Acoustic Differences among English -s Allomorphs in a Children's Book Reading Task

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In the acquisition of English morphophonology, the third singular *–s* marker on verbs (e.g., wants) has a protracted course of development compared to other grammatical functions carried by *–s* related morphemes, specifically plural *–s* (e.g., dogs) and possessive *–s* (e.g., Pete's). Phonological constraints cause three allomorphs, or variant surface forms of morphemes, to arise for each of these three morphemes (i.e., [s], [z], and [əz]). Previous explanations for the developmental variation observed for these three morphemes focused on parent input frequency, sentence position, or acoustic duration. In these investigations, the allomorphs of these morphemes were typically collapsed, so it has not been possible to understand interactions between phoneme category (i.e., [s] vs. [z]) and morpheme type (i.e., third singular, plural, and possessive) [1-3]. The current study investigates this interaction in the characteristics of spectral moments for each allomorph production. The two measures reported are the duration of the production and its center of gravity (i.e., mean frequency of spectral energy). If these measures differ between third singular *–s* and the other morpheme types, we could better understand the relative difficulty with third singular *–s* experienced by children acquiring English typically and with language impairment especially.

Participants included ten college students studying speech pathology. Participants were recorded reading a children's book strategically designed to have numerous opportunities for the third singular morpheme, but also included the other *–s* related morphemes. Allomorphs were coded for phoneme category and morpheme type (see Table 1). For the spectral analysis, the audio sample was resampled at 22 kHz, and four equally spaced spectra (i.e., 15 ms window) across the middle 80% of each fricative duration were averaged. The total fricative duration and the center of gravity frequency were computed in Praat [4]. The duration and center of gravity for all 43 allomorph opportunities were averaged across participants. Differences in conditions were analyzed with a linear mixed model.

A significant interaction existed between phoneme category and morpheme type both for duration ($F = 59.35$; $p = .000$) and for center of gravity ($F = 8.85$; $p = .000$; see Tables 2 and 3). First, the phoneme [s] had a longer duration than [z] in monomorphemic words (e.g., "fence" vs. "his") and as a plural marker (i.e., "seats" vs. "dogs"). However, [s] was not longer than [z] when used as a marker of third singular (e.g., "hits" vs. "runs"). Next, the center of gravity was significantly lower in frequency for monomorphemic [s] than for plural [s] ($p = .01$) and possessive [s] ($p = .000$). However, monomorphemic [s] was *not* different from third singular [s].

The majority of English-acquiring children's experience with [s] and [z] occurs in monomorphemic words, in which [s] was significantly longer than [z]. This experience may complicate the acquisition of third singular allomorphs, for which this duration distinction between [s] and [z] was not found. Further complicating the acquisition task is that most of children's experience with [s] as a bound morpheme (i.e., plural *–s* or possessive *–s*) occurs with a significantly different spectral frequency than that of the [s] phoneme in monomorphemic words. Specifically, when marking plural or possessive, the dominant spectral frequency for [s] shifted to a comparatively higher frequency. However, this was not the case when [s] was used to mark third singular, for which center of gravity resembled that of the [s] in single-morpheme words. From infancy, statistical learning supports the identification of morpheme boundaries, so this resemblance could hinder segmentation of the root verb from the third singular marker [5]. Together, these findings contribute to our understanding of why third singular *–s* has a distinctly longer period of acquisition among the s-related morphemes in English.

References

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Table 1

Number of Trials in the Reading Stimulus for each Morpheme (Multiplied by Total Observations across Participants, n=10)

	Phoneme Category	
Morpheme Type	[s]	[z]
Monomorphemic	1 (10)	6 (60)
Plural	2 (20)	1 (8)
Possessive	2 (20)	0 (0)
Third Singular	15 (148)	16 (160)

Note. Values reflect the number of opportunities in the stimulus multiplied by participants (i.e., $n = 10$). One participant did not produce two of the third singular [s] trials. Values with a duration under 35 *ms* were removed for violating the assumptions of the spectral analyses using 15 *ms* windows. As a result, two productions of plural [z] were removed prior to analysis.

Table 2

Mean (Standard Deviation) Duration (ms) of [s] and [z] by Morpheme Type

	Phoneme Category	
Morpheme Type	[s]	[z]
Monomorphemic	154.44(37.66)	78.54(13.21)
Plural	101.37(27.59)	66.06(27.64)
Third Singular	91.40(8.71)	85.40(9.67)

Table 3

Mean (Standard Deviation) Center of Gravity (Hz) for Morphemes by Phoneme Category

		Morpheme Type			
		Monomorphemic	Plural	Possessive	Third Singular
Phoneme	[s]	7442.77(1000.15)	7743.11(1177.99)	8060.94(866.71)	7442.07(945.81)
Category	[z]	7090.37(793.50)	7467.86(1317.20)	--	7091.60(831.79)