# Velar Fronting Revisited*

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## 1. Introduction

It is widely believed that child language may sometimes be a better test than adult language for what is possible in human grammar. The generalizations that children construct (often based on ultimately non-representative selections of data) may, as Bernhardt & Stemberger (1998:5) point out, be a purer reflection than adult language —which is the result of historical change, often subject to lexical and/or sociolinguistic pressure— of what kinds of phonological generalizations human beings can make.

There are nonetheless certain phonological processes attested in child language which do not seem consistent with any known adult systems. Such child-specific patterns are problematic under the *continuity* assumption (Macnamara 1982, Pinker 1984), according to which the process of language acquisition is continuous, such that the formal properties of the grammar, which are constrained by universal linguistic principles, do not change. Only the structures that are allowed by the grammar change over the course of time, which yields the patterns observed at each stage in development (Goad 2000).

This paper will focus on one such process, namely velar fronting (henceforth, VF; e.g. Chiat 1983, Brett, Chiat & Pilcher 1987, Stoel-Gammon & Stemberger 1994, Stoel-Gammon 1996, Bills & Golston 2001, Dinnsen 2002). Our discussion is based primarily on previously unpublished data from E, a first-language learner of English. E displays VF to coronal in a positionally-determined fashion: velars undergo fronting in onsets of prosodically strong positions only (in word-initial and stressed onsets; e.g. *kiss* [k̲ɪs] → [t̲ɪs], *again* [əˈɡ̲ɪn] → [əˈd̲ɪn]), while they are realized as target-like in every other, prosodically weaker, positions (e.g. *back* [bæk̲]; *bagel* [ˈbejɡ̲u]).

On the face of it, VF is problematic for the continuity assumption, if analyzed through grammatical properties only. Though commonly found in the literature on the first language acquisition of phonology, VF finds no correlate in the realm of adult languages. In addition, the positional effects of E's prosodically conditioned version of VF go counter to the cross-linguistic observation that prosodically prominent positions are privileged; much recent research has been driven by the observation that these positions typically allow greater prosodic complexity and are the least likely to obscure segmental contrasts. VF contradicts all existing theories of positional neutralization, which predict neutralization in weak, rather than strong, positions (see §3.2).

While previous studies of children displaying similar patterns attribute VF to a universal developmental path (e.g. Stoel-Gammon 1996) or to aspects of the children's grammatical organization (e.g. Bills & Golston 2001, Dinnsen 2002), we argue that an explanation of VF requires a look at the physiological limitations inherent to the vocal tract at early ages. In offering an extragrammatical explanation for why child and adult grammars may differ, we are thus able to reconcile VF with current theories of positional neutralization and retain the essence of the continuity assumption.

The paper is organized as follows. In §2, we introduce the data from E, as well as some methodological details. In §3, we discuss the relevant theoretical background. Our proposal is detailed in §4. A brief conclusion is offered in §5.

* The two authors have contributed equally to this research and are listed alphabetically. We would like to thank Jonathan Barnes, Carrie Dyck, Margaret Kehoe, John Ohala, Orhan Orgun, Mits Ota, Joe Pater, Jen Smith, and Doug Wharram for their useful feedback at earlier stages of this research. This research was funded in part by a SSHRC postdoctoral fellowship to Y. Rose. Email contact: inkelas@socrates.berkeley.edu; yrose@mun.ca.

## 2. Data and Methodology

Our discussion of VF focuses primarily on a new longitudinal corpus from E, a monolingual learner of English. E has one brother, who is two years and five months older. The data from E were gathered in a naturalistic, diary setting by his mother, a trained phonologist. E's father, also a professional linguist, participated in the data collection as well, to a lesser extent. Data collection was performed as often as possible, during unstructured sessions and regular familial activities. The period of data gathering spans from E's age 0;06.09 to 3;09.29, with most of the data collected prior to the last year of the study. Indeed, between ages 0;06.09 and 2;09.09, a span which corresponds to the child's phonological development peak (i.e. during which most aspects of the target grammar were acquired), 1549 utterances were collected. An additional 80 utterances were gathered over the last year of the study, during which the mother was focusing mainly on the development of the lateral approximant /l/ (itself a worthy subject of study, but beyond the scope of this paper).

Early notes on E's productions suggest that VF was not yet in force in late babbling (e.g. [gæ], [gægæ], [ægægæ]; around age 0;6), nor did it occur in E's very first words (e.g. [kæt̚], [kæʔ], [kæ] 'catch'; 0;9).

Between ages 1;00.27 and 2;02.28, however, E displayed a systematic pattern of VF to coronal. The most central aspect of VF in E's outputs is the fact that this process is positionally-determined. Indeed, VF was found in the onsets of syllables bearing either primary or secondary stress, as well as word-initially even in unstressed syllables, i.e. in the phonetically *most* salient consonantal positions of the word. During this time span, attempts at velar consonants were attested in 787 examples which, when sorted by relevant prosodic contexts, reveal how systematically VF applied in prosodically strong positions. Examples of this process are presented in (1).

(1) VF in onsets of prosodically strong positions (288/337; 85,5%)

a. Word-initial primary-stressed syllable onset

| | | |
|---|---|---|
| [tʰʌp] | 'cup' | 1;09.23 |
| [doː] | 'go' | 1;10.01 |
| [ˈtuwɔ] | 'cool' | 1;11.02 |

b. Word-internal primary-stressed syllable onset

| | | |
|---|---|---|
| [əˈdɪn] | 'again' | 1;10.25 |
| [dʊˈdʊ] | 'Gügü' | 1;11.21 |
| [taˈdɛɾə] | 'together' | 2;01.21 |

c. Word-internal secondary-stressed syllable onset

| | | |
|---|---|---|
| [ˈhɛwˌtɔptɛə] | 'helicopter' | 2;00.19 |
| [ˈæwəˌdɛɾɚ] | 'alligator' | 2;01.18 |
| [ˈhɛksəˌdɔn] | 'hexagon' | 2;02.22 |

d. Word-initial unstressed syllable onset

| | | |
|---|---|---|
| [dʊˈdʊ] | 'Gügü' | 1;11.21 |
| [tʌnˈdʌktə] | 'conductor' | 2;01.21 |

VF systematically failed to apply in any of the other contexts where velar consonants were expected, namely, onsets of non-initial unstressed syllables, in (2a), word-internal codas, in (2b), and word-final position, in (2c).

(2) Velar productions outside of prosodically strong onsets

a. Onsets of unstressed syllables (98/112 cases; 87.5%)

| | | |
|---|---|---|
| [ˈmɑŋki] | ‘monkey’ | 1;08.10 |
| [ˈbejgu] | ‘bagel’ | 1;09.23 |
| [ˈbʌkɨt] | ‘bucket’ | 2;01.11 |

b. Word-internal codas (15/16 cases; 93.8%)

| | | |
|---|---|---|
| [ˈæktʃwi] | ‘actually’ | 1;11.22 |
| [ˈɑktəpʊs] | ‘octopus’ | 2;01.05 |
| [ˈɑktəgɑn] | ‘octagon’ | 2;01.05 |

c. Word-final consonants (236/263 cases; 89.7%)

| | | |
|---|---|---|
| [bɪg] | ‘big’ | 1;00.13 |
| [bʊkʰ] | ‘book’ | 1;07.22 |
| [ˈpædjɔk] | ‘padlock’ | 2;04.09 |

Finally, note that VF to coronal as found in E’s outputs is non-assimilatory, in the sense that it has nothing to do with consonant-vowel interactions (cf. Robin; Levelt 1994:93ff), as can be seen in the examples in (3).

(3) VF independent from consonant harmony and C-to-V interaction

| | | |
|---|---|---|
| [ˈtʰʊk] | ‘cook’ | 1;09.29 |
| [ˈtɑfiˌmejkə] | ‘coffee maker’ | 1;10.14 |
| [ˈtokoˌnʌt] | ‘coconut’ | 2;00.19 |

## 3. Background

A survey of the literature reveals three recent proposals about VF, which we review in §3.1. In §3.2, we briefly discuss prevalent approaches to positional effects within the recent literature on adult phonology. As we will see, none of these approaches can account satisfactorily for the type of VF found in the productions of E and several other children displaying similar effects.

### 3.1 Previous approaches to VF

Previous approaches to prosodically conditioned VF exhibited by children with patterns similar to E’s generally attribute the process to a grammatical preference for velars to be final, rather than initial, in words or syllables.

#### 3.1.1 Universal developmental path

From a corpus of 67 children, Stoel-Gammon (1996) generalizes that “if a child produces velars correctly in some, but not all, words, *position of the target velar* is the factor that determines whether the targets are produced accurately or are fronted to alveolars” (pp. 202-203; our emphasis). From this generalization, she proposes a universal learning path for the acquisition of velars, in (4).

(4) Universal path in the acquisition of velars (Stoel-Gammon 1996:206)[1]

a. Stage 1: VF in all positions
b. Stage 2: Velar acquisition in coda positions; VF in onset position
c. Stage 3: Velar acquisition in all positions

1. Note that the claimed universality of this learning path is undermined by the fact that it is based on the observation of English acquisition data only.

However, this hypothesis raises a number of questions. First, the early forms (babbling and actual words) produced by E, which did contain velars in strong positions, contradict this path. Second, there is no demonstration that the three stages have actually been attested in a unique grammar. This point calls for the need of additional longitudinal investigations of phonological acquisition. Third, because word-medial onsets of unstressed syllables resist fronting (e.g. *cooking* [ˈk̠ʊkɪŋ] → [ˈt̠ʊkɪŋ]), similar to velars in coda position, Stoel-Gammon suggests that these onsets are analyzed by the child as codas, as illustrated in (5), where the word-medial (5a) and word-final (5b) [k] is syllabified as codas.

(5) Word-medial onsets of unstressed syllables as codas (Stoel-Gammon 1996)

a. 'cooking' [tʊkɪŋ] b. 'cook' [tʊk]


This hypothesis, which lacks independent support within child language (see below), contradicts cross-linguistic observations that placeless and coronal consonants are favored in coda position, as opposed to labial or, in the case at stake here, velar consonants (e.g. Itô 1986, Blevins 1995; see also §3.2).

Under a weaker interpretation of Stoel-Gammon's hypothesis, one might assume that the word-medial [k] in (5a) is in fact ambisyllabic, i.e. syllabified both in onset and in coda positions. This is the essence of Bills & Golston's (2001) proposal.

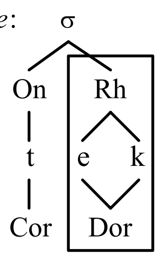
### 3.1.2 Rhymal licensing

Taking a representational approach, Bills & Golston (2001) propose that VF arises from a feature licensing relation in child language. Following Sagey (1986), they assume that all vowels are phonologically specified for the feature Dorsal. In fronting grammars, they propose, Dorsal consonants are licensed only by a (Dorsal-bearing) vowel within the same subsyllabic constituent. Because codas are syllabified within the rhyme, they are thus licensed by the preceding vowel, as illustrated by the domains within rectangles in (6). By contrast, word-initial onsets are clearly outside the rhyme, and thus Dorsal onsets cannot be locally licensed by a following (or for that matter a preceding) vowel. Consequently, target velars in onset position must undergo fronting to Coronal.

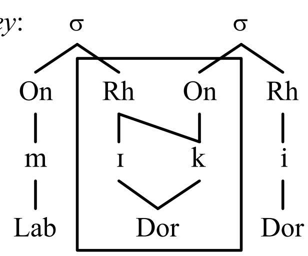
(6) Licensing relations

a. Rhymal licensing b. Ambisyllabicity ([k] = ambisyllabic)

*cake*:




*Mickey*:




To explain the absence of neutralization in the onsets of unstressed syllables, Bills & Golston propose that post-stressed-syllable onsets are ambisyllabic. Because an ambisyllabic velar belongs to the same rhyme as the preceding vowel, its Dorsal feature is licensed, and therefore the velar is protected from neutralization (6b).

Although the analysis proposed by Bills & Golston (2001) accounts for the general VF facts, it raises a number of questions. First, this analysis rests on the assumption that onsets of unstressed syllables are ambisyllabic in the child's representations. However, independent evidence for ambisyllabicity in child language is at best questionable (Stemberger & Bernhardt 2002). A more serious objection is the lack of evidence in adult language for the type of vowel-to-consonant licensing of Dorsal on which Bills & Golston's analysis relies.

### 3.1.3 Edge restrictions

Dinnsen (2002) entertains an approach to VF, couched in Optimality Theory (OT; Prince & Smolensky 1993), which uses the constraints in (7) to capture Stoel-Gammon's (1996) generalization that VF in prosodically weak positions implies VF in strong positions but not vice-versa.

(7) Constraints (Dinnsen 2002)
  a. *#k: Avoid velars word-initially
  b. *k: Avoid velars
  c. MAX(Place): Preserve input Place features

(8) OT account of the typology of VF (Dinnsen 2002)

| Context | Constraint ranking | *Gum* and *big* |
|---|---|---|
| a. Everywhere | *#k >> *k >> MAX(Place) | [dʌm], [bɪd] |
| b. Initially only | *#k >> MAX(Place) >> *k | [dʌm], [bɪg] |
| c. Nowhere | MAX(Place) >> *#k >> *k | [gʌm], [bɪg] |
| d. Post-vocalically only | Impossible | [gʌm], [bɪd] |

Although this account describes the general VF facts, it poses a number of problems. First, the constraint *#k, in (7a), lacks independent support. We are not aware of a language which has velar obstruents but bans them word-initially. Ad hoc constraints like *#k conflict with the essential OT premise that constraints are universal and must be motivated by factorial typology.

Our second criticism of Dinnsen's account concerns the pattern in (8d). In order to rule out this non-occurring pattern, it is crucial to stipulate that a constraint such as *k#, i.e. the word-final counterpart of *#k in (7a), is universally impossible. The introduction of *k# would open the possibility of VF in prosodically weak, but not strong positions, a pattern which, to our knowledge, has never been documented. Unfortunately, *k#, as opposed to *#k in (11a), actually does find support in adult languages such as Spanish, which allows for velar consonants word-initially but not word-finally. It thus remains to be explained why VF in weak positions does not occur in child language.

## 3.2 Current theories of positional neutralization

It is important to evaluate VF within the context of other position-sensitive phonological neutralization effects. Within the recent literature in phonological theory, two main types of positional effects have been observed (in adult language). On the one hand, it is common for lexical contrasts to be maintained in prominent positions but neutralized in nonprominent positions; the opposite is rarely if ever true. This generalization is captured in Optimality Theory by theories of positional faithfulness (e.g. Beckman 1997, Steriade 2001), in which faithfulness constraints can be indexed to structurally or phonetically strong positions but not to weak ones. The other generalization about prominent positions is that they tend to attract prosodic complexity (augmentation) not found in, or at least not attracted to, nonprominent positions. This generalization is captured in Optimality Theory by theories of Positional Markedness (e.g. Itô, Mester & Padgett 1995, Zoll 1998, Smith 2002), in which certain marked features or structures are required to appear in prominent positions.

These approaches to positional asymmetries in general, and positional neutralization in particular, share the assumption that featural contrastiveness should consistently be favored in prosodically strong positions, while neutralization should be confined to weak positions. Positional VF of the sort exhibited by E, in which weaker prosodic positions actually license more contrasts than stronger ones, pose a challenge to all of these approaches.

In summary, none of the existing grammatical accounts of VF in children accounts for the connection between VF and child language. VF is not an attested adult pattern, nor, according to the extensive literature on positional neutralization discussed above, do we expect it be.

## 4. Current proposal

Our explanation for the occurrence of positional VF in E and other children acquiring English is that VF is a grammaticalized artifact of the physiological inability to articulate velar consonants in prosodically strong positions in early stages of children's development. The current proposal is superior to purely grammatical accounts like those in §3 in being able to explain (a) why velars, rather than coronals, are neutralized, (b) why VF occurs only in strong, rather than weak, prosodic positions, and (c) why prosodically conditioned VF is unique to children. In short, we argue that the normal phonetic strengthening of velars in strong position in adult English conspires with the differently proportioned vocal tract of young children to potentiate precisely the VF pattern exhibited by E and others.

The first factor which contributes to VF in children's productions concerns physiological characteristics of the vocal tract at early ages. Studies by Fletcher (1973), Kent (1981) and, especially, Crelin (1987:94ff) demonstrate that in young children, the size of the tongue is much bigger, relative to the rest of the vocal tract, than it is in adults, while the palate is proportionally shorter. Based on comparative measurements, Crelin shows that the vocal tract of a two-year-old has basically the same shape as in a newborn infant, with the tongue filling the supralaryngeal cavity almost entirely. At around age two, the vocal tract begins its progressive evolution towards its adult shape, which is generally not attained before age six.

The second component of our explanation for VF comes from research in (adult) articulatory phonetics showing that consonants in prosodically strong positions, e.g. stressed or word-initial onsets, show larger amplitude in their articulatory gestures than those in other positions, e.g. codas or onsets of unstressed syllables. This difference in gesture magnitude appears to disproportionately affect velars, yielding a greater, more forward linguo-palatal contact for velar consonants in this position than for velars in weaker prosodic contexts (e.g. Fougeron & Keating 1996, Fougeron 1999).

This result from adult phonology is directly relevant to child language, given that research on phonological development in general shows children to be extremely faithful to target stressed syllables. For example, in words that undergo truncation at early production stages, stressed syllables enjoy faithfulness more than any other syllable in the word (e.g. Fikkert 1994, Pater 1997, Rose 2000). In addition, the literature on speech perception and production demonstrates that children are very sensitive to the phonotactics of their target languages (see Jusczyk 1997 for a review). This observation is also supported in the literature on covert contrasts (e.g. Scobbie 1998).

We argue that this faithfulness to English phonotactics, especially in stressed syllables, is the second major factor at the source of VF, alongside the physiological constraints discussed above. Bigger tongue size, when combined with a relatively shorter palate, implies that even a slight increase of vertical tongue movement, required in the enhanced articulations in prosodically strong positions, will have direct consequences for the child's production of target velars. The greater emphasis on the dorsal articulator expands tongue contact into the coronal region, yielding the coronal release.

In summary, the fact that adult speakers of English strengthen velars in strong positions, the fact that children are sensitive to positional strength effects in early acquisition, and the disproportionately large tongue and short palate of young children together produce the expectation that VF should arise in at least some children, and that if it does arise, it should do so first in strong positions, consistent with Stoel-Gammon's (1996) generalization.

### 4.1 VF grammaticalization

The fact that most English-learning children do not display VF but, rather, faithfully produce target velars in early productions argues against an approach to VF that is exclusively phonetically determined (i.e. extra-grammatical). Rather, the variation between fronting and non-fronting children suggests that children's grammars react differently to physiological constraints on acquisition of the type discussed here. The role that articulatory constraints play in the VF phenomenon should thus not distract us from the crucial observation that, in children like E who exhibit positional VF, this process crucially reflects central aspects of the child's grammatical organization.

The articulatory difficulty related to the pronunciation of velars at early ages initially led E to produce strong velars that are phonetically coronal. We propose that this phonetic implementation (articulatory planning) of onset strengthening in prosodically strong positions was phonologized by the child, who applied it consistently throughout the 14-month period during which VF was observed in his productions. Because of the physiological limitations hindering E's ability to faithfully reproduce target velars in prosodically strong onsets in English, he opted for an alternate mapping which did still faithfully maintain onset enhancement in stressed syllables, although the superficial form it took (coronal release) was not segmentally accurate on the surface. This faithfulness to the English prosodic phonotactics in stressed syllables at the cost of segmental unfaithfulness thus constitutes an interesting case where neutralization of a surface segmental contrast reveals a deep understanding of the target language by the child. Only later in the course of his development did E, aware of the phonetic discrepancy between his strong velars and the ones of the ambient language, revise his motor planning to finally produce target-like velars in all positions.

This leads to the following logical question, concerning the factors that led E to eventually master the Coronal ~ Dorsal contrast in prosodically strong onsets: should this stage of acquisition be related to a reproportioning of the tongue through physiological development, or to a greater physiological control of the linguo-palatal contact? A full answer to this question would require more research, using methodologies such as ultrasound scanning (e.g. Gick 2001), which would enable a clear diagnosis of the articulatory limitations with regard to the production of velar consonants across developmental stages.

Despite the current lack of evidence from such a potential study, we argue that physiological factors alone cannot explain the VF pattern; the grammar must play a role in the way that VF was phonologized by the child, as further evidenced by the fact that velars in strong prosodic positions were, from an articulatory perspective, possible in E's late babbling and very early words. Articulation alone also cannot explain how VF gets resolved by the child. Indeed, while growth of the diverse components of the vocal tract is progressive, E, as of around age 2;02.28, started to produce velar consonants in word-initial and stressed syllables in a categorical fashion. During the ten-day transitional period between ages 2;02.21 and 2;03.00, 27 target velars in strong positions were noted, out of which 22 cases (81.5%) underwent fronting. During the next two-week period (ages 2;03.05 to 2;03.21), the process was attested in only 2/14 (14%) target velars, and then disappeared from E's productions. Moreover, on two occasions around this transitional period, at E's age 2;01.14 and 2;03.21, E's mother witnessed the child producing nonsense words containing velars in stressed syllables (e.g. [ɡæk], [kæk], [kɑŋk]), as if E was, on those occasions, practicing the motor planning required to correctly produce velars in prosodically strong positions. These attestations suggest that E engaged in overt articulatory training in order to master his new motor planning for strong velars.

Our treatment of VF in prosodically strong positions as a grammatical process is completely at odds with the controversial view, expressed by Hale & Reiss (1998), that children lack articulatory control in a way comparable to evidence found in the "intoxicated speech of the captain of the *Exxon Valdez* around the time of the accident at Prince William Sound" (Hale & Reiss 1998:669). Hale & Reiss argue that precisely such a lack of control yields the processes observed in child phonology. We disagree: a child-only phonological process like VF, when cast in its appropriate context, actually reveals a great deal of articulatory control. Despite obvious physiological disadvantages at early ages, children such as E display extremely systematic and well-controlled articulations reflecting their grammatical organization, rather than behaving like the drunk captain Hale & Reiss refer to and unwittingly failing through physical disability to articulate the target segments.

### 4.2 General predictions

The current proposal offers insight into two general observations about VF. First, as mentioned above, the current proposal correctly predicts Stoel-Gammon's (1996) generalization that VF in prosodically weak positions implies VF in strong positions as well but not vice versa. On the one hand, children with across-the-board VF are unable to correctly position their tongue dorsum to produce velar consonants in prosodically weak positions. In stronger positions, if anything, this problem can only be worse. For example, if English-learning children are sensitive to the phonotactics of their target language, their linguo-palatal contact will extend even further in the coronal area. Only a slight phonetic difference will result from this, which would most probably go unnoticed unless investigated through fine-grain acoustic analysis or visually diagnosed through ultrasound scanning. Children who, like E, display positional VF only in strong positions differ from the first group in the sense that they are capable to reproduce velars in weak prosodic environments. As argued for above, a slight enhancement of this articulation yields an extended contact of the dorsum into the front area of the palate, from which VF results. Crucially, the opposite cannot be true: if a child is able to pronounce velars in prosodically strong positions, i.e. with an enhanced articulation, nothing can prevent this child from producing velars in weaker positions, as these require a lesser linguo-palatal contact.

Second, our approach also readily explains why VF is not attested in adult languages. The source of this process is due to physiological limitations inherent to the child's vocal tract, reported in §4. The fact that these limitations are not found in a normally-developed adult vocal tract is enough to explain the absence of positional VF from adult systems.

The adoption of this latter view could be interpreted in a way that makes the children's grammars more complex than adult grammars. However, this interpretation is not necessary. We propose, in the spirit of the phonology-phonetics interface outlined in Barnes (2002), that the component of E's grammar that is responsible for the coronal realization of target velars in prosodically strong positions is required in any grammar. Indeed, the function of the child's grammar which causes VF in specific phonological contexts is required in all instances of mapping abstract phonemic categories to windows of phonetic realization. Under this view, fronted versions of target velars in child language pattern as allophones, therefore, as the result of a phoneme-to-sound grammatical rule.

This last point relates directly into the issue, addressed in the introduction of this paper, of the implications of VF for the continuity assumption. Because the source of the unnaturalness of VF crucially lies outside of the child's phonological competence, the current proposal does not require any rule or constraint contradicting the continuity assumption. In fact, once the interacting factors (grammatical and physiological) are considered separately in the characterization of this process, VF actually reveals the extreme consistency with which a developing grammar can cope with external factors while adhering fully to the fundamental principles of UG.

## 5. Conclusion

In this paper, we discussed the empirical and formal aspects of positional VF to coronal consonants as observed in children learning English. In the productions of these children, VF arises only in onsets of prosodically strong syllables. On the face of it, this process appears unnatural, because is has no correlates in adult languages. First, (positional) VF has not been documented in the field of adult phonology. Second, this neutralization process occurs in strong, rather than weak, position. This process is thus superficially problematic for the continuity assumption, under which grammars, at any stages in their development, should reflect possible adult grammars.

Going beyond previous analyses of this phenomenon, we incorporated the physiological dimension of the problem into the current proposal. We argued that VF arises as a grammatical process of articulatory enhancement of onset consonants in prosodically strong positions. This process, however, is subject to non-grammatical, physiological constraints caused by the shape of the vocal tract in young children. Under this view, the process is compatible with the continuity assumption, as the constraints from which result the coronal articulation are outside of the grammar.

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