Acoustic investigations of the syllabic *-es* plural in 2-year-olds' speech: A preliminary investigation

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Abstract

Children have been found to acquire /-ə z/ plurals (e.g. *nos<u>es</u>*) later than /s,z/ plurals (e.g. *cat<u>s</u>, dog<u>s</u>*) (Brown, 1973). This study explores why there is delayed acquisition of the syllabic *-es* plural and whether word length or segmental factors are involved. We conducted an elicited imitation task involving eight target items, half with a disyllabic root (e.g. *letter* → *letter<u>s</u>*), and half with a monosyllabic root (e.g. *bus* → *bus<u>es</u>*). Children saw pictures of the items on a computer and repeated pre-recorded three-word-utterances with the target both utterance-medial and utterance-final. Acoustic analysis was used to determine the presence or absence of the plural morpheme. Preliminary results from two children show that they have more trouble producing the syllabic *-es* morpheme, especially when the target word is in utterance-medial position. This suggests articulatory difficulties with the two consecutive fricatives especially when there is less time for the child to perceive/produce the word without phrase-final lengthening.

Keywords: speech acoustics, child language acquisition, syllabic plurals.

Introduction

Children's early productions of grammatical morphemes have been found to be highly variable (Brown, 1973; Berko, 1958). In particular, children have been found to acquire /-əz/ syllabic plurals which are required after word-final sibilants (e.g. *nose<u>s</u>*) later than /s,z/ plurals required after non-sibilants (e.g. *cat<u>s</u>, dog<u>s</u>*). Several studies have investigated why this might be.

The classic Berko (1958) study involved a morpheme elicitation task to see if children (aged five to seven) possessed morphological rules. She found that children were able to form plurals requiring /-s/ or /-z/ but failed to produce the morpheme when the root ended in /s/ or /z/ as the plural required the more complex /-əz/. Berko suggested that children at this age may think that a final sibilant makes the word plural. Goad (1989) furthered this research to include another stage in plural acquisition which comes between the child adding nothing to the root and adding the syllabic *-es* plural. In this stage, children add the underlying plural morpheme *-s* to the root word which results in two consecutive fricatives produced without the schwa (e.g. *bus-s*). Goad refers to this as a gemination strategy. This is used prior to children learning to add the schwa epenthesis in line with the Obligatory Contour Principle (OCP) (McCarthy, 1986), which states that adjacent identical phonemes are not allowed (hence *bus-s* must then become *bus<u>e</u>s*).

However, these two studies only investigated assumed deep structure motivations for the acquisition pattern of the syllabic *-es* plural. Kirk and Demuth (2006) and Song, Sundara and Demuth (2009) propose that some of the variability in children's early productions of grammatical morphemes may be due to phonological context effects such as phonological complexity and ease of articulation. For example, Kirk and Demuth found that the variability could be accounted for by word duration and word position. Regarding word

duration, Kirk and Demuth found that codas of monosyllabic words are produced more accurately compared to disyllabic words. Monosyllabic words have longer syllable durations providing the articulators more time to approximate their targets as there is an inverse relationship between the number of syllables in a word and their duration. From this we would also expect difficulties in the production of plurals of disyllabic words.

Studies on the past tense morpheme production (for example Berko, 1958; Marchman, Wulfeck, & Weismer, 1999) have shown that adding an extra syllable to the inflected word makes the word more difficult for the child to produce compared to when the past tense morpheme results in a coda cluster (e.g. melted /mel-təd/ vs. baked /bæɪ kt/) This poses the question of whether similar effects occur when the plural adds an extra syllable to the word. Hence the aim of the current study was to examine children's acquisition of the *-es* plural morpheme in monosyllabic nouns (e.g. *bus* → *buses*) compared to disyllabic plural nouns (e.g. *letter* → *letters*).

Song et al. (2009) showed that production of third-person singular *-s* was better in contexts that were phonologically less difficult, such as when the word had a less complex coda, or was in the lengthened utterance-final position. Theodore, Demuth and Shattuck-Hufnagel (2010) also found this utterance position effect in children's production of the plural *-s* in monosyllabic words, but did not find any coda complexity effects. In regard to utterance position, Theodore et al. found that children produced the plural morpheme *-s* more often in utterance-final position compared to utterance-medial position. This is probably due to phrase-final lengthening which gives the child more time to perceive/plan/produce and articulate the morpheme. This supports Kirk and Demuth (2006) who found that coda consonants are more likely to be omitted in non-final, unstressed contexts, probably due to the shortened duration compared to words in phrase-final

position. Theodore et al. also suggested that the difficulty in producing utterance-medial morphemes could be because the child still has to plan and articulate the following word, whereas this is not required when the word is utterance-final. The current study will therefore incorporate utterance position lengthening effects by comparing the production of the syllabic *-es* plural in utterance-medial and utterance-final positions. Note that utterance-initial position does not need to be considered as well as utterance-medial position as Swanson and Leonard (1994) found no durational differences between the two.

Another possible explanation for the delay of the /-əz/ plural after /s/ or /z/ may be that it is articulatory difficult for the child. Smit (1993) found that fricatives are often acquired later than stops, which occur at a higher frequency. This may suggest an articulatory difficulty in the child producing the /-əz/ morpheme after a fricative as they have to produce a fricative twice, separated only by the reduced vowel schwa. Berko found that children were worst at adding the /-əz/ morpheme when the singular also ends in /z/ compared to other phonemes including /s/. Smit found that codas ending in /z/ were only produced accurately 43% of the time at age three compared to codas ending in /s/ (accuracy 60%). Berko however found that children correctly produced the high frequency familiar word *glasses*, showing capability of producing the /-əz/ morpheme in words that are plural dominant and a part of their lexicon, but may not yet be analysed as a plural.

This past research leads to several questions. Is the delayed acquisition of the *-es* morpheme following the fricative /s/ or /z/ due to children assuming the word is already plural because it ends with this fricative? Is it all disyllabic plural words that children have trouble producing from an increased phonological processing load, or is this more so when the plural adds a syllable? Is the delayed acquisition of the syllabic plural because of difficulties in the articulation and production of two consecutive challenging phonemes? To

answer these questions it will be assumed that if there is morpheme absence, then it is likely that children have the assumption that a final fricative makes a word plural. If there is syllable or morpheme reduction, it is likely that it is the longer word duration that is the problem. However, if there are variable realisations of the syllabic plural, then it is more likely that the plural absences may be due to segmental problems. Given the previous findings it is more likely that if there are problems in the production of this morpheme, they will present themselves in utterance-medial position.

The current experiment [1]aimed to answer these questions by examining the production of the *-es* plural in two-year-old children by conducting acoustic analysis of speech from an elicited imitation task. It was hypothesised that the variability would be explained more by segmental factors rather than word duration or incorrect morpheme application. Firstly it was hypothesised that children would have more trouble producing the target word when the plural adds a syllable (i.e. in the CVs/z+əz *(buses/noses)* contexts) than the already disyllabic words (i.e. the CVCə+z *(letters)* contexts) in both utterance-medial and utterance-final positions. Secondly it was hypothesised that more plurals would be realised when the target word is in utterance-final position compared to utterance-medial position due to the increased amount of time the child has for both perceiving and producing the word in utterance-final position due to phrase-final lengthening.

Method

Participants

Preliminary results are reported here from two typically developing subjects, each from monolingual Australian-English-speaking homes. One was a 26-month-old male and the

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other was a 28-month-old female. Both children were healthy on the day of testing and passed the hearing screening otoacoustic emission (OAE) test. Their MacArthur CDI vocabulary test percentile scores were both strong at 100 and 99 respectively.

Stimuli

Eight target plural nouns were selected for the experiment, four of which had a disyllabic root and were in CVCə+z context (e.g. *letter* → *letters*), and four that had a monosyllabic root ending in either /s/ or /z/ so that it becomes disyllabic once pluralised (e.g. *bus* → *buses*). The second group of words were split into two contexts (CVs+əz and CVz+əz) to control for voicing. Each target word appeared in two sentences, one utterance-medially and the other utterance-finally as shown in Table 1. A female native speaker of Australian-English was recorded producing the sixteen 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 at a sampling rate of 44.1 K. Afterwards, each sentence was segmented using the Praat software.

Table 1*. Target nouns and their corresponding stimulus sentences*

	Target	Transcription	Utterance-medial	Utterance-final
CVCə+z	Letters	/letəz/	My letters come	Send my letters
	Tigers	/tɑegəz/	His tigers bite	Pat his tigers
	Bakers	/bæɪ kəz/	The bakers cook	See the bakers
	Ladders	/lædəz/	The ladders break	Climb the ladders
CVs+əz	Horses	/ho ːsəz/	Her horses kick	See her horses
	Buses	/bɐ səz/	The buses come	Hear the buses
	Noses	/nəʉzəz/	Their noses blow	Touch their noses

CVz+əz	Hoses	/həʉzəz/	The <u>hoses</u> bend	Pull the <u>hoses</u>

The target words were high frequency, familiar, picturable nouns with similar lexical frequencies across the two conditions (the sum of plural frequencies for the CVCə+z words was 126 and the sum of plural frequencies for CVs/z+əz was 117). These frequencies were extracted via ChildFreq from the CHILDES database which calculates the child's frequency of saying the target word per 1 000,000 words between two to three-years-old.

The stimulus sentences were all in the present tense. To control for utterance length, each sentence consisted of two monosyllabic words plus the disyllabic target noun. To control for any articulatory influences, the target noun in utterance-medial position was always followed by a word that began with a stop at a different place of articulation to the alveolar plural *-s*. Following Theodore et al. (2010), this makes the context more challenging and reduces the possibility of resyllabification of the plural with the following word. When the target word was in utterance-final position, the preceding words were either "*the"* or a pronoun, thereby controlling for rhythmic effects across conditions.

Each target noun was represented by a picture to serve as a visual prompt during the experiment. All pictures were real photos with minimal background distractions. Each picture appeared twice on the PowerPoint slide. Brown (1973) noted that for children two means 'more than one' hence the plural is required. Zapf and Smith (2008) also found that children were much more likely to produce the plural of well known nouns presented as identical objects rather than just similar objects (e.g. having two of the same type of dog rather than having two dogs of different breeds). The PowerPoint presentation then consisted of each of the sixteen stimulus prompts which were then pseudo-randomised. The presentation began with the auditory direction "*Say what I say"*.

Procedure

The child and their 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. After becoming familiarised with the experimenters by engaging the child with a picture book or toys, the child was invited to "play a game".

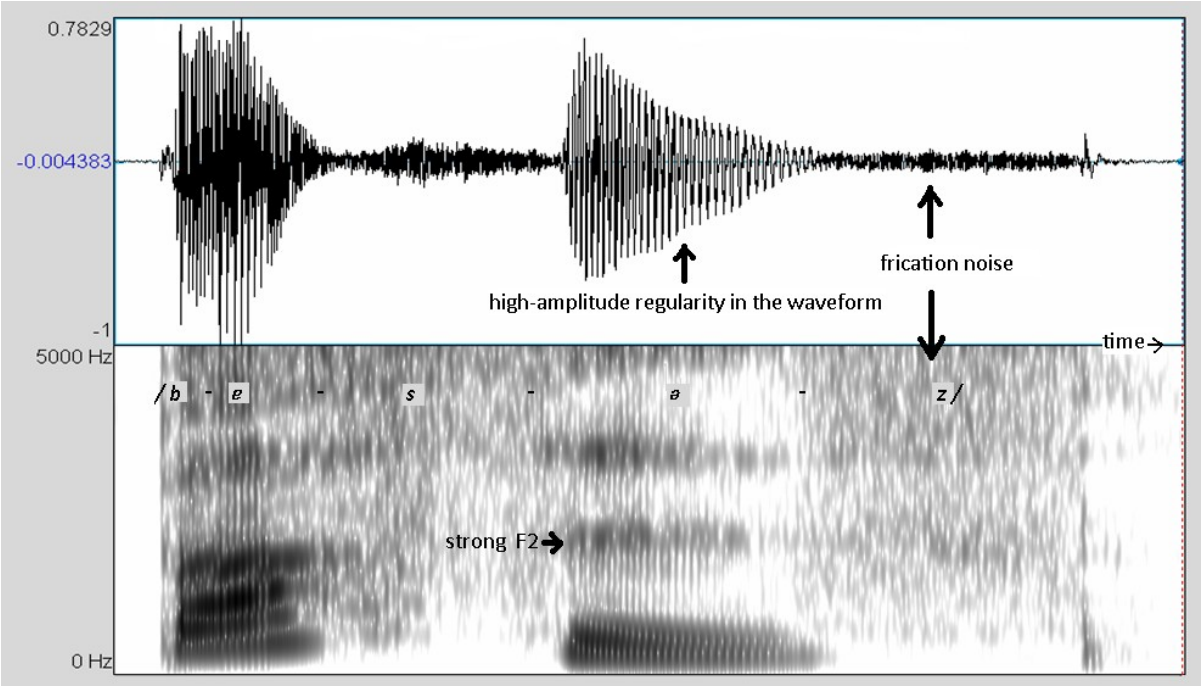
The room was equipped with two Mac mini computers (one used for the PowerPoint and the other for the sound recording), Sony SRS-55 speakers, and a Behringer C-2 microphone. The microphone was placed on the table near the child in order to best capture his or her speech. The child was directed to face the computer and was asked to repeat what the computer said. The experiment began with a brief warm-up period in order to familiarise the child with the task, and to check the sound levels. Once the child was ready the test items began. For each item, two pictures of the target noun appeared on the monitor along with the auditory prompt, and the child was directed to repeat the prompt. If needed, three attempts were allowed for each utterance in order to obtain one acceptable recording to be analysed. The child was encouraged with praise for each trial. Following the completion of the task (which took about 10 minutes), the child's 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 child was also screened by otoacoustics emissions for normal hearing. The entire procedure took approximately 30 minutes. The child was given a T-shirt and the parents a gift card for their time.

Acoustic Analysis – Coding

Each utterance was recorded using Pro Tools LE, then excised and coded using Praat. Tokens were excluded if they had poor acoustic quality (e.g. were whispered or had interfering background noise) or if the child failed to produce the correct target word in the sentence.

The relevant coding labels and criteria as outlined in the "Manual for coding acoustic events: Child Language Lab" (2011) were used for coding the final syllable of the target words (*letters, tigers, bakers, ladders, horses, buses, noses, hoses*). This criterion outlines the acoustic events and their relevant codes for identifying stops, schwas and fricatives. The cues were identified by visual inspection of the waveform, spectrogram and listening to the utterance. Figure 1 shows a representative waveform and spectrogram illustrating the acoustic cues of interest.

Figure 1. *Representative waveform and spectrogram showing acoustic landmarks for the target word* buses

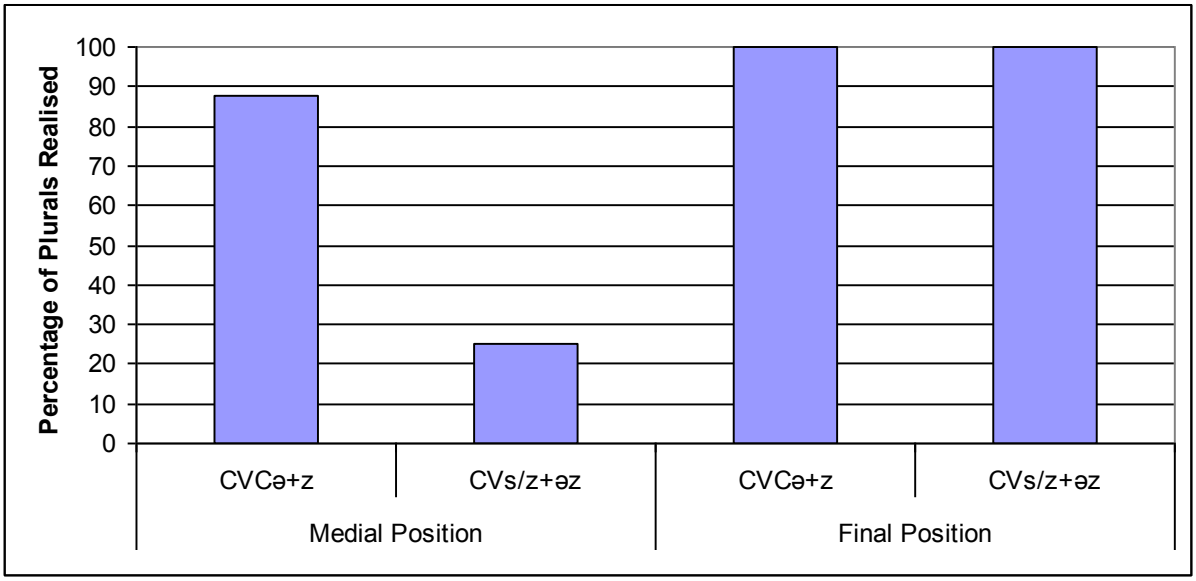


After the preceding stop or fricative, the first cue of the *-es* production was the presence of high-amplitude regularity in the waveform and strong second formant (F2) representing the schwa. The second cue was for the devoiced /z/ which was high frequency, aperiodic noise following periodicity for the vowel. We used the presence or absence of the schwa and devoiced /z/ acoustic cues to determine whether or not the plural was realised. The /-əz/ duration of the target words were also measured. This was so durational utterance position effects could be compared.

Results

For the first subject, 12 out of 16 tokens were included in the analysis (four tokens were excluded due to poor acoustic quality or failure to produce the required utterance). For the second subject, all 16 tokens were included. Figure 2 shows the percentage of fully realised plural productions out of those attempted. Note that in order for the syllabic plural production to be considered fully realised, the child had to produce both the /ə/ and the /z/ phonemes.

Figure 2. *Percentage of realised plural productions in utterance-medial and final position across subjects*



Notice that when the target word is in utterance-final position for both conditions the results are at ceiling. The fact that the children were able to accurately produce these plurals provides evidence against Goad's suggestion that incorrect productions are due to the child applying the wrong morpheme. Also, notice the difficulties in producing the CVs/z+əz words (requiring the syllabic plural) utterance-medially compared to the CVCə+z context. The fact that the former are produced less often than the CVCə+z words rules out the possibility of the disyllabic word durational effects explaining the difficulties.

Figure 3 gives a closer look at the syllabic plural realisations for each the CVs+əz and CVz+əz contexts for each child. Notice that the errors are only evident when the target words are in are utterance-medial position, suggesting segmental or articulatory effects may be the main contributor to these problems.

Figure 3.*Percentage of realised plural productions for each context in utterance-medial and final position*

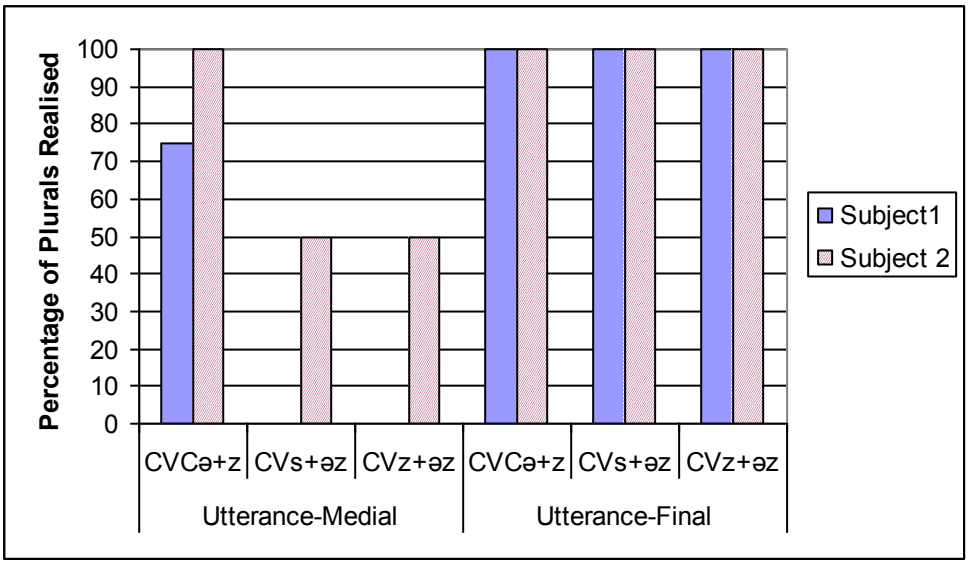


Figure 4 shows the difference in the /-əz/ phoneme durations in utterance-medial and utterance-final positions.

***Figure 4**. Comparison of the average duration of the final syllable of the target word in utterance-medial and final positions for each subject*

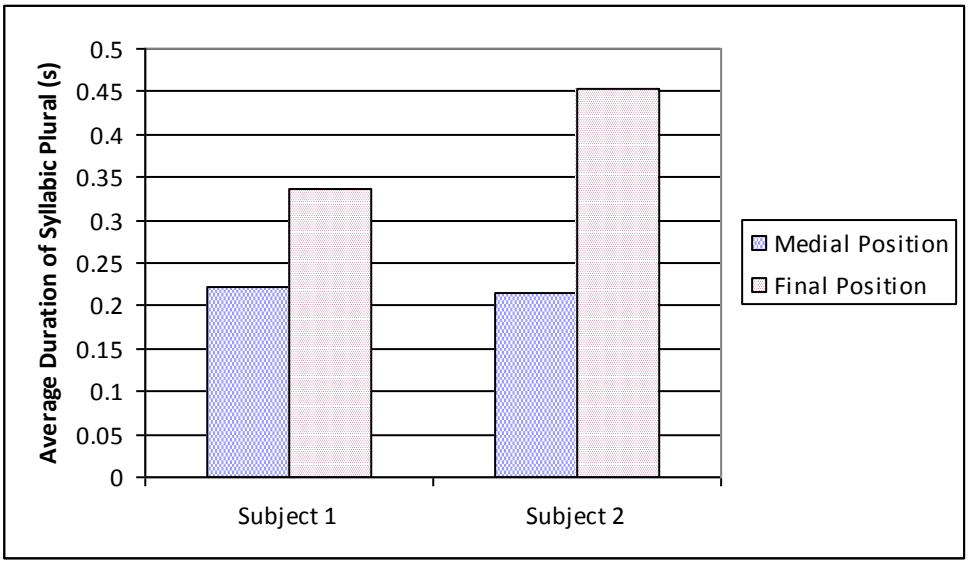


Figure 4 shows that the phonemes are much shorter in utterance-medial position. This less amount of time to articulate the syllabic plural is likely to account for the difficulties in its production. Table 2 shows a phonetic realisation of the various attempts of these plurals.

***Table 2.** Phonetic realisation of CVs/z+əz target words in medial position*

Target Word	Subject 1 Production	Subject 2 Production
/bɐsəz/	/bɐs-s/	/bɐsə/
/hoːsəz/	/hoːsiː/	/hoːsəz/
/həʉzəz/	/həʉzə/	/həʉzə/
/nəʉzəz/	-	/nəʉzəz/

Table 2 shows the /-əz/ plural only being realised on two of the seven occasions, but on four occasions the schwa was produced without the final fricative. In another case, two final fricatives were produced leaving out the schwa (*bus-s*) which could be construed as an example of Goad's (1989) gemination strategy. The child however only did this utterance-medially and on one occassion, so segmental factors are still more likely to explain the

delayed acquisition of the syllabic plural morpheme rather than incorrect morpheme application.

Discussion

As previously reviewed, children have been found to acquire /-ɘz/ syllabic plurals later than /s,z/ plurals. The aim of this study was to explore why this is the case and whether word length or segmental factors such as phonological complexity, articulatory difficulty, or utterance position, contribute most. As in previous studies (e.g. Berko, 1959), children had more trouble producing the plural of the target word when it necessitates the addition of a syllable. This difficulty was particularly evident for both subjects when the syllabic plural was produced in utterance-medial position. A comparison of the durations of the final syllable in utterance-medial and utterance-final positions showed that the syllable is much longer when the target word is in utterance-final position. One reason why more plurals are realised in utterance-final position could therefore be because of the increased amount of time the child has for both perceiving and producing the word due to phrase-final lengthening. This is consistent with the findings of Theodore et al. (2010).

From this it would seem that it is not necessarily all disyllabic plural words that children have trouble producing from an increased processing load, but the difficulty in production arises more so when the plural adds a syllable. This is likely to be explained by either articulatory difficulties, or that the child is applying the wrong grammatical morpheme, assuming that the root word is already plural because it ends with the sibilant fricative. In our study, both children were at ceiling in producing the syllabic plural when it appeared in utterance-final position where they had longer time to perceive and articulate it. This shows that they have actually acquired this rule, but it is still vulnerable in particular

segmental contexts. In utterance-medial position, extra planning is needed to produce the following word after the target word. This is likely to account for the partial application of the syllabic plural rule by adding only the schwa or fricative rather than applying the wrong grammatical morpheme.

Following on from this study, future research areas could include longitudinal studies into the development of producing the syllabic *-es* plural, as well as comparisons between child and adult productions of this plural. The effects of of word frequency in child language acquisition could also be explored as this study focussed on the production of the syllabic *-es* plural in high frequency words, but it would be interesting to investigate if there are any differences in its production when applied to lower frequency words.

Conclusion

In this preliminary investigation, the production of the syllabic *-es* plural morpheme in two-year-old children was found to be more problematic than the production of the plural in disyllabic words, particularly when the target word was in utterance-medial position. As this study is only in its early stages, strong conclusions cannot yet be drawn. These preliminary results suggest, however, that that the delayed acquisition of this morpheme is due more to segmental factors than word duration or incorrect morpheme application. This is shown by the difficulty in articulating the fricatives in a short space of time when there is additional planning required for the following word. Hopefully, with further investigation of more subjects, clearer results will be evident. These can then provide a baseline measure to compare with the suspected difficulties and delays in grammatical morpheme acquisition for children with SLI and the hearing impaired.

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