POSITIONAL NEUTRALIZATION: A CASE STUDY FROM CHILD LANGUAGE

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A new longitudinal diary study of a child (E) learning American English reveals two patterns of segmental neutralization: velar fronting, in which /k/ and /g/ are realized as [t] and [d], and lateral gliding, in which /l/ is realized as [j]. Both phenomena are restricted to prosodically strong positions, affecting only consonants in word-initial position or in the onsets of stressed syllables. An explanation for positional velar fronting that combines phonetic and grammatical considerations is proposed to account for the occurrence of the effect in children but not adults: the greater gestural magnitude of prosodically strong onsets in English interacts with the anatomy of the young child's vocal tract to produce coronalization of prosodically strong velars. E extended the resulting pattern to lateral gliding, which developed later and has similar grammatical conditioning but less direct phonetic motivation.*

1. Introduction. It is widely known that there are phonological processes attested in child language that do not seem consistent with any known adult systems. Such child-specific patterns, sometimes termed 'invented', 'unnatural', or 'crazy' rules (see e.g. Buckley 2003 for a recent overview), are problematic under the continuity hypothesis (e.g. Macnamara 1982, Pinker 1984), according to which the formal properties of the grammar, which are constrained by universal linguistic principles, do not change. While children's grammars change over the course of time, the continuity hypothesis predicts that the grammar at every stage of development should belong to the set of possible adult grammars.[1]

This article focuses on two such problematic processes, namely positional velar fronting (PVF) and positional lateral gliding (PLG), occurring in the speech of one child, E, a first-language learner of English. The data are drawn from a longitudinal diary corpus compiled between 1998 and 2001. Over a fourteen-month period beginning early in his second year, E displayed velar fronting to coronal in a positionally determined fashion, hence the term positional velar fronting: target velars were produced as coronals in the onsets of prosodically strong positions only, that is, in word-initial and/or stressed onsets (e.g. *kiss* [**k**ɪs] → [**t**ɪs], *again* [ə'**g**ɪn] → [ə'**d**ɪn]), while they were realized as target-like elsewhere, that is, in codas and in word-medial onsets of unstressed syllables, both of which are prosodically weak positions (e.g. *back* [bæ**k**], *bagel* ['bej**g**u]).

During an overlapping period whose onset came eight months later than that of PVF, E also displayed positional lateral gliding (PLG): target /l/ was produced as [j] in onsets

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[1] The continuity hypothesis is generally assumed in optimality theory approaches to the acquisition of phonology; see Fikkert 1994, Goad 1997, Pater 1997, among many others. On unnatural (i.e. nonadult-like) patterns in child phonology, see, among many others, Smith 1973, Kiparsky & Menn 1977, Macken 1979, Bernhardt & Stemberger 1998, Pater & Werle 2001, Buckley 2003, Buckley & Seidl 2005.

of prosodically strong positions, and as [w] elsewhere, that is, in prosodically weaker positions.

On the face of it, both phenomena are problematic for the continuity hypothesis. Neither PVF nor PLG is attested in the realm of adult languages, nor should we expect either to be: both involve segmental neutralizations that take place in prosodically strong positions, precisely where the theoretical literature on positional neutralization predicts major place of articulation contrasts in consonants to be preserved (e.g. Smith 2000, 2002, DeLacy 2002). E is thus displaying phonological mappings of a type that is very unnatural, apparently unattested, in adult language.[2]

Velar fronting (VF) is commonly found in the literature on first-language acquisition of phonology (Ingram 1974, Chiat 1983, Stoel-Gammon & Dunn 1985, Brett et al. 1987, Stoel-Gammon & Stemberger 1994, Stoel-Gammon 1996, Bills & Golston 2002, Dinnsen 2002), as are various types of lateral gliding (see e.g. Bernhardt & Stemberger 1998), albeit not conditioned in the precise manner exhibited by E. The data from E are unique in the structural parallels between the two processes that they exhibit; we argue that these parallels are evidence of a grammatical analysis, on the child's part, of both effects.

The proposal developed in this article, based on close scrutiny of E's longitudinal data, is as follows: for solid, articulatory, albeit child-specific, phonetic reasons, E developed, and subsequently phonologized, a PVF pattern that turns out actually to be fairly common among children learning English. E then extended this pattern to lateral gliding, for which it has less solid phonetic motivation. We argue that as E was coming to terms with the allophony of laterals in English, he appealed to his existing positional system for velars to resolve the issue of the distribution of light and dark /l/ in English. This phonologization account—in which a gradient articulatory effect is (re)analyzed as a categorical phonological rule—of E's PVF and PLG patterns makes sense out of the discrepancies with adult language, and also reconciles E's neutralization patterns with current theories of positional neutralization, allowing in both of these ways the essence of the continuity hypothesis to be retained.

In what follows, we first introduce the corpus used in this study and the PVF and PLG patterns that emerge from it. We next relate E's case to other instances of PVF and PLG in the acquisition literature, and then return to the continuity hypothesis by comparing positional neutralization in child language to positional neutralization in adult language. Finally, we introduce our proposal and offer evidence bearing on the grammatical status of E's PVF and PLG patterns.

2. THE E CORPUS. This study is based primarily on a new longitudinal corpus from E, a typically developing monolingual learner of English with no history of hearing problems or language delays. E has one sibling, a brother who is two years and five months older and who also exhibited normal phonological development (see n. 10). E's mother is a native speaker of American English. E's father is a native speaker of Turkish, but fluent in English; his slight Turkish accent is unlikely to have been a factor in E's PVF and PLG patterns (see n. 14 and 16). During the course of language development, E was raised in a monolingual English-speaking environment. He was

[2] In addition to PVF and PLG, there exist several other child-specific processes that can target consonants in onset position while leaving coda consonants intact: consonant harmony, whose trigger, target, and directionality effects vary considerably across children (e.g. Rose 2000, Pater & Werle 2001), nonharmonizing default consonant substitutions (e.g. Dunphy 2006), and fricative stopping (e.g. Dinnsen 1996, Edwards 1996, Marshall & Chiat 2003; see also Bernhardt & Stemberger 1998).

exposed to minimal amounts of Turkish but was virtually never addressed directly in this language. As of age 2;7, due to his sibling's entry into a Spanish immersion school program, E began to be exposed to some Spanish, including the word *hola* which we cite in n. 6, but not the Spanish of native speakers. In brief, we cannot identify any factor related to E's linguistic environment other than the general phonological and phonetic properties of English discussed in later sections that could have yielded the patterns of PVF and PLG discussed in this article.

The data from E were gathered in a naturalistic, diary setting primarily by his mother, a trained phonologist. E's father, also a phonologist, participated in the data collection as well. Data collection was performed as often as possible, during unstructured sessions and regular family activities. The period of data gathering spans E's ages 0;06.09 to 3;09.29, with most of the data collected prior to the last year of the study. Between ages 0;06.09 and 2;09.09, a span that corresponds to E's phonological development peak (i.e. during which most aspects of the target grammar were acquired), a total of 3,267 words (distributed over 1,713 utterances) were transcribed phonetically. An additional 113 words were transcribed over the last year of the study, during which E's mother was attending mainly to the development of /l/.

A concern with any use of diary data is of course the impossibility of instrumental analysis or verification of the transcriptions of the child's speech.[3] As discussed in fuller detail in §8.2, we cannot assert unequivocally whether E completely merged /k/ and /t/, /g/ and /d/, and /l/ and /j/ in strong position, or, instead, produced phones of strong /k/, /g/, and /l/ that the adult listeners could not distinguish from strong /t/, /d/, and /j/, respectively. Only instrumental studies can distinguish children with complete mergers from children with near-mergers, or covert contrasts (e.g. Macken & Barton 1979, Hewlett 1988, Gibbon & Scobbie 1997, Scobbie 1998, White 2001). As discussed below, however, other evidence, namely the grammatical conditioning of the patterns observed, the abrupt and systematic transitions into and out of the PVF and PLG patterns, and the structural congruency between the two very articulatorily and acoustically different patterns, supports the existence of an underlying grammatical system regulating the articulatory gestures that create the contrasts perceived by the transcribers. This system, rather than the question of complete versus incomplete phonetic neutralization, is the focus of the present study.

It must also be noted that in the field of early phonological development, the majority of the longitudinal studies currently available in the public domain are based on methods comparable to those used in the E study (e.g. Smith 1973, Pater 1997; see Ingram 1989: Ch. 2, Bernhardt & Stemberger 1998, and Bills & Golston 2002 for surveys of the seminal diary studies in the field). It is only recently that more modern corpora incorporating multimedia recordings have been made available, mostly through the CHILDES project (http://childes.psy.cmu.edu/).

According to Ingram (1989:8), '[a]n undeniable strength is that the observer [in diary studies] clearly knows the child well; behaviors noted, consequently, are not idiosyncratic, but presumably either common ones or ones that mark a new development'. This is true of the E corpus, which is also rich in detail. Because it includes a variety of multisyllabic word shapes not occurring in many other studies of PVF, the E corpus provides crucial test cases for the distribution of the patterns in E's outputs, most often with several examples noted for each context. This makes possible refined longitudinal tracking of E's development. The present study thus offers a stepping-

[3] We are grateful to Ben Munson for discussion of these issues.

stone for the design of future instrumental, more comprehensive research on the topic of prosodically determined segmental effects in language development.

We note, finally, that in spite of the inability to instrumentally verify the transcriptions in the E corpus, the units relevant to this study (consonant major places of articulation, coronal versus labial renditions of approximants) are all phonetically salient, especially for experienced phonologists such as the ones who collected the data. In light of all of these observations, we argue that the data from the E corpus, despite providing a partial picture of a potentially larger set of facts, are appropriate for all intents and purposes of the current study.

3. E'S PVF PATTERN. Between the ages of 1;00.27 and 2;02.28, E systematically produced target velars as coronals in the onsets of syllables bearing either primary or secondary stress, as well as word-initially even in unstressed syllables, that is, in the phonetically MOST salient consonantal positions of the word. By contrast, in prosodically weak positions—syllable codas and the onsets of medial unstressed syllables—velar fronting (VF) did not occur, and the velar-coronal contrast was maintained.

During this crucial fourteen-month time span, the corpus contains 738 words with velar targets. In 357 of these words, the relevant velar (/k/ or /g/) was in metrically strong position; VF applied in 296 cases, for an overall rate of 82.9%. Examples of VF in prosodically strong position are given in 1.

(1) VF in onsets of prosodically strong positions (% velar targets produced as coronal)

a. Word-initial primary-stressed syllable onset (253/299 = 85%)

[**tʰ**ʌp]	'cup'	1;09.23
[**d**oː]	'go'	1;10.01
[ˈ**t**uwɔ]	'cool'	1;11.02

b. Word-medial primary-stressed syllable onset (24/25 = 96%)

[əˈ**d**ɪn]	'again'	1;10.25
[dʊˈ**d**ʊ]	'Gügü' (proper name)	1;11.21
[taˈ**d**ɛɾə]	'together'	2;01.21

c. Word-medial secondary-stressed syllable onset (17/28 = 61%)[4]

[ˈhɛwˌ**t**ɔptɛɝ]	'helicopter'	2;00.19
[ˈæwəˌ**d**ɛɾɚ]	'alligator'	2;01.18
[ˈhɛksəˌ**d**ɔn]	'hexagon'	2;02.22

d. Word-initial unstressed syllable onset (2/5 = 40%)[5]

[**d**ʊˈdʊ]	'Gügü' (proper name)	1;11.21
[**t**ʌnˈdʌktə]	'conductor'	2;01.21

In a small percentage of cases, E omitted the target velar entirely (e.g. *goose* /uʃ/, 1;5.4) or produced some other consonant in its place (e.g. *glasses* /bæːs/, 1;7.29). Table

[4] Because words of this prosodic type are not often reported in studies of consonant substitution in acquisition, we provide the full list here, in alphabetical order: *acorn*, *alligator*, *corkscrew*, *cupcakes*, *difficulty* (2x), *haircut*, *helicopter* (3x), *hexagon* (2x), *octagon*, *open key*, *pancake(s)* (5x), *pantograph*, *peacock*, *pine-cone*, *playground* (2x), *pussycat*, *raincoat* (2x), *suitcase*. *Open key* was judged to be a single word at the time, a command to open the door with the key.

[5] None of the three other cases—all instances of *caboose*, uttered on the same day at age 1;8.1—show target-like production of the target velar. Consonant deletion is found instead ([ʌbuəʂ], [buəʂ], [byʂ]), further demonstrating that velars in strong position are problematic for E at this stage.

1 shows that these two strategies ('omission' and 'other', respectively) occurred twenty-three times; their combined rate is 6%.

	TOTAL	VF	VELAR PRODUCED	OMISSION	OTHER
Word-initial onset, stressed	299	253 (84.6%)	31 (10.4%)	10	5
Word-initial onset, unstressed	5	2 (40%)	0	3	0
Word-medial onset, primary stressed	25	24 (96%)	0	0	1
Word-medial onset, secondary stressed	28	17 (60.7%)	7 (25%)	0	4
ALL	357	296 (82.9%)	38 (10.6%)	13 (3.6%)	10 (2.8%)
VF VS. VELAR PRODUCTION ONLY		89.0%	11.0%		

TABLE 1. Productions of target velars in strong positions.

When, as shown in the bottom line of Table 1, productions in which velars are fronted ('VF') are compared only to those in which velars are produced accurately, the VF pattern emerges even more strongly: it occurs in 296 of 334 cases, for a rate of 89%. This is a highly robust pattern, especially if one considers that child language typically displays important amounts of variation, even within individuals (e.g. Berg 1995).

The extent of VF in prosodically strong positions is also highlighted by the virtual absence of VF in any of the prosodically weak contexts in which velar obstruents occur in English, namely onsets of noninitial unstressed syllables (2a), word-medial codas (2b), and word-final position (2c). During the VF time span, E produced 381 words with a target velar in weak position.

(2) Velar productions outside of prosodically strong onsets (% velar targets produced as velar)

a. Onsets of unstressed syllables (92/96 = 95.8%)

[ˈmɑŋ**k**i]	'monkey'	1;08.10
[ˈbej**g**u]	'bagel'	1;09.23
[dɑ**g**l̩ɣz̥]	'goggles'	2;0.24
[ˈbʌ**k**ɨt]	'bucket'	2;01.11

b. Word-medial codas (24/29 = 82.8%)

[ˈæ**k**t͡ʃwi]	'actually'	1;11.22
[ˈɑ**k**təpʊs]	'octopus'	2;01.05
[ˈɑ**k**təgɑn]	'octagon'	2;01.05

c. Word-final consonants (235/256 = 91.8%)

[bɪ**g**]	'big'	1;00.13
[bʊ**kʰ**]	'book'	1;07.22
[ˈpædjɔ**k**]	'padlock'	2;04.09

In 351 (92.1%) of the 381 instances of prosodically weak velars overall, the velar (/k/ or /g/) was produced accurately. As with the prosodically strong velars, there was a very low rate (3.1%) of consonant omission; in 2.6% of cases, E employed 'other' strategies (i.e. neither VF nor accurate velar production nor omission). At least two of the eight examples identified in Table 2 as instances of VF in weak prosodic position could also arguably be classified as cases of 'other', that is, the kind of consonant harmony or metathesis that did occur sporadically in E's productions over this time span: in both *duck/quack* (?) [dæt] (1;5.13) and *doggies* [dadis] (1;9.24) there is another coronal in the word.[6]

[6] The other six instances in which a prosodically weak velar was realized as coronal were *peacock* [tipɑt] (1;11.28) and five similar productions of the word *thanks*, for example, [hæts] (1;6.13).

	TOTAL	VF	VELAR PRODUCED	OMISSION	OTHER
Word-medial onset, untressed	96	1 (1%)	92 (95.8%)	0	3
Word-medial coda	29	0	24 (82.8%)	4	1
Word-final coda	256	7 (2.7%)	235 (91.8%)	8	6
ALL	381	8 (2.1%)	351 (92.1%)	12 (3.1%)	10 (2.6%)

TABLE 2. Productions of velars in weak positions.

Given that E did sporadically exhibit apparent consonant harmony, as in *doggies* [dadis], it is important to affirm that E's clear pattern of VF to coronal in metrically strong position is not an artifact of assimilation (cf. child Robin in Levelt 1994:93ff., who displays VF as the result of consonant-vowel interactions; child Trevor in Pater 1997:n. 30 displays a similar behavior). As shown in 3 below, VF is dependent neither on the presence of a coronal consonant nor on the presence of a front vowel elsewhere in the word.

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

[ˈ**tʰ**ʊ**k**]	'cook'	1;09.29
[ˈ**t**ɑfiˌmej**k**ɘ]	'coffee maker'	1;10.14
[**t**ʌmɪn]	'coming'	1;10.23
[**d**ɑbəs]	'garbage'	1;11.02
[**t**ʌp]	'cup'	1;11.16
[ˈ**t**o**k**oˌnʌt]	'coconut'	2;00.19
[**d**ɑ**g**l̩ˠz̥]	'goggles'	2;00.24
[**tʰ**ʌvɚ]	'cover'	2;02.22

While certain individual words in E's corpus may be consistent with an interpretation of consonant harmony, vowel-to-consonant effects, or even dissimilation, the only generalization that holds over the corpus as a whole is PVF.

4. E'S PLG PATTERN. During a thirteen-month period beginning at 1;8.21, eight months after the onset of PVF, E displayed a pattern of lateral realization that is strikingly parallel in its conditioning to his PVF pattern. Target /l/ in prosodically weak position was realized as [w], homophonous with target /w/, while target /l/ in strong position was realized systematically as [j], homophonous with target /j/. We term this pattern POSITIONAL LATERAL GLIDING (PLG). Evidence for the lexically neutralizing character of the pattern is presented in §8.2.

In the span between 1;8.21 and 2;9.9, the E corpus contains 302 words with target singleton laterals. (E also produced a number of words with consonant clusters containing laterals, which are discussed separately below.) In 136 of these cases, the target lateral was in prosodically strong position. E produced 108 of these prosodically strong laterals as the palatal glide [j], for an overall rate of 79.4%. The /l/ → [j] pattern is illustrated by the examples in 4, sorted by prosodic position.

(4) /l/ → [j] in onsets of prosodically strong positions[7]

a. Word-initial primary-stressed syllable onset (75/94 = 79.8%)

[**j**æmp]	'lamp'	1;10.0
[ˈ**j**ɪdiə]	'Lydia'	2;1.8
[**j**ʊks **j**ɑjk ʌ **j**ɪŋkən **j**ɑg]	'Looks like a Lincoln log!'	2;9.9

[7] Stress and aspiration are transcribed only intermittently in the E corpus; some forms have it marked, while others do not. The principal transcriber attributes this variability in transcription practice to E's consistent accuracy in these areas, which permitted its omission in transcriptions.

b. Word-initial unstressed syllable onset (1/1 = 100%)
‘[**j**]ivan’ ‘Livan’ (adult [li'van]) 2;8.19

c. Word-medial primary-stressed syllable onset (11/17 = 64.7%)

[ha**j**ow]	‘hello’	1;10.0
[vajə'**j**ɪn]	‘violin’	2;5.29
[ˌstɛwə'**j**uʷnə]	‘Stellaluna’	2;7.10

d. Word-medial secondary-stressed syllable onset (21/24 = 87.5%)[8]

['mædəˌ**j**ɑjn]	‘Madeline’	2;4.2
[gɔwdi**j**ɔks]	‘Goldilocks’	2;4.2
[pæd**j**ɔk]	‘padlock’	2;4.9

E’s realization of target /l/ was more variable than his realization of velar obstruents; this is not too surprising, given the greater phonetic variability of the realization of /l/ in adult English (see §7.3). As seen in Table 3, E occasionally realized prosodically strong /l/ as [l] (9/136 = 6.6%) or as a (labio)velar sonorant, symbolized for convenience as [w] (also 6.6%). Even more sporadically, strong target /l/ was realized as some other consonant altogether, for example, in *leaves* [hip] (1;9.21); such productions, categorized in Table 3 as ‘other’, occurred in 5.1% of the cases. In just three cases (2.2%), strong target /l/ was omitted entirely, as in *like* [ɑjk] (2;1.12).

	TOTAL	[l]	[j]	[w/lˠ/l̩/u]	OMISSION	OTHER
Word-initial onset, stressed	94	8 (8.5%)	75 (79.8%)	3	1	7
Word-initial onset, unstressed	1	0	1 (100%)	0	0	0
Word-medial onset, primary stress	17	0	11 (64.7%)	4	2	0
Word-medial onset, secondary stress	24	1 (4.2%)	21 (87.5%)	2	0	0
TOTAL	136	9 (6.6%)	108 (79.4%)	9 (6.6%)	3 (2.2%)	7 (5.1%)

TABLE 3. Realization of target /l/ in prosodically strong positions.

The strong overall tendency (79.4%) to realize prosodically strong /l/ as the palatal glide [j] contrasts with the pattern for prosodically weak /l/, which was overwhelmingly produced as (labio)velarized, both in onset and coda position. In 161 attempts at prosodically weak singleton /l/, E produced 123 instances of a (labio)velarized segment, for an overall rate of 76.4%; in onsets this segment was always [w], while in coda position, either [w], [u], or (acoustically very similar) heavily velarized, often syllabic, [lˠ]. Examples of (labio)velar realizations of prosodically weak target /l/ are given in 5.

(5) /l/ → [w] in prosodically weak positions

a. Intervocalic unstressed syllable onset (36/53 = 67.9%)

[hæ**w**ətʰʌəkɚ]	‘helicopter’	1;11.10
[æ**w**ədɛɾɚ]	‘alligator’	2;1.18
[ˌstɛ**w**ə'juʷnə]	‘Stellaluna’	2;7.10
[nɛk**w**əs]	‘necklace’	1;11.22

b. Word-medial coda: realized as [w] or a back, round vowel (7/13 = 53.8%)

[hʌ**o**p hʌ**o**p]	‘help help!’	1;8.27
[ho**w** mi]	‘hold me’	1;10.25
[hɨ**w**də]	‘Hilda’	1;11.10

[8] Because words of this prosodic type are not often reported in acquisition studies of consonant substitution, we provide the complete list here, in alphabetical order: *calculator*, *Caroline*, *Eli* (7x), *Emmeline*, *flashlight*, *Goldilocks*, *hola* (Spanish ['ola]), *hopalong*, *Madeline* (5x), *Mona Lulu*, *padlock* (2x), *singalong*, *totlot*, *waterlily*. (A note on *hola*: although its second syllable does not have secondary stress in Spanish, we speculate that E interpreted the unreduced [a] vowel as evidence of stress, as it would be in English.)

c. Word-final: realized as [w], [u], or [lˠ] (80/95 = 84.2%)

[bejg**u**]	'bagel'	1;9.24
[sɤkklˠ]	'circle'	1;11.05
[fɛ**w**]	'fell'	2;0.19

A summary of the realizations of target /l/ in prosodically weak position is presented in Table 4.

	TOTAL	[l]	[j]	[w/lˠ/l̩]	OMISSION	OTHER
Word-medial onset, unstressed	53	0	8 (15.1%)	36 (67.9%)	0	9
Word-medial coda	13	1 (7.7%)	0	7 (53.8%)	5	0
Word-final coda	95	9 (9.5%)	0	80 (84.2%)	3	3
TOTAL	161	10 (6.2%)	8 (5%)	123 (76.4%)	8 (5%)	12 (7.5%)

TABLE 4. Realization of target /l/ in prosodically weak positions.

In contrast to prosodically strong positions, where [j] was the normal realization for target /l/, E produced only eight instances of [j] for target /l/ in prosodically weak position, for a negligible rate of 5%. Interestingly, six of these eight forms were instances of the word *yellow*, produced variously as [jɛjow] (four times) and [dʲɛjow] (twice); the other two were *tulip* [tujip] and *Lulu* [juju], for both of which the possibility of secondary stress on the second syllable could account for the /l/ → [j] production.[9]

4.1. ONSET CLUSTERS. During the PLG period, E produced eighty-seven words with target onset clusters whose second consonant was /l/. All such clusters were in prosodically strong position. Thirty-five clusters involved a velar (/kl/, /gl/); forty-seven involved a labial (/pl/, /bl/, /fl/). The remaining five were all instances of /sl/. Following target velars and labials, target /l/ was omitted in twenty-three cases (28%), most occurring prior to 2;0, that is, in the first four months of the PLG period. When target /l/ was overtly realized, its form depended on the place of articulation of the preceding onset consonant. In target velar-initial clusters, the effects of PVF and PLG operated in tandem: target /kl/ and /gl/ were produced as alveopalatal affricates ([t͡ʃ] and [d͡ʒ]), the result of simultaneous coronalization of the velar and palatalization of the lateral. In labial-initial clusters, target /l/ assimilated in place to the preceding consonant and was produced as a labial vocoid for which we use [w] as the cover symbol, noting that it was variously transcribed as [w] or [u] (as seen, for instance, in the data in 6b,c). Thus, affricates aside, the only complex onsets that E produced during the PLG period were those whose second component was [w]: [dw], [pw], [fw].[10]

(6) Realization of lateral-final onset clusters

a. Velar-initial clusters: /Cl/ realized as affricate (21/35 = 60%) or /l/ omitted (11/35 = 31.4%)

[**t͡ʃ**iːn]	'clean'	1;11.0
[ˈ**d͡ʒ**æsəs]	'glasses'	2;2.1
[**t**owzɨt]	'close it'	1;10.25
[**d**æsəs]	'glasses'	1;9.11

[9] E's older sibling pronounced *yellow* as [lɛlow] during this time, which could have contributed to the consonant harmony in E's own [jɛjow] productions. This word aside, no velar fronting or lateral gliding was attested in the sibling's speech, which was phonologically adult-like during the span of this study except for the production of target /θ/ as [f] and target /ð/ as [d] or [v], a pattern shared by E (and many other children of similar ages).

[10] E also produced one instance of [sj], *slide* [sjajd], at 1;8.29, during the PLG period, and one instance of [gw], in *glasses* [gwæsəz], at 2;3.5, while PLG was still in effect but PVF had ended.

b. Labial-initial clusters: /l/ realized as [w] (33/47 = 70.2%) or omitted (12/47 = 25.5%)

[p**u**ænɨts]	'planets'	1;10.18
[b**w**æ̃kət]	'blanket'	1;10.2
[f**w**ejks]	'flakes'	1;11.26
[piːz]	'please'	1;10.28
[bu]	'blue'	2;1.11
[fɑj]	'fly'	1;9.26

c. /s/-initial clusters: /l/ omitted (3/5 = 60.0%) or realized as [w] or [j]

[s**j**ajd]	'slide'	1;8.29
[ʂɪp]	'sleep'	1;10.2
[s**u**ɪpɨzəz]	'slippers-s'	1;10.28
[siːp]	'sleep'	2;0.19
[sɪp]	'slip'	2;11.12

Of the thirty-five /kl/ and /gl/ clusters produced during this period, only two, both instances of *glasses*, resisted PVF; target /l/ was omitted in one case ([gæsəs]; 1;11.22) and realized as [w] in the other ([gwæsəz]; 2;3.5). A summary of the realization of /l/ in onset clusters is provided in Table 5.

	TOTAL	OMISSION	AFFRICATION	[w]	[j]
Velars (/kl/, /gl/)	35	11 (31.4%)	21 (60.0%)	3 (8.6%)	0
Labials (/pl/, /bl/, /fl/)	47	12 (25.5%)	2 (4.3%)	33 (70.2%)	0
/sl/	5	3 (60.0%)	0	1 (20.0%)	1 (20.0%)

TABLE 5. Realization of target /l/ in onset clusters.

In summary, although fewer in number than singleton /l/ onsets, onset clusters containing /l/ were produced in a manner consistent with the PLG pattern observed for singleton laterals; velar-lateral clusters also showed the effects of PVF.

Like the realization of singleton /l/ as [j] or [w], the realization of clusters consisting of a lingual (i.e. coronal or velar) consonant followed by /l/ as affricates was, impressionistically, neutralizing. During the PLG span, E correctly produced numerous target alveopalatal affricates, that is, /t͡ʃ/ and /d͡ʒ/ (7a), with which the realizations of target /kl/ and /gl/ were judged by the parent transcribers to acoustically merge, respectively. E also produced seemingly acoustically identical affricates for many rhotic-final target clusters whose first member was lingual, as shown in 7b.

(7) Other productions of alveopalatal affricates during the PLG span

a. Target affricates produced accurately

[**t͡ʃ**ijz̥]	'cheese'	1;10.02
[**d͡ʒ**ɛm]	'Jem'	1;10.02

b. Lingual-rhotic clusters produced as affricates

[**t͡ʃ**ɛjn]	'crane'	1;11.26
[**t͡ʃ**ejn]	'train'	1;11.26
[**d͡ʒ**iːn]	'green'	2;1.10
[**d͡ʒ**ɪŋk]	'drink'	2;1.5

While there is a degree of affrication on the plosives in stressed lingual-rhotic onset clusters in the adult spoken English to which E was exposed, his productions during the PLG period indicate that he nonetheless correctly analyzed C*r* clusters into a plosive followed by a rhotic. Table 6 shows that E varied seemingly freely between realizing a C*r* cluster as an affricate, on the one hand, and preserving the C and realizing the

/r/ as a labial vocoid, on the other. Alternations like [d͡ʒ] ~ [dw] for the onset of *dragon* (2;2–2;3) and [d͡ʒ] ~ [gw] ~ [g] for *grape* (1;9) show that E stored *dragon* and *grape* with /dr/ and /gr/ onsets, respectively. Similar evidence can be adduced for *train*, *truck*, *drink*, as seen in Table 6.

Table 6 also shows that affrication is subject to a gradient effect of voicing and vowel quality. Affrication is more likely with /tr/ and /kr/ (24/45 = 53%) than with /dr/ or /gr/ (17/44 = 39%), and before front vowels (33/64 = 52%) than before back vowels (8/25 = 32%). (Lest too much be read into these numbers, note that the sample of strong /gr/ onsets before back vowels consists only of five instances of *Gromit*, all minor variations on [wɑmɨt].)

	REALIZATION	BEFORE BACK VOWEL	BEFORE FRONT VOWEL	TOTAL	TARGET FORMS
/tr/		12	17	29	
	[t͡ʃ]	6 (50%)	10 (59%)	16	train, tree, trike, truck, trumpet
	[tw]	0	3 (18%)	3	treat, train
	[t]	3 (25%)	3 (18%)	6	treat, truck
	sibilant	3 (25%)	1 (9%)	4	train, truck
/dr/		4	13	17	
	[d͡ʒ, dz]	0	4 (29%)	4	dragon, drink
	[dw]	4 (100%)	6 (43%)	10	dragon, drink(ing), driv(ing), dry, dream(ed)
	[d]	0	1 (7%)	1	drinked
	other	0	2 (14%)	2	drowned, drink
/kr/		4	12	16	
	[t͡ʃ]	2 (50%)	6 (50%)	8	crane, crayon, cream, crickets, crossing, crumb
	[t]	1 (25%)	3 (25%)	4	cracker, cricket, cried
	[kw]	0	1 (8%)	1	crash
	other	1 (25%)	2 (17%)	3	scream(ed), corkscrew
/gr/		5	22	27	
	[d͡ʒ]	0	13 (59%)	13	grapes, green, grin, playground
	[gw]	0	6 (22%)	6	grape(s), grass, gray
	[g]	0	3 (11%)	3	grape(s)
	[w]	5 (100%)	0	5	Gromit

TABLE 6. Outcomes of target C*r* clusters.

5. PLG AND PVF IN OTHER CHILDREN. While there is, to our knowledge, no exact precedent for the contextual conditioning of E's PLG pattern documented in the literature, its individual subcomponents connect with commonly observed patterns. Lateral gliding is a frequently attested consonant substitution among children, and children's lateral substitutions in general are known to be subject to prosodic conditioning. For example, Bernhardt and Stemberger (1998:305–6, 331ff.), who survey a variety of different patterns for the acquisition of laterals, observe that it is common for /l/ to be realized as [j] in onset position but as [w] or a similar vowel in coda position. This is close to the description of E's pattern, with the important caveat that E substitutes [j] for strong but not weak onset /l/s. Without more detailed data on children exhibiting the substitution pattern that Bernhardt and Stemberger describe, it is difficult to know whether E's pattern is the same as, or different from, those PLG patterns that have previously been described.

E's PVF pattern is more clearly precedented in the context of child language. VF itself is a relatively common pattern in the literature on both normally developing and phonologically delayed children. A number of studies of VF cite positional effects on the pattern, all in the direction of what we have seen for E. We begin with the only other longitudinal corpus study of which we are aware in which PVF occurs, and then turn to a set of cross-sectional studies of the phenomenon.

5.1. PVF IN ANOTHER LONGITUDINAL CORPUS. In a longitudinal corpus study of PVF in another child, Bills and Golston (2002) describe a pattern that conforms in close detail to E's. For a period of nine months beginning at age 2;9, Sine, also a monolingual learner of American English, displayed PVF: her velars underwent neutralization to coronal word-initially and in onsets of primary- or secondary-stressed syllables only, but not in onsets of medial unstressed syllables, or in coda positions. Bills and Golston document the pattern through Sine's age 3;6. Representative examples are provided in 8.

(8) Sine's velar neutralization patterns (ages 2;9–3;6)

a. VF in primary-stressed word-initial syllables

[**t**ek]	'cake'
[ˈ**t**ʊkiz]	'cookies'
[ˈ**t**æmɰʌ]	'camera'

b. VF in primary-stressed word-medial syllables

[pəˈ**t**ʌz]	'because'
[ˌoˈ**t**e]	'OK'
[fɔˈ**d**ɑt]	'forgot'

c. VF in secondary-stressed word-medial syllables

[ˈpænˌ**t**ek]	'pancake'
[ˈbəbo ˌ**d**ʌm]	'bubble gum'

d. No VF in unstressed word-medial onsets

[ˈtʊ**k**iz]	'cookies'
[ˈtɑɪ**g**ʌ]	'tiger'
[ˈbɪ**g**ʌ]	'bigger'

e. No VF in coda position

[ˈɫu**k**]	'look'
[ˈdɔ**g**]	'dog'
[ˈpante**k**]	'pancake'

Bills and Golston analyze Sine's PVF in terms of the metrical foot: velars are licensed only when adjacent to a dorsal element in the same subconstituent of the foot, and when unlicensed must front to coronal. Bills and Golston subdivide the foot into two constituents: what we may call the foot-onset, which consists of the onset of the foot-initial syllable, and the foot-rhyme, which consists of everything after the foot-onset. Thus in a monosyllabic foot like *cake*, the foot-rhyme is coextensive with a syllable rhyme; however, for a trochaic foot like *cookie*, the foot-rhyme is coextensive with the rhyme of the first syllable plus the entire following syllable. On the assumption that all vowels are dorsal, Bills and Golston analyze Sine's PVF as follows: velars that share a foot subconstituent with a dorsal element are pronounced as velar, but otherwise they front to coronal. All codas and medial unstressed syllable onsets, which by the phonotactics of English share a foot-rhyme with a vowel, are thus fronting environments.

Bills and Golston's generalization about Sine is, thus far, essentially the same as our generalization about E. Our use of 'strong' position equates to Bills and Golston's foot-onset; our use of 'weak' equates to foot-rhyme. Where the accounts differ is in the details of their predictions about velars in branching syllable onsets, and here the data differ between E and Sine as well. Complex onsets appear in Sine's corpus at 3;2, midway through the VF period. Velars that are initial in complex onsets, that is, /gl/, /kl/, /gr/, /kr/, and /kw/, do not undergo VF, as shown in 9a. As shown in 9b, however, /k/ does front when final in an onset cluster, that is, when preceded by /s/ and followed by a vowel.

(9) Sine's velars in consonant clusters (ages 3;2–3;6)
  a. Velar-initial onset clusters: no fronting
    [ˈ**g**ɫæsɪz] 'glasses'
    [ˈ**k**ɰɻæk] 'quack'
    [ˈ**k**ɰɻɪs] 'Chris'
  b. Velar-final onset clusters: fronting
    [ˈs**t**ɪn] 'skin'
    [ˈs**t**up] 'scoop'

Bills and Golston's foot-based generalization accommodates these facts: for Sine, the realization of /l/, /r/, and /w/ following a velar in an onset cluster is dorsal, and thus licenses the preceding velar in the same foot-onset. In /sk/ onset clusters, by contrast, the velar is not licensed within the onset, and must front, as in *scoop* [ˈs**t**up] (9b). This pattern departs from that seen for E, who fronted strong velars regardless of whether they were simple onsets, followed by a liquid, or preceded by /s/.

It is not the minor differences between Sine and E that interest us here, however, so much as the striking parallels: complex onsets aside, for both children, velars front in prosodically strong (foot-initial or word-initial) positions and do not front in prosodically weak (foot-medial or foot-final) positions.

5.2. CROSS-SECTIONAL STUDIES OF PVF. Both Chiat (1983) and Stoel-Gammon (1996) have carried out cross-sectional studies that reveal, in basic outline, the same PVF pattern that E and Sine exhibit.

Chiat (1983) reports on two separate documentations, one month apart, of a five-year-old boy with a phonological delay. In both imitative and spontaneous speech, child Stephen, a learner of (British) English, fronted his velars to alveolars word-initially (10a) and in the onsets of word-medial stressed syllables (10b). He did not front velars in the onsets of word-medial unstressed syllables (10c) or in word-final position (10d).

(10) Data from Stephen, age 5;9 (Chiat 1983:289)
  a. [**d**əˈlɛk] 'collect'
    [ˈ**d**ɒldɪlɒks] 'Goldilocks'
  b. [bɪˈ**d**ɒz] 'because'
    [rɪˈ**d**ɔːd] 'recórd' (v.)
  c. [ˈrɛ**g**ɔːd] 'récord' (n.)
    [ˈbeɪ**g**ə] 'baker'
  d. [bæ**g**] 'back'
    [dəˈlɛ**k**] 'collect'

Stoel-Gammon (1996) reports, in a survey of cross-sectional data from sixty-seven normally developing children, a pattern in which velars are fronted word-initially but not word-finally (see also Stoel-Gammon & Dunn 1985 for description of another such case). Stoel-Gammon notes that word-medial onset velars are fronted only if the syllable is stressed. This pattern is illustrated in 11 with data from one subject.

(11) Data from subject ML, age 2;6 (Stoel-Gammon 1996:203–5)
a. VF in word-initial position
[**t**ʌp] 'cup'
[**t**ɪd] 'kid'
[**d**eɪm] 'game'
b. VF in stressed word-medial onsets
[bi**t**ʌz] 'because'
[o**tʰ**eɪ] 'OK'
[wə**t**un] 'raccoon'
c. No VF in unstressed word-medial onsets
[tɪ**k**o] 'tickle'
[twæ**k**ʊ] 'cracker'
[twa**k**ədaɪjo] 'crocodile'
d. No VF in coda position
[tʊ**k**] 'cook'
[tɪ**k**] 'kick'
[ja**k**] 'lock'

In fronting velars word-initially and in the onsets of word-medial primary-stressed syllables, but not word-finally or in the onsets of medial unstressed syllables, the children studied by Chiat (1983) and Stoel-Gammon (1996) manifest a pattern identical to E's and Sine's. However, it is not possible to know from their results whether, like E, their subjects would also front velars in the onsets of secondarily stressed medial syllables as well. Stoel-Gammon does not report on the production of such words, and it is possible that there were no such forms in the data she collected. In the data reported by Chiat for child Stephen, the only words that appear to have secondary stress are compounds, and in these words Stephen is not entirely consistent, fronting secondarily stressed velar onsets in *teacake*, *egg cup*, *teacup*, and *dressing gown* but not in *racing car* or *zoo-keeper*.[11] As Chiat notes (289), however, *racing car* contains *car*, one of three exceptional words in which Stephen systematically articulated the velars correctly instead of exhibiting VF. (The other two were *gun* and *camel*; Chiat 1983:288.)

Aside from peculiarities observed across children such as the ones noted above, it seems clear that PVF is relatively common among children. Stoel-Gammon (1996) has even suggested that PVF is universal. In her study of sixty-seven children, Stoel-Gammon documents three patterns of VF: fronting of velars in all positions, fronting of velars in no positions, and the PVF pattern we have discussed. Stoel-Gammon interprets these states as ordered stages in a universal path to the acquisition of velars, in which the first stage is to front all velars and the final stage is to front none of them. This proposed universal path is inferred from the cross-sectional survey; we are aware of no developmental analysis to support Stoel-Gammon's hypothesis, and E's own data are inconsistent with it. Early transcriptions of E's productions suggest that VF was not in force in late babbling (e.g. [gæ], [gægæ], [ægægæ], [ki], [dædæ], [tʰæ]; age 0;6), nor did it occur in E's very first words (the only relevant transcribed examples being [kæt˺], [kæʔ], [kæ] for *catch* (age 0;9) vs. [dæː] for *there!* (age 0;10)). Thus E started out in Stoel-Gammon's stage 3 (no VF) before exhibiting stage 2 (PVF), and never exhibited stage 1 at all.

[11] Chiat also observes that Stephen does not front the /k/ in *waistcoat*, but we do not know whether the target *coat* syllable was stressed or not.

6. Positional neutralization in child vs. adult language. PVF and PLG occur in prosodically strong position. For sake of discussion, we call this type of segmental neutralization strong merger. It is essentially unique to children.

6.1. Strong merger in child language. The best-documented instance of strong merger in acquisition is PVF itself, but other neutralizations also fall into this category. Marshall and Chiat (2003) mention two cases of strong merger in addition to that of E. One, originally discussed by Chiat (1989), is Stephen, who, at ages 4;7–4;10, realized fricatives (e.g. /s/) as stops (e.g. [t]) word-initially but not word-finally.[12] Stephen realized intervocalic fricatives correctly in the onset of unstressed syllables, for example, *person* [pɜːsən], but stopped them in the onset of stressed syllables, for example, *before* [bɪpɔː]. Primary and secondary stress pattern alike; word-medial secondary stress also induces fricative stopping, for example, *missile* (target [ˈmɪˌsaɪl]) (Marshall & Chiat 2003:651). Marshall and Chiat (2003:655) also point to Allison, discussed by Rvachew and Andrews (2002), who stops fricatives word-initially and in word-medial strong syllable onsets but realizes them correctly word-finally and in word-medial weak syllable onsets. The data in 12 are taken from Rvachew & Andrews 2002:193.

(12)	Word-initial (stressed):	*sadly* [dɑdi], *fish* [pɪs]
	Word-medial onset (stressed):	*casino* [kətino], *uniform* [jubo]
	Word-medial onset (unstressed):	*glasses* [wæsəs], *muffin* [mʌfɪn]
	Word-final position:	*yes* [jɛs], *giraffe* [dəwæf]

6.2. Weak merger and strong enhancement in adult language. PVF in particular, and for that matter strong merger in general, are virtually unknown in adult language, whether as a synchronic alternation or as a sound change (see in this context our discussion of augmentation patterns below). While velar and coronal plosives commonly merge, typically to a fricative or affricate, in palatalization environments (such as preceding a high front vocoid) or jointly debuccalize to glottal stop in coda or word-final position, it is rare to find either *k*, *t* → *t* or *k*, *t* → *k* in a particular prosodic position. In fact, it is not all that common to find *k*, *t* merging to either *t* or *k* at all.

There are some examples of the latter; for instance, Proto-Athapaskan *k and *t merged to *k* in some daughter languages, including the Apachean languages Jicarilla, Lipan, and Kiowa-Apache (Hoijer 1942:218), Yellowknife Chipewyan (Haas 1968: 166), and Fort Resolution Chipewyan (Rice 1978). This change was, however, apparently prosodically unconditioned, arising from heavy aspiration; Hoijer and Haas both lay out a path in which original [t^h], [k^h] turned into [t^x], [k^x] and eventually merged to [k^x] or [k^h].[13] The closest examples we can cite of prosodically conditioned merger in the area of sound change are quite different from PVF. In Atayal, *k* (from *p) is beginning to shift to *t* in word-final position (Rau 2000), but only in some words. The High German Consonant Shift, which affricated the voiceless plosives *t*, *p*, *k*, was prosodically conditioned, starting following short vowels (and later extended to more prosodic environments) (see e.g. Iverson & Salmons 2003). However, it did not collapse *t* and *k*; instead, it affricated both while preserving the place contrast. The closest parallel of which we are aware in synchronic alternations comes from a Taiwanese

[12] The Stephens of Chiat 1983 and Chiat 1989 are different children.

[13] In a number of Austronesian languages, proto *t became *k*, a change that started in word-final position; however, as argued by Blust (2004), it was contingent on the prior loss of *k and thus does not represent a prosodically conditioned merger of *t* and *k* per se.

secret language that collapses /k/ and /t/ to /t/ reduplicant-finally (DeLacy 2002:277, based on descriptions in Li 1985 and Trigo 1988).

In sum, strong merger of major place of articulation is rare if not nonexistent in adult language. There is, of course, massive positional neutralization in adult language—but it takes different forms: on the one hand, what we may call WEAK MERGER, that is, the loss of contrast in weak position, and on the other hand STRONG ENHANCEMENT, that is, the fortition of segments in prosodically strong position. Weak merger is exemplified by phenomena such as coda devoicing or unstressed vowel reduction; strong enhancement is exemplified by processes like stressed onset aspiration or stressed vowel lengthening.

Weak merger 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, thus protecting strong positions from undergoing neutralizations that weak positions undergo. Strong enhancement or augmentation effects are captured in optimality theory by theories of positional markedness (e.g. Itô et al. 1995, Smith 2002, Zoll 2003), in which certain marked features or structures are required to appear in prominent positions. According to Smith (2002), the only consonant augmentation expected in word-initial position is reduction in sonority; PVF is not a case of this. The extensive survey of consonantal-place markedness in DeLacy 2002 upholds the generalization that weak merger is frequent while strong merger is infrequent or unattested.

In sum, neither positional faithfulness nor positional markedness can describe strong mergers like PVF, in which a segmental contrast is lost in a position of unambiguous strength. This is a virtue insofar as PVF is unattested in adult language, but a liability when it comes to describing what occurs in child language.

Existing optimality theory approaches to PVF and other child-specific phonological phenomena have offered constraint rankings that are capable of describing the phenomenon. For example, Dinnsen (2002) proposes a constraint banning velars from occurring word-initially; when high-ranked, this constraint prevents the faithful realization of velars in word-initial position, deriving (part of the) PVF effect. Bills and Golston (2002) and Marshall and Chiat (2003) propose foot-licensing accounts in which velars are permitted only in certain positions within the foot. The problem with analyses of this type is that they do not explain why children have these grammars and adults do not, a question raised by Marshall and Chiat as well. What makes the grammars of children unique, and must the continuity hypothesis be abandoned?

7. A PROPOSED SOLUTION. To solve the strong-merger puzzle, we must look more deeply than at the level of phonological constraints for an explanation of the apparent difference between child and adult language. It is widely accepted (see e.g. Hyman 1976, Ohala 1981, 1983, Blevins & Garrett 1998, Steriade 2001, Barnes 2002, Blevins 2004) that the explanation for many phonological universals, or near-universals, in adult language lies with universal phonetic tendencies that are phonologized. It is thus plausible to turn to phonetics for insight into child language as well. Others have used this approach effectively for child-specific phonological phenomena, including consonant harmony (see e.g. Fey & Gandour 1982, Pater 1997, among others, and Buckley 2003 for a recent overview), but it has not yet been investigated for PVF, PLG, or the puzzling phenomenon of strong merger in general.

7.1 PHONETIC MOTIVATION FOR ADULT POSITIONAL NEUTRALIZATION. A great deal is known about the phonetic underpinnings of positional neutralization in adult language; the topic has recently been surveyed, for example, by Steriade (1997, 2001) and Barnes

(2002). Barnes finds that phonetic duration is the primary cause of positional asymmetries in vowel neutralization. Word positions with greater phonetic duration—initial, final, and (in many languages) stressed syllables—are positions where segmental contrasts are easiest to perceive and are, therefore, most immune to reduction effects. Similarly, increased phonetic duration can give rise to the kinds of augmentation effects that are most common in strong positions, for example, vowel lengthening, diphthongization, palatalization, aspiration, and gemination. Both Barnes and Steriade make the additional argument that phonetics is ultimately responsible for positional asymmetries by showing that the very same prosodic position may count as 'strong' relative to some phenomena and 'weak' with respect to others. For example, word-initial consonants are often subject to fortition. In English, voiceless plosives aspirate in prosodically strong positions, including word-initially; in other languages, a larger inventory of consonants is permitted word-initially than elsewhere. But in at least one case, discussed by Steriade (2001), word-initial position counts as weak. In a number of languages maintaining a contrast between apical-alveolar and retroflex places of articulation, the distinction is collapsed word-initially. The reason offered by Steriade is the low phonetic perceptibility of the retroflex-nonretroflex contrast when no vowel precedes.

In summary, then, adult phonology exhibits both potentially neutralizing weakenings, for example, consonant spirantization or vowel reduction, in weak positions, and potentially neutralizing augmentations, for example, vowel lengthening or consonant gemination, in strong positions. What counts as weak and strong depends on the phonetics and phonology of the dimension under focus. Given a particular dimension, however, adult languages generally behave similarly. To the extent that vowel inventories differ in stressed versus unstressed position, stressed positions maintain more quality contrasts. Insofar as consonants display more laryngeal contrasts in one type of position than another, onsets license a greater number of contrasts than codas. For any given neutralization, the weak/strong division falls in more or less the same way in all languages.

7.2. Phonetic motivation for pvf in child language. Given tendencies such as the ones observed above for adult phonological systems, what phonetic fact, if any, could underlie strong merger of velars and coronals in child language? We do not have the answer for every case that has been documented, but the wealth of data on E makes it possible to tender a hypothesis at least for PVF effects in children acquiring English.[14]

Our proposal is that PVF is a phonologized, grammatical artifact of the physiological and related motor difficulties inherent to the articulation of velar consonants in prosodically strong positions during early stages of children's language development. The normal phonetic strengthening of velars in strong position in adult English conspires with the differently proportioned vocal tract of young children to make possible precisely the PVF pattern exhibited by E, Sine, and others.[15]

[14] As already noted, E was exposed to some spoken Turkish and to his father's slight Turkish accent while speaking English; however, nothing specific to the phonetics or phonology of Turkish seems relevant to the PVF pattern. Voiceless plosives in Turkish are aspirated unless followed by a homorganic consonant; aspiration has not been observed to vary noticeably with stress or syllable position.

[15] Blevins (2004:123–25) speculates that with their relatively higher VOT and higher amplitude bursts, /k/ and /t/ are the most mutually confusable plosives. While this potential for acoustic confusion seems not to have led to any onset mergers unconditioned by vowel quality in sound change proper, it resonates with the articulatory-acoustic explanation we are providing here for acquisition, in which the (temporary) merger is common.

This phonetically motivated phonologization account is able to explain (a) why the outcome of neutralization is coronal, rather than velar; (b) why VF occurs only in strong, rather than weak, prosodic positions; and (c) why prosodically conditioned VF is unique to children. Treating PVF as the phonologization of a phonetically motivated effect also sheds light on the congruent pattern of PLG, as we explain below; PLG can be seen as an extension of the conditioning environment of PVF to a new phonological mapping.

The first factor that contributes to (P)VF in children's productions concerns physiological characteristics of the vocal tract at early ages. Studies by Fletcher (1973), Kent (1976, 1981, 1992), Crelin (1987), and Kent and Miolo (1995) converge in describing young children's vocal tracts as significantly different from those of adults in terms of sizes, proportions, overall configuration, and motor abilities.

Concerning the shape of the vocal tract, 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. Kent (1992:69) notes that children have a 'relatively anterior tongue mass, a closely approximating velum and epiglottis, and a relatively high larynx'. At around age two, the vocal tract begins its progressive evolution toward its adult shape, which is generally not attained before age six. Vocal tract developments involve, among other details, tongue retraction into the pharyngeal area, a widening of the palatal/alveolar region of the vocal tract, and an increase in the height of the palatal vault, which yields an expansion of the space within which the tongue can move (Bosma 1975), thereby enabling easier production of lingual contrasts than what is possible at young ages (see Fitch & Giedd 1999, Vorperian et al. 2005 for supporting studies using magnetic resonance imaging). These facts generally imply that velar consonants should be articulated closer to the front area of the palate across young children, even those not exhibiting (P)VF. This implication is supported by Fletcher's (1989) electropalatographic (EPG) measurements of linguo-palatal contacts in the production of lingual consonants by typically developing children across various age groups. As Fletcher demonstrates, linguo-palatal contacts involved in the production of velar consonants are more forward in younger children than in older ones.

Turning next to articulatory considerations, Kent (1992:70ff.) reports that the inherent peculiarity of the tongue (a muscular hydrostat, the only muscular system of this kind in the human body) affects the production of lingual consonants in two ways. First, when producing stop coronals and velars, young children initially use ballistic tongue movements whose relative force lacks the refined control typically seen in older speakers. Second, as evidenced by the relatively late development of liquid contrasts in English (e.g. Dinnsen 1992, Bernhardt & Stemberger 1998), it is only at relatively late stages that children attain the 'motoric developments [that] pertain primarily to tongue shaping and fine force control' (Kent 1992:75–76).

We argue that all of the physiological and articulatory issues listed above can potentially contribute to the emergence of PVF and PLG. However, while Gibbon and colleagues attribute patterns of lingual contrast neutralization largely to poor motor control (see Gibbon 1999 for a summary of the findings based on EPG measurements), we stress here the phonological conditioning that can be associated with variable productions of both target velars and, later in development, target laterals.

The explanation for the positional aspect of PVF comes from articulatory-phonetic research on adults showing that consonants in prosodically strong positions, for example, stressed or word-initial onsets, show larger amplitude in their articulatory gestures than those in other positions, for example, codas or onsets of unstressed syllables. This difference in gesture magnitude appears to affect velars in particular, 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 are produced more faithfully than are other syllables in the word (e.g. Fikkert 1994, Pater 1997, Rose 2000; see Kehoe & Stoel-Gammon 1997 for a general review). In addition, the literature on speech perception and production demonstrates that children are highly sensitive to the phonotactics of their target languages (see Jusczyk 1997 for a survey). This observation is also supported in the literature on covert contrasts in acquisition (e.g. Macken & Barton 1979, Hewlett 1988, Gibbon & Scobbie 1997, Scobbie 1998, White 2001), which has documented cases in which listeners fail to detect a contrast between two segments that instrumental techniques can show are articulated differently but whose acoustic differences are nonetheless below the threshold of perceptibility.

We argue that faithfulness to English prosodic organization, especially in stressed syllables, is the second major factor underlying PVF. In the context of imperfect articulatory control, 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 that characterizes fronted velars.

This approach to PVF makes two important predictions. First, it correctly predicts the generalization for children, first noticed by Stoel-Gammon (1996), that VF in prosodically weak positions implies VF in strong positions but not vice versa. 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. The result is a slight phonetic difference that would most probably go unnoticed unless investigated through fine-grain acoustic analysis or visually diagnosed through electropalatography (e.g. Gibbon et al. 2001) or ultrasound scanning (e.g. Gick 2002). Children who, like E, display VF only in strong positions differ from the first group in the sense that they are capable of reproducing 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, that is, with an enhanced articulation, nothing can prevent this child from producing velars in weaker positions, as these require a lesser linguo-palatal contact.

The implicational prediction that weak merger implies strong merger can also be extended to other strong mergers in child language, for example, fricative stopping, reported by Dinnsen (1996), Edwards (1996), and Bernhardt and Stemberger (1998), whereby fricative consonants are neutralized to stops in prosodically strong positions (e.g. word-initial and stressed onsets), but accurately realized as fricatives in weak positions (e.g. word-medial, unstressed onsets, codas). Given that young children do not have a refined control of the force applied to their articulatory movements, the articulatory enhancement inherent to consonants in strong positions is enough to explain a pattern of stopping in this context. Note, however, that we do not make the prediction that a child fronting velars should also display stopping of fricatives, or vice versa. Even though we claim that the two phenomena can be related to common grammatical or articulatory sources, we do not argue for any implicational relationship between them, because of the different combinations of articulatory gestures required in the production of different consonants in different positions within the word. While a child may have an issue with one type of target consonants (e.g. strong velars), this does not imply similar issues with other types of consonants, unless, of course, the child has generalized production problems, something that could be suggestive of some kind of articulatory or speech disorder. This latter issue is, however, tangential to our study.

Second, our approach also readily explains why PVF is not attested in adult languages, as discussed in §6.2. PVF has its source in physiological limitations inherent to the child's vocal tract. 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. Note that the proposal that early productions are affected by child-specific grammatical constraints is not novel. For example, Pater (1997:247) proposes a phonetically motivated REPEAT constraint to explain consonant harmony, another emergent process in child language. This constraint refers to the preference for repeated articulatory gestures in child language (see also Pater 2002 and Hayes 2004:n. 2, as well as Blevins 2004 for additional discussions of child-specific constraints; cf. Hale & Reiss 1998).

7.3 EXTENSION TO LATERALS: PLG. While its origins are not identical to those of PVF, the PLG pattern exhibited by E is also illuminated, albeit not wholly explained, by phonetic factors, in this case related to the production of /l/. The phonetic variability of /l/ in adult English is well known. As discussed in an influential article by Sproat and Fujimura (1993), /l/ in American English is articulated with two gestures: apical extension on the one hand, and dorsal lowering and retraction on the other. Whether an /l/ is dark (velarized) or light depends on the phasing of these two gestures, which is in turn affected by the phonetic duration of the /l/ in question. For word-initial /l/, the apical gesture is phased earlier than the dorsal gesture, which is subject to undershoot, producing a clear-sounding /l/; for final /l/, the dorsal gesture occurs earlier and is more fully realized, producing a dark variant. For adults, Sproat and Fujimura argue, light and dark /l/ are not discrete allophones but overlapping regions of a phasing continuum. However, the kind of gradient phasing that adults have mastered for /l/ is not easy for children of E's age. As Goodell and Studdert-Kennedy (1993) observe, many differences between the speech of young children and adults 'seem largely to arise from the children's difficulties in timing both the precise duration of a gesture and its onset or offset with respect to other gestures' (724).

Some children short-circuit the phasing problems with /l/ by using a single phasing for all instances of /l/. Instead of choosing this strategy, E opted for two alternants: [j] (with one phasing) and [w] (with another). What is interesting is that his distribution of these two alternants does not necessarily correlate with the way in which adults realize /l/. Studies of the phonetic realization of intervocalic /l/, including Sproat &

Fujimura 1993 and Huffman 1997, show that intervocalic /l/ is realized somewhere in between the dark and light extremes that are found word-initially and word-finally. Huffman suggests that stress has an important effect, pointing to the difference between darker allophones of /l/ found in her study of words like *belief* compared to lighter allophones found by Sproat and Fujumura for words like *Beelik* (with initial stress). Huffman hypothesizes that in stressed syllables the gestures of onset consonant and vowel nucleus are more separated than they are in unstressed syllables, accounting for why the dorsal gesture of (phonetically darker) /l/ in *belief* occurs sooner, that is, is more distant from that of the following stressed vowel, than the dorsal gesture for (phonetically lighter) /l/ in a word like *Beelik*. Whatever the explanation, this limited amount of data suggests that E's pattern of realizing stressed intervocalic /l/ onsets as [j] and unstressed ones as [w] may not be based entirely on the adult phonetic pattern. The mismatch between E's pattern of target lateral production and the continuum that phonetic studies have reported for the realization of laterals in English is expressed in 13.

(13) Adult allophones of /l/ versus E's substitution patterns

	WORD-INITIAL	UNSTRESSED MEDIAL ONSET	STRESSED MEDIAL ONSET	CODA/WORD-FINAL
Adult	lightest ⟷			darkest
E	[j]	[w]	[j]	[w]

The Huffman, Sproat, and Fujimura studies are, of course, not based on the individual speakers with whom E interacted; as a referee observes, further variation in the realization of /l/ is possible, even likely.[16]

What we do know, however, is that there is an independent and sufficient explanation for E's allocation of the [j] and [w] alternants of word-medial /l/ onsets, namely the existing PVF pattern in E's grammar. We postulate that E appealed to the PVF pattern in allocating his two realizations for target /l/. Faced with a continuum of acoustic allophones of target /l/, coupled with the motoric difficulty of producing laterals in general, we speculate that E assigned the clearest allophone (which occurs in word-initial position) to [j] and the darkest (coda position) to [w], based on phonetic similarity. As for the more intermediate allophones in the continuum, that is, onsets in word-medial position, which may have been fairly variable in the input E was exposed to, we can imagine a number of potential outcomes; he could have appealed to vowel quality, or realized all medial onset /l/s as [w], or all as [j], or he could have varied freely. Instead he followed a pattern congruent with PVF: all strong onsets patterned together (as [j]), and all weak positions (weak onsets and all codas) patterned together (as [w]). The upshot is that while the treatment of the most extreme allophones of /l/ was driven phonetically, the treatment of the more intermediate allophones was influenced by the existence of the PVF mapping, which had already primed E to be sensitive to strong versus weak positions.

Note that we are not claiming that the PVF-influenced distribution of /l/ realizations was better, that is, more optimal, than one of the alternative distributions we can imagine; we are simply suggesting that it was available because of its independent existence in the grammar. In this respect E's extension of the PVF pattern to a new phonological

[16] In Turkish, the contrast between palatal ([l^j]) and plain ([l]) laterals is phonemic, though it merges (to palatal) in the environment of front vowels (see e.g. Zimmer & Orgun 1992). We are aware of nothing specific to Turkish, to which E was indirectly exposed via his father's slight Turkish accent in speaking English, that could explain E's PLG pattern, which is insensitive to vowel quality.

domain can be seen as phonological analogy, where a salient phonological alternation or distribution is extended to new cases (see e.g. Vennemann 1972, Kiparsky 1988, 1995; on the huge topic of linguistic analogy more generally, see e.g. Anttila 1977, Anttila & Brewer 1977, Hock 1991, Lahiri 2003, among many others). The analogical overextension of phonological patterns in child language acquisition is well documented (e.g. Priestly 1977, Macken 1979, Rescorla 1980, Johnson 1995, among many others). Phonological priming in acquisition is discussed by, among others, Kiparsky (1995: 656), Wedel (2004), and Blevins (2004), who refers to it as 'Structural Analogy' (154), the phenomenon whereby the existence of a contrast in a language catalyzes the acquisition of another similar contrast. While Blevins, Kiparsky, and Wedel focus on the acquisition of segmental contrasts (qualitative and quantitative), the general priming effect should be equally expected in segment-to-position mappings of the sort considered here; the salience in early acquisition of prosodic units like syllable onset, stressed syllable, and foot is well documented (see e.g. Echols & Newport 1992, Gerken 1996, Fikkert 1998, Rose 2000, among many others).

When phonological analogy occurs, and if so in what direction, is difficult to predict, and we explicitly distance ourselves here from any general claims that analogy is optimizing, or otherwise deterministic.[17] Sometimes all that can be said in any given case is that analogy did take place, and that is what we say here. In E's case the basis of analogy is not an existing word, or paradigm, but a phonological mapping, a logical possibility referred to by McCarthy (2005) (harking back to Zwicky 1970) as 'taking a free ride' on an existing unfaithful phonological mapping in the grammar.

Attributing E's PLG pattern not only to phonetics but also to analogy offers an explanation for its apparent rarity, as it is the result of a conspiracy of several variables. If it had a direct, uncomplicated phonetic explanation we would expect it to be more frequent, as in fact PVF is.

8. Grammaticality of pvf and plg. Both the PVF and PLG patterns exhibited by E have clear phonetic motivation. However, as seen already with PLG, phonetics is not the whole story. In this section we introduce evidence that both PVF and PLG patterns were phonologized as a stable component of E's grammar, rather than constituting mere performance effects caused by immature motor control or anatomy.

8.1. Competence versus performance. The fact that most English-learning children do not display (P)VF but, rather, faithfully produce target velars in early productions (e.g. Smit 1993) argues against an approach to (P)VF that is exclusively phonetically determined (i.e. extragrammatical). Rather, the variation between fronting and nonfronting 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 PVF phenomenon should not distract us from the crucial observation that, in children like E who do manifest full-blown PVF, this process 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 were phonetically coronal. We propose that this phonetic implementation (articulatory planning) of onset strengthening in prosodically

[17] We are also studiedly neutral with respect to the question of whether, as some scholars have argued, imperfect acquisition is the source, or a source, of diachronic change (see e.g. Lightfoot 1999, Blevins 2004, Albright 2005; cf. Honeybone 2005 for an opposing view); we do, however, strongly agree that some of the same phonetic factors affect both acquisition and sound change (possibly independently).

strong positions was phonologized by E, who applied it consistently throughout the fourteen-month period during which PVF 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 that still faithfully maintained 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 ~ velar contrast in prosodically strong onsets: should this stage of acquisition be related to reproportioning of the tongue through physiological development, or to greater physiological control of the linguo-palatal contact? Brett and colleagues (1987) argue on the basis of VOT evidence that velar fronting is NOT the result of overall greater motoric difficulty for velars. However, a full answer to this question would require more research, using methodologies such as electropalatography (e.g. Gibbon et al. 2001) or ultrasound scanning (e.g. Gick 2002), 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 articulation alone also cannot explain how PVF was resolved. While growth of the diverse components of the vocal tract is progressive, E's PVF stages were discrete. E produced both coronals and velars accurately in his babbling and very early words, but starting at 1;0.27 systematically fronted his velars in strong positions all the way through 2;3.0. By the time of the next documentation, five days later at 2;3.5, PVF had ceased categorically; in thirty words with target strong velars documented from 2;3.5 to the end of the corpus study (3;9.29), PVF occurred only in the word *again*, which was uttered four times in succession, as [əd͡ʒɪn], [d͡ʒɪn], [əʒɪn], and [ʒɪn] (2;3.21).[18] Moreover, on two occasions around this transitional period, at E's ages 2;01.14 and 2;03.21, E's mother witnessed him producing nonsense words containing velars in stressed syllables (e.g. [gæk], [kæk], [kɑŋk]). One is tempted to interpret these attestations as E practicing the motor planning required to correctly produce velars in prosodically strong positions.

(14) Abrupt cessation of PVF between 2;3.0 and 2;3.5

PVF IN FORCE			PVF NOT IN FORCE		
[**t**ɔtəvejɾɚ]	'cultivator'	2;2.26	[**k**ʌwtɪvejɾə]	'cultivator'	2;3.18
[**tʰ**eim]	'came'	2;3.0	[**k**ʌmɪn]	'coming'	2;3.8
[**d**on]	'going'	2;3.0	[**g**wæsəz]	'glasses'	2;3.5

[18] The utterances of *again* are anomalous in another way, namely in that the expected outcome of VF would be [(ə)dɪn], without affrication, as *again* was typically pronounced before 2;3. The word *again* is one of the more frequently occurring words in E's corpus, appearing twenty-three times between 1;2.4 and 2;3.2, in various forms. The twenty-six other words containing velars transcribed in the post-PVF period were, in alphabetical order: *acorn*, *cactus*, *Cadillac*, *camel*, *camera*, *can*, *Caroline*, *clock*, *cockroach*, *color*, *colored*, *coming* (2x), *could*, *cultivator*, *get*, *glasses* (2x), *Goldilocks*, *gorilla*, *got*, *scream*, *screamed*, *skeleton*, *skinny*, *washcloth*.

PLG had similarly discrete transitions. As mentioned earlier, prosodically strong [l] is attested in babbling ([lɑ], [umlæ]; 0;6) and in an early apparent word, *flower* [blɑ] (0;9). Then followed a stable eleven-month period in which prosodically strong target /l/ was realized neither as [l] NOR as [j]. Rather, a range of other strategies ([w]-gliding, consonant harmony, metathesis, omission) was used instead, as documented in full in 15.

(15) 11-month period between [l] use and PLG: no use of [l] (or [j]) for strong /l/

‘hello’	[howow], [hawow], [həwow], [hoːwow], [oːwow], [owow], [hoˈwow]	1;3.17 (2x), 1;4.11, 1;4.14 (2x), 1;4.18, 1;8.3	gliding to [w] and/or harmony
‘Lego’	[gɑgow], [gwɑgow], [gɑ]	1;6.23 (2x), 1;6.24	harmony
‘balloon’	[nʉː], [nʉːn], [nʉnʉ], [bʷuːn]	1;4.14 (3x), 1;8.15	harmony, omission
‘lunch’	[nʲʌt͡ʃ]	1;7.21	metathesis
‘flashlight’	[ˈpɑtow]	1;8.3	fricative stopping, metathesis

During this same eleven-month period, weak /l/ was either omitted or realized as [w] or [u]. Interestingly, the only documented use of [w] for strong /l/ during the 0;9–1;8 period involves the word *hello*, which was invariably pronounced with a final [w] as well, suggesting that consonant harmony might be the source of the medial [w]. Consonant harmony, which E exhibited only sporadically, is also clearly implicated in the productions of *Lego* and *balloon*.

Once PLG began, it held systematically through 2;9.9, at which point there was a lull in transcriptions for several months. By the time transcription next resumed, at 3;1.25, PLG had completely ceased. It is the parent transcriber’s recollection that the reason for resuming transcription on 3;1.25 was the parent’s observation of a sudden change in the production of /l/. From 3;1.25 onwards, E realized singleton onset /l/ as either [w] or [lʲ], seemingly in free variation, with the proportion of [lʲ] increasing gradually until, sometime after the end of the period under documentation, strong /l/ was no longer substituted with [w] at all.

(16) Examples of words with strong target /l/ from the post-PLG period

[ajdəlʲajz]	‘idolize’	From the song *A you’re adorable . . .*	3;09.29
[wʌv wajt]	‘love light’	From the song *A you’re adorable . . .*	3;09.29
[lʌv lajt]	‘love light’	From the song *A you’re adorable . . .*	3;09.29
[awown]	‘alone’		3;09.29

Our characterization of PVF and PLG as grammatical processes is at odds with the controversial view, expressed by Hale and Reiss (1998:669), that children’s lack of articulatory control affects their productions in a way comparable to the ‘intoxicated speech of the captain of the *Exxon Valdez* around the time of the accident at Prince William Sound’. 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 unwittingly failing through physical disability to articulate the target segments.

It may also be noteworthy that the onset of PLG at 1;8.21coincided with an expansion in E's productive morphological and syntactic capacity. Prior to 1;9, virtually all of E's transcribed utterances were single, monomorphemic words. Starting at 1;9, the record shows E producing phrases and morphologically complex words (*blue blanket* [bu bwæŋk], *Jem's shoes* [d͡ʒɛms ʃuːs], etc.). A connection between grammatical development and expansion of phonological complexity has been noted for other children in the literature as well (e.g. child Kyle, discussed in Salidis & Johnson 1997). Future research is needed to determine the robustness of this type of correlation.

8.2. Complete versus incomplete neutralization. Many studies of segmental neutralizations in children, including VF, have raised the question of whether the neutralization is complete or whether children are instead making distinct articulations that adult listeners simply are not distinguishing perceptually (see e.g. Macken & Barton 1979, Hewlett 1988, Edwards et al. 1997, Gibbon & Scobbie 1997, Scobbie 1998, White 2001).[19] Without ultrasound (e.g. Gick 2002) and electropalatography (EPG; e.g. Gibbon et al. 2001), we cannot verify instrumentally that E was in fact completely merging /k/ and /t/, /g/ and /d/, /l/ and /j/, and /l/ and /w/. However, it does not really matter to the claim that PVF and PLG are grammatical whether they are grammatical phonological patterns, operating on abstract phonological categories and merging distinct lexical entries into identical phonological segments and, therefore, identical phonetic outputs, or grammatical phonetic patterns mapping distinct phonological categories to near-identical phonetic outputs. In the spirit of the phonology-phonetics interface outlined by Keating (1988), Cohn (1990), and Barnes (2002), among others, we assume that the phonology-phonetics mapping 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 that produces PVF in specific phonological contexts is required in all instances of mapping abstract phonemic categories to windows of phonetic realization. Whether the [t] produced for target /k/ is classified as the phoneme /t/ or an allophone of /k/ does not matter; either would be the result of a phoneme-to-sound grammatical correspondence.

That said, some noninstrumental evidence does suggest, at least for PLG, that neutralization was complete. As shown below, E displayed lexical effects that appear to be the direct consequence of complete neutralization. In the post-PLG period, when E was realizing strong onset /l/ as [l] or [w] but no longer as [j], he produced the words *lose* and *use* in homophonous fashion: [luz] or [wuz] (in free variation). Morphologically related words (*losing*, *lost*, *using*, *used*) were also pronounced with [l] or [w] onsets. Our explanation for the realization of *use* as [luz] is that during the PLG period, both *lose* and *use* were realized identically as [juz], and E lexified them identically as underlying /luz/. As a result, when strong /l/ → [j] substitution ceased, and underlyingly /l/-initial words were pronounced with initial [l] again, the homophony persisted. Had the /l/ → [j] substitution not been neutralizing, there would be no explanation for the subsequent parallel behavior of *lose* and *use*. A similar phenomenon occurred with the word *yellow*, which E produced as [lɛlow] or [wɛwow] following the cessation of

[19] Not all EPG studies disconfirm neutralization; for example, Wrench and colleagues (2002) use EPG to confirm complete merger in a ten-year-old with Down Syndrome.

PLG.[20] As example 17 shows, other words beginning with /j/, for example, *you*, were unaffected by the cessation of /l/ → [j]; the relexification affected only a handful of lexical items.

(17)	PLG (before 2;3)	post-PLG (after 2;3)	
	/l/ → [j]	/l/ → [l] ~ [w]	UR
'use'		luz ~ wuz	/luz/
'lose'		luz ~ wuz	/luz/
'you'	ju	ju	/ju/
'yellow'	jɛjow	lʲɛlʲow ~ wɛwow	/lɛlow/

Another piece of potential lexical evidence for complete neutralization involves the phrase *hello hole*, uttered prior to the PLG period at 1;8, when E realized /l/ as [w] in all positions. E laughed upon producing this utterance; his mother's interpretation at the time was that E, who always enjoyed rhymes, was amused by the realization that *hello* and *hole* sounded identical: [hawow hawow]. (At the time, E produced all /oʊ/ syllable rhymes as a disyllabic string similar to [awow].) Although this possible baby pun does not, even if correctly interpreted by E's mother, bear on the question of whether PLG was one hundred percent acoustically neutralizing, it could suggest that the /l/ → [w] substitution neutralized /l/ and /w/ in E's ears, as it did to those of his attentive parent.

9. Conclusion. This article shows the value of a longitudinal study in evaluating important issues such as the continuity hypothesis and the competence versus performance debate. It was in part the careful observation of the onset and offset of E's PVF and PLG patterns that led to the conclusion that the patterns were grammatical.

PVF and PLG initially appeared problematic to the continuity hypothesis, being, at least in the case of PVF, well attested in child language but unheard of in adult language. Yet what we have seen is that the discontinuity is only superficial. When one considers the phonetic motivations between the positional neutralizations in child and adult language, the essential picture is the same. Phonetic similarity can lead to phonological neutralization in both cases, simple anatomical differences between adults and children explaining why certain patterns, like PVF, arise only in children.

Rather than posing a problem for the continuity hypothesis, PVF actually reveals the extreme consistency with which a developing grammar can cope with external factors while adhering fully to the fundamental principles of universal grammar. The continuity hypothesis is supported, not at a superficial descriptive level, at which children and adults clearly differ, but at a deeper, more explanatory level. Child and adult grammars are composed of the same essential elements, arranged according to the same motivating principles.

More generally, our conclusions also support the view that child language can be a better test than adult language for what is possible in human grammar. The generalizations that children construct, often based on ultimately nonrepresentative selections of data, may, as Bernhardt and Stemberger (1998:5) point out, be a purer reflection than adult language, which is the result of historical change, subject to lexical and/or sociolinguistic pressure, and often affected by literacy, of what kinds of phonological generalizations human beings can make. Children are creative learners and do not simply parrot,

[20] Note, however, that as mentioned in n. 9, E's older sibling pronounced *yellow* as /lɛlow/ too, which may have influenced E's underlying representation for the word.

imperfectly, the adults around them; nonetheless, children and adults alike use the same essential grammatical representations.

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