster omission. The most common error was the reduction to the stop only, which indicates that the third person singular morpheme is the most fragile component and is compromised when utterance length is increased. The omission of both stop *and* fricative further demonstrates the fragility of the morpheme, but also the difficulty of producing any part of the coda under increased performance demands. In contrast, preservation of the morpheme rather than the stop suggests that the morpheme is the articulatory target. This was also found for possessive *-s,* where children produced the morpheme at the expense of the stop coda in the utterance-medial position (e.g., *Doug's* produced as *Dou's* [dɐz]) (Mealings & Demuth, 2013).

A recent study using ultrasound imaging methods showed that for the lexical item *box,* the articulators appeared to target the /k/, whereas for *rocks,* the articulatory target was the plural /s/, for both children and adults (Song et al., 2013). This suggests a difference in articulatory planning for the production of morphemic versus nonmorphemic coda clusters. Thus, although the most common errors found in the present study involved morpheme omission, it was interesting that many of the children also had some errors involving coda morpheme (fricative) preservation over lexical coda (stop) preservation. Further investigation into the types of errors children make in such elicited imitation tasks would help to reveal the nature of their strategies for speech planning and how this differs as a function of grammatical and prosodic context.

The findings from this study also raise many other issues for further research. First, it would be interesting to explore the potential effects of different types of grammatical complexity on children's production of grammatical morphemes (e.g., Grela & Leonard, 2000), where syntactic, semantic, and/or lexical probabilities could be manipulated while keeping utterance position and length constant. We anticipate that such factors will also play a role in explaining some of the variable use of grammatical morphemes as children's MLU increases.

Second, it would be interesting to look at the effects of increased utterance length on the production of other grammatical morphemes, such as plural *-s* and possessive *-s,* as both of these morphemes are earlier acquired (Brown, 1973). These morphemes also have different semantic roles that may influence their perception and production (Zapf & Ettlinger, 2011). For example, the plural is a nominal marker that can be easily represented pictorially, perhaps aiding its production. The third person singular, however, is more difficult to "see." It would therefore be appropriate to see if increasing utterance length has an adverse effect on the production of these morphemes as well.

In addition, it would be valuable to look at syllabic morphemes (e.g., *bus-es*). These morphemes increase word length and are reportedly acquired later than their segmental counterparts (Berko, 1958; Brown, 1973). However, these morphemes are also much less frequent and are articulatorily challenging due to the fricative-schwa-fricative sequence, with partial omissions common utterance medially in 2-year-olds' speech (e.g., *bus-eh*; Mealings et al., 2013). Preliminary findings also suggest much later acquisition of these syllabic morphemes by children with SLI (Tomas, Smith-Lock, & Demuth, 2012). We therefore anticipate that the increased grammatical complexity in longer utterances may further adversely affect syllabic morpheme production.

Finally, it would be interesting to design a study that can further tease apart the various factors contributing to variable third person singular production. Our study showed that phonological complexity and grammatical complexity combine to affect morpheme production, but a study that is able to test these aspects independently would provide further insight into the mechanisms underlying morphological development. It would also be beneficial to conduct a study examining the effects of utterance length on learners' perceptual sensitivity to the presence or (ungrammatical) absence of the third person singular morphemes. In a study using three-word utterances, Sundara et al. (2011) suggested that poor utterance-medial perception of the morpheme was due to shorter duration/less acoustic salience. A perception study using stimuli like those here, however, could shed light on the potential effects of utterance length on learners' acquisition of grammatical morphemes that tend to occur utterance medially.

The findings of the present study raise questions about how utterance length may affect morpheme production in children with language or hearing impairments. It would be interesting to investigate whether these children are affected by utterance length and position in the same way as the typically developing children in our study were, or if the effect is greater in one group compared to the other. It would also be beneficial to see if children with language or hearing impairments show the same distribution of error types when cluster reduction is examined, or if their productions follow a different pattern to children who are typically developing in their language and hearing abilities.

Conclusions

This study aimed to experimentally investigate the possibility that increased utterance length would have an adverse effect on 3-year-olds' production of third person singular *-s*. The results revealed the expected utterance position effect, with significantly lower production of the third person singular morpheme in the utterance-medial compared to utterance-final position for the five-word utterances. The results also showed the predicted lower performance utterance medially on the five-word utterances compared to the three-word utterances, where fricative duration was less than half of that found in the utterance-final position. These results suggest that increased utterance length (hence increased grammatical complexity), when combined with the phonologically more challenging utterance-medial position, results in significantly lower production of the third person singular *-s* morpheme. These findings contribute to a growing body of literature showing a close link between phonological and morphological development as well as the effects of phonological/prosodic context on children's variable realization of grammatical morphemes.

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Appendix

Inflected and Uninflected Frequencies of a Child Age 3;0 Saying Target Verb per Million Words (Extracted via ChildFreq From the CHILDES Database)

Target	Inflected frequency	Uninflected frequency
sits	37	756
bites	32	249
talks	16	398
hits	16	314