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Regularization in the face of variable input: Children's acquisition of stem-final fricative plurals in American English

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Abstract: From a young age, children go through a stage of leveling irregular forms. They are also known to probability-match variable phenomena. However, it is still unclear how children treat phenomena that are both irregular and variable. Does their tendency to overregularize take over, leading them to seize on the regular occurrences and produce them at an even higher rate than adults, or do children probability-match in these cases? In order to study this question, we turn to the variably-voiced plurals of English nouns that end in a voiceless fricative, like *leaves*, *houses*, and *paths*. We find that children seem to probability-match for /s/ and /θ/-final stems (e.g. *houses, paths*), but not for /f/-final stems (e.g. *leaves*). This finding has implications for our understanding of first language acquisition, and how learners acquire words with multiple processing requirements.

Keywords: first language acquisition, sociolinguistic variation, language change, morphology, phonology

1 Introduction

A bird's-eye look at the literature on children's first language acquisition initially presents a paradox. Preschool-aged children are simultaneously excellent at mirroring the adult input they receive, matching the usage rates of variable sounds and words as produced by their parents (e.g. Labov 1989; Smith et al. 2007), but they are also overextenders, regularizing irregular forms in ways that they never hear in the input (e.g. Marcus et al. 1992). A growing body of literature has attempted to reconcile these contradicting observations, demonstrating that children probability-match under some circumstances and regularize under others (e.g. Hudson Kam and Newport 2005).

To date, however, the literature on first language acquisition has largely looked at these two phenomena separately. In this paper, we ask: how do children produce forms that are simultaneously variable *and* irregular? Do children probability-match the rates shown in adults' production, as they do with other cases of sociolinguistic variation? Or do they seize on the irregularity of these forms and overregularize them beyond adults' levels, as they are known to do with irregular forms that are invariant in adults' speech?

As a test case to answer this question, we study the variable voicing of stem-final fricatives in a small set of English words. English plurals are typically formed by affixing a /-z/ suffix to a noun, which is variably realized as [s], [z], or [əz], depending on the preceding segment. For example, if /-z/ follows a voiceless nonsibilant segment, it is realized as [s] (e.g. [meɪt] *mate* – [meɪts] *mates*); if /-z/ follows a voiced nonsibilant segment, it is realized as [z] (e.g. [meɪd] *maid* – [meɪdz] *maids*); and if /-z/ follows a sibilant segment, it is realized as [əz] (e.g. [meɪz] *maze* – [meɪzəz] *mazes*). However, there is a set of nouns ending in anterior voiceless fricatives /f, θ, s/ which pluralize via a slightly different process. Instead of the /-z/ suffix assimilating to the voicedness of the stem-final segment, these stem-final fricatives assimilate to the /-z/ plural suffix, resulting in singular–plural pairs like [pæθ] *path* – [pæðz] *paths*, [wʊlf] *wolf* – [wʊlvz] *wolves*, and [hɑʊs] *house* – [hɑʊzəz] *houses*. The complete list of these 34 nouns as identified by Jespersen (1942:258–264) is given below.

(1) /f/-final: *beef, calf, dwarf, elf, half, hoof, knife, leaf, life, loaf, oaf, roof, scarf, self, sheaf, shelf, staff, thief, turf, wharf, wife, wolf*

(2) /s/-final: *house*

(3) /θ/-final: *bath, cloth, lath, moth, mouth, oath, path, sheath, truth, wreath, youth*

This pattern has its roots in Old and Early Middle English wherein the plural suffix, /-əs/, was affixed to nouns without any of the allomorphic variation we see today. Anterior fricatives /f, θ, s/ were then voiced intervocalically, leading to singular–plural pairs like [paθ] *path* – [pað-əs] *paths*, [wʊlf] *wolf* – [wʊlv-əs] *wolves*, and [hu:s] *house* – [hu:z-əs] *houses* (Lass 2000; Ringe and Eska 2013). After several changes throughout the 12th–15th centuries induced by contact with other languages, this voicing process became fossilized, restricted to a fixed set of lexical items, rather than an active phonological process. In other words, what was once an active phonological process is now a lexical exception. This fossilized pattern is not diachronically stable, however, as there is evidence of a linguistic change in progress whereby, for many speakers, the stem-final fricatives in (1)–(3) do not consistently voice in the plural, but rather variably remain voiceless and have the plural /-z/ affixed according to typical realization patterns (MacKenzie 2018). This means that a word like [wʊlf] can be realized as either [wʊlvz] or [wʊlfs] in the plural. Thus, the phenomenon of stem-final fricative voicing provides an example of a morphophonological alternation that is both irregular and variably produced.

In the rest of this paper, we survey the existing literature on children's acquisition of variable (Section 2.1) and irregular (Section 2.2) forms, with a focus on previous work on the production of the words in (1)–(3) (Section 2.3). We then present results from a corpus study of children's production of stem-final fricative voicing using data from CHILDES (MacWhinney 2000) (Sections 3 & 4). We find evidence that children both probability-match *and* overregularize, subject to phonological factors. We discuss the implications of this finding in Section 5.

2 Background

2.1 Children's acquisition of variable input

Pre-school aged children generally do a good job of replicating the probabilistic variation they hear in their input and matching the probabilities at which variably alternating forms surface (Labov 1989; Roberts 1994; Kerswill 1996; Roberts 1997; Kerswill and Williams 2000; Smith et al. 2007, 2013). Work in this area has considered a large number of phonetic, phonological, and morphological variables, such as vowel production, word-final coronal stop cluster simplification, *-ing*/*-in'* variation, verbal *-s* absence, and demonstrative choice.

Generally, consistent conditioning is necessary for children to learn probabilistic variation, because when this is missing (i.e. variability is not conditioned, as from an L2 speaker), children tend to regularize the input they receive (Hudson Kam and Newport 2005, 2009; Hudson Kam 2015). While some studies have found that input shared across a large number of speakers is necessary for children to learn probabilistic variation (Hendricks et al. 2018), others have shown that the input from an individual caregiver is central to what a child will produce. For example, Miller (2013) found that Chilean Spanish-speaking children closely mirror the rates of /s/-lenition produced by their caregivers, highlighting the importance of input, not just by the community at large, but also by individuals.

The phenomenon of probability-matching is complicated by the introduction of irregular forms. Many studies have found that adults learn variation while children impose regularity in artificial language tasks (Hudson Kam and Newport 2005; Ross and Newport 1996; Hudson Kam and Newport 2009). However, these studies found that consistent conditioning leads to children learning variation rather than regularizing patterns. In the following section we address the cases in which children do regularize input.

2.2 Children's acquisition of irregular morphology

Cases of children regularizing irregular morphology are well documented. In general, researchers have found that English-speaking children overregularize at least some irregular past tenses and plurals throughout the preschool years and into elementary school, producing forms like *breaked* for *broke* and *mans* for *men* (Graves and Koziol 1971; Bybee and Slobin 1982; Marcus et al. 1992; Marcus 1995; Marchman et al. 1997; Maslen et al. 2004). It is only with time and repeated exposure to irregular classes of words that children learn to produce these atypical morphological patterns.

The goal of the present paper is to understand whether children overregularize the irregular fricative voicing words under study in comparable ways to how they overregularize irregular forms that are invariant in adult language, like *broke* and *men*. To do this, we would like to have a firm grasp of the rates at which children overregularize those adult-invariant forms, as a baseline for comparison. However, this is a matter of some debate. For one, it depends on the age of the child and the frequency of the word in question. But the apparent rate of overregularization is also susceptible to the elicitation or sampling strategy used (Maratsos 2000).

A commonly-cited statistic is that found by Marcus (1995), who studied noun plural overregularization among ten children in the CHILDES corpus. Marcus found that the overall rate of overregularization was 8.5%, similar to the rate of past tense overregularization displayed by the same children (7.3%, Marcus et al. 1992). This would indicate that, in general, rates of overregularization are quite low. However, Maratsos (2000) points out that the true rate of overregularization is likely to be higher, because infrequent verbs, which tend to be overregularized the most (Bybee and Slobin 1982), are by definition the least frequently observed in a sample of a child's speech. Samples of naturally-occurring speech are likely to be biased toward more frequent verbs, and hence toward verbs that tend to be overregularized at lower rates.

Indeed, other studies using different methodologies have found higher overregularization rates. In a study where parents self-report their child's production of irregulars, Marchman et al. (1997) find that 1–2.5-year-olds overregularize past tenses at a rate of around 11%, and plurals at a rate of 16%. Maslen et al. (2004), in a longitudinal study of 8–10% of the language produced by a single preschooler (from ages 2–3), find an overall overregularization rate of roughly 10% for past tenses and 7% for plurals, but they also find that the rates are highly dependent on frequency, with low-frequency plural nouns showing an overregularization rate of 23% (p. 1326). Both studies agree that overregularization of plurals precedes that of past tenses and exceeds it at first, but that the past tense overregularization rate subsequently comes to exceed the rate for plurals.

Studies of elicited language, which are not subject to the bias against low-frequency forms cited earlier, tend to find higher overregularization rates. Bybee and Slobin (1982:271), in a study that combines spontaneously-produced and elicited past tense forms, find that preschoolers overregularize irregular past tenses at an average rate of 39%. That said, this average rate abstracts over wide differences depending on the phonological shape of the particular past tense form, with different phonological classes showing overregularization rates ranging from 10% (for *caught*-type verbs) to 80% (for *blew*-type verbs). By third grade, the overall rate has dropped to 17%, but high rates are still shown for *send, hit,* and *feel*-type verbs (55%, 27%, and 20%, respectively). Widely differing overregularization rates by phonological class are also found by Graves and Koziol (1971), in an elicitation study of irregular plurals among elementary school-aged children. They find that fricative voicing words (on which we'll see more in Section 2.3) are regularized at an average rate of 53%, and other irregular plurals (*men, teeth, mice*) at an average rate of 39%.

2.3 Production of stem-final fricative voicing among adults and children

Adults' production of the variable stem-final fricative voicing words in (1)–(3) is documented in MacKenzie's (2018) study of three corpora of conversational speech. MacKenzie reports that rates of stem-final fricative voicing vary based on the phoneme. Namely, plurals of /f/-final stems (such as *wolf*) voice at a high, stable rate (80%) in apparent time, while plurals of /θ/-final stems (such as *path*) voice at a low but stable rate (47%), and plurals of the /s/-final stem *house* are voiced at a rate of 51% on average, but progressively less in apparent time. MacKenzie demonstrates that this variation is predictable in large part by the frequency of individual lexical items, and by the average frequency of a given phoneme class.

That is, not only is there more voicing of more frequent items; two items of equal frequency will differ in voicing if they belong to different phoneme classes which themselves differ in frequency.

No acquisition study has focused on how children acquire variable stem-final fricative voicing specifically. However, we do have some limited evidence on how children produce a subset of the fricative voicing words in (1)–(3). Graves and Koziol's (1971) production study, targeting children between the ages of six and nine, included the elicitation of *knife* and *leaf* in the plural. They found that children in first and second grade regularized these words (that is, used the voiceless rather than the voiced ending) 58% of the time, while children in third grade regularized these words 44% of the time, demonstrating a progressive trend toward adult-like performance over time. The children showed more overregularization of these forms than of the other irregular plurals studied (*men, teeth, mice*). In another production study, Berko (1958) asked children and adults to produce the plural of nonce words. Adults were found to produce the plural of one word, [hif] *heaf*, as [hivz] 42% of the time. This pronunciation with a voiced fricative is in line with other stem-final fricative voicing patterns found for words like *wolf* and *leaf*. While we might expect this word to be produced as [hivz] 80% of the time, in line with MacKenzie's (2018) findings, participants may have produced this nonce word with a voiceless fricative in line with other words, such as *giraffe*, which do not undergo the same fricative voicing process. Children, on the other hand, only produced the word as [hivz] 3% of the time, suggesting that children ages four to seven are generally not extending this pattern to nonce words. Other studies of children's irregular plural production have included fricative voicing words among the irregular plurals studied, but they either have so little data on these words that it is difficult to draw conclusions from them (as in Maslen et al. 2004), or they don't lay out the results for the fricative voicing words specifically (as in Marcus 1995). An additional concern with Marcus's (1995) study is that the data is based on orthographic transcriptions rather than the audio source, which risks using data that does not actually represent the child's utterance, a point which we will return to in Section 3.2. Finally, no study to date examines /s/- or /θ/-final stems, only /f/-final ones. Thus, there is a gap in the literature which requires a fuller analysis of this variable in order to understand how children acquire words that are both irregular and variably produced among adults.

Accordingly, we are left with a novel question that can inform research on both first language acquisition and language change: When faced with an irregular morphological form and variable input of that form, does children's tendency to overregularize take over, leading them to seize on the regular forms and produce them at an even higher rate than adults? Or do children probability-match in these cases, remaining faithful to adults' productions? The key place to look will be in children's production of /f/-final stems, which MacKenzie found to be conservative among adults, preserving the irregular voiced pronunciation 80% of the time. Do children match this, or do they overregularize, producing these words with more voiceless plurals?

In order to address these questions, we turn to children's first language acquisition. We collected a total of 257 plural tokens across 15 corpora and 61 children to examine children's production of these irregular plural forms. In doing so, we stand to better understand how variable input and morphological regularization interact in a variable that is being lost in real time. Although the data collected from the adult-language corpora in MacKenzie (2018) does not directly represent the input that children in CHILDES are getting, this comparison currently provides the best opportunity to study American English productions of this variable at different points throughout the lifetime. Future studies directly comparing adult and child production of this variable within the same speech community would be welcome and undoubtedly informative.

3 Methods

We conducted a corpus study using data from CHILDES (Braunwald 1971; Bloom et al. 1974; Bellinger and Gleason 1982; Sachs 1983; Hall et al. 1984; Wilson and Peters 1988; MacWhinney and Snow 1990; MacWhinney 1991; Davis and MacNeilage 1996; MacWhinney 2000; Dickinson and Tabors 2001; Demuth et al. 2006; Parsons 2006; Weist and Zevenbergen 2008; Weismer et al. 2013; Steinberg et al. 2013). All American English corpora with corresponding audio or video recordings were searched for the plural and singular forms of the irregular stem-final fricatives listed in (1)–(3) using a CLAN script (MacWhinney 2000). Where voicing of a plural is represented orthographically (i.e. for the /f/-final stems such as *knifes/knives*), we searched for both possible spellings.

3.1 Participants

257 plural targets were found from 15 corpora and 61 different children. The corpora used are enumerated in Appendix A, and all contain audio recordings, except for the Providence corpus which contains video recordings. Another 443 singular targets were sampled from the same children to determine whether singular stem-final fricatives were also variably voiced. For every plural token obtained, 2 singular targets of the same word were also analyzed from that child. If the child did not say the same word in the singular, two other singular items ending in the same phoneme were analyzed instead (when available). This analysis was central in determining whether a child who produces, say, plural *knives* also has singular *knive*, which would suggest regularization but in the opposite direction than anticipated.

The analysis ultimately showed that, as would be expected, children do not voice their singular stem-final fricatives, with the exception of one child from the MacWhinney corpus who voiced one singular stem-final fricative and one child from the Peters/Wilson corpus who voiced two singular stem-final fricatives (MacWhinney 1991; Wilson and Peters 1988). Both children also produced several voiceless singular stem-final fricatives, which suggests that they do not have a single underlying representation of the singular form. They were therefore kept in the study, and we acknowledge that it is possible, although uncommon, for children to produce both voiced and voiceless singular stem-final fricatives.

3.2 Procedure

The 257 plural stem-final fricative tokens reflect 16 of the 34 lexemes listed in (1)–(3). The absence of the remaining 18 lexemes is likely due to the fact that lower-frequency words were less likely to come up in children's spontaneous speech. The lexemes found in plural form were *calf*, *dwarf*, *elf*, *half*, *knife*, *leaf*, *life*, *roof*, *scarf*, *self*, *shelf*, *wolf*, *house*, *bath*, *mouth*, and *sheath*. Altogether there were 182 plural /f/-final tokens, 52 plural /s/-final tokens, and 23 plural /θ/-final tokens. The number of tokens per word can be found in Figure 1. In keeping with Maslen et al. (2004), lexemes that were part of a compound were not included in the analysis.

After each plural target was identified, it was checked to ensure it was not an irrelevant homograph (e.g. the verb *leaves* as opposed to the plural of the noun *leaf* or the verb *lives* as opposed to the plural of the noun *life*) or part of a compound (e.g. *themselves*). If the lexeme passed both of these exclusion criteria, the first author analyzed the recording auditorily and, in cases where the voicing was ambiguous, analyzed the spectrogram's voicing bar in Praat (Boersma and Weenink 2015). Auditory, rather than orthographic, coding of /θ/- and /s/-final forms was essential, because the voicing in these forms is not represented orthographically. But auditory coding of /f/-final forms, where voicing is represented in the spelling, was also necessary, because CHILDES transcriptions of these forms are not reliable. Specifically, out of the 80 /f/-final plurals that were clearly voiceless on the audio recording, 64 of them (80%) had nevertheless been transcribed as voiced, that is, with a <v> in the spelling. Mistranscription primarily went in this direction; of 102 /f/-final plurals that were clearly pronounced with voicing, only 2 were transcribed as being voiceless, resulting in a mistranscription rate of about 2%. This asymmetrical mistranscription rates likely reflect orthographic conventions: spellings like *leafs* and *knifes* are non-standard, hence it is not surprising that transcribers would generally avoid using them. This high mistranscription rate casts doubt on other studies of /f/-final fricative voicing words that relied only on CHILDES written transcripts, such as Marcus (1995).

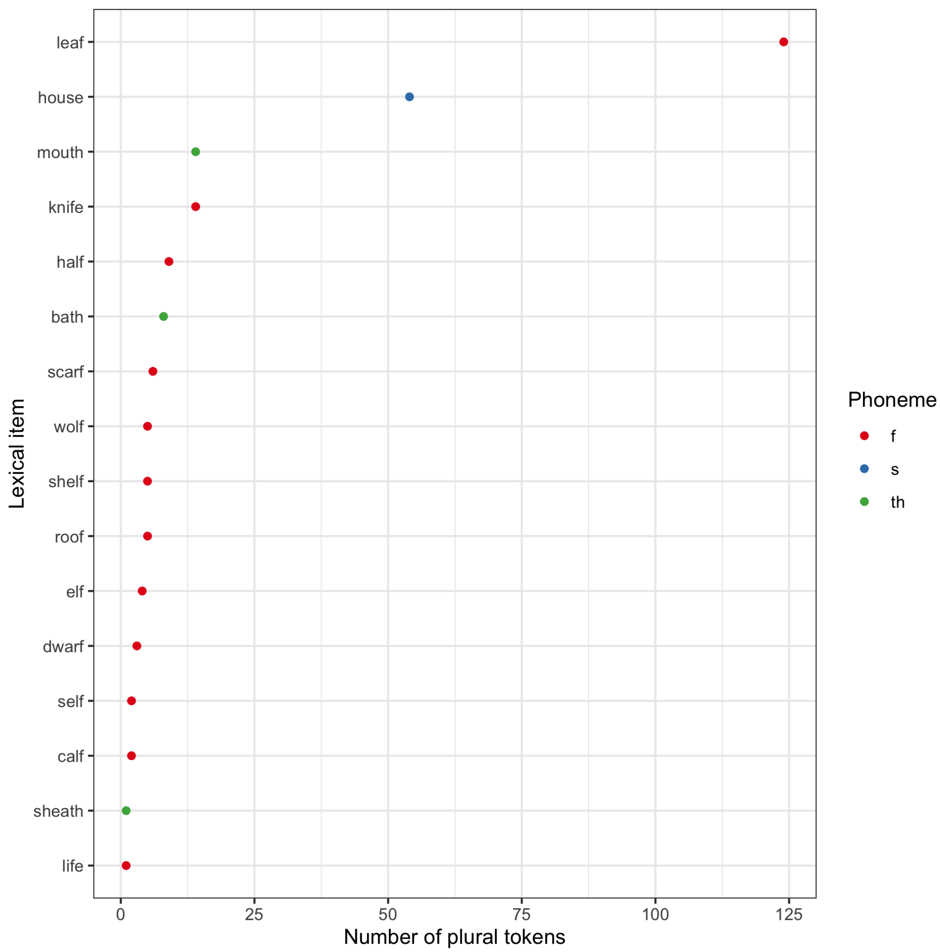

Figure 1: Number of plural tokens per word.

Tokens were coded for the following information: corpus, word, child ID, child age, child gender, year of recording, stem-final phoneme (/f, θ, s/), and voicing. Then statistical modeling was carried out via mixed-effects logistic regression using the `lme4` package (Bates et al. 2015) in R (R Core Team 2017) with the bobyqa optimizer (200,000 iterations). Voicing was the response variable; phoneme, age (continuous and centered around the median), and decade of recording (categorical) were analyzed as fixed effects; and child ID was included as a random intercept. The interaction between age and phoneme was analyzed to determine whether children voice the three fricatives at different rates as they age. This would be expected, as children's speech becomes increasingly adult-like as they get older, and MacKenzie (2018) finds that the three fricatives have different rates of voicing, with some change in apparent time. Gender wasn't significant, so it was not included in the final model. This choice was made after ANOVA analyses showed that reducing model complexity in this way did not decrease informativity. The reference level of the treatment-coded phoneme predictor in the model was changed to make all possible pairwise comparisons of the three different phonemes, with the Bonferroni correction to control for multiple comparisons. See Appendix B for the model output.

4 Results

Figure 2 shows voicing rates by stem-final phoneme. Significance values from the mixed-effects logistic regression are provided above the bars.

As in the adult data (MacKenzie 2018), reproduced in Figure 3, /θ/-final forms are voiced at a significantly lower rate than /f/-final forms ($\beta = -2.68$, $p < 0.001$). Also as in the adult data, /s/-final forms do not show a significantly higher rate of voicing than the /θ/-final forms ($\beta = 1.61$, $p = 0.17$). However, in contrast to the adult data, /s/-final forms do not significantly differ from /f/-final ones ($\beta = -1.07$, $p = 0.15$). In the adult data, this comparison is significant, with /f/-final forms showing a voicing rate of 80%, and /s/-final forms showing a voicing rate of 51%. Children are not voicing /f/-final forms nearly as much as adults do: they are overregularizing them by producing an [f] instead of a [v] in the plural.

Figure 4 plots voicing by phoneme and age. The x-axis represents age as a continuous variable, and the y-axis represents whether a given token was produced with a voiced or voiceless phoneme. It shows that the rates of stem-final fricative voicing change as children get older, generally reaching more adult-like patterns with age. However, this effect differs by phoneme. Specifically, /f/-final fricatives are voiced increasingly with age ($\beta = 0.89$, $p < 0.001$), while the age x fricative interaction term does not reach sig-

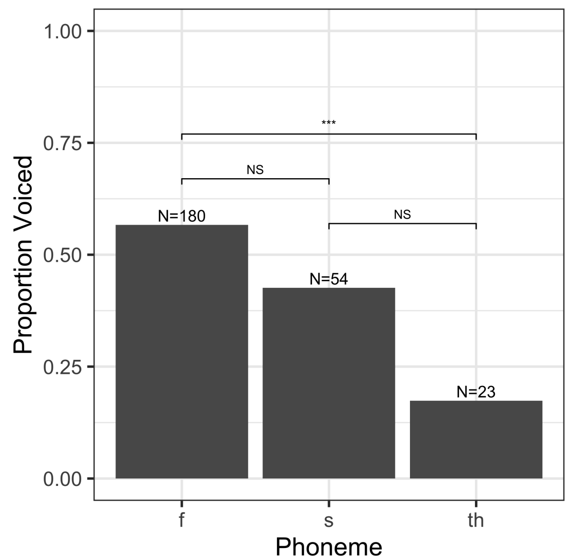

Figure 2: Proportion of voicing for each phoneme among children. Numbers on bars represent the total number of data points per category. Significance values above the bars are based on a mixed-effects logistic regression as detailed in the text.

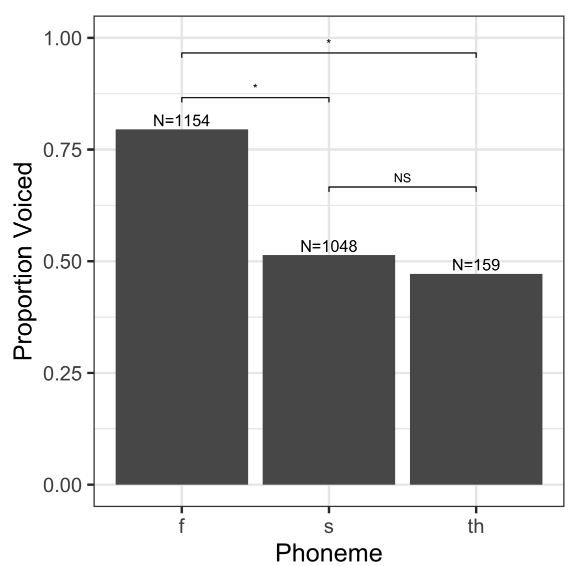

Figure 3: Proportion of voicing for each phoneme among adults. Numbers on bars represent the total number of data points per category. Significance values above the bars are based on mixed-effects logistic regression. Data from MacKenzie (2018).

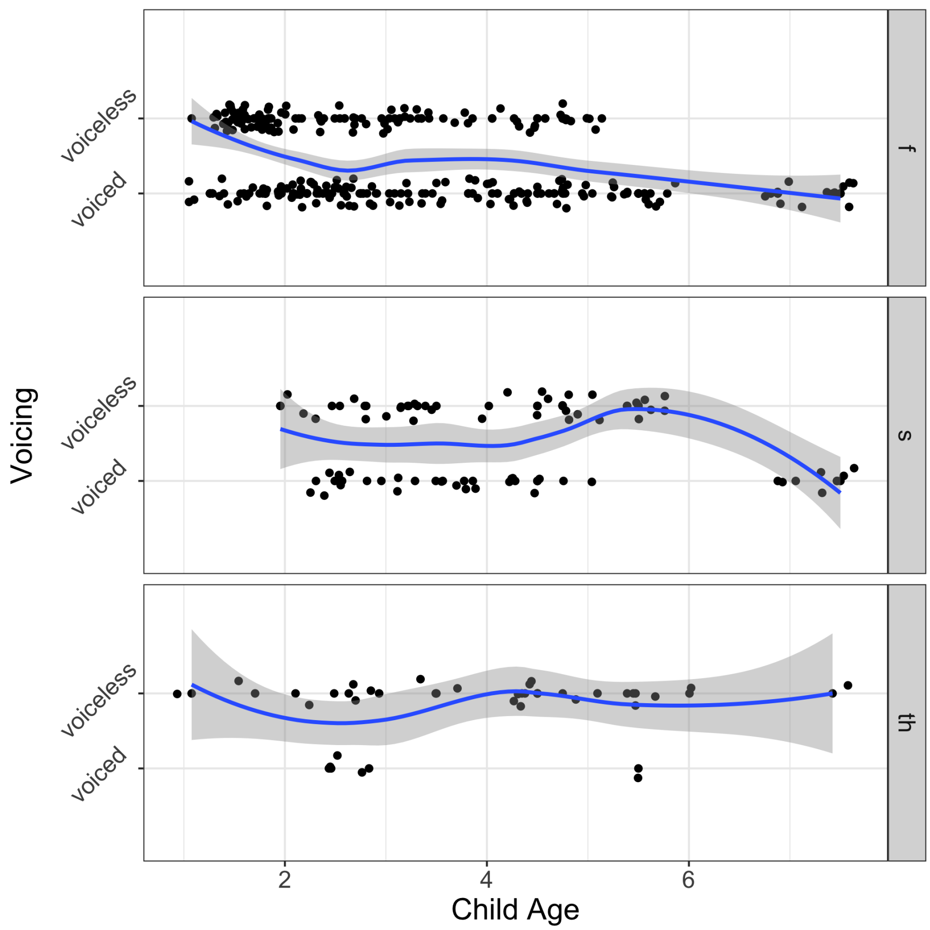

Figure 4: Children's plural stem-final fricative voicing by age. Each dot reflects one plural token, coded for the voicing of its stem-final fricative and the age of the child who uttered it. Trend lines represent LOESS smooths with 95% confidence intervals shaded in gray.

nificance for the other two fricatives (/s/: $\beta = -0.53$, $p = 0.08$; /θ/: $\beta = -1.09$, $p = 0.03$).[1] Although the vast majority of /f/-final fricatives (96%) are voiced after age 5, only about 50% of /s/-final fricatives are, and even fewer /θ/-final fricatives (17%) are voiced after the age of 5.

Finally, it is worth noting that we find a significant negative effect on voicing among children recorded in the 1980s, who voiced less than children recorded in the 2000s ($\beta = -3.07$, $p < 0.001$), as shown in Figure 5. This could be attributed in part to the fact that the only two corpora that focused on gathering data

[1]As indicated by the 0.03 p-value, the interaction effect of age for /θ/ is borderline. However, when we re-run the model with /θ/ as the reference level of phoneme, the main effect of age (which represents the effect of age on /θ/ specifically, because the phoneme x age interaction is still included) is resoundingly not significant ($p = 0.64$). As is evident from Figure 4, only a handful of voiced tokens of /θ/ are produced. We thus do not find convincing evidence for an effect of child age on voicing of /θ/-final plurals.

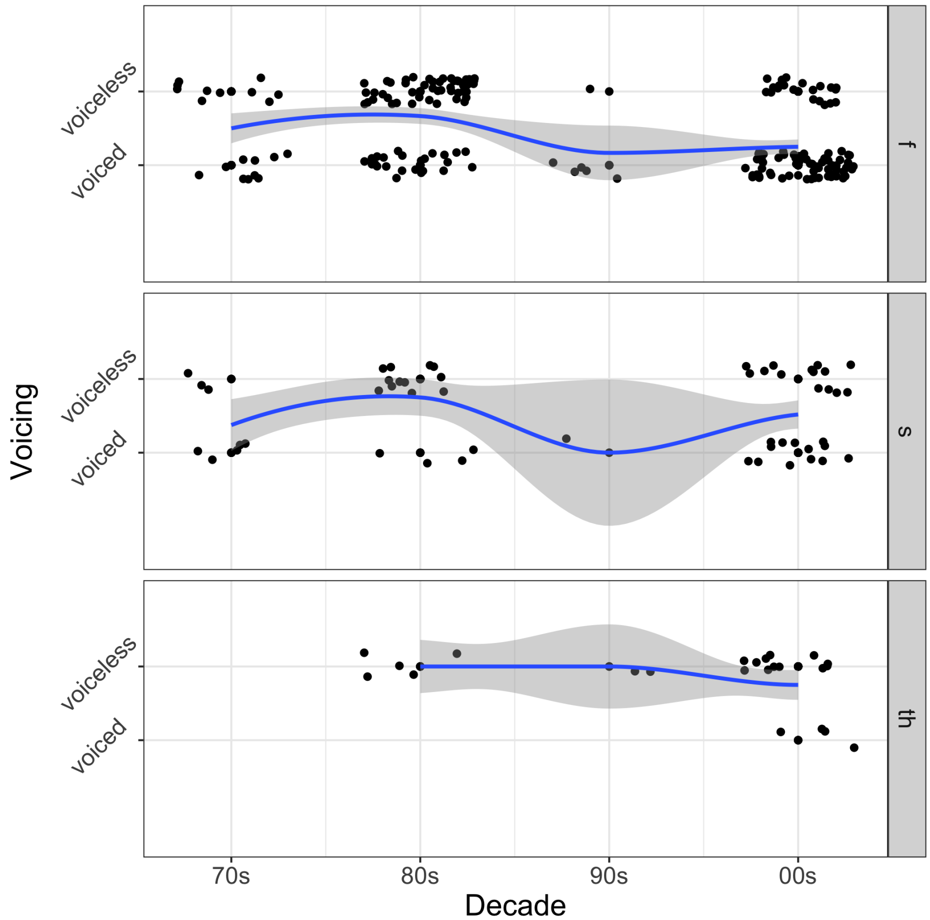

Figure 5: Children's plural stem-final fricative voicing by decade. Each dot reflects one plural token, coded for the voicing of its stem-final fricative and the decade of the corpus in which it was recorded. Trend lines represent LOESS smooths with 95% confidence intervals shaded in gray.

from children of diverse racial and socioeconomic backgrounds were the Hall corpus and the HSLLD corpus, which make up the bulk of the 1980s data (Hall et al. 1984; Dickinson and Tabors 2001). Thus, it is possible that children in these communities were less likely to voice their stem-final fricatives in the plural. This possibility deserves further consideration in future work.

5 Discussion

The previous section found that, to some extent, children produce variable fricative voicing words in line with adults. Like adults, children show a hierarchy of phonemes with /θ/ and /s/ at the bottom (showing the least voicing) and /f/ at the top (showing significantly more voicing than /θ/). However, children diverge from adults in how much they maintain the irregular voicing of /f/-final stems. Adults voice /f/ at a very high rate, significantly more than /s/; children do not. We thus simultaneously see evidence of both probability-matching *and* overregularization: children match the relative ordering of /s/- and /θ/-final stems, and of /f/ and /θ/-final stems, but simultaneously overregularize /f/-final stems, failing to match the high rate of voicing that those stems show in adult language.

One possible explanation for why the children in this study diverge from adults' high rate of voicing in /f/-final stems is that children are performing the same process of overregularization that leads them to produce forms like *breaked* and *mans*. It is possible that adults' 80% rate of voicing in /f/-final stems is enough for children to perceive them as invariantly irregular, along the same lines as *broke* and *men*. As a result, their tendency to overregularize kicks in, and they bring these items in line with the vast majority of English nouns, which do not voice in the plural. By contrast, children don't perceive /s/- and /θ/-final stems in the same way, because they are robustly variable among adults (/s/-final stems: 51% voicing among adults; /θ/-final stems: 47% voicing among adults, based on MacKenzie 2018). Because these items are more obviously variable, children probability-match them instead.

Under this interpretation, however, the high rate of overregularization shown by /f/-final stems is surprising given their relatively high frequency in adult language. MacKenzie (2018) found that the average frequency of /f/-final irregular plurals is 3.56 on van Heuven et al.'s (2014) Zipf scale (where 1 is lowest frequency and 7 is highest frequency), with several very high-frequency items in the class, such as *lives* (5.15), *leaves* (4.66), *wives* (4.19), *thieves* (3.96), *knives* (3.85), and *wolves* (3.78). High-frequency items like these would seem to be the ones most likely to preserve their irregularity in child language (Bybee and Slobin 1982; Hooper 1976; Yang 2002), and would be less likely to overregularize, contrary to what we have found. On a potentially related note, many of these items are not very frequent in child language: *lives*, the most frequent plural in adult language, occurs only once in our child data; *wives*, another item that is highly frequent in adult language, does not occur in our child data at all. Frequency among adults may not translate into frequency in the child's experience.

But there is another possible explanation for children's high rates of regularization of /f/-final stems, and that is that they are extending the change present in /s/- and /θ/-final stems to the /f/-final category. Recall that the historical change in English has been in the direction of loss of voicing in these irregular plurals, but that it has not been operating across all three phonemes at the same rate. Specifically, MacKenzie (2018) found that the change was close to complete in /θ/-final stems, and rapidly progressing in the /s/-final stem *house*, but that the /f/-final stems were conservative, generally preserving voicing. Our data is compatible with a scenario under which children are picking up on the change away from voicing in /s/- and /θ/-final stems and overgeneralizing it to /f/-final stems, beyond adult levels of production.

In fact, a growing body of research finds exactly this: that very young children overdo changes in progress by extending them beyond the environments where adults use them. For instance, Roberts and Labov (1995) find that 3-year-old Philadelphians extend the tense allophone of /æ/ to lexical items where it is traditionally unattested. Similarly, Hall and Maddeaux (2020) find that 4–6-year-olds in Toronto extend adult-like post-coronal /u/-fronting to new, non-post-coronal phonological environments. Cournane (2019) connects these extensions of adult patterns to the same process of overgeneralization described in Section 2.2, as well as to the process of incrementation that leads teens to advance changes in progress (Labov 2001). However, unlike the process as it is observed in teens, young children evidently retreat from this overshoot. This has been summarized as a "two steps forward, one step back" pattern.

6 Conclusion

By studying stem-final fricative voicing, we are able to further our understanding of how children deal with input that is both irregular and variable. Our findings replicate the adult-language pattern reported in MacKenzie (2018) by which /θ/-final stems show the least voicing and /f/-final stems the most voicing. However, our results diverge from MacKenzie (2018)'s findings in that rates of voicing of /f/-final stems are not nearly as high among children as they are among adults, such that voicing of /f/-final and /s/-final stems do not significantly differ for children, despite differing significantly among adults. While the ordering of /θ/- and /s/-final voicing rates is in line with what we would expect from children probability-matching the input they are receiving from adults, the treatment of /f/-final stems does not match the adult pattern. It appears that children are overregularizing /f/-final forms, either to match the dominant pattern of plural formation in English, or to extend the change that has affected the /θ/- and /s/-final classes into the /f/-final class.

Our paper has thus made a number of contributions to the literature. First, we have shown the merits of using spontaneous speech and audio recordings rather than relying on written transcriptions. Second, we have documented children's production in the understudied scenario of variable regularization. And third, we have provided another case that appears to offer support for the theory that children overshoot adult input in ways that are consistent with the advancement of language change, even if they may subsequently dial this back (Cournane 2019). Future research attempting to replicate our findings with an elicitation task and with child and adult speakers from the same speech community will be welcome.

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A Appendix

Table 1: Corpora Analyzed

Corpus	Age Range of Children	Number of Children	Singular Targets	Plural Targets
Bloom	1;9-3;2	3	8	4
Braunwald	1;0-6;0	1	22	11
Davis	0;7-2;4	21	17	14
EllisWeismer	2;6-5;6	138	58	29
Gleason	2;1-5;2	48	6	3
Goad	1;5-3;6	2	6	3
Hall	4;6-5;0	39	24	12
HSLLD	2;0-6;0	83	16	8
MacWhinney	0;7-8;0	2	72	36
Peters/Wilson	1;7-4;1	1	25	34
POLER	5;0-12;0	26	0	1
Providence	1;0-3;0	6	112	56
Sachs	1;1-5;1	1	10	5
Snow	2;3-3;9	1	12	6
Weist	2;1-5;0	6	55	35

B Appendix

Figure 6: Generalized linear mixed effects model output. Phoneme is treatment-coded, with /f/ as the reference level.

```
     AIC      BIC   logLik deviance df.resid
   262.5    298.0   -121.3    242.5      247

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.5862 -0.5202  0.1782  0.5564  2.2069

Random effects:
 Groups  Name        Variance Std.Dev.
 ChildID (Intercept) 1.287    1.134
Number of obs: 257, groups:  ChildID, 61

Fixed effects:
                   Estimate Std. Error z value Pr(>|z|)
(Intercept)          0.9688     0.4035   2.401 0.016349 *
Phonemeth           -2.6795     0.7427  -3.608 0.000309 ***
Phonemes            -1.0672     0.5451  -1.958 0.050257 .
age.cent             0.8861     0.2281   3.885 0.000102 ***
Decade70s           -0.4881     0.7681  -0.636 0.525079
Decade80s           -3.0685     0.7664  -4.004 6.24e-05 ***
Decade90s            0.9681     1.2300   0.787 0.431223
Phonemeth:age.cent  -1.0918     0.4892  -2.232 0.025624 *
Phonemes:age.cent   -0.5326     0.3042  -1.751 0.080025 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:
            (Intr) Phnmth Phonms ag.cnt Dcd70s Dcd80s Dcd90s Phnmt:.
Phonemeth   -0.305
Phonemes    -0.388  0.156
age.cent    -0.038 -0.095 -0.031
Decade70s   -0.429  0.125 -0.032  0.007
Decade80s   -0.432  0.188  0.147 -0.299  0.222
Decade90s   -0.260 -0.067  0.105  0.121  0.109  0.089
Phnmth:g.cn  0.029 -0.150 -0.006 -0.436 -0.005  0.129 -0.130
Phnms:g.cnt  0.061  0.019 -0.504 -0.503  0.089  0.049 -0.131  0.244
```