Acquisition of Sociolinguistic Variation:
Acoustic Characteristics of s-lenition in the Speech of Spanish-speaking Children

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1. Introduction

There is a considerable amount of research examining Spanish syllable final /s/ lenition (as illustrated in 1) in adult-to-adult speech.

(1)   gatos   [gatos], [gatoh], [gato]
        cat-PL
        'cats'

S-lenition is wide-spread in many dialects of Spanish, including Spanish spoken in the Caribbean region, coastal Mexico, Central America (but not in Costa Rica and Guatemala), and the Pacific coast of Colombia, Ecuador, coastal Peru, Chile, Paraguay, Uruguay, and much of Argentina (Lipski, 1994).

Spanish s-lenition is a phonological process that weakens both morphological /-s/ (plural marker /-s/; 2sg verbal affix /-s/) and non-morphological /s/ (e.g. bus 'bus' [buh]) and a variety of linguistic and extralinguistic factors have been found to contribute to s-lenition in adult-to-adult speech – these include morphological function, following phonological context, word position, word length, gender, age, and speech style (Alba, 2004; Cepeda, 1995; File-Muriel & Brown, 2011; Miller, 2013a; Poplack, 1980, among many others).

There are very few studies dealing with the acquisition of s-lenition in children (Miller, 2007, 2013). In fact, relatively few studies have focused on developmental sociolinguistics at all; although, this line of research has recently been gaining more attention (Foulkes, Docherty, & Watt, 2005; Foulkes & Docherty, 2006; Miller, 2007, 2013a; Roberts, 1997; Smith, Durham, & Fortune, 2007, 2009). Nevertheless, the vast findings on s-lenition in adult-to-adult speech push us to consider how it is that s-lenition is acquired. For example, what is the process by which children begin to lenite /s/? And, what role might acquisition processes and child-directed speech play in the relative contribution (i.e., factor weights) of each of the linguistic and extralinguistic constraints on s-lenition in adult speech?

The majority of research on s-lenition has treated it segmentally, describing /s/ as being fully articulated [s], reduced to an aspiration [h], or deleted. However, this approach to the study of /s/ lenition has recently been challenged by researchers who have taken a subsegmental approach whereby frication duration and center of gravity (COG) measures are correlated with various linguistic and extralinguistic factors (Erker, 2010; File-Muriel & Brown, 2011). According to Erker (2010), "a subsegmental approach more adequately characterizes the relationship between variation in the acoustic signal and its conditioning factors [p. 23]." He finds that what is sometimes characterized together as one variant in segmental approaches, may show variation in terms of frication duration. For example, he found that the full form [s] is longer word-finally

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and before pauses than before vowels, which, in turn, is longer before vowels than before consonants.

The present study builds on subsegmental approaches to the study of s-lenition in adult-to-adult speech by examining s-lenition – as measured by frication duration – in young Spanish-speaking children and their caregivers. The study of s-lenition in children has implications, not only for the study of developmental sociolinguistics, but also for language acquisition research. Children must acquire not only /s/ lenition and its conditioning factors, but also the grammatical morphology (e.g. plural marking, 2sg verbal affix) that is affected by s-lenition. One question we might ask is what is the impact of s-lenition on the acquisition of plural morphology in young children (see Miller 2007, Miller & Schmitt 2012). In this paper the following research questions will be addressed:

(i) How does s-lenition in children's speech compare to s-lenition in their caregivers' speech?
(ii) Does s-lenition in child-directed speech (CDS) pattern differently than s-lenition in adult-directed speech (ADS)?

2. Background
2.1. Spanish /s/ lenition

Spanish s-lenition is a phonological process that affects both morphological /-s/ and non-morphological /s/, as shown in (2).

(2) a. el   bus   [bus], [buh], [bu]
        the-SG bus-SG
        'the bus'

    b. los   gatos   [los], [loh], [lo]
        the-PL cat-PL   [gatos], [gatoh], [gato]
        'the cats'

    c. Cantas   [kantas], [kantah], [kanta]
        Sing-2SG
        'You sing.'

Omissions are more common in working-class speech than in middle-class speech, are produced more often by male adult speakers than by female adult speakers, and are more frequent in informal speech than in formal, careful speech. Moreover, there are various morphological and phonological factors that contribute to s-lenition (Alba, 2000, 2004; Cepeda, 1995; File-Muriel & Brown, 2011; Lipski, 1994; Miller, 2013a). Cepeda (1995) reports that /s/ tokens preceding [-Continuant] consonants show more [h] than tokens in any other phonological context. Likewise, she finds that plural marker /-s/ is aspirated more frequently than nonmorphological /s/. Finally, studies have reported that word position impacts s-lenition (File Muriel & Brown, 2010; Miller, 2013a): /s/ is aspirated more frequently in word medial and word final position (preconsonantal and prevocalic) than in phrase final position.

While most studies on s-lenition describe it in terms of aspiration and deletion of final /s/, it has been argued that this classification does not completely reflect the nature of the sounds

involved. Widdison (1995) argues that aspiration arises due to co-articulation between /s/ and its preceding vowel – as such, a partially devoiced vowel occurs even with the full [s] variant. When [s] is shortened to an omission, the remaining partially devoiced vowel is perceived as an aspiration. He reformulates the traditional rule of s-lenition (shown in 3) with that shown in (4) and notes that "(4a) represents the physical reality of speech, while (4b) corresponds to the listeners' misattribution of lexical importance to the automatic vocalic murmur in the absence of a good [s] [Widdison, 1995: 187]."

(3)   s → h/ ____ C

(4) a.   /Vs/ → [Vhs]
    b.   [Vhs'] → /vh/

In a recent study involving a larger set of the data presented here, Miller (2013a) uses a segmental approach to examine s-lenition in children and their caregivers. She finds that overall children produce fewer [h] tokens than their caregivers (see also Miller, 2007). Assuming Widdison's proposal, it may be that the segmental approach is missing variability in children's speech in terms of /s/ shortening. In other words, children may lenite (i.e., shorten /s/) in many of the same linguistic contexts as their caregivers, but they may not always shorten /s/ to the point of leaving only [h]. As such, a segmental approach might group together various durations of the full variant [s] which, as has been pointed out by Erker (2010), would not allow us to see structured variability within this [s] category. To examine more carefully this issue, in the present paper we use a subsegmental approach that focuses on /s/ duration.

2.2. Acquisition of sociolinguistic variation

Very few studies have examined children's acquisition of sociolinguistic variation but the studies that do exist indicate that while most children show variable usage from the earliest ages tested, younger children do not completely pattern with adults on the linguistic and extra-linguistic contexts of usage (Guy & Boyd, 1990; Kovac & Adamson, 1980). For example, Roberts (1997) reported that at 4 years of age, English-speaking children show patterns of t/d deletion in final consonant clusters (e.g. mist, missed, kept) but that the patterns of deletion differed from that found in adult speech. In particular, both children and caregivers deleted t/d when it was lexical (e.g. mist) but not when it was morphological (e.g. jumped, missed); however, unlike adults, children also deleted t/d on semiweak verbs (e.g. kept, slept) and in the semiweak context they did so at near-categorical rates (also see Smith, Durham, & Fortune, 2009; Guy & Boyd, 1990).
In terms of when the linguistic and extralinguistic constraints on usage are acquired, studies indicate that phonological constraints are acquired earliest, followed by morphological constraints, and later extralinguistic constraints (Smith et al., 2009; Roberts, 1994). Labov (1989) proposed that this ordering of constraints in the acquisition of variable rules may be universal; however, Labov (1989), himself, found a different ordering where social and stylistic constraints were acquired earlier than linguistic constraints. Nevertheless, the age at which linguistic and extralinguistic constraints are acquired differs across studies – a finding that may be related to the type of variation under investigation (e.g. morphological, phonological) and the frequency of

the variable forms in child-directed speech (as opposed to adult-directed speech) (Foulkes et al., 2005; Foulkes & Docherty, 2006; Miller, 2013a; Smith et al., 2007).

Some research has indicated that caregivers use more standardized forms in child-directed speech (Foulkes et al., 2011); however, other studies find few differences between CDS and ADS and have suggested that caregivers only alter the forms in their CDS that they consciously know to be stigmatized in their language (Smith et al., 2007, Miller 2013b). This is important because it has been shown that there is a close link between caregiver speech and child speech in the production of variable forms – the more variable the caregiver, the more variable the child (Smith et al., 2007).

3. Naturalistic Speech Study
3.1. Data Collection

The data for this study come from the Miller-Schmitt Corpus[1] (Miller & Schmitt, 2012; Miller, 2013a) and, for the present paper, we present the production data of seven children and their caregivers[2]: Nico (2;08) Jorge (3;06), Pablo (4;04), Maria (4;04), Diego (5;04), Elena (5;04), and Pedro (5;09).

All recordings were made in a small lab playroom located in a working-class neighborhood in Chile over a period of 4 – 6 weeks. The lab playroom contained several toys including puzzles, toy train sets, stamps, baby dolls, play food and kitchenette, craft activities (e.g. puppet making, beading necklaces, finger painting), puppets, children's books, and felt boards.

Caregivers and children were left alone in the playroom during each recording session. Recordings were made with a Marantz PMD660 compact flash recorder (recorded at 48kHz) that was connected to two AT831b cardioid lavalier condenser microphones that were each connected to a baseball cap (one for the caregiver and one for the child). This placed the microphone approximately 7 inches in front of the participant's mouth. Measures were taken to control background noise, such as hissing noises from heaters and other electronic equipment. These procedures allowed us to obtain high quality sound recordings – which are necessary for detecting aspiration – while still maintaining an environment that would elicit large amounts of highly vernacular, interactional speech.

3.2. Data Analysis

A total of 2246 tokens were extracted from child and caregiver speech (963 child tokens and 1283 caregiver tokens). Each token was first coded segmentally by a trained research assistant

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[1] The Miller-Schmitt Chilean Corpus (Miller & Schmitt, 2012; Miller, 2013a) contains conversational interactions between Chilean children and their caregivers and also between caregivers and other adults. The recordings were collected from May to August both in 2008 and 2009 by Karen Miller (Penn State University), with support from Calvin College (Grand Rapids, MI) and the National Science Foundation (NSF# BCS-1061805). These data are part of a larger collaborative project with Cristina Schmitt (Michigan State University), which compares acquisition of grammatical morphology in contexts of ambiguous input. This project also includes a corpus of Mexican child and caregiver speech collected by Cristina Schmitt (Schmitt-Miller Corpus).

[2] The seven children discussed in the present paper are a subset of the children discussed in Miller (2013a). Some of the tokens have been removed from those presented in the original paper and some new tokens have been added. The decision to remove tokens was made when PRAAT delineation of the /s/ segment was too difficult. Tokens were added as more data were transcribed and analyzed. The names used in this paper are pseudonyms and not the real names of the children.

who was a native speaker of Chilean Spanish. The research assistant listened to each token and then assigned it to one of three broad categories: full form [s], aspiration [h], omission [zero].

Next, for the subsegmental analysis, a second research assistant delineated the /s/ segments of each token in PRAAT (Boersma & Weenink, 2013) using both the waveform and the spectrogram. Following procedures used in previous subsegmental analyses (see Erker, 2010) the window length in the spectrogram was 0.005 seconds with a dynamic range of 40 dB. The spectrogram method was set for Fourier Analysis and a Gaussian Window shape and pre-Emphasis was set at 6 dB/oct. The onset of each /s/ segment was determined by the cessation of the F2 of the preceding vowel and the initiation of high frequency frication. The offset of the /s/ segment was determined by the cessation of frication. Tokens where no frication was detected were recorded as having zero /s/ duration and were not included in the subsegmental analysis.

Tokens were coded for the independent variables: following phonological context, morphological function, and word position.

- **Following Phonological Context:** We divided data into two contexts: [-Continuant] consonant and other.
- **Morphological Function:** A three-way division was made – nonmorphological /s/, plural marker /-s/, and 2sg verbal affix /-s/.
- **Word Position:** There were three contexts – word-medial position (e.g., *listo* 'ready', *este* 'this'), word-final position (preconsonantal and prevocalic) (e.g., *las arañas de Pedro* 'the spiders of Pedro'), and phrase-final position (prepausal) (e.g., *Tiene perritos* 'He has dogs'). This coding is consistent with the generally accepted contexts of syllable-final Spanish /s/-lenition (see Brown & Torres Cacoullos, 2002, and references therein).

3.3. Results

The *segmental analysis* (coding for the broad categories of [s], [h], and omissions) shows that children use the full variant [s] when speaking to their caregivers 29.6% of the time. They produce [h] 26.8% and zero 43.6% of the time. Caregivers produce the full variant [s] 18.4% of the time, [h] 44.3% of the time, and zero 37.3% of the time. Similar to the findings reported in Miller (2013a), children produced much less [h] than their caregivers. This is the first indication that children – although variable at this age – are not completely adult-like in their use of s-lenition. Both caregiver and child production of the three variants is similar to what has been reported for adult-to-adult and child-to-adult (i.e., where the adult is a non-kin research assistant) speech in past research (Cepeda, 1995; Miller, 2007). This is illustrated in Table 1.

The *subsegmental analysis* – which in the present paper focuses on the frication duration of the [s] and [h] tokens – shows that children and caregivers alter their duration of /s/ as a function of the independent variables investigated here. For phonological context, both children and caregivers showed the shortest duration of /s/ when it preceded a [-Continuant] consonant than in the other phonological contexts (Children: $F(1,513) = 273.022$, $p < .001$; Caregivers: $F(1,768) = 272.555$, $p < .001$). Morphological function significantly affected the duration of /s/ in both children and their caregivers (Children: $F(2,512) = 4.863$, $p < .01$; Adults: $F(2,767) = 10.311$, $p < .001$). The plural marker /-s/ was significantly longer than the 2sg verbal affix /-s/ ($p < .001$) and nonmorphological /s/ ($p < .001$) in caregivers but only significantly longer than nonmorphological /s/ ($p < .05$) in children. Word position also significantly affected /s/ durations in both children and their caregivers (Children: $F(2,512) = 156.986$, $p < .001$; Adults: $F(2,767) =$

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342.721, $p < .001$). Durations were significantly longer phrase finally than word medially or word finally in both children and in their caregivers ($p < .001$). They were also longer word finally than word medially in children ($p < .001$) and in their caregivers ($p < .01$). Table 2 illustrates these findings.

Table 1.
Percentage of [s], [h], and zero in child (adult directed v. caregiver directed) and adult (adult-directed v. child-directed) speech in two studies

	Miller (2007) Punta Arenas, Chile (Plural Marker /-s/)		Present Study Punta Arenas, Chile (All final /s/)	
	Child-to-Adult RA	Adult-to-Adult RA	Child-to-Caregiver	Caregiver-to-Child
[s]	22 ($n = 108$)	13 ($n = 34$)	29.6 ($n = 285$)	18.4 ($n = 236$)
[h]	21 ($n = 104$)	43 ($n = 110$)	26.8 ($n = 258$)	44.3 ($n = 568$)
Zero	58 ($n = 287$)	44 ($n = 113$)	43.6 ($n = 420$)	37.3 ($n = 479$)

Table 2.
Mean duration and standard deviations (in milliseconds) of /s/ in child and adult speech

	Adults	Children
Phonological Context		
[-CONT] Consonant	30 (18)	49 (33)
Other	89 (67)	125 (62)
Morphological Function		
Nonmorphological	56 (57)	88 (65)
Plural Marker	77 (66)	108 (60)
2sg Verbal Affix	52 (44)	83 (47)
Word Position		
Word Medial	31 (19)	45 (28)
Word Final	43 (36)	82 (49)
Phrase Final	129 (66)	137 (63)

4. Conclusion

The goal of this paper was to examine the use of s-lenition in the speech of children and their caregivers. We set out to examine how s-lenition in children's speech – as measured by frication duration – compares to that in their caregiver's speech, and how CDS compares to ADS. Both questions were posed at the beginning of this paper and, in what follows, we will address each of them in turn.

(i) How does s-lenition in children's speech compare to s-lenition in their caregivers' speech? While the segmental analysis indicates that children produce fewer tokens of [h] than their caregivers, the subsegmental analysis indicates that children pattern with their caregivers on /s/ duration (i.e., duration of [s] and [h]) across the different linguistic contexts examined. The subsegmental analysis indicates that children, like their caregivers, adjust their /s/ duration as a function of phonological context, morphological function, and word position. This suggests that, like adults, children are leniting final /s/, just not as often to the point of an aspiration. Assuming Widdison's proposal on the nature of s-lenition, our future research will focus on co-articulation abilities in children and how that might relate to their development of s-lenition.

(ii) Does s-lenition in child-directed speech (CDS) pattern differently than s-lenition in adult-directed speech (ADS)? The segmental analysis of caregiver speech shows similar proportions of [s], [h], and zero as previous studies of /s/ lenition in Chilean adult-to-adult speech (Miller, 2007). This suggests that caregivers do not alter their use of s-lenition when speaking with their children. Turning to the subsegmental analysis, the results for caregiver speech are similar to what has been reported on adult-to-adult speech in Erker (2010); however, we need to be careful in this comparison because Erker examined a different dialect of Spanish and only focused on the frication duration of the full variant [s] (not including aspiration). Nevertheless, one difference that arises between the two studies is that caregivers in the present study produce longer durations of the plural marker /-s/ than of nonmorphological /s/, which does not appear to be the case in Erker's (2010) study. This may indicate a difference between CDS and ADS; caregivers may lenite less often when /s/ is meaning bearing. However, again we must be careful in this interpretation as Miller (2013a) also indicates that caregivers omit the plural marker more often than non-morphological /s/ and omissions were not included in our subsegmental analysis. Our future research will consider the implications of this finding for the acquisition of plural morphology in children acquiring dialects of Spanish with s-lenition.

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