ON THE ROLE OF SEGMENTAL CONTRASTS IN THE ACQUISITION OF CLUSTERS[*]

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Abstract: The acquisition of an underlying contrast between /l/ and /r/ has been claimed to be a necessary prerequisite to the acquisition of clusters (Archibald 1998). To evaluate this claim, an archival database including more than a hundred children with phonological delays, ages 3;0 to 8;6, was consulted. A number of apparent counterexamples were identified. All problematic cases reliably produced consonant + /l/ clusters but lacked an underlying contrast between /l/ and /r/. In an effort to reconcile these (apparent) counterexamples with the many compliant cases, these data were further reanalyzed within optimality theory (McCarthy and Prince 1995). The analyses revealed that the apparent clusters were more properly understood as complex segments similar to affricates. Thus, while such cases do not contradict Archibald's proposal, they do provide a richer account of the development of clusters. The paper concludes with a discussion of the implications of OT accounts for the learnability of structure and for clinical treatment.

1. Introduction

A continuing concern of acquisition research is how consonant clusters are acquired. Some researchers have claimed that the acquisition of clusters is ordered along the lines of markedness, so that less marked clusters are acquired before more marked clusters (e.g., Elbert, Dinnsen, & Powell 1984). Others have approached the question from the point of view of typological universals (e.g., Eckman & Iverson 1993). Another approach appeals to the Sonority Sequencing Principle (Clements 1990) to account for cluster acquisition (e.g., Chin 1996). Still others have proposed that certain other segments or structures must be acquired before clusters may be produced. For instance, a recent paper by Lleó and Prinz (1997) claims that affricates must be acquired in the onset position before clusters may be produced in this position. Archibald (1998) proposes an interesting implicational universal whereby the presence of consonant + liquid clusters implies the presence of an underlying contrast between /l/ and /r/.

Archibald's claim is interesting for a couple of reasons. First and foremost, it has never before been proposed that the contrasts in which a segment is involved may affect whether or not it may occur in a cluster. If a learner has acquired the segment /r/, why should it be restricted only to certain environments? Secondly, Archibald's claim is readily testable. Every learner, whether of a first or second language, is predicted to be unable to produce consonant + liquid clusters until the underlying /l/ versus /r/ contrast is acquired. Learners who are able to produce these clusters but who lack the underlying contrast would serve as counterexamples to this claim. With this in mind, there are two goals for the present paper. First, some (apparent) counterexamples to Archibald's claim from first language (L1) acquisition of English will be presented. Second, a detailed account for one of these counterexamples will be presented that shows how the data may be analyzed in a way that is consistent with Archibald's claim.

The paper is organized as follows. In section 2, a summary of Archibald's hypothesis is provided. In section 3, data are presented which appear to be at odds with Archibald's claim. In section

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4, an analysis within the framework of Optimality Theory (OT; McCarthy & Prince 1995) is given. In the final section, theoretical and clinical implications of this account are presented.

2. Archibald's Proposal

The purpose of Archibald's paper is to address issues that relate to the nature of the mental representation of interlanguage (IL) grammars. The main focus is to show that it is necessary to posit a hierarchical constituent structure to account for second language (L2) phonology. Specifically, Archibald claims that the Sonority Sequencing Principle is derived from the underlying structure of segments, relying crucially on the notion of phonological government and a Minimal Sonority Parameter. One result of this theory is an implicational universal that states that the presence of onset clusters implies the presence of an /l/ versus /r/ contrast underlyingly.

Archibald claims that sonority is a phonological construct derived from the complexity (or featural specification) of the segmental representation. Important here is that the underlying structure or specified features of a segment are dependent upon the contrasts that it is involved in. Thus in Korean, for example, in which /l/ and /r/ do not contrast, the underlying representation for these segments contains less structure than the representations of these segments in English, in which /l/ and /r/ are contrastive. In other words, in Korean, /l/ and /r/ have identical underlying representations, while the English /l/ differs from /r/ in that /l/ is specified as [lateral], due to its contrast with /r/.

Permissible clusters in a language are determined by the interaction of phonological government and the Minimal Sonority Parameter. The Minimal Sonority parameter determines the minimum amount of structure that a segment must have in order to phonologically govern an adjacent segment. When one segment governs another, the two segments may form a cluster. To take up the Korean example, liquids do not have the minimum structure required by its high setting of the Minimal Sonority Parameter to govern adjacent segments and are therefore prohibited from being part of a cluster. In English, on the other hand, the more elaborated structure of liquids combined with the lower setting of the Minimal Sonority Parameter permits them to govern adjacent segments, forming clusters. The development of an underlying contrast between /l/ and /r/ is a necessary prerequisite for the (re)setting of the Minimal Sonority Parameter to the lower English setting. Therefore, Korean speakers learning English will be unable to reliably produce /l/ and /r/ in clusters until they acquire this contrast, even though they can produce the liquids in singletons in their native language.

Archibald reports on three types of evidence to support his hypothesis. First of all, an analysis of data collected from Korean students learning English is consistent with his claim in that none of the subjects has acquired the underlying distinction between /l/ and /r/ nor are they able to reliably produce these segments in clusters. Archibald also calls on evidence from L1 acquisition. He notes that Amahl (Smith 1973) did not begin producing consonant + liquid clusters until he had acquired the /l/ versus /r/ contrast. Finally, he employs cross-linguistic evidence. He investigated a number of languages with only one liquid to see if they permitted consonant + liquid clusters. He states that there are no robust counterexamples to his claim, i.e. that no language with one liquid permits these types of clusters.

Archibald's claim is certainly a provocative one. As stated above, the idea that the ability to produce a segment in a cluster is crucially dependent upon whether or not that segment contrasts with another segment has never before been proposed. The hypothesis is also a testable one. While Archibald reports on some evidence from second language acquisition that does not disconfirm his claim, evidence from first language acquisition provides another means of evaluating Archibald's hypothesis. In the next section I will present some evidence from first language acquisition of English which appear to contradict Archibald's claim.

3. (Apparent) Counterexamples

In order to test Archibald's hypothesis for first language acquisition, a search was made of an archival database containing data for approximately 100 subjects exhibiting functional phonological delays. The goal of the search was to find subjects who had no underlying contrast between /l/ and /r/, as evidenced by their failure to produce the segments in at least two minimal pairs, but who were able to produce either Cl- or Cr- clusters. In the database, 16 subjects were found who met these criteria. Of these 16, 5 produced a liquid in clusters reliably. Reliable production is important because Archibald states that liquids may be produced in clusters with considerable variation before the underlying contrast is acquired. Reliable production is not possible until the phonemic contrast is acquired. "Reliably" here means that the subjects produced the liquid in 85% of target Cl- clusters. All subjects scored at or below the 13th percentile on the Goldman-Fristoe Test of Articulation (Goldman & Fristoe 1986). In addition, all subjects excluded at least 5 sounds from their pre-treatment phonemic inventories. Performance on other standardized tests, such as the Peabody Picture Vocabulary Test-Revised (Dunn & Dunn 1981), shows that these children are otherwise normally developing. A summary of pertinent information on these subjects is found in (1).

(1)

Subject	Age	Gender	Phonemes Excluded	GFTA[1]	PPVT-R[2]
4T	4;6	F	• ‿ ʎ	6th percentile	77
31	4;5	M	ɤ ‿ ʎ ‿	13th percentile	108
38	5;8	M	ʎ ʑ ‿ʑ ○ ↗ ‿	1st percentile	103
44	5;2	M	ɤ ‿ ʎ ‿ ‿ʑ ○↗ ‿ ħ	2nd percentile	95
106	4;3	M	∵ • ʎ ʑ ‿ʑ ○↗ ℓ ‿	3rd percentile	93

Summary of background on subjects

Subject 4T produced [l] for target /l/ in singletons but substituted [w] for /r/ in singletons as well as in clusters. She produced [l] in 100% of target Cl-clusters. Samples of her production are given in (2).

(2) Subject 4T (4;6)
    a. Target word-initial /l/
       [ℓ↦∩‿]   'light'
       [ℓ∵○◦∪]   'ladder'
       [ℓ∵ɤ∩∵]   'laughing'

    b. Target word-initial /r/
       [‿↦‿]   'rock'
       [‿↦∩○]   'ride'
       [‿◆]   'run'

    c. Target consonant + /l/ clusters
       [↕ℓ‿ħ↦∪≫↘]   'bluehouse'
       [‿ℓ○ʑ]   'sleep'
       [○ℓ‾‿]   'glove'

    d. Target consonant + /r/ clusters
       [↕‿◦○↗]   'bridge'
       [○‿‿]   'dress'
       [ɤ‿◦∪]   'throw

Subject 31's data look very similar to those of Subject 4T. He produces [l] for target /l/ in singletons and substitutes [w] for /r/. Subject 31 produces [l] in target Cl- clusters 87.5% of the time but substitutes [w] for /r/ in target Cr- clusters. Representative examples are shown in (3).

(3) Subject 31 (4;5)
    a. Target word-initial /l/
       [ℓ∵ℓ∪]   'ladder'

    b. Target word-initial /r/
       [‿]   'rock'

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[1] Goldman-Fristoe Test of Articulation (Goldman and Fristoe, 1986)
[2] Peabody Picture Vocabulary Test-Revised (Dunn and Dunn, 1981)

[ℓ↦∩‥]   'light'   [‗¯◆]   'run'
[ℓ⊙∩•]   'leg'   [‗⊙∩◆]   'rain'

c. Target consonant + /l/ clusters   d. Target consonant + /r/ clusters
   [↕ℓ‗ℏ↦∪‖‖]   'bluehouse'   [↕‗¯⅄∘∪]   'brother'
   [‥‥‗ℓ∘≺]   'sleep'   [‥∘ℏ↦∪‗‗]   'treehouse'
   [•ℓ↕]   'glove'   [‥‥∵≺]   'crash'

Subject 38 follows the same pattern as Subjects 4T and 31 above. He produces [l] for /l/ in singletons and in target Cl- clusters in 87.5% of obligatory contexts. [w] is substituted for /r/ in singletons and clusters. The data in (4) provide some samples.

(4) Subject 38 (5;8)
   a. Target word-initial /l/   b. Target word-initial /r/
      [ℓ⊙∩•]   'leg'   [‗ ≫]   'rock'
      [ℓ∵◆∪]   'ladder'   [‗¯◆]   'run'
      [ℓ∘≻‗]   'leaf'   [‗∘◆]   'read'

   c. Target consonant + /l/ clusters   d. Target consonant + /r/ clusters
      [↕ℓ↦∪‗]   'bluehouse'   [bw¯s]   'brush'
      [≺ℓ↦∪]   'flower'   [dw∵s]   'dress'
      [•ℓ¯‗]   'glove'   [○∘∪∩∵˙]   'throwing'

Subject 44's data are also similar to those of the other subjects. He produces [l] for target /l/ in singletons and substitutes [w] for target /r/. In clusters he produces /l/ in 87.5% of target Cl- clusters. In target Cr- clusters, he substitutes [w] for /r/ and deletes the initial consonant. The only exception is target /br-/ clusters, which are produced as [bl-]. Data are given in (5) below.

(5) Subject 44 (5;2)
   a. Target word-initial /l/   b. Target word-initial /r/
      [ℓ⊙∩•]   'leg'   [‗ ‥]   'rock'
      [ℓ∘↕]   'leaf'   [‗¯◆]   'run
      [ℓ∵≰∪]   'ladder'   [‗∘]   'read'

   c. Target consonant + l clusters   d. Target consonant + /r/ clusters
      [↕ℓ‗ℏ↦∪]   'bluehouse'   [‗ •]   'frog'
      [↕ℓ∘∪]   'blow'   [‗∘ℏ↦∪]   'treehouse'
      [•ℓ≫∘]   'glove' (dim.)   [↕ℓ∩○∘]   'bridge' (dim.)

(6) Subject 106 (4;3)
   a. Target word-initial /l/   b. Target word-initial /r/
      [‗∵○∪]   'ladder'   [‗∩◆]   'ring'
      [‗∘≻]   'leaf'   [‗∪≻]   'roof'
      [‗∵≻]   'laugh'   [‗ ‥]   'rock'

   c. Target consonant + /l/ clusters   d. Target consonant + /r/ clusters
      [≺ℓ⊙∩◆]   'plane'   [≺ℓ∩○∘]   'pretty'
      [•ℓ‗]   'glue'   [‗ℓ∘]   'tree'
      [ℓ∘◆]   'clean'   [ℓ↦∩]   'cry'

The final counterexample is Subject 106. He substitutes [w] for both /l/ and /r/ in singletons. Target stop + liquid clusters are produced invariably as Cl- clusters while fricative + liquid clusters are reduced to the fricative. This asymmetry will be taken up later in this paper. Some data are provided in (6).

As the above data show, counterexamples to Archibald's claim certainly do exist. All of the subjects lack an underlying contrast between /l/ and /r/ but are able to reliably produce Cl- clusters. On the other hand, it does seem that Archibald's claim is largely true. Out of the 111 subjects in the da-

tabase, only these five are inconsistent with respect to his hypothesis. The other 106 subjects are consistent with his claim in one of three ways. First of all, some subjects may have an underlying contrast between /l/ and /r/ and still fail to produce consonant + liquid clusters. Some subjects have the underlying contrast and produce the relevant clusters. Finally, some subjects may lack an underlying contrast and also fail to produce consonant + liquid clusters. The number of subjects complying with each of these four conditions is given in (7).

(7)

	/l/ vs. /r/ contrast	No /l/ vs. /r/ contrast
Produce consonant + liquid clusters	5 subjects	5 subjects
Fail to produce consonant + liquid clusters	1 subject	100 subjects

Number of subjects meeting each of four conditions

Given the fact that so many cases support Archibald's hypotheses, we are led to wonder if there is another way of accounting for the above data that can be reconciled with Archibald's claim. In the next section, we will do just this with the data for Subject 106.

4. OT Analysis of Subject 106

Recall that Subject 106 substituted [w] for /l/ and /r/ in singletons but produced [l] in target stop + /l/ clusters and also substituted [l] for /r/ in target stop + /r/ clusters. In addition, [l] is substituted for /w/ in target stop + /w/ clusters. However, in all true clusters[3] that consist of a fricative + /l, r, w/, the cluster is reduced to a fricative. Adjunct clusters[4], on the other hand, are reduced to the second element of the cluster. Finally, the affricates /ʧ/ and /ʤ/ are realized as [tl] and [dl] respectively. This is summarized in the table in (8).

(8)

		Target	S106 Production
True Clusters	**Stop + Sonorant Clusters**	[pl-] [tr-] [kw-]	[pl-] [tl-] [l-]
	Fricative + Approximant Clusters	[fl-] [θr-] [sw-]	[f-] [θ-] [s-]
Adjunct clusters		[sk-] [sm-]	[k-] [m-]
Complex segments		[ʧ-] [ʤ-]	[tl-] [dl-]

Summary of data with representative examples

Note that there is a striking similarity between the production of affricates and the production of stop + sonorant clusters. Both surface as stop + [l] clusters. These two classes also differ markedly from target fricative + approximant clusters and adjunct clusters, both of which are reduced to singletons, though we might expect all of the clusters to pattern in the same way. Given this patterning, we can propose that the stop + sonorant clusters are represented underlyingly as complex segments similar to affricates, while the fricative + approximant clusters and adjunct clusters are represented as two separate segments in the underlying representation, thus accounting for the surface patterns.

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[3] A true onset cluster in English generally rises in sonority, e.g., stop or fricative + liquid or glide.

[4] Adjunct clusters are generally those that fall in sonority, e.g. /s/ + stop. In this paper, /s/ + nasal clusters are assumed to be adjunct clusters because they pattern just like /s/ + stop clusters.

Such an idea is not, in fact, a new one. For example, Barton, Miller and Macken (1980) claimed that children represent clusters initially as single units before treating them as composed of separate segments. In a recent paper that supports this notion, Barlow and Dinnsen (1998) present a longitudinal account of a child with a phonological disorder who seems to display this behavior. They claim that, at the first point in time, the child represents all clusters as single segments underlyingly. As the child develops, she begins to represent these target clusters as complex onsets.

In the following subsections of the paper, an account of the data for Subject 106 will be presented within optimality theory (McCarthy & Prince 1995). It will be shown that stop + sonorant clusters and affricates are represented as complex segments underlyingly, while target fricative + approximant clusters and adjunct clusters are represented as sequences of two segments in the underlying representation. It is assumed in the tableaux that follow that all of the child's inputs are adult-like on the segmental level, though the underlying structures may differ from those of an adult.

4.1 Singletons

As noted above, Subject 106 substitutes [w] for /l/ and /r/ in singletons. In addition, the coronal stops [t] and [d] are substitutes for the velar stops /k/ and /g/ respectively. Fricatives are produced target-appropriately. Representative examples are given in (9) below.

(9) Target singletons

    a. Target initial stops   b. Target initial fricatives

         [⨞∩ᵖ∴◆∘∪]   'piano'   [⤳↦∩˗]   'five'

         [˗ˉ◆]   'tongue'   [˖⌐∩◆]   'seven'

         [○○∩˗]   'gate'   [∩⨞∘∪]   'zipper'

    c. Target initial liquids

         [˗∴○∘∪]   'ladder'

         [˗○∩○]   'leg'

         [wid]   'read'

         [˗∪⤳]   'roof'

To account for these data, the constraints and ranking in (10) are required. The high ranking of *Dorsal will prevent /k/ and /g/ from surfacing in singletons, while the ranking of *Labial over *Coronal ensures that that a coronal consonant will be substituted for the velars. However, the ranking of *Labial equally with Ident[place] means that target labials will surface as labials, since a coronal substitute for a target labial will violate Ident[place] and then *Coronal. As for the sonorants, the high ranking of *Liquids prevents /l/ and /r/ from occurring in the optimal output, while the high-ranked Ident[son] guarantees that a sonorant rather than an obstruent will be substituted for the liquids. Finally, the high-ranking constraint Ident[j] assures that the palatal glide [j] will never be produced for any input segment besides /j/, which is consistent with Subject 106's production: he always faithfully produces [j] for target /j/ and does not use [j] as a substitute for any other segments.

(10) Constraints and initial ranking

    (a) *Dorsal: Avoid the feature [dorsal].

    (b) *Liquids: Avoid the liquid consonants /l/ and /r/.

    (c) Ident[son]: The value of the feature [sonorant] in the output must be identical to the input value for corresponding segments.

    (d) Ident[j]: The segment [j] in the output must correspond to a /j/ in the input and vice versa.

    (e) Ident[place]: The value of a place feature in the output must be identical to the input value for corresponding segments.

    (f) *Labial: Avoid the feature [labial].

    (g) *Coronal: Avoid the feature [coronal].

Ranking: *DORSAL, *LIQUIDS, IDENT[son], IDENT[j] >> IDENT[place], *LABIAL >> *CORONAL

The tableau in (11) shows how a candidate with an initial coronal is chosen as the optimal output for input /•⊙∩⌣/. The faithful candidate (a) violates undominated *DORSAL. Candidate (d) fatally violates the high-ranked constraints IDENT[son] and IDENT[j] and is eliminated. Candidates (b) and (c) both violate IDENT[place] resulting in a tie. The tie is broken by candidate (c)'s violation of *LABIAL. Thus, candidate (b), [○⊙∩⌣], is selected as the optimal output.

(11) [○⊙∩⌣] for input /•⊙∩⌣/ 'gate'

/•⊙∩⌣/	*DORSAL	*LIQUIDS	ID[son]	IDENT[j]	ID[place]	*LABIAL	*COR
(a) •⊙∩⌣	*!						*
☞(b) ○⊙∩⌣					*		**
(c) ↕⊙∩⌣					*	*!	*
(d) ⌒⊙⌒⌣			*!	*	*		**

In (12) we see how [w] is chosen as the substitute for a target /l/. Candidates (a) and (c) with initial liquids and final velar consonants both violate undominated *DORSAL and *LIQUIDS and are eliminated. Candidate (b) with an initial [l] violates *LIQUIDS, which is fatal. Candidate (d), with a [d] substituted for the initial /l/ of the input, is eliminated by IDENT[son]. Candidate (f), in which a palatal glide is substituted for the input /l/ fatally violates IDENT[j]. As a result, candidate (e), [⌣⊙∩○], is chosen as the optimal output.

(12) [⌣⊙∩○] for input /ℓ⊙∩•/ 'leg'

/l⊙∩•/	*DORSAL	*LIQUIDS	ID[son]	IDENT[j]	ID[place]	*LABIAL	*COR
(a) l⊙∩•	*!	*					*
(b) ℓ⊙∩○		*!			*		**
(c) r⊙∩•	*!	*					*
(d) ○⊙∩○			*!		*		**
☞(e) w⊙∩○					**	*	*
(f) ⌒⊙⌒○				*!	*		**

In this section we have seen how the production of singletons can be accounted for using a few crucially ranked constraints. This allows us to see how coronal stops are substituted for velar stops and how [w] is substituted for liquids. This will be important in later sections of the paper because, in stop + sonorant clusters, [l] is realized for target /l r w/. In addition, in target velar stop + /l r w/ clusters, /k/ and /g/ are realized target appropriately. Any analysis offered must account for these conflicting facts. First, however, we will turn to affricates.

4.2 Affricates

As mentioned above, target affricates, generally analyzed as complex segments, are produced as stop + [l] sequences. Some examples are given in (13).

(13) Data for affricates
  a. Target /⌣⋉/   b. Target /○↗/
    [⌣ℓ∩⋉]   'chip'   [○ℓ⌣⌒]   'jelly'
    [⌣ℓ ⌣]   'chalk'   [○ℓ⌣∪]   'jail'
    [⌣ℓ⌣∪]   'chair'   [○ℓ⌣]   'juice'

In order to account for these data, the following constraints are needed, in addition to those given above in (10).

(14) Additional constraints and ranking

(a) *COMPLEXSEGMENT&$_{ons}$*W: Avoid complex segments and [w] in the domain of the same onset.

(b) *COMPLEXONSET: Avoid branching onsets.

(c) PARSE: Preserve the input structure of branching segments in the output. (Adapted from Barlow & Dinnsen 1998)

(d) MAX: A segment in the input must be present in the output.

(e) *COMPLEXSEGMENT&$_{ons}$*FRICATIVES: Avoid complex segments and fricatives in the domain of the same onset.

(f) *COMPLEXSEGMENT: Avoid branching segments.

(g) *W: Avoid the glide /w/.

(h) *FRICATIVES: Avoid obstruent fricatives.

Ranking: *COMPSEG&$_{Ons}$*W, *COMPONS, *R, PARSE, MAX, *COMPSEG&$_{Ons}$*FRIC, IDENT[j] >> *L, *DORSAL, IDENT[son] >> IDENT[place], *LABIAL >>*CORONAL, *COMPSEG, *W, *FRIC

The constraint *COMPLEXONSET prevents onset clusters and must be high-ranked since, according to the analysis presented here, this subject fails to produce such structures. *COMPLEXSEGMENT, on the other hand, prevents branching segments such as affricates. Since these types of structures do surface in the subject's production, this must be low-ranked. PARSE is a faithfulness constraint antagonistic to *COMPLEXSEGMENT and must be ranked above it. MAX is a faithfulness constraint that militates against deletion of an input segment in an output. The markedness constraint *W must be ranked low in order to allow the labial glide to surface in singletons. When this constraint is conjoined[5] with *COMPLEXSEGMENT and when this conjoined constraint is undominated, /w/ is prevented from occurring in a complex segment. A similar situation is seen with regard to the conjoined constraint *COMPLEXSEGMENT&$_{ons}$*FRICATIVES. Each of the conjuncts of the constraint must be low-ranked since fricatives may occur in singletons and since complex segments do surface. The high-ranked conjoined constraint prevents fricatives from occurring as part of complex segments. Note also that *LIQUIDS has been exploded so that *R is now ranked above *L, accounting for why [l] surfaces in complex segments.

Interestingly, the conjoined constraint *COMPLEXSEGMENT&$_{Ons}$*W favors the surfacing of the more marked segment /l/ over the less marked segment /w/ in a complex segment. The end result is that a more marked substitute, /l/, is only licensed in certain contexts, in this case the complex segment. This type of licensing, in which marked structures are restricted to certain positions, is argued for by Zoll (1998) and receives further support here.

Another consideration that must be taken into account at this point is the notion of Richness of the Base (Smolensky 1996). Richness of the base states that there may be no language-specific restrictions on the input. Regarding the current problem, this means that, even though it appears that the subject represents affricates and stop + sonorant clusters as complex segments, we cannot restrict the input by claiming that they must be represented as complex segments in the input. We must allow for the possibility that they are represented as sequences of two segments. In other words, the account presented here must show that either input will result in the same output.

Considerations of richness of the base are especially relevant when assessing constraint violations. As an example, consider an input /O↗⌣ℓ^{c}/. The initial /O↗/ has two possible structural representations. First of all, it may be represented as a complex segment, indicated by the parentheses, as in /(O↗)⌣ℓ^{c}/. On the other hand, it may be represented as a sequence of two segments, as in /O↗⌣ℓ^{c}/. Next, if we consider an output candidate [O⌣ℓ^{c}], the violations that it incurs depend on the input that it corresponds to. For instance, if the candidate corresponds to an input with an initial complex segment (i.e., /(O↗)⌣ℓ^{c}/), then the candidate will incur violations of PARSE and

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[5] See Smolensky (1995) for information on local constraint conjunction.

IDENT[place]. The candidate violates PARSE because it has failed to preserve the input structure of the complex segment, since part of the segment has been deleted. The IDENT constraint is violated because the [place] feature of the missing part of the complex segment has not been parsed in the output. On the other hand, if the candidate corresponds to an input with an initial sequence of two segments (i.e., /○↗∟ℓ↻/), rather than one complex segment, then it only incurs a MAX violation for failing to parse an input segment in the output. The candidate does not violate PARSE because the input has no complex segment. It does not violate the IDENT constraint because these violations are assessed on corresponding segments. Because the corresponding segment is not present in the output candidate, IDENT violations are not incurred in this case. In the tableaux that follow, any output candidate in which a sequence of input segments, regardless of their structure, is reduced to a singleton will incur a violation of either PARSE, along with the IDENT constraints, or MAX. Rather than show all of these duplicate candidates in every tableaux, only one is shown. The selection of the optimal candidate will not be different.

In the case of those candidates in which an entire input sequence is parsed, a similar situation arises. As an example, consider an input / ˍ°◆/ and two output candidates, (a) [(ˍ)°◆] and (b) [ˍ°◆]. If candidate (a), with a complex segment, corresponds to an input with a sequence of two segments, then it does not violate MAX because the complex segment of the output candidate serves as the correspondent to both of the input segments. Candidate (b), with a complex onset, violates PARSE if it corresponds to an input with a complex segment (i.e., /(ˍ)°◆/). Candidate (b) satisfies MAX, however, because the complex segment of the input has a correspondent in the output candidate. In these cases, no violations are indicated in the tableaux for PARSE and MAX. An examination of the tableaux indicates that the outcome would be the same.

The tableau in (15) shows how these constraints interact to choose [○ℓ∟ˍ↻] for input /○↗∟ℓ↻/ with a complex segment. Parentheses around two segments indicate a complex segment. Because of the number of constraints, the undominated constraints share a column. The same has been done for the low-ranked constraints. In addition, multiple violations of a single low-ranked constraint are indicated only when they are crucial to selecting the optimal output. Candidates (a) and (b) are eliminated because they violate the high-ranked conjoined constraint *COMPLEXSEGMENT&ₒₙₛ*FRICATIVES. Candidates (c) and (e) fatally violate *COMPLEXONSET, while candidates (h) and (i) are eliminated by high ranked PARSE. Candidate (f) is ruled out by the high-ranked *R, leaving candidate (d) as the winner.

(15) [○ℓ∟ˍ↻] for input /○↗∟ℓ↻ 'jelly'

/○↗∟ℓ↻/	UNDOMINATED	*L	*DORS	ID[son]	ID [place]	*LAB	LOW-RANKED CONSTRAINTS
(a) (○↗)∟ℓ↻	*COMPSEG&*FRIC!	*					*COR, *FRIC, *COMPSEG
(b) (○↗)∟ˍ↻	*COMPSEG&*FRIC!				*	*	*COR, *FRIC, *COMPSEG, *W
(c) ○↗∟ˍ↻	*COMPONS!				*	*	*COR, *FRIC, *W
☞ (d) (dℓ)∟ˍ↻		*		*	*	*	*COMPSEG, *W, *COR,
(e) ○ℓ∟ˍ↻	*COMPONS!	*		*	*	*	*COR, *W
(f) (○ˍ)∟ˍ↻	*R!			*	*	*	*COMPSEG, *W, *COR,
(g) (○ˍ)∟ˍ↻	*COMPSEG&*W!			*	**	**	*COMPSEG, *COR, *W
(h) ○∟ˍ↻	PARSE!				**	*	*COR, *W
(i) ↗○ˍ↻	PARSE!				**	*	*COR, *W, *FRIC

In this section we have seen how the constraints interact to select [○ℓ] and [‗ℓ] as substitutes for [○↗↘ and [‗≺] respectively. The high-ranked constraint *COMPLEXSEGMENT&ons*FRICATIVES accounts for why the input fricative of the affricates does not appear in the optimal output candidate. In addition, *COMPLEXONSET is high-ranked, which prevents the affricates from being realized as complex onsets. In the next section, we will see how the same constraints have similar consequences for target stop + sonorant clusters.

4.3 Target Stop + Sonorant Clusters

As previously mentioned, target stop + sonorant clusters all surface as stop + [l] clusters. This poses a particularly interesting problem because target /l/ is replaced by [w] in singletons. In addition, coronal stops are substituted for target velars in singletons, yet these velar stops surface as velars in clusters. Data are given in (16).

(16) Target stop + sonorant clusters

    a. Target stop + /l/ clusters   b. Target stop + /r/ clusters

       [≺ℓ○∩◆]   'plane'   [≺ℓ∩○ᵒ]   'pretty'

       [↕ℓ∘∪]   'blow'   [‗ℓᵒ]   'tree'

       [•ℓ‗]   'glue'   [ℓ↦∩]   'cry'

    c. Target stop + /w/ clusters[6]

       [ℓ↦∩‖‗]   'quiet'

       [ℓᵒ◆]   'queen'

In addition to the constraints given above, the constraint in (17) is required.

(17) Additional constraint and ranking

    IDENT[place]_COMPSEG: The value of [place] features of obstruents in the input must be identical in the output for complex segments.

    Ranking: *COMPSEG&Ons*W, *COMPONS, *R, PARSE, MAX, *COMPSEG&Ons*FRIC, IDENT[j], IDENT[place]_COMPSEG >> *L, *DORSAL, IDENT[son] >> IDENT[place], *LABIAL >> *CORONAL, *COMPSEG, *W, *FRIC

This additional constraint is similar to other positional faithfulness constraints such as FAITHONSET. The basic idea is that it is more important to preserve the input place features of complex segments than to substitute coronal segments for velars. The high ranking of this constraint allows velars to surface in complex segments, but not in singletons. The constraint must crucially be limited to apply only to place features of obstruents. Clearly, if the constraint applied to sonorants as well as obstruents, it would be fatally violated by a candidate in which a [kl] sequence corresponds to an input /kw/. Since this is exactly what does occur, the constraint is restricted to apply only to obstruents.

(18) [≺ℓ○∩◆] for input /≺ℓ○∩◆/ 'plane'

/≺ℓ○∩◆/	UNDOMINATED	*L	*DORS	ID[SON]	ID [place]	*LAB	LOW-RANKED CONSTRAINTS
(a) ≺ℓ○∩◆	*COMPONS!	*				*	*COR
☞(b) (≺ℓ)○∩◆		*				*	*COMPSEG, *COR
(c) ≺‗○∩◆	*COMPONS!, *R					*	*COR
(d) (≺‗)○∩◆	*R!					*	*COMPSEG, *COR
(e) ≺‗○∩◆	*COMPONS!				*	**	*COR, *W
(f) (≺‗)○∩◆	* COMPSEG&*W!				*	**	*COMPSEG, *W, *COR

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[6] Target /tw-/ clusters were produced in delayed imitation and with no consistent substitute.

(g) ⪦⊙∩◆	PARSE!				*	*	*	*COR
(h) ℓ⊙∩◆	PARSE!	*				*		*COR

The tableau in (18) shows how target /pl-/ clusters are realized target-appropriately. Candidates (a), (c) and (e) fatally violate *COMPLEXONSET and are eliminated. Candidate (d), with a complex segment consisting of a stop + [r], violates high-ranked *R, while candidate (f) is eliminated from consideration by undominated *COMPLEXSEGMENT&_ons*W. Candidates (g) and (h), which simplify the initial sequence of the input, violate PARSE. Thus, candidate (b), with a complex segment, wins, because it does not violate any of the undominated constraints.

(19) [⪦ℓ∩O] for input /⪦_∩_/ 'pretty'

/⪦_∩_/	UNDOMINATED	*L	*DORS	ID[son]	ID [place]	*LAB	LOW-RANKED CONTRAINTS
(a) ⪦_∩O	*R!, *COMPONS					*	*COR
(b) (⪦_)∩O	*R!					*	*COMPSEG, *COR
(c) ⪦ℓ∩O	*COMPONS!	*				*	*COR
☞(d) (⪦ℓ)∩O		*				*	*COMPSEG, *COR
(e) ⪦_∩O	*COMPONS!				*	**	*COR, *W
(f) (⪦_)∩O	*COMPSEG&*W!				*	**	*COMPSEG, *W, *COR
(g) ⪦∩O	PARSE!			*	*	*	*COR
(h) _∩O	*R!, PARSE				*		*COR

The next tableau, (19), deals with the substitution of [l] for /r/. Because all candidates which are faithful to the /r/ of the input violate the undominated *R, they are eliminated. This is shown by candidates (a), (b) and (h). If a [w] is substituted for the /l/ of the input, as it is in singletons, the candidate is eliminated by *COMPLEXONSET or the conjoined constraint *COMPLEXSEGMENT&_ons*W, as we see with candidates (e) and (f). Candidate (g), which fails to parse the underlying /l/ at all, violates the PARSE constraint. Candidate (d), whose onset consists of a complex segment in which [l] is substituted for /r/, wins.

(20) [ℓO◆] for input / _O◆/ 'queen'

/ _O◆/	UNDOMINATED	*L	*DORS	ID[son]	ID [place]	*LAB	LOW-RANKED CONTRAINTS
(a) _O◆	*COMPONS!		*			*	*COR
(b) (_)O◆	*COMPSEG&*W!		*			*	*COMPSEG, *COR
(c) kℓO◆	*COMPONS!	*	*		*		*COR
☞(d) (ℓ)O◆		*	*		*		*COMPSEG, *COR
(e) _O◆	*COMPONS!, *R		*		*		*COR
(f) (_)O◆	*R!		*		*		*COMPSEG, *COR
(g) (_ℓ)in	ID[place]_COMPSEG!	*			**		*COMPSEG, *COR
(h) O◆	PARSE!		*	*	*		*COR
(i) _O◆	PARSE!				*	*	*COR

Tableau (20) addresses two problems. First, it demonstrates that IDENT[place]_{COMPSEG} prevents a coronal from being substituted for a velar in a complex segment. Secondly, it illustrates how a candidate in which [l] is substituted for an input /w/ is chosen as optimal. Any candidate with a consonant + [w] in the onset violates either *COMPLEXONSET or *COMPLEXSEGMENT&_{ons}*W. However, these constraints do not prevent [w] from occurring as a singleton. Candidates (a), (c) and (e) fatally violate *COMPLEXONSET. The conjoined constraint *COMPLEXSEGMENT&_{ons}*W eliminates candidate (b). Candidate (f) is removed from consideration because it violates high-ranked *R. The expected winner based on the data for singletons, candidate (g), in which a [t] is substituted for the input /k/, violates IDENT[place]_{COMPSEG}. Finally, (h) and (i) fatally violate PARSE. Thus, candidate (d), [(ℓ)◦◆] is selected as the optimal output.

In this section we have seen how target stop + sonorant clusters are all realized as complex segments consisting of a stop + [l]. Though richness of the base forces us not to restrict the input, the principle of lexicon optimization, which states that the form which provides the most harmonic mapping from input to output should be stored in the lexicon, will select the optimal output form. In the case of target affricates and target stop + sonorant clusters, the optimal candidates with complex segments will be selected as the representation in the lexicon. In the next section, we will turn to the fricative + approximant clusters, which are produced quite differently.

4.4 Target Fricative + Approximant Clusters

It was noted above that target fricative + approximant clusters differ markedly from target stop + sonorant clusters. While the latter are represented as complex segments, it appears that the fricative clusters are actually represented as sequences of two segments, rather than as complex segments. If the subject represented all target true clusters in the same way, then we would expect the fricative + approximant and stop + sonorant clusters to pattern in the same way. Instead, all of the fricative + approximant clusters are reduced to the fricative. Data are given in (21) below.

(21) Target fricative + approximant clusters[7]

    a. Target fricative + /l/ clusters   b. Target fricative + /r/ clusters

       [⌐◦O]   'sled'   [≻ O]   'frog'

       [⌐◦≺]   'sleep'   [≻¯◆⌐]   'front'

       [≻↦∩]   'fly'   [≻∩◆]   'friend'

    c. Target fricative + /w/ clusters

       [⌐◦≺]   'sweep'

       [⌐∩∓∩··˙]   'swimming'

       [⌐◦≮◦∪]   'sweater'

One additional constraint must be added here to account for these data. This constraint, and the ranking, is given in (22).

(22) Additional constraint and ranking

    IDENT[cont]: The value of the feature [continuant] in the output must be identical to the input value for corresponding segments.

    Ranking:*COMPSEG&_{Ons}*W, *COMPONS, *R, PARSE, MAX, *COMPSEG&_{On}*FRIC, IDENT[j], IDENT[place]_{COMPSEG}, IDENT[cont] >> *L, *DORSAL, IDENT[son] >> IDENT[place], *LABIAL >> *CORONAL, *COMPSEG, *W, *FRIC

This new constraint eliminates any candidate that does not preserve the continuancy of a corresponding segment in the input. In tableau (23), it is violated by candidates (e) and (f), in which a [t] is substituted for the input /s/. Candidates (b) and (e) both violate two constraints each, eliminating

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[7] Other fricative clusters such as [⌐] and [≮⌐] were not produced with consistent substitutes in singletons or clusters and are thus not included here.

them from consideration. The remaining candidates tie with one another because they all violate only one undominated constraint. Moving down to the next level of constraints, candidates (c), (d) and (f) are eliminated because of their violations of *L, leaving candidates (a), (g) and (h) still in contention. In the next tier of constraints, candidates (a) and (h) are eliminated because they each violate *LABIAL twice. Candidate (g), [‿ʕ], therefore emerges as the most harmonic.

(23) [‿ʕ] produced for input /‿ʕ/ 'sweep'

/‿ʕ/	UNDOMINATED	*L	*DORS	ID[son]	ID [place]	*LAB	LOW-RANKED CONSTRAINTS
(a) ‿ʕ	*COMPONS					**!	*COR, *FRIC
(b) (‿)ʕ	*COMPSEG&*FRIC, *COMPSEG&*W!					*	*COR, *FRIC, *COMPSEG, *W
(c) ‿lʕ	*COMPONS	*!			*	*	*COR, *FRIC
(d) (‿l)ʕ	*COMPSEG&*FRIC	*!			*	*	*COMPSEG, *COR
(e) ‿lʕ	*COMPONS, ID[cont]!	*			*	*	*COR
(f) (‿l)ʕ	ID[cont]	*!			*	*	*COMPSEG, *COR
☞(g) ‿ʕ	MAX					*	*COR, *FRIC
(h) wʕ	MAX					**!	*W
(i) sip[a]	PARSE			*!	*	*	*COR, *FRIC

[a]corresponds to an input with a complex segment.

In this section we have seen how the ranking of the constraints acts to predict the child's production of target fricative + approximant clusters. While target stop + sonorant clusters are represented as complex segments, the high ranking of *COMPLEXSEGMENT&$_{ons}$*FRICATIVES and IDENT[cont] predicts that target fricative + approximant clusters are represented as sequences of two adjacent segments in the lexicon, rather than as complex segments. This is especially clear when we compare candidates (g) and (i) in (23). Candidate (g), the optimal candidate, corresponds to an input consisting of a sequence of two segments, whereas candidate (i) corresponds to a complex segment in the input. Candidate (i) ties with candidate (g) because they both violate one undominated constraint. But, moving down in the hierarchy, candidate (i) violates IDENT[son] in the next stratum of constraints. Therefore, candidate (g), derived from two consecutive segments in the input, is optimal. The principle of lexicon optimization tells us that the subject will thus select an input consisting of a sequence of two segments, rather than one complex segment, to store in the lexicon.

4.5 Adjunct Clusters

The third type of structure that must be accounted for is adjunct clusters. The initial /s/ of such clusters is traditionally analyzed as occupying the adjunct position, which is not dominated by the onset, but is dominated only at the syllable level (Levin 1985). Such an analysis is motivated by the fact that adjunct clusters differ from true clusters in that they violate the Sonority Sequencing Principle and also allow homorganic clusters. In the case of Subject 106, target adjunct clusters are reduced to the second element, while other target fricative clusters are reduced to the least sonorous segment, i.e. the fricative, as shown in (21). Representative data for the adjunct clusters are given in (24).

(24) Data for adjunct clusters[8]

a. Target /s/ + nasal clusters

[◆∴‥]   'snack'
[◆☉∩‥]   'snake'
[〒○∪‥]   'smoke'
[〒 ‖]   'small'

b. Target /s/ + stop clusters[9]

[○○∪‥]   'stove'
[○ ◁]   'stop'
[↕◁∪]   'spill'
[↕‥◆]   'spoon'

To account for these data, two additional constraints are required. These constraints and the final ranking are given in (25).

(25) Additional constraints and ranking

(a) MAX[nasal]: A nasal segment in the input must be present in the output.
(b) *ADJUNCT: Adjuncts are prohibited. (Adapted from Barlow 1998)

Ranking: MAX[nasal] >> *COMPSEG&_Ons_*W, *COMPONS, *R, PARSE, MAX, *COMPSEG&_Ons_*FRIC, IDENT[place]_COMPSEG_, IDENT[cont], *ADJUNCT >> *L, *DORSAL, IDENT[son] >> IDENT[place], *LABIAL >> *CORONAL, *COMPSEG, *W, *FRIC

The constraint *ADJUNCT prevents any candidate with a segment in the adjunct position from surfacing. The other constraint, MAX[nasal], prevents deletion of any nasal segments. MAX[nasal], a specific instance of MAX, must be ranked above the more general constraint and is thus undominated.

The tableau in (26) illustrates how [〒○∪‥] is chosen as the optimal output for input /‥〒○∪/ 'smoke'. In this tableau, a period after an initial segment indicates that this segment occupies the adjunct position. In this example, candidates (f), (g), (i) and (j) all violate the undominated MAX[nasal] constraint resulting in their elimination from consideration. Moving down to the next stratum of constraints, the remaining candidates each violate one constraint, resulting in a tie. Candidate (a) loses in the next level of constraints due to its violation of *DORSAL. The tie persists through the next stratum of constraints, in which the remaining candidates each incur two violations. As for the low-ranked constraints, candidate (h) only violates one of these while the remaining candidates each violate two or more, thus revealing candidate (h) as the winner.

(26) [〒○∪‥] produced for input /‥〒○∪

/‥〒○∪ /	MAX [nasal]	SECOND LEVEL OF CONSTRAINTS	*L	*DORS	ID [son]	ID [place]	*LAB	LOW-RANKED CONSTRAINTS
(a) ‥ 〒○∪		*ADJ		*!			*	*COR, *FRIC
(b) ‥ 〒○∪‥		*ADJ				*	*	*COR, *COR, *FRIC!
(c) ‥〒○∪‥		*COMPONS				*	*	*COR, *COR, *FRIC!
(d) (‥〒)○∪‥		*COMPSEG&*FRIC				*	*	*COMPSEG, *COR!, *COR, *FRIC
(e) (‥〒)○∪‥		ID[cont]				*	*	*COR, *COR, *COMPSEG!
(f) w○∪‥	*!	MAX				*	*	*COR, *W
(g) l○∪‥	*!	MAX	*			**		*COR, *COR
☞(h) 〒○∪‥		MAX				*	*	*COR
(i) ‥○∪‥	*!	*ADJ, MAX				*		*COR, *COR, *FRIC
(j) ‥○∪‥	*!	MAX				*		*COR, *COR,

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[8] Target /skw-/, /sk-/, /spl-/, and /spr-/ were all produced in delayed imitation so that data is not included here.
[9] Though it appears that the subject produces voiced stops for voiceless stops, it is likely that these voiceless stops are actually unaspirated voiceless stops, which were perceived as voiced stops.

							*FRIC
(k) ◆∘∪		MAX				**	*COR, *COR!

The tableau in (26) shows how an output is selected for a target adjunct cluster. What is unclear is whether the subject represents these clusters underlyingly as adjunct clusters or as simple sequences of two segments. Whether the output is derived from input adjunct clusters or sequences of two segments is irrelevant because *ADJUNCT and *COMPLEXONSET are dominated only by MAX[nasal]. Thus, any type of /s/ + stop cluster will never surface. Target adjuncts are also prevented from surfacing as complex segments because of undominated *COMPLEXSEGMENT&$_{ons}$*FRICATIVES. It appears that, because adjunct clusters and true fricative + approximant clusters are simplified in different ways, the subject makes a distinction between the two. It will be impossible to confirm whether there truly is a distinction until some of these structures begin to appear in the child's speech. If the subject represents target adjunct clusters as true clusters, then both types should appear in his production at the same time due to demotion of *COMPLEXONSET. If, on the other hand, the subject represents them differently, then adjuncts should appear before the true clusters, or vice versa, depending on whether *ADJUNCTS or *COMPLEXONSET is demoted first.

5. Conclusion

In the above account, it is claimed that Subject 106 has knowledge of two, or possibly three, structures. Target affricates and target stop + sonorant clusters are represented as complex segments. Target fricative + approximant clusters, on the other hand, are represented underlyingly as sequences of two adjacent segments. As for target adjunct clusters, it cannot be determined how they are represented, either as adjuncts or as sequences of two segments. All of this information is summarized in (27).

(27)

		Target English	S106's Production	S106's Representation
Complex Segments		[⋌ -] [○↗-]	[ℓ-] [○ℓ-]	Complex segments
True Clusters	**Stop + Sonorant Clusters**	[⋌ℓ-] [⟶-] [⸺-]	[⋌ℓ-] [ℓ-] [ℓ-]	Complex segments
	Fricative + Approximant Clusters	[ℓ-] [⟶-] [≻ -]	[⸺-] [⸺-] [≻-]	Sequence of two segments
Adjunct Clusters		[⋌-] [◆-]	[↕-] [◆-]	Adjunct clusters or sequences of two segments

Summary of Subject 106's productions

Such an account has certain theoretical implications. First of all, Archibald's claim that a contrast between /l/ and /r/ is a necessary prerequisite for production of consonant + liquid clusters is supported by such an account. Subject 106 cannot be said to have acquired a contrast between /l/ and /r/ since he fails to produce them in singletons. What appear to be consonant + liquid clusters are in reality complex segments. Thus, Subject 106's production is consistent with Archibald's claim.

This leads to an important question: how can Archibald's claim be translated into optimality theoretic terms? This is accomplished by proposing a conjoined constraint,

*COMPLEXONSET&_{Ons}*LIQUIDS.[10]   The conjoined constraint must always be ranked above its two individual conjuncts, *COMPLEXONSET and *LIQUIDS, which is consistent with independently motivated claims about constraint conjunction (Smolensky 1995). Thus, in order to achieve a ranking consistent with adult English, which allows consonant + liquid clusters, this conjoined constraint must be demoted below the relevant faithfulness constraints. As the conjoined constraint is demoted through the constraint hierarchy, it forces demotion of its two individual conjuncts in order to remain ranked above them. Therefore, the two individual conjuncts will be demoted below the relevant faithfulness constraints before the conjoined constraint. This predicts that both liquid consonants and complex onsets will emerge before consonant + liquid clusters.

Such a prediction has clear implications for treatment. For instance, if a child presents with /l/ but not /r/ in his phonemic inventory, and thus with no clusters, treatment on /r/ may force demotion of the constraint *R, predicting that the child will be able to produce both liquids as singletons. However, there may be no change in the child's production of clusters, since demotion of *R has no effect on the higher-ranked *COMPLEXONSET&_{Ons}*LIQUIDS. On the other hand, if the same child is treated on consonant + liquid clusters, thus forcing demotion of the conjoined constraint, it is predicted that the child will acquire not only /r/, but also consonant + liquid clusters.

This account is also consistent with Lleó and Prinz's (1997) claim that affricates must be acquired before clusters in onset position. Subject 106 fails to produce any affricates target-appropriately and also fails to produce any onset clusters. The subject does have some knowledge of branching structure at the segmental level, as evidenced by his production of target stop + sonorant clusters and target affricates as complex segments. This is compatible with previous studies of cluster acquisition. For example, Barlow and Dinnsen (1998), in their longitudinal account of the cluster development of a single subject, claim that the child first represents all clusters as single underlying segments. At later points in time, the child represents only certain clusters as complex segments, while others are represented as complex onsets. The account presented here offers further evidence for the hypothesis that branching structure emerges first at the segmental level, suggesting that the constraint *COMPLEXONSET must universally outrank *COMPLEXSEGMENT. Further research is needed to investigate such a claim.

While the above account reconciles the data from Subject 106 with Archibald's claim, similar analyses may be proposed for the other counterexamples discussed in section 3. For these four subjects, apparent consonant + liquid clusters may be analyzed as complex segments. The basic constraint rankings needed to achieve this are given in (28).

(28) Constraint rankings for Subjects 4T, 31, 38 and 44

(a) Subject 4T: *COMPLEXONSET&_{Ons}*LIQUIDS >> *S[11], *R, *DORSAL, IDENT[sonorant], IDENT[l][12], MAX, PARSE >> *LABIAL, IDENT[place], *L >> *CORONAL, *W, *COMPLEXONSET >> *COMPLEXSEGMENT

(b) Subject 31: *COMPLEXONSET&_{Ons}*LIQUIDS, IDENT[place]_{CompSeg} >> *R, *DORSAL, IDENT[sonorant], IDENT[l], MAX, PARSE >> *LABIAL, IDENT[place], *L >> *CORONAL, *W, *COMPLEXONSET >> *COMPLEX SEGMENT

(c) Subject 38: *COMPLEXONSET&_{Ons}*LIQUIDS >> *R, IDENT[sonorant], IDENT[l], MAX, PARSE, IDENT[place] >> *L, *COMPLEXONSET >> *COMPLEXSEGMENT

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[10] Such a constraint is not required in the above account due to the high ranking of the individual conjuncts. It is clear, however, that its inclusion in the tableaux would not affect the selection of optimal outputs in any of the examples.

[11] *S: Avoid the segment /s/.

[12] IDENT[l]: The segment [l] in the output must correspond to a /l/ in the input and vice versa.

(d)   Subject   44:   *COMPLEXONSET&$_{\text{ONS}}$*LIQUIDS   >>   *COMPLEXSEGMENT&$_{\text{ONS}}$*W, *FRICATIVES,   *COMPLEXSEGMENT&$_{\text{SEG}}$OCP[place][13]   >>   *R,   IDENT[sonorant], *COMPLEXONSET, MAX, IDENT[continuant] >> PARSE, IDENT[l]

In this way, the data for these subjects may be reconciled with Archibald's claim and they, like Subject 106, would no longer be considered counterexamples.

The above account provides evidence that supports the claims both of Archibald (1998) and of Lleó and Prinz (1997). This suggests overall that the acquisition of clusters is restricted by the acquisition of other structures. In other words, clusters may not be acquired until certain requirements, such as the acquisition of a contrast or the acquisition of branching structure at the segmental level, are met. Future research may uncover other prerequisites to the acquisition of complex onsets.

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[13] OCP[place]: Avoid adjacent identical place specifications.

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