The Role of the Input in Young Children's Speech Production is Modulated by Syllable Position

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The aim of the current study is to investigate the role of the input on an English-speaking child's production of fricatives in onset and coda positions. Transcript data from a child-mother dyad from Providence Corpus (Demuth, Culbertson & Alter 2006) in CHILDES database (MacWhinney 2000) was examined. The child and the adult production frequency of fricatives in both onset and coda positions were calculated. The results suggested the role of the input in child's production was modulated by syllable position; more specifically, the child's production of fricatives was predicted by the mother's input frequency better in coda position than in onset position. This study sheds light on the ways in which the input may interact with innate learning biases during the course of language acquisition.

Keywords*:* input, onset, coda, language acquisition

1 Introduction

Language acquisition is a complex and gradual process. How do children acquire the sound system of the ambient language? How do children's phonological knowledge and representations progress with development? Recently, an expanding research line has been exploring the characteristics of speech produced by infants and toddlers during the early periods of language acquisition and whether/how their production might be guided by the input (Edwards & Beckman 2008, Zamuner 2003, Zamuner, Gerken & Hammond 2005). The output patterns

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observed from these studies provide an avenue for examining the Input Hypothesis (Olmsted 1966, Zamuner 2003), which proposes that the input plays an important role in early language acquisition. The aim of the current study is to examine whether the influence of the input on children's production of fricatives is pervasive, or is modulated by syllable position.

The Input Hypothesis argues that language acquisition is influenced by the patterns in the ambient language or input: frequent patterns or sounds are acquired earlier than infrequent ones (Beckman & Edwards 2000, Edwards & Beckman 2008, Olmsted 1966, Zamuner, Gerken & Hammond 2005). This hypothesis is supported by considerable evidence showing that children's speech perception and production reflect language-specific phonological pattern frequency at many levels of linguistic representation. For example, children's pre-linguistic vocalization reflects ambient language patterns (De Boysson-Bardies, Halle, Sagart & Durand 1989, Vihman, Macken, Miller, Simmons & Miller. 1985). During the latter half of the first year, infants begin to learn about the sound organization in their native language (Jusczyk, Goodman & Baumann 1999, Jusczyk, Luce & Charles-Luce 1994, Seidl, Cristià, Bernard & Onishi 2009, Wang & Seidl 2014). As children's phonological systems continue to develop, influences of the ambient language become more clearly. These influences of the input are found to be mirrored in children's speech production at segmental (Edwards & Beckman 2008, Munson 2001, Zamuner 2003, Zamuner, Gerken & Hammond 2004), prosodic (Demuth 2001, Gennari & Demuth 1997, Levelt, Schiller & Levelt 1999), as well as word levels (Lleo & Demuth 1999, Naigles & Hoff-Ginsberg 1998). For example, a comparison of children's early word-initial consonant inventories between English (Ingram 1981) and Quiche (Pye, Ingram & List 1987) suggested [tʃ] and [l] are the two most early and frequent word-initial consonants in Quiche whereas they only occur later for English-learning children. Moreover, Zamuner, Gerken and Hammond (2005) found a significant correlation between English-learning children's coda production and the corresponding coda frequency in English, suggesting that coda production is best characterized by frequently occurring properties in the input.

While the relationship between the input and speech production can be very complex, such that the amount of speech, the conversation style, and the frequency of forms in the input can affect language development, this paper will focus on the relationship between the frequency of forms in the input and child sound production in onset and coda position. Although a few studies demonstrated a positive relationship between children's production and input phoneme frequencies in coda position in English (Zamuner, Gerken & Hammond 2004) , they examined stops but not fricatives; furthermore, none of those studies have looked at both onset and coda position and thus we do not know whether/to what degree the input phonotactic probability may affect fricative production in these two positions. Based on prior studies showing children's speech production of segments mirrors the input within a language (Edwards & Beckman 2008, Edwards, Beckman & Munson 2004, Munson 2001, Zamuner 2003, Zamuner, Gerken & Hammond 2004), there are two possible hypotheses regarding the influence of the input on children's production of fricatives. The first we will call the "Strong Input Hypothesis". This

hypothesis suggests that the influence of the input on children's speech production is independent of syllable position. This means that regardless of syllable position, i.e., whether it is in the onset or coda position, the input frequency always directly predicts children's production frequency. The second we will term the "Weak Input Hypothesis". This hypothesis suggests that the influence of the input is not pervasive, but is modulated by syllable position. If the latter hypothesis were true, we would expect that the influence of the input on children's speech production might only be found in one syllable position, but not in the other.

In order to assess these two hypotheses, speech samples collected from a mother-child dyad from the CHILDES database were examined and the distribution of the eight fricatives [f, v, s, z, θ, ð, ʃ, ʒ] that form a natural class in English was calculated. The Methods section introduces how the transcription data is coded as well as how the frequency of fricatives is calculated for both the mother's and the child's speech; the Results section describes analyses conducted to address the two hypothesis outlined above. Finally, the significance and shortcomings of the current study are provided in the Discussion section.

2 Methods

2.1 The Transcript Data

Speech samples from a mother-child dyad from the Providence Corpus, (Demuth, Culbertson & Alter 2006), which are part of the CHILDES English corpora database (MacWhinney 2000), were collected. This corpus was built to study English-learning children's early phonological and morphological development. The data included are longitudinal recordings of a monolingual English-speaking child's (Naima) spontaneous interaction with her mother in a natural setting at home. They were recorded for approximately 1 hour every week beginning at the onset of first word stage at around 1 year of age. Their interactions were recorded on a monthly basis for 3 years. The age range during the recording was from 11.28 to 46.10 months. The data consist of approximately 88 hours of speech. Adult utterances were orthographically transcribed using CHAT convention (cf. MacWhinney, 2000). Child utterances were transcribed with broad phonemic transcription, the majority of which were not marked with syllable or word boundaries. Thus, a large amount of the transcription of child's utterances was composed of sequences of sounds that were not segmented into prosodic words, making the analyses more complicated. We will address the issue as to how we solve this problem in section 2.2 The Data Coding Procedure.

The input phonotactic probabilities of fricatives were based on all the words produced by the mother in an infant-directed register, regardless of their structures. While we would prefer to compare child-mother productions of onset and coda fricatives within each prosodic word structure, i.e., to compare child and mother production of target fricatives for each CVC, CVCCVC, etc. types, we were not able to do so due to the fact that the participants under

examination had not yet begun to produce recognizable English words; consequently, their speech was not segmented into prosodic words in the corpus. For example, their production consisted of strings that could not be related to adult lexical items, such as [əwʌdɪfɔ]. Given that it is not known what was the minimal unit they intended to produce, we have chosen not to compare mother and child's production within each prosodic word type. For the similar reason, we did not control for word class or morphological complexity, as this information was not marked in the corpus.

2.2 Data Coding Procedure

2.2.1 Adult Productions

As mentioned above, the Providence Corpus does not provide phonetic transcription for the conversation of adult speakers (none of the corpora in CHILDES database does). Therefore, the phonetic transcriptions of input conversations were obtained from the CELEX English corpus (Baayen, Piepenbrock & Gulikers 1995). Since this corpus contains words produced in citation forms, it was assumed that the mother produced her words with dictionary-like pronunciation, with the caveat that adult conversation often deletes sounds or changes the characteristics of target sounds. For example, vowels in unstressed syllables may be reduced to schwa (Burzio 2007, Pitt 2009). Consequently, this method only provides a crude measure of adults' speech. Nonetheless, the analysis would not be affected severely by the differences between our dictionary citations and real continuous speech, given that mothers were using infant-directed speech register (IDS), which is characterized by exaggerated acoustic cues in both vowels and consonants (Cristià, McGuire, Seidl & Francis 2011). In some instances, the corpus did not contain the phonetic transcription, for example, the plural word *dogs* was not found in the CELEX database. These forms were transcribed by hand, either by referring to other words in the dictionary and author's intuitions. We also included all the proper nouns (e.g., the child's names), since these types of input may also have an effect on children's production.

We investigated all the eight fricatives in English, namely [f, v, s, z, ɵ, ð, ʃ, ʒ]. To calculate positional probabilities for each fricative in onset and coda positions, first the number of times each fricative occurred in each position (onset vs. coda) for each session (total 88 sessions included) was counted. In order to partially correct for the different numbers of total segments produced by the mother for each session, once the frequency of all the fricatives were calculated, this number was divided by the total number of segments produced by the mother in the same session. I then took the log of the ratio with an aim of weighting a percentage change at the low-frequency end of the distribution more heavily than the same percentage change at the high-frequency end.

2.2.2 Child Production

As we have mentioned above, child speech was not segmented into prosodic words, because they had not yet begun to produce recognizable English words. Thus a large proportion of child production consisted of sequences of segments which did not correspond to any meaningful words or sentences, such as [ɑðeɪætðəɛ̃nbeɪn]. As a result, the syllabification and decision on syllable onset and coda was manually done based on English children's acquisition order of syllable types (Levelt, Schiller & Levelt 1999), with the order of CV, CVC, V, VC, CVCC, VCC, CCV, CCVC, and CCVCC. Based on this criterion, the utterance [ɑðeɪætðəɛ̃nbeɪn] was syllabified as [ɑ.ðeɪ.æt.ðə.ɛ̃n.beɪn]. It should be noted that the majority of the syllables under analysis contain relatively simple structure, such as CV, CVC, V, VC, given that the child under examination was very young; and it is uncommon for her to produce more complex syllable structures such as VCC, CCV, CCVC, or CCVCC. These characteristics simplified the syllabification process. English phonotactic restrictions have also been taken into consideration, for example, the utterance [iʊŋədædi] was syllabified into [i.ʊŋ.ə.dæ.di], instead of [i.ʊ.ŋə.dæ.di], given the sound [ŋ] is not allowed in onset position in English. After all the utterances have been syllabified, the overall frequency of the eight fricatives [f, v, s, z, ɵ, ð, ʃ, ʒ] was counted in both onset and coda positions for each session. Similar to what has been done in adult production, once the frequency of all the fricatives was calculated, this number was divided by the total number of segments produced by the mother in the same session, which was followed by logarithm transformation.

3 Results

In order to address the question of whether the influence of the input is pervasive, or modulated by syllable position, a simple linear regression analysis was performed in onset and coda positions separately with log frequencies of adult production as the continuous independent variable, and log frequencies of child production of fricatives as the dependent variable. Due to a lack of production of fricatives in coda position in children's speech, 1 session was excluded from the analyses in coda position. Thus, a total of 88 and 87 sessions were analyzed for onset and coda, respectively. The Pearson correlation analysis did not show any correlation between the child and the adult's production, $r = .050$, $p = .642$; regression analysis revealed that in onset position, the child's production cannot be predicted by the adult production, $F(1, 87) = 0.253$, $p = .616$, Adjusted $R^2 = .009$ (child: $M = -1.32$, $SD = 0.24$; adult: $M = -1.21$, $SD = 0.03$). However, in coda position, Pearson's correlation analysis showed a significant correlation between the child and the adult's production, $r = .281$, $p = .008$; subsequent regression analysis showed that the child's production of fricatives can be predicted by adult production, $F(1, 86) = 7.27$, $p = .008$, Adjusted $R^2 = .079$ (Figure 1) (child: $M = -1.44$, $SD = 0.28$; adult: $M = -1.33$, $SD = 0.03$). Thus, the result suggested that the child's production of fricatives can be predicted by the mother's

input frequency in coda position, but not in onset position.

4 Discussion

The goal of the current study was to provide a preliminary investigation of the question whether child production of fricatives can be predicted by adult production in onset and coda positions. Since we were interested in how/to what extent the immediate input may affect children's language acquisition, we calculated child and adult production of fricatives in each recording session. Based on the data from the child-mother dyad under examination, the results

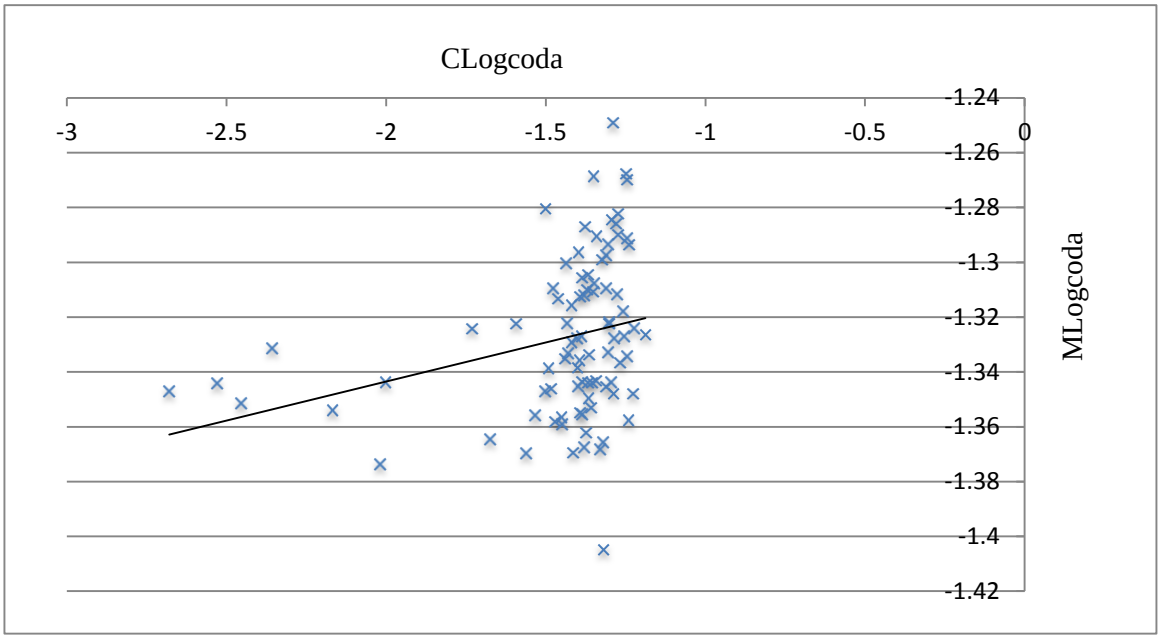

Figure 2: Regression of the adult and the child production of fricatives in coda position. The horizontal axis (CLogonset) represents child production in coda position; the vertical axis (MLogonset) represents adult input in coda position.

showed that child's production frequency can be predicted by adult production frequency only in coda position, but not in onset position.

The results suggest that the role of the input on young children's language acquisition must be evaluated against the role of learning bias. In the Introduction section, two predictions were proposed concerning the role of input. The first was that child production can be predicted by input in both onset and coda positions; the second was that the role of input is modulated by syllable position, and thus input may have a larger effect on one position than the other. It seems that our results support the second hypothesis that the role of the input is modulated by syllable

position. One possible interpretation of this asymmetry would be that onset is the position that is learned earlier than coda during the course of language acquisition, i.e., the participant in our study may have already learned the onset. This is because child learners may have learning biases which render them to pay more attention to unmarked onsets over marked codas at the very beginning of language acquisition. Within several theories of language acquisition (Chomsky 1965, 1986, Prince & Smolensky 1993), the unmarked properties of languages are learned earlier than marked ones during the course of language acquisition. For example, a universally unmarked syllable structure is CV, such that all languages permit CV syllables, but many avoid syllables with codas (Blevins 1996). Thus, syllable onset is regarded as an unmarked position, while syllable coda is regarded as a marked position. If this bias were present in learners it would exist across the world's languages and would exist, at least for some time period, regardless of the input to the child. The similarities that we see from previous research lend support to the presence of this bias. For example, children's early words are mostly open syllables, rather than closed syllables (Blevins 1996). Thus, it is likely that the participant in our study began to pay less attention to the onset position by the age of one-year-old; however, since she was still actively learning how to produce coda fricatives, she might switch most of her attention to coda position. This may explain why the more fricatives the participant received in the input, the more she would produce the same segments in this particular position. Another possibility would be that there is less variation of fricatives in codas than in onsets in the input; an examination of the data showed that mothers always produced more types of fricatives in onset than in coda position; consequently, these children may be less sensitive to the more variable onset. This may explain why language-learning children's production frequency of fricatives is more correlated with the input in coda position. In general, our finding is consistent with Wang and Seidl (2014)'s finding which showed an asymmetrical learning pattern of onset and coda fricatives for 12-month-olds; furthermore, our explanation fits well with Levelt, Schiller and Levelt (1999)'s finding that English and Dutch children's acquisition of syllable types follow the path of CV and then CVC. Many children learning English and Dutch initially avoid the use of coda consonants, producing early words with unmarked 'core' CV syllables, and then in stage 2, they begin to produce CVC structure.

Before concluding, we should enumerate some limitations of this study, which may have influenced the finding reported here. First of all, as mentioned in the Method section, I did not control for factors such as syllable type (CVC, CVCCVC, etc.), category (content vs. function), or word class (noun vs. verb, etc.), which may impact our results. Second, we did not investigate the biphoneme sequence frequencies (e.g., CV and VC), which may also have an effect on children's production. In addition, CELEX was used to transcribe adults' production; however, the real adult production may involve phonological changes such as deletion and reduction. Finally, this study only provides a preliminary examination of one child-mother dyad's interaction; though there are 88 recording sessions in the dataset, we still cannot be sure whether our finding can be extended to other children; thus further studies investigating more extensive

data are encouraged.

With the caveat expressed above, the results suggest that the role of the input is more salient in phonologically unmarked structure, i.e. syllable onset, than in phonologically marked structure, namely, syllable coda. Furthermore, the investigation of input influence on child production suggests that our understanding of the role of input needs to take into consideration the role of learning biases. Specifically, input may play a more important role on the structure which infants are actively learning; however, the importance of input may wane on the structures that children have already learned. The study sheds light on the role of innate learning bias and Input Hypothesis on language acquisition, as well as how they may interact with each other.

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