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Acoustic Evidence for Positional and Complexity Effects on Children's Production of Plural –*s*

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Purpose: Some variability in children's early productions of grammatical morphemes reflects phonological factors. For example, production of 3rd person singular –*s* is increased in utterance-final versus utterance-medial position, and in simple versus cluster codas (e.g., *sees* vs. *hits*). Understanding the factors that govern such variability is an important step toward modeling developmental processes. In this study, the authors examined the generality of these effects by determining whether position and coda complexity influence production of plural –*s*, which phonologically manifests the same as 3rd person singular –*s*.
Method: The authors used an elicited imitation task to examine the speech of 16 two-year-olds. Eight plural nouns (half contained simple codas, half contained cluster codas) were elicited utterance-medially and utterance-finally. Acoustic analysis of each noun was used to identify acoustic cues associated with coda production.
Results: Results showed that plural production was more robust in utterance-final versus utterance-medial position but equally robust in simple versus cluster codas.
Conclusions: These findings extend positional effects on morpheme production to plural –*s*. An effect of coda complexity was not observed for plural but was observed for 3rd person singular, which raises the possibility that the morphological representation proper influences the degree to which phonological factors affect morpheme production.

Key Words: grammatical morphemes, coda complexity, acoustic analysis, distinctive feature cues, phonology

It is widely documented in the literature on language acquisition that children's early productions are highly variable, even for a given speaker. As a case in point, consider Example 1 below, which shows within-speaker variability for multiple productions of the target word *dog,* drawn from the Providence Corpus (Demuth, Culbertson, & Alter, 2006) available on the Child Language Data Exchange System (CHILDES) database (MacWhinney, 2000). During a 2-week period beginning at age 1;3 (years;months), this child produced several different utterances of the target word *dog*. These utterances included the adultlike form as well as forms that contained apparent segmental deletions and substitutions (i.e., the addition of unexpected feature cues).

Example 1

Naima (1;3)

a. [dʌ]

b. [dɑgə]

c. [dɔg]

Indeed, the variability in children's early words is often characterized by a host of processes including not only such segmental substitution and deletion, which involve phonological variability within a given syllable, but also linking (i.e., "resyllabification"), which involves variability across syllable boundaries.

Just as productions of individual segments are variable in early child speech, so too are early productions of grammatical morphemes (Bloom, 1970; Brown, 1973). Variability in the production of grammatical morphemes has typically been taken as evidence that children's developing grammars are syntactically incomplete, with a syntactic construct seen as mastered only when the child produces a given morpheme consistently (e.g., Marcus et al., 1992). However, recent findings suggest that within-speaker variability in the production of grammatical morphemes may not indicate impoverished syntactic representations, but rather interactions between syntactic and other levels of language representation and

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speech planning. That is, these morphemes may be more likely to be produced in certain phonological contexts compared to other contexts. Central to this argument are findings indicating that variability in morpheme production is often systematically distributed, being sensitive to both semantic and phonological factors. In terms of semantics, it has been found that the past-tense morpheme is produced earlier for accomplishment verbs compared to activity verbs (e.g., Bloom, Lifter, & Hafitz, 1980; Johnson & Morris, 2007), and the plural morpheme is more robustly produced when labeling a set of objects that are similar versus distinct (e.g., producing *dogs* to label a set of four poodles vs. a set of four different dogs; Zapf & Smith, 2008). In terms of phonological factors, grammatical morphemes are also produced more reliably when they occur as part of a trochaic foot compared to when they are unfooted (e.g., Gerken, 1996) or as part of a simple coda consonant rather than a complex coda cluster (e.g., Marshall & van der Lely, 2007). Based on the findings of phonological influences on morpheme production, Demuth and McCullough (2009) proposed the *prosodic licensing hypothesis,* which predicts that children are more likely to produce morphemes in phonologically simple, or unmarked, contexts.

Recent support for the prosodic licensing hypothesis comes from work by Song, Sundara, and Demuth (2009), who examined the production of third person singular *–s* in 2-year-old children. Their results, drawn from perceptual analysis of corpus data and an elicited imitation experiment, were twofold. First, production of third person singular *–s* was more robust for verbs with simple codas (e.g., *cries*) compared to verbs with cluster codas (e.g., *drives*). In other words, children often reduced a target cluster coda to a singleton coda by omitting the morpheme. Second, production of third person singular *–s* was more robust when the verb was produced utterance-finally compared to utterance-medially (e.g., *There he cries* vs. *He cries now*). Thus, their results showed that morpheme production was increased in phonologically less difficult contexts, both at the level of the syllable/word (i.e., coda complexity) and the phrase (i.e., utterance position). This raises the possibility that similar phenomena might be found with other English inflectional morphemes as well. Understanding the factors that govern such systematic variability and describing the generality of these factors are important steps toward developing a model of the acquisition process.

To explore this issue, the current experiment extended previous work in two ways. First, we experimentally examined production of plural *–s,* a grammatical morpheme that phonologically manifests the same as third person singular *–s* but is generally acquired earlier in development (Brown, 1973). Second, we quantified morpheme production using acoustic analysis of the speech signal instead of perceptually based transcription methods. Each of these aspects is addressed in turn.

As reviewed above, Song et al. (2009) demonstrated that production of third person singular *–s* is systematically influenced by prosodic and segmental structure. In the current study, we examined whether these effects of position and complexity also occur for production of plural *–s*. This provides a theoretically interesting comparison to earlier work on third person singular *–s* in that both of these morphemes phonologically manifest as /s/ following voiceless coda consonants (e.g., *cats*), and as /z/ following voiced coda consonants (e.g., *dogs*) and CV nouns (e.g., *bees*). However, plural *–s* is generally acquired earlier than third person singular *–s* (Brown, 1973; Zapf & Smith, 2007). This is likely the result of many factors, including the higher frequency of plural *–s* in child-directed speech, the more frequent use of nouns compared to verbs in children's early speech, as well as the increased cognitive salience of nouns compared to verbs for young children (Pinker, 1984). Thus, one might expect better overall production of the plural by 2-year-olds, with no effects of either coda complexity or utterance position. Alternatively, it may be the case that coda complexity and utterance position influence both morphemes equally. Preliminary evidence from Ettlinger and Zapf (2008) showed that plural *–s* production was increased in simple compared to cluster codas (e.g., *keys* vs. *trucks*); however, the nature of stimuli examined in their study does not rule out the possibility that other factors (e.g., syllable length, onset complexity) may underlie the observed complexity effect.

Song et al. (2009) quantified morpheme production using perceptual transcription of children's utterances, a method that is commonly employed in research on language acquisition and in clinical practice. In this study, we took a different approach, which was to examine the acoustics of children's utterances. At the heart of this consideration was the finding that children sometimes make acoustic distinctions that are not detected by adult listeners (e.g., Scobbie, 1998; Scobbie, Gibbon, Hardcastle, & Fletcher, 2000). Such covert contrasts have been documented in the speech of typically developing children and children with language impairments (Forrest, Weismer, Hodge, Dinnsen, & Elbert, 1990), and they have been demonstrated for both the stop-voicing contrast (e.g., Macken & Barton, 1980; Weismer, Dinnsen, & Elbert, 1981) and the stop-place-of-articulation contrast (White, 2001). Recent work has extended the documentation of covert contrasts in children to fricatives (Li, Edwards, & Beckman, 2009). These findings raise the question of how much more might be revealed about children's language abilities from acoustic analysis, as in some cases transcription may underestimate a child's knowledge of language.

To this end, some researchers have examined novel transcription methods that manipulate the task for the listener/transcriber. It has been shown that transcription can be influenced by many factors, including the perceived age of the speaker, the phonetic expertise of the transcriber, and whether or not the speaker and transcriber share the same native language, as well as whether or not the transcriber is given one or multiple categories in which to designate a transcription (as reviewed in Munson, Edwards, Schellinger, Beckman, & Meyer, in press). In this study, we considered a different approach as a complement to perceptual transcription, which was to examine the acoustics of speech for individual cues to segmental features (Shattuck-Hufnagel, Demuth, Hanson, & Stevens, in press). Such an approach provides a potentially more fine-grained analysis of children's early productions of grammatical morphemes than has been previously used (e.g., Song et al., 2009).

In the current experiment, we examined production of plural *–s* in 2-year-old children using acoustic analysis of speech in an elicited imitation task. Productions of eight plural nouns were elicited both utterance-medially and utterance-finally; half of the plural nouns contained simple codas (e.g., *bees*), and half contained more complex cluster codas (e.g., *dogs*). Acoustic analysis was used to determine the presence or absence of cues to the plural morpheme and the extent to which this was systematically related to coda complexity and/or utterance position. We found that, as for third person singular *–s,* plural production was more robust in utterance-final compared to utterance-medial position. However, unlike earlier findings for third-person singular, there was no evidence that coda complexity influenced production of the plural; that is, this morpheme was equally robust in simple and cluster codas. These findings provide several insights into the various factors that may influence morpheme production, as outlined in the Discussion.

Method

Subjects

The subjects were 16 children from the Providence, RI, community. All children were full-term 2-year-olds (nine girls, seven boys) from monolingual English-speaking homes. The children ranged in age from 2;3 to 2;6, with a mean of age of 2;5. All children were healthy on the day of testing and had typically developing speech and language skills according to parental report. MacArthur Communicative Development Inventories (CDI; Fenson et al., 2000) percentile scores on vocabulary size ranged from 15 to 90+ (mean = 47.5). An additional 10 children participated in the experiment but were not included in the analyses reported below. Six were excluded because they did not speak during the experiment. An additional four were excluded because they did not meet the criterion for inclusion, which was to repeat at least 12 of the 16 prompts presented during the experiment. This is consistent with the attrition rate reported in previous experiments using similar tasks with children of this age (e.g., Song et al., 2009).

Stimuli

Eight target plural nouns were selected for use in the experiment, half of which contained a simple coda (e.g., *cows*) and half of which contained a cluster coda (e.g., *dogs*). These are listed in Table 1. In light of findings that have shown lexical influences, including those of phonotactic probability, on children's productions (e.g., Zamuner, 2009) and findings indicating that segmental characteristics may also influence children's productions (e.g., Kirk, 2008), an attempt was made to control the lexical and segmental characteristics of the target plural nouns. That is, the eight monosyllabic CV(C)*s* target words were selected to be highly frequent, familiar, picturable nouns. Eight pictures (one for each target noun) were selected to serve as visual prompts during the experiment. All pictures were selected to be realistic representations of the nouns (as opposed to cartoon-style) and to be of similar size and interest. On each trial, the child saw two copies of each picture on the computer screen in order to provide the appropriate semantic referent for the plural noun.

All target words begin with a stop consonant, except *heads,* which begins with a fricative. All simple targets were selected such that the uninflected form contains CV syllable structure, and the vowels across the simple targets vary. The cluster targets were selected according to similar constraints, with the only difference being that the uninflected form contains CVC syllable structure, with the final consonant being a voiced stop. As a consequence, the morpheme for both simple and cluster targets phonologically manifests as /z/, eliminating the possibility that voicing of the morpheme and coda complexity could be confounded. Furthermore, the variability

Table 1. Stimulus sentences for the simple and cluster coda targets in medial and final utterance position.

Coda	Target	Utterance position: Medial	Utterance position: Final
Simple	*cows*	My cows grazed.	See my cows.
	bees	His bees buzzed.	Hear his bees.
	boys	Her boys came.	See her boys.
	pies	My pies baked.	Taste my pies.
Cluster	*dogs*	My dogs barked.	Touch my dogs.
	pigs	His pigs grew.	Hear his pigs.
	heads	Their heads bump.	See their heads.
	bags	Her bags dropped.	See her bags.

in vowels across the selected simple and cluster targets is comparable.

As shown in Table 1, each target noun was embedded in two sentences, one in which it appeared utterance-medially and one in which it appeared utterance-finally. To control for utterance length, all stimulus sentences consisted of three monosyllabic words. To control for potential articulatory and phonological influences at the phrase level, the utterance-medial sentences were constructed such that the target noun was always followed by a word that begins with a labial or velar stop consonant (i.e., a stop at a different place of articulation than the plural *–s*). This had the added effect of making this a challenging context for the production of the plural morpheme, reducing the possibility of linking effects (i.e., resyllabification) with the following word.[1]

A female native speaker of American English was recorded producing the 16 sentences in an infant-directed speech register. The recording session took place in a sound-attenuated booth. Speech was recorded directly to computer at a sampling frequency of 44.1 kHz and 16-bit quantization via microphone connected to a preamplifier. Each sentence was excised from this long sound file into separate files using the Praat software (Boersma & Weenink, 2010).

For each sentence, three acoustic measurements were performed using Praat. First, we measured the duration of the entire sentence, calculated by the latency between the onset and offset of vocal energy present in the utterance. Second, we measured the duration of the target noun as the difference between the onset of closure for the initial stop consonant and the offset of high-frequency frication energy associated with the plural *–s*. Third, we measured the duration of the plural *–s,* taken as the difference between the onset and offset of high-frequency, aperiodic noise associated with fricative production. These measurements are shown in Table 2.

Each set of measurements was submitted to an analysis of variance (ANOVA) with complexity (simple vs. cluster) as a between-subjects factor and utterance position (medial vs. final) as a within-subjects factor. In terms of sentence duration, neither an effect of complexity, $F(1, 6) = 4.97$, $p = .067$, or position, $F(1, 6) = 0.31$, $p = .599$, nor an interaction between these factors, $F(1, 6) = 0.61$, $p = .464$, was observed, indicating that, as expected, the overall duration of the sentences was approximately the same. In terms of duration of the target noun, the expected effect of position was observed in that targets in final position were longer than targets in medial position, $F(1, 6) = 84.26$, $p < .001$, due to phrase-final lengthening (Turk & Shattuck-Hufnagel, 2007). Neither an effect of complexity, $F(1, 6) = 0.95$, $p = .368$, nor any interaction between utterance position and complexity were observed, $F(1, 6) = 0.23$, $p = .646$. Finally, the duration of plural *–s* was greater in final compared to medial position, $F(1, 6) = 27.56$, $p = .002$, but did not differ significantly for simple compared to cluster codas, $F(1, 6) = 0.08$, $p = .786$, and there was no interaction between utterance position and coda complexity, $F(1, 6) = 0.001$, $p = .977$. To summarize, these analyses indicate that the overall duration of the stimuli was comparable for both simple and cluster coda targets in both utterance positions. Moreover, the duration of the target noun and the duration of the plural morpheme were equivalent across simple and cluster codas but were longer in utterance-final compared to utterance-medial position. These characteristics are comparable to those of the stimuli used for the third person singular *–s* experiments reported in Song et al. (2009).

Table 2. Plural *–s*, target, and sentence duration in ms for the simple and cluster coda prompts in medial and final position.

			Duration (ms)		
Coda	Position	Prompt	–s	Target	Sentence
Simple	Medial	His bees buzzed.	85	661	1,919
		Her boys came.	111	597	1,705
		My cows grazed.	64	534	1,918
		My pies baked.	87	746	1,976
	Final	Hear his bees.	299	1,006	1,893
		See her boys.	328	1,293	2,042
		See my cows.	216	989	1,720
		Taste my pies.	188	1,034	1,805
Cluster	Medial	Her bags dropped.	90	577	1,677
		My dogs barked.	87	729	1,868
		Their heads bump.	72	565	1,731
		His pigs grew.	128	558	1,679
	Final	See her bags.	210	967	1,806
		Touch my dogs.	229	1,079	1,900
		See their heads.	419	1,004	1,824
		Hear his pigs.	211	984	1,759

Procedure

After a brief familiarization with the experimenter (often involving engaging the child with a picture book), the child was invited into a sound-attenuated room with a parent to "play a game" with the experimenter. The room contained a child-sized table and chairs, with a computer monitor and speakers on top of the table. The room

[1]As stated above, the stimuli for the current experiment were designed such that in all cases, the plural morpheme phonologically manifests as /z/. However, informal analyses of our data indicate that many of the plural *–s* productions were devoiced, in line with earlier research showing that many word-final and utterance-final voiced fricatives are phonetically realized as completely or partially devoiced (Stevens, Blumstein, Glicksman, Burton, & Kurowski, 1992). Critically, our acoustic analysis captured morpheme productions that manifested as fully voiced (/z/), fully devoiced (/s/), or something intermediate.

was equipped with two lavalier microphones (Audio-Technica 700 Series) connected to a computer in an adjoining room via the MBox 2 Audio Interface (Digidesign). An attempt was made to attach one of the microphones to the collar of the child's shirt or to place it in a child-sized backpack for the child to wear. However, in most cases, the microphones were placed on the table near the child in order to best capture his or her speech. Following a brief warm-up period in which the child was asked to repeat what the computer said, the child was directed to face the computer in order for the game to begin.

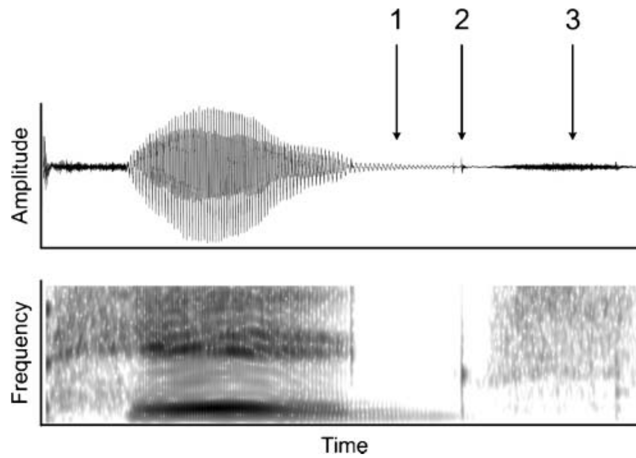
On each trial, a picture of the target noun appeared on the monitor along with the auditory prompt, and the child was directed to repeat the prompt. Five attempts were allowed before the child could move to the next trial. The child was encouraged with praise and, in some cases, stickers, for successful trials. Following the completion of the 16 trials, parents were asked to fill out a brief demographic survey and the MacArthur CDI Short Form in order to estimate the child's vocabulary size. The entire procedure took approximately 30 min.

Acoustic Analysis

Each utterance was excised using Praat and was saved to an individual file for subsequent acoustic coding. One coder performed all acoustic measurements, and a second coder re-measured 25% of the utterances. Reliability between the two coders was 90%. Following conventions established by Shattuck-Hufnagel et al. (in press), each utterance was coded for an assortment of acoustic cues to the distinctive features of the coda segments, three of which are reported in the current article. This method is based on Stevens's (2002) *feature-cue–based model,* which proposes that a given feature contrast may be signaled by a number of different acoustic cues and that the precise set of cues that a speaker employs may vary depending on the other features in the feature bundle (i.e., the phonemic segment) as well as on the segmental and structural context in which the feature occurs. This model separates the acoustic cues in the speech signal into (a) acoustic landmarks, which are robustly detectable abrupt changes in the acoustic signal that provide information on the articulator-free features that correspond to manner of articulation (Halle, 1992; Stevens & Hanson, 2010), and (b) an additional set of cues to articulator-bound features (such as voicing and place of articulation), which are found in the vicinity of the landmarks (Keyser & Stevens, 2006; Stevens & Keyser, 2010).

All cues were identified by a combined visual inspection of the waveform and spectrogram (and listening, in some cases), which were generated using Praat. Figure 1 shows a representative waveform and spectrogram illustrating the three acoustic cues of interest. The first cue, which served as the acoustic metric of plural *–s*

Figure 1. Representative waveform (top panel) and spectrogram (bottom panel) for the target noun *dogs*. The arrows indicate the acoustic landmarks: (1) voice bar, (2) release burst, and (3) frication noise.



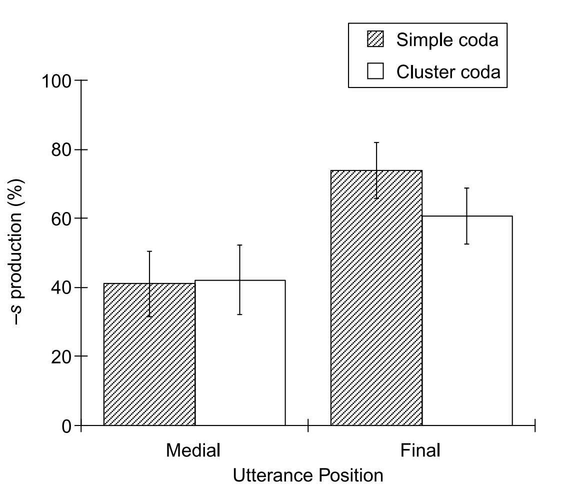
production, was the presence of high-frequency, aperiodic noise following periodicity for the vowel. If coda complexity and utterance position influence production of plural *–s* in the same way as third person singular *–s,* then we would expect to observe increased presence of high-frequency, aperiodic noise in targets with simple compared to cluster codas and in targets produced utterance-finally compared to utterance-medially. The second and third cues, the release burst and voice bar, are associated with voiced stop-consonant production and thus pertain to the targets with cluster codas. A *release burst* results from the release of pressure generated by occluding the vocal tract for stop production while air continues to flow through the vocal folds into the mouth and acoustically manifests as a sudden spike of transient energy. A *voice bar* occurs when the oral and nasal tracts are closed for stop-consonant production although the vocal folds continue to vibrate, and manifests acoustically as a simple waveform of low amplitude with little to no energy in the higher frequencies during the consonant closure. Thus, both voice bar and release burst are evidence that the coda stop was produced, and fricative noise is evidence for the morpheme. Measuring these cues allowed us to examine in detail the degree to which cluster codas were reduced to singleton codas.

Results

Effects of Position and Complexity on Plural –s

The presence or absence of high-frequency, aperiodic noise was used to categorize each utterance as containing plural *–s* or not containing plural *–s,* respectively. Thus, our metric of morpheme production was taken as the adult standard according to both production and perception criteria. Given earlier work on production of plural *–s,* this metric is valid in that children in this age range can produce the morpheme according to the adult standard; however, one consequence of selecting this metric is that it may underestimate the extent to which the morpheme is produced for children who may be engaged in a period of fricative "stopping," a point that we consider further below. For each child, the proportion of tokens that contained the morpheme (as indicated by the presence of frication noise) was calculated for simple and cluster codas in utterance-medial and utterance-final positions by collapsing across the four tokens of each type. Figure 2 shows mean morpheme production across the 16 children. In order to examine the statistical significance of children's performance, mean plural *–s* production across children was submitted to a repeated-measures ANOVA with the factors of coda complexity (simple vs. cluster) and utterance position (medial vs. final). As expected, the results of the ANOVA revealed a main effect of position, $F(1, 22) = 16.582$, $p < .001$, in that the morpheme was produced in a greater proportion of utterance-final tokens (74.7%) compared to utterance-medial tokens (43.4%). However, although plural *–s* was present in a slightly greater proportion of the simple coda targets (64.2%) compared to the cluster coda targets (53.8%), this difference was not statistically significant, $F(1, 22) = 0.987$, $p = .331$. Moreover, there was no interaction between utterance position and coda complexity, $F(1, 22) = 0.819$, $p = .375$. Thus, as was found for production of third person singular *–s* (Song et al., 2009), children's production of plural *–s* was influenced by the position of the noun in the utterance, with better production in utterance-final position.

Figure 2. Mean percent plural *–s* production for medial and final utterance position for simple and cluster coda targets. Error bars indicate standard error of the mean.



However, unlike what was found for third person singular *–s,* there was no evidence of a syllable-level effect of coda consonant complexity. This led us to conduct a finer-grained analysis of the coda clusters to determine if there might be cluster simplification even when plural *–s* was produced.

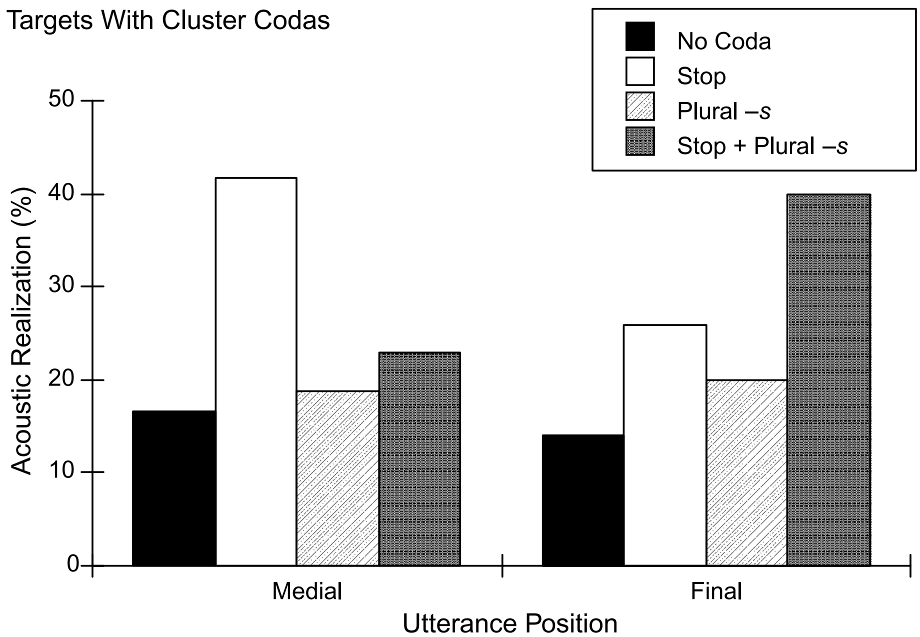
Reduction of the Cluster Codas

A second analysis was conducted in order to examine more closely the acoustic realization of the cluster codas (*bags, dogs, heads, pigs*). Recall that previous work has shown that for third person singular *–s,* morpheme production is more robust in simple compared to complex codas (Song et al., 2009). In other words, children often omit the morpheme in cluster codas, perhaps to decrease the articulatory difficulty of producing a cluster. However, a child faced with more segmental complexity than he or she can handle might have the choice of reducing that complexity by eliminating either the stop consonant in a cluster or the plural morpheme.

Although we did not find evidence of an effect of coda complexity on production of plural *–s* in the current experiment, we wanted to determine if, in those cases where children did reduce the cluster coda to a singleton, there was a tendency to omit or to preserve the morpheme. To this end, the following descriptive analysis was performed. Each production of a cluster target was placed into one of four categories based on the acoustic cues present in that utterance: (a) a coda was considered to be realized as a cluster if it contained either a stop burst or voice bar, indicating production of the stop, and frication noise, indicating production of the morpheme; (b) a coda was considered to be omitted if both the stop burst and voice bar were absent, as well as frication noise; (c) a cluster target was considered to be reduced to a stop if it contained only a burst or voice bar and no frication noise; and (d) a cluster target was considered to be reduced to plural *–s* if it contained only frication noise and no burst or voice bar.

Figure 3 shows the proportion of utterances assigned to each of these categories for both utterance positions. In both medial and final positions, only a very small proportion of cluster targets were realized without codas, as is expected for children of this age. In addition, more cluster targets were realized as clusters in utterance-final position (40%) compared to utterance-medial position (23%). This is consistent with the account that utterance-final position is a simpler context, which supports increased production of the more difficult cluster coda. Finally, in those cases where the cluster target was reduced to a singleton coda, in both medial and final utterance position, more utterances were reduced to only a stop than to only the plural *–s*. Thus, although overall production of plural *–s* was not influenced by coda

Figure 3. Proportion of utterance-medial and utterance-final targets with cluster codas acoustically realized as No Coda, Stop only, Plural –*s* only, and as Stop + Plural –*s*. Within each of the medial and final positions, the sum of the four bars shown is 100.



complexity and most complex targets were realized with plural –*s,* in the cases where children did reduce the complex cluster, there was a tendency to do so by omitting the morpheme. This finding might reflect the tendency for some children to engage in a period of "stopping," wherein fricative targets are produced as stops. Evidence of such a phonological process would attenuate the claim that cluster reduction was accomplished via deletion of the morpheme. Additional data on production of nonmorphemic /z/ would be necessary in order to examine if this is indeed the case; however, to the extent that in both medial and final utterance positions most targets were produced with plural –*s* (either alone or as part of the cluster), it seems unlikely that stopping is a major contributor to the current findings. We discuss the larger implications of these findings below.

Discussion

As reviewed in the introduction, it has long been documented that children's early word productions are highly variable in form. In the case of grammatical morphemes, some of this variability is systematically distributed in response to both semantic and phonological factors, which poses a challenge for accounts positing that such variability is solely the consequence of incomplete syntactic representations. The goal of the current study was, therefore, to further examine possible sources of systematic, context-governed variability in the production of grammatical morphemes.

In the current experiment, we examined 2-year-old children's production of plural –*s*. Productions of nouns with simple codas (e.g., *bees*) and cluster codas (e.g., *dogs*) were elicited both in utterance-medial and utterance-final position. Each production of the target noun was analyzed acoustically in order to determine the presence or absence of plural –*s*. The results showed that the children produced plural –*s* more often utterance-finally compared to utterance-medially but that production was equally frequent for simple and cluster codas, at least in the contexts used here. This finding is striking because Song et al. (2009) demonstrated that both utterance position and coda complexity can affect children's production of third person singular –*s,* which phonologically manifests the same as plural –*s*. Thus, although the same segment is being produced, it conveys a different meaning, and it is differentially influenced by the phonological factors examined presently. In the next sections, we outline possible explanations for the differential influence of coda complexity on morpheme production, beginning with methodological considerations between the two studies and concluding with the theoretical consideration that the nature of the syntactic representation itself underlies these effects.

Methodological Considerations

It is possible that the lack of a complexity effect on production of plural *–s* compared to third person singular *–s* is a consequence of several methodological differences between the two studies. For example, the metric of morpheme production in Song et al. (2009) was perceptual transcription, whereas acoustic analysis was used in the current experiment. To the extent that the methods in the current article provide a potentially more fine-grained metric of morpheme production, it is possible that the acoustic analysis used in the current study allowed for identification of frication noise that listeners might not have detected, perhaps due to short duration or low amplitude. Such an account would be consistent with other findings of covert contrast in children's early productions (e.g., Scobbie et al., 2000). However, results from a recent study that directly compared acoustic and perceptual metrics of coda production for nonmorphemic segments indicate that there was no difference for perceptual versus acoustic coding of nonmorphemic /s/ and /z/ codas (Theodore, Demuth, & Shattuck-Hufnagel, 2010). Thus, we suspect that different procedures for assessing morpheme production across these two studies do not account for the different results. On the other hand, the target verbs used in Song et al. were more varied compared to the stimulus set used in the current works in that the morpheme was realized as both /s/ and /z/ in Song et al. but only as /z/ in the current study. Furthermore, the target verbs in Song et al. were placed in carrier phrases where the following context was not controlled for sonority, whereas the following context in the present study always contained a stop. Thus, it is possible that interactions between the phonological structure of the target words and the following context mediated the complexity effect differentially for the plural and third person singular morpheme in medial position. A final difference between the two studies concerns the mean age of the children examined, which was 2;2 in Song et al. and 2;5 in the current study. Because the complexity effect on morpheme production is clearly a developmental process (i.e., adults no longer exhibit this effect), it is possible that the 3-month difference between the children examined reflects a period of time in which coda complexity ceases to influence morpheme production. Further support for this possibility comes from a comparison of the mean vocabulary size of the two experimental groups as measured by raw scores on the MacArthur CDI—80.5 in the current study, but only 75 in the Song et al. study on the short form of the CDI (100 possible words). Thus, the children in the current study were linguistically more advanced, at least on measures of vocabulary size, which could have reduced the complexity effect. Finally, as noted in the introduction, both the plural morpheme and nouns in general have higher frequency in everyday speech than do verbs and third person singular morphology, possibly facilitating production. Future research should examine morpheme production with all these considerations in mind.

Syntactic Considerations

The effects of coda complexity and utterance position on morpheme production have been explained as a consequence of morpheme production being more robust in phonologically simpler contexts, as outlined by the prosodic licensing hypothesis (e.g., Demuth & McCullough, 2009). However, the precise dimensions that determine the ease of producing inflectional morphemes in particular contexts remain unclear. Possible relevant factors, in addition to complexity and position within the utterance, might include the stability of lexical representations, segmental markedness factors, ease of articulation, and planning factors related to the translation of phonological representations into motor commands. What is known, however, is that production of third person singular *–s* appears to get a boost in both simple syllable structures and utterance-final position. Consistent with these findings, the results from the current study indicate that producing plural *–s* is easier in utterance-final contexts, suggesting that this is a robust effect due to either perceptual and/or production/planning factors. However, there is no evidence of a syllable complexity effect in the contexts used here, suggesting that the older age of the children, and/or lexical frequency factors, may mediate the complexity effect. We use these findings to generate the following hypotheses.

The apparent fact that the effects of utterance position and coda complexity on morpheme production may be decoupled for individual morphemes suggests that these two influences may have separate loci. If both effects were due to articulatory difficulty, for example, we might expect consistently to observe these effects hand in hand. Additional data from experiments manipulating whether the plural *–s* is followed by a consonant versus a vowel (which might provide an "easier" medial context) might help determine whether this is indeed the case. In addition, the qualitative differences in how utterance position and coda complexity influence production of the phonologically identical third person singular and plural morphemes may reflect influences at the morphological level itself. That is, due to a variety of factors, including frequency in the input (Hsieh, Leonard, & Swanson, 1999), and even general cognitive factors, including semantic saliency (Pinker, 1984), some morphemes may simply be easier to acquire than others (Brown, 1973), and this difference may influence the degree to which production of a given morpheme is influenced by contextual factors. This hypothesis is currently being tested in experiments that manipulate grammatical status while controlling for both input-based factors (e.g., lexical frequency) and lexical/articulatory factors (e.g., phonotactic probability), with the goal of further explicating the relationship among these levels of production during language acquisition.

The findings from the current experiment indicate potential considerations in evaluating and diagnosing speech and language disorders in children. Specifically, the robust influence of utterance position on morpheme production for both plural *–s* and third person singular *–s* indicates that clinicians should take this into account when eliciting productions for clinical evaluation. For example, a lack of morpheme production in utterance-medial position may not reflect impoverished syntactic representations; rather, it may reflect issues in articulatory coordination. In addition, given the disparate effects of coda complexity on production of the plural and third person singular morphemes, the phonological characteristics of tokens used in a diagnostic evaluation should be similar in order to more directly compare morphemic knowledge and competence. Furthermore, the current data contribute to an explanation of the locus of deficits in children with specific language impairment (SLI). Specifically, production of both the plural and third person singular morphemes is facilitated in utterance-final compared to utterance-medial position, which is consistent with the surface account of morpheme difficulty in children with SLI in that the weaker surface form of medial position (e.g., shorter in duration) is also the case where fewer morphemes were produced (Leonard, Eyer, Bedore, & Grela, 1997).

In sum, the findings from this study replicate the positional effect found in a previous examination of third person singular *–s*. That is, 2-year-olds produced the plural morpheme more frequently in utterance-final compared to utterance-medial position. Hsieh et al. (1999) noted that in adult speech, morphemes in utterance-medial position were shorter in duration than those that occurred utterance-finally. In addition, Kirk and Demuth (2006) found that children omitted simple coda consonants more often in nonfinal, unstressed contexts. Both of these findings suggest that utterance-final position is privileged in terms of facilitating the production of final consonants, be they inflectional or not. This could be due to the fact that the increased duration of utterance-final syllables, at least in a language like English, provides children with more time to articulate a coda consonant. Such an advantage would not be found in medial contexts, where there is less time to articulate and/or plan for the coda. In medial contexts, there is also the added difficulty of having to plan for and articulate the next word, which is not a consideration when a word is produced in utterance-final position. Finally, given the shorter duration of inflectional morphemes utterance-medially in adult speech, there may also be decreased perception of these forms (Sundara, Demuth, & Kuhl, 2011), a factor that plays an additional role in the less robust production in medial contexts, especially in a modeled elicitation task such as the one used here. The findings from the current experiment thus raise many issues for future investigation regarding the factors that contribute to the variable nature of children's early productions of grammatical morphemes—an issue of central importance for evaluating what children know about the language they are learning.

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