Coda Formation vs. Onset Maximization: 
Issues in the Syllabification of VCV Sequences*

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The formation of syllable margins does not always give preference to onsets over codas. In the three cases analyzed here, coda formation overrides onset formation, preventing high sonority segments from being parsed as onsets, often resulting in violations of the maximal onset principle. In Taimyr Pidgin Russian and in some children’s acquisition of Japanese, rhotics are allowed only in coda position, driving epenthesis and neutralization respectively. In Lama, metathesis and obstruent sonorization work together to maximize sonority in codas while minimizing sonority in onsets.

**Keywords:** syllables, coda formation, maximal onset principle, intervocalic consonants, rhotics

1. Introduction

Under a rule-based analysis, basic syllabification is done in three steps (Steriade 1982): identify appropriate nuclei, assign as many pre-nuclear consonants (onsets) to the syllable as possible, then assign any remaining unassociated consonants as coda segments. This has become the standard approach to syllabification, as evidenced by syllabification discussions in introductory textbooks (see, for example, O’Grady, Archibald, Aronoff & Rees-Miller (2005: 87-89)). This approach to syllabification has the advantage of incorporating several of the universal tendencies associated with syllables typologically. For example, building onsets before codas and including as many segments as the language will allow in onset position incorporates the maximal onset principle (Blevins 1995, Itô 1986, Clements & Keyser 1983, among others). Given this approach, a /VCV/ sequence will be “universally syllabified as /…V.CV…/”

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1 Itô (1986) refers to this as the Principle of CV-Precedence, Clements and Keyser (1983) refer to it as The Onset First Principle.
(Blevins 1995: 230). In these discussions, the coda position seems to be given the role of 'catch-all', taking in whatever unassociated segments remain after onset formation. One argument put forth in this article is that the maximal onset principle is a much weaker principle than these discussions suggest.

While the maximal onset principle does play a large role in syllabification, violations of this principle do occur and have been discussed in the literature. Coda formation has been shown to override onset formation in order to satisfy other prosodic requirements. For example, there is a fairly substantial body of research arguing that some medial consonants (/VCV/ sequences) in English either are not codas throughout the derivation (resyllabification) or are not purely codas (ambisyllabicity) (see, for example, Kahn 1976, Selkirk 1982, Hammond 1997, Jensen 2000), dependent upon stress among other things. And Itô (1986) discusses parses of VCCV sequences as VC.CV in Icelandic when the consonant sequence would make a well-formed word-initial onset. But in most of these discussions, something other than pure syllabification triggers the violation of the maximal onset principle. It is more difficult to find discussion of coda formation triggering effects in other aspects of phonology. In this paper, we see several instances in which the necessity of parsing a segment as a coda rather than as an onset triggers other processes like prothesis and neutralization.

Research on coda formation is also complicated by issues surrounding the identification of coda segments. While intervocalic consonants are generally considered to be onsets even though they could also potentially be codas, word-final consonants often do not pattern as coda segments and cannot be assumed to be true coda segments. For example, Piggott (1999) argues that some word-final consonants are licensed as codas (Direct licensing) while other word-final consonants may be licensed as onsets (Indirect licensing). Others (Itô 1986 and Fudge 1969, for example) have argued for the extrasyllabic nature of some word-final consonants. Patterns such as these cause us to look word-internally for evidence of coda-triggered phonology.

There is a good deal of literature devoted to discussion of segmental restrictions on coda segments. Many languages restrict place of articulation in codas, ban specific segments from filling a coda position, or restrict specific segments to filling only coda position. For example, in Japanese, the only allowable codas are a nasal segment which assimilates in place of articulation to a following onset segment or the first half of a geminate obstruent (Itô 1986). And English (Giegerich 1992: 297-301) and many other languages allow the velar nasal [ŋ] only in coda position. In general, however, the expectation is that any consonant in a language can fill an onset position and that any segment allowed in coda position must also be allowed as an onset. Prince and Smolensky (1993: 160) make this explicit: "There are languages in which some possible onsets are not possible codas, but no languages in which some possible codas are not
possible onsets.” I argue against this position.

Discussion of the classes of consonants that are preferred in coda vs. onset position generally focus on sonority. While the preference is for comparatively low sonority segments in onset position, the preference in coda position is for comparatively high sonority segments. For example, Clements (1988, 1990) argues for a steep sonority rise over the first half of a syllable (a low sonority onset plus nucleus) and a shallow sonority fall over the second half of a syllable (nucleus plus high sonority coda). Likewise, Prince and Smolensky (1993) identify the most sonorous codas as the best (most harmonic) codas and the least sonorous onsets as the most harmonic. The preference for high sonority codas vs. low sonority onsets would argue for the possibility of a language in which some very high sonority segments are disallowed in onset position (because they are too sonorous) yet are possible coda segments (precisely because they are high sonority), contra the position stated above that the set of possible coda segments must be a subset of the set of possible onset segments. In addition, the sonority preferences for onsets vs. codas would also predict the possibility of violation of the maximal onset principle when a high sonority consonant is intervocalic.

This article addresses both issues, highlighting three languages where coda formation overrides other factors in syllabification. In section 2, a discussion of Taimyr Pidgin Russian (TPR) is provided. In TPR, we see an instance of a language in which the set of possible coda segments is not a subset of the possible onset segments. In this language, prothesis on word-initial /r/ and epenthesis within word-medial consonant clusters are both motivated by a ban on [r] in onset position. In Lama, discussed in section 3, obstruents are banned from coda position and in satisfying this ban, we see evidence of a phonology working to maximize sonority in codas while minimizing sonority in onsets. The ban on coda obstruents, coupled with obstruent-final stems and CV suffixes, creates a situation in which the CV of the suffix metathesizes in order to parse the stem-final obstruent as an onset and the higher sonority consonant of the suffix as a coda. Section 4 discusses an example of the acquisition of a high sonority consonant only in coda position before its acquisition in onset position. In some children’s acquisition of Japanese, the distinction between /d/ and /ɾ/ is neutralized in word-initial (onset) position while [ɾ] surfaces in intervocalic (coda) position. In section 5, a short optimality theoretic analysis of these phenomena is provided. Section 6 concludes the paper.

2. Taimyr Pidgin Russian Rhotic Codas

Taimyr Pidgin Russian (TPR, Stern 2005, 2009) is a Russian-lexifier pidgin spoken on the Taimyr Peninsula in northern Siberia among speakers of lan-
guages from several language families in addition to Russian. Nganasan (and Nenets and Enets in the west) are from the Samoyedic branch of the Uralic language family, Dolgan is a northern dialect of Yakut, a Turkic language, and Evenk is a Tungusic language. The syllable structure of the language is largely (C)V(C). Because Russian allows a variety of consonant clusters, one of the most obvious phonological characteristics of TPR is cluster reduction. Word-initial obstruent clusters usually undergo deletion of the initial consonant, as in (1a). Word-initial obstruent-sonorant clusters are usually simplified by the insertion of a vowel between the two consonants as in (1b) or in a few cases by metathesis as in (1c).

(1) TPR Russian² Gloss
   a. kól'ka skol'ko 'how much'
   b. barát brat 'brother'
   c. dilíný dlinnyí 'long'
   c. pirfół prishēl 'came' (Stern 2005: 298)

The deletion, epenthesis, and metathesis in (1) are all motivated by the ban on onset clusters in TPR. In each case, the resulting form can be syllabified as CV or CVC as in (2).

(2) Potential CV(C) syllabification in TPR

What is most interesting in TPR for the purposes of this paper, however, is that epenthesis also occurs in non-initial consonant-liquid clusters, as we see in TPR *matiri < Ru. smotri ‘look!’ (Stern 2005: 298). In this case, the epenthetic [i] breaking up the [tr] cluster is not motivated by the (C)V(C) syllable structure of TPR. The syllabification *[mat.ri] would fit the syllable template as we see in (3). The form with epenthesis, *matiri, would be parsed into syllables as [ma.ti.ri], also in (3), under most approaches to syllabification. While the syllabification of the epenthetic form (*matiri) does have simpler CV structure, TPR does not require CV structure and in some forms (such as pirfół in (2)) seems to prefer the creation of CVC syllables instead of adding additional CV.

² Russian words are transliterated from Cyrillic using the Library of Congress system.
syllables.

(3) Potential syllabification of *matri vs. matiri in TPR

\[ \text{O R O R } \text{vs. O R O R O R} \]
\[ \text{N C N N } \text{N} \]
\[ \text{*m a t r i m a t i r i} \]

In addition, TPR does not allow word-initial [r]. This restriction occurs in several of the languages spoken in Siberia (see, for example, Baertsch (2009) for a similar discussion of Sakha (Yakut) rhotics). In the examples given in (4), Russian words with initial [r] take a prothetic vowel in TPR.

(4) TPR Russian Gloss

\begin{tabular}{lll}
urúski & russkiï & 'russian' \\
urusát & rézat' & 'to cut' \\
urúba & ryba & 'fish' \\
\end{tabular}

(Stern 2005: 298)

In the examples in (4), like the epenthesis in (3), the prothetic vowel again seems to be unmotivated as far as syllable structure is concerned, as the comparison of *rúski vs. urúski in (5) shows.

(5) Potential syllabification of *rúski vs. urúski in TPR

\[ \text{O R O R } \text{vs. R O R O R} \]
\[ \text{N C N N C N} \]
\[ \text{*r u s k i u r u s k i} \]

The prothetic vowel in this case seems to be required solely to satisfy the ban on word-initial [r]. But the end result of the prothesis, metathesis, and epenthesis processes is that we see [r] either in coda position, as in pirföl in (2), or intervocally, as in barát in (2), matiri in (3), and urúski in (5).

Compare the situation in TPR with the well known prothesis on Spanish words with word-initial s-clusters (Harris 1983), which is also prominent in the acquisition of English by Spanish speakers (see, for example, Carlisle (1999)). Prothesis in Spanish is motivated by the syllable structure constraints on Span-
ish which do not allow adjunct clusters (s-clusters). Thus, a Spanish speaker faced with a form like English *step* is unable to syllabify the initial [s]. Spanish syllabification will incorporate *tep* into a syllable leaving the initial [s] stranded. The prothetic vowel provides a nucleus which allows the stranded [s] to be syllabified as the coda to the (new) initial syllable, as in (6).

(6) Syllabification of *estep* in Spanish

I argue here that, like Spanish s-clusters, the prothetic vowel in the TPR forms in (4) and (5) provide a nuclear vowel to which the following [r] can be attached as a coda segment and that all intervocalic [r] in TPR are parsed as coda segments. The epenthesis in initial obstruent-sonorant clusters (1), epenthesis in word-medial obstruent-sonorant clusters in (3), and prothesis on word-initial [r] in (4) all have the effect of putting [r] in intervocalic position, which makes a coda parse of the [r] as in (7) a viable option.

(7) Coda parse of intervocalic [r] in TPR

The coda parse of intervocalic [r] in conjunction with the metathesis in (1) and (2) which unambiguously puts [r] in coda position effectively provides a coda parse of all of the rhotics that surface in TPR. It removes the need for a ban on word-initial [r] in TPR and unifies all of the phenomena described above. It satisfies the preference for comparatively high sonority in coda position. It incorporates the dispreference for comparatively high sonority onsets. A number of onsetless syllables do occur under this analysis, but given that prothesis itself creates an onsetless syllable, this is clearly not problematic for TPR. We are left, then, with a requirement to parse [r] as a coda overriding the maximal onset principle in intervocalic position.
3. Lama Obstruent Codas

Like TPR, Lama (Lamba), a Gur language spoken in northern Togo (Ourso & Ulrich 1990) attracts high sonority segments to coda position and tries to minimize high sonority segments as onset segments. Lama is also primarily (C)V(C) but has stricter coda restrictions than TPR as it does not allow obstruents (low sonority) in coda position. And while there is no outright ban on high sonority segments in onset position in Lama, there are few environments in which glides and rhotics must be parsed as onsets.

The labial glide is allowed in word-initial position where it must be parsed as an onset and it contrasts with [p] in this position. It is allowed intervocally and contrasts with [p] in intervocalic position as well, but as we saw in the discussion of TPR above, there are two possible parses of an intervocalic consonant. Lama [awɔr] ‘place, position’ (Ourso & Ulrich 1990: 136) could be parsed as [aw.ɔr] as easily as [a.woɔr] in this case. Glides are also disallowed post-consonantly.

The ban on obstruent codas in Lama is responsible for several phonological processes. For example, /p/ surfaces as [w] when forced into coda position, as in (8).

(8) [p] ~ [w] alternation in Lama

\[ kpap\-\text{\textit{\textasciitilde}}} \quad \text{‘to be similar’} \quad kpaw-\text{\textit{\textasciitilde}}} \quad \text{‘to reconcile’} \]

\[ yap\-\text{\textit{\textasciitilde}}} \quad \text{‘to buy’} \quad yaw \quad \text{‘buy!’} \quad (\text{Ourso & Ulrich 1990: 136}) \]

The ban on obstruent codas is satisfied in inflectional morphology in two ways: deletion and metathesis. When an inflectional suffix of the form /-wa/ (past tense or class 2 noun suffix) follows a stem-final consonant other than /m/, the glide is deleted as in (9).

(9) Glide deletion in Lama

\[ /s\text{\textit{\textasciitilde}}}p+wa/ \quad \text{‘to die+past’} \rightarrow [s^{\text{\textit{\textasciitilde}}}p\text{\textit{\textasciitilde}}} \quad ‘died’} \]

\[ /w\text{\textit{\textasciitilde}}}t+wa/ \quad \text{‘to sell+past’} \rightarrow [w\text{\textit{\textasciitilde}}}t\text{\textit{\textasciitilde}}} \quad ‘sold’} \quad (\text{Ourso & Ulrich 1990: 137}) \]

Consonant-glide clusters rise in sonority and will therefore incur a violation of the Syllable Contact Law (Vennemann 1988). The violation of syllable contact is corrected by the deletion of the glide in each case. However, glide deletion accomplishes more than just the correction of the syllable contact violation.

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3 After /m/, the glide is strengthened to the homorganic stop [p].

4 After a vowel-final root, the glide surfaces: /n\text{\textit{\textasciitilde}}}+wa/ ‘to see’ → [n\text{\textit{\textasciitilde}}}wa] ‘saw’ (Ourso & Ulrich 1990: 137).
When a glide-initial suffix is added to a stem-final obstruent, something must occur to prevent a coda syllabification of the obstruent. Glide deletion not only prevents a high sonority segment from filling an onset position, it ensures that a lower sonority segment (in the example above, an obstruent) will fill the onset position and solves the problem posed by the potential coda obstruent.

When an inflectional suffix of the form /-rə/ (class 7 noun suffix) is added to a stem, the alternations that result again seem to be uniquely suited to avoid coda obstruents. When /-rə/ follows a stem-final obstruent, the suffix metathesizes to [ə-r] as in (10). This process allows the obstruent to be parsed as an onset and puts the relatively high sonority [r] in coda (word-final) position.

(10) Metathesis in Lama

/ɑkpet+rə/ → [ɑ.kpɛ.tə] ‘baboon (class 7)’
/waas+rə/ → [waas.ər] ‘viper (class 7)’
/asap+rə/ → [a.sə.pər] ‘red ant (class 7)’ (Ourso & Ulrich 1990)

After sonorant-final stems, metathesis does not occur. In these cases, the rhotic of the /-rə/ suffix strengthens to [ɖ], followed by the deletion of a stem-final non-nasal sonorant or place assimilation of a stem-final nasal sonorant, as in (11). The end result in these forms is again either a single intervocalic obstruent (in onset position) or a homorganic nasal-stop cluster.

(11) [r] strengthening in Lama

/məl+rə/ → [mə.qə] ‘millet (class 7)’
/sər+rə/ → [sa.qə] ‘frog (class 7)’
/yem+rə/ → [yen.qə] ‘hippo (class 7)’ (Ourso & Ulrich 1990)

Given the ultimate deletion of the stem-final sonorant in these forms, the strengthening of /r/ to [ɖ] would not be necessary simply to satisfy a syllable contact restriction. Strengthening results in a more preferred obstruent onset [ɖ] over the original, dispreferred, high sonority [r]. While strengthening after sonorants has the effect of minimizing sonority in onset position, strengthening cannot help the forms in (10). In the forms in (10), metathesis is required to avoid the potential obstruent coda.

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5 Ourso and Ulrich (1990) treat this as schwa deletion followed by schwa insertion rather than as metathesis. I prefer metathesis as a single process more in keeping with a parallel processing (optimality theoretic) approach rather than a serial (rule-based) approach to the data.

6 In addition to inflectional /-rə/, Ourso and Ulrich (1990) also discuss the agentive suffix /-rə/. The derivational suffix /-rə/ triggers slightly different phonology: [l] does not delete, nasal place assimilation is not present, [r] geminates with the suffixal [r], and stem-final [p] patterns with [w]. While the details are different, the effect is similar. The alternations avoid an onset parse of obstruent segments.
4. Acquisition of [d] and [ɾ] in Japanese

Coda effects are also evident in language acquisition. For example, Ueda and Davis (2001, 2005)\(^7\) discuss an interesting developmental path for the acquisition of Japanese /d/ and /ɾ/. At the earliest stage in this pattern, both /d/ and /ɾ/ surface as [d] in word-initial position as the data in (12) shows.

(12) Word-initial /d/ and /ɾ/ in Japanese, stage 1

/remeŋ/ → [demoŋ] ‘lemon’
/risu/ → [disu] ‘squirrel’
/daruma/ → [daduma] ‘tumbler’
/denʃa/ → [denʃa] ‘tumbler’ (Ueda & Davis 2005)

A pattern like this is not unusual as stops are some of the first sounds acquired word initially and children commonly employ a substitution strategy for sounds not yet acquired (see, for example, Ingram (1989) for common processes affecting child language acquisition). The stop [d] is very low sonority, making an excellent onset. The flap/tap [ɾ], on the other hand, is a very high sonority segment, differing from [d] in being [+son], but otherwise sharing place of articulation and voicing.

In word-medial (intervocalic) position, /d/ and /ɾ/ also both surface as [d], as shown in (13). Thus, target /d/ is produced target-appropriately both in word-initial and intervocalic position and target /ɾ/ always surfaces as [d] (word-initially and intervocically).

(13) Word-medial /d/ and /ɾ/ in Japanese, stage 1

/terebi/ → [te.de.bi] ‘television’
/sora/ → [so.da] ‘sky’
/namida/ → [na.mi.da] ‘tear’
/budoo/ → [buu.doo] ‘grape’ (Ueda & Davis 2005)

The intervocalic production of /d/ and /ɾ/ represented in (13) is also not surprising. In each case, the surface [d] is parsed as an onset segment.

Following a period of transition in which intervocalic /ɾ/ is produced variably as [d] or [ɾ] (Ueda & Davis' stage 2), there is a stable period during which intervocalic /ɾ/ is always produced as [ɾ], but word-initial [ɾ] still surfaces as

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\(^7\) Ueda and Davis (2001, 2005) discuss two different developmental paths to the acquisition of /d/ and /ɾ/. The path of primary interest in this paper is labeled Type I in Ueda and Davis (2001) and as Type B in Ueda and Davis (2005). The other path (Type II/Type A in Ueda and Davis 2001, 2005, respectively), which Ueda and Davis (2001) identify as clinically more serious than Type I is not discussed in this paper. It involves non-adult-like underlying representations at the early stages on my analysis and has little to add to the present discussion.
[d] (stage 3 for Ueda & Davis). It is this stage that is of primary interest to us in this paper. The acquisition of [ɾ] intervocally before its acquisition in word-initial position seems somewhat odd if in both cases the [ɾ] is in onset position. However, we again have a case of a high sonority intervocalic consonant ([ɾ]) with no corresponding word-initial consonant. If [ɾ] can be parsed as an onset in the middle of a word, it should also be allowed as an onset at the beginning of a word. But, as a high sonority segment, [ɾ] makes a fine coda segment. I argue that at this stage, the child acquiring Japanese has acquired [ɾ] as a coda segment, as in (14) below. This situation is similar to the situation in TPR above in which /r/ cannot surface in onset position but it is allowed in coda position.

(14) Syllabification of [sora] ‘sky’ vs. [namida] ‘tear’ in Japanese, stage 3

The syllabification in (14) provides an explanation for the continued substitution of [d] for /r/ in word-initial position at this stage. The child’s syllable template does not yet allow for segments as sonorous as [ɾ] in onset position but does allow [ɾ] in coda position. This is clearly not the case in adult Japanese where a coda parse of [ɾ] would violate Coda Condition (‘codas must be place linked to a following onset’, Itô 1989, Itô & Mester 1994). Until the Coda Condition becomes active in the child’s speech, a coda parse of [ɾ] is certainly viable.

While it is not uncommon for children to acquire segments in word-initial position first, it is less common for children to acquire segments in intervocalic position first, as in the data presented above. However, when segments are acquired intervocally first, those segments tend to be sonorants. For example, Bernhardt and Stemberger (2002) present data on the acquisition of intervocalic consonants by 44 English speaking children with phonological delays and found that 11.4% of the children in their study who had acquired [l] or [ɹ] showed a pattern in which [l] and/or [ɹ] surfaced in intervocalic position only (not in word-initial position and not in word-final position). The next most common segment to appear in intervocalic position only was [d] (which they suggest may be flap [ɾ]) at 4.5%. On my analysis here, I would expect these intervocalic-only patterns to be characteristic of children who treat the approximants as coda segments, along with a substantial number of the 20% of
children they studied who showed a pattern of both intervocalic and word-final approximants (see, however, Piggott (1999) for discussion of word-final vs. syllable-final segments).

Following another period of transition (Ueda & Davis' stage 4) in which word-initial /ɾ/ surfaces variably as [d] or [ɾ], an adult-like production of both /d/ and /ɾ/ becomes the norm (stage 5 for Ueda & Davis). At this point, the child correctly produces /ɾ/ as [ɾ] in word-initial position as well as in intervocalic position. It is at this stage that onset [ɾ] is allowed to surface. On my analysis here, however, this is not necessarily an adult-like representation. I would argue that either of the syllabifications given in (15) are possible at this stage and that until the Coda Condition becomes active in the child's language, both possibilities remain viable.

(15) Syllabification possibilities for [sora] 'sky' in Japanese, stage 5

Once Coda Condition has taken root, the onset parse will be the only possible syllabification for an intervocalic [ɾ] and the production will then be adult-like.

5. An Optimality-theoretic Analysis of Coda Effects

Within Optimality Theory, maximal onset principle effects result from the interaction of the Onset and NoCoda constraints. An intervocalic consonant parsed as an onset will incur violation of neither constraint while that same intervocalic consonant parsed as a coda will incur violations of both constraints. Therefore, on the basis of just these two constraints, the onset parse will always win. In order for the coda parse to win, both constraints must be low ranking in the language under discussion (evidenced by the presence of onsetless syllables and codas, respectively) and their effects must be completely overridden by other constraints. Adopting the split margin approach to syllabification presented in Baertsch (1998, 2002), coda constraints can interact with onset constraints and relevant Faithfulness constraints deriving the effects described in the previous sections of this article. On this approach, one margin hierarchy (M₁) governs a singleton onset, capturing the preference for low sonority onsets and, interacting with the Onset constraint and Faithfulness con-
straints, governs whether onsets are required and identifies the set of possible onsets (as does Prince & Smolensky’s (1993) Margin Hierarchy). A second margin hierarchy (M$_2$) governs coda segments, capturing the preference for high sonority codas and, interacting with Faithfulness constraints, M$_1$ constraints, and Peak constraints, determines the set of possible coda segments in a language. The M$_1$ and M$_2$ hierarchies are given in (16) with the relevant sonority levels necessary for the current analyses.

(16) The margin hierarchies

M$_1$ hierarchy (governing onsets):

$\ldots*M_1/\{+hi\} >> *M_1/r >> *M_1/l >> *M_1/Nas >> *M_1/Obs$

M$_2$ hierarchy (governing codas):

$*M_2/Obs >> *M_2/Nas >> *M_2/l >> *M_2/r >> *M_2/\{+hi\} \ldots$

The interaction of these margin constraints with Faithfulness constraints can create a situation in which an intervocalic segment will be parsed as a coda segment rather than being parsed as an onset segment. Taking up the Japanese analysis in section 4 again, at the first stage, both /d/ and /ɾ/ surface as [d] whether in word-initial position or in intervocalic position. In both word-initial and intervocalic position, the surface [d] is parsed as an onset (a violation of *M$_1$/Obs). Since *M$_1$/Obs is the lowest ranked constraint in the M$_1$ hierarchy, we would expect to find obstruents in onset position very early in the acquisition process. Thus, the winning candidate for underlying /d/ is faithful and parsed as an onset segment (violating *M$_1$/Obs, but avoiding violation of Id[son]) whether in word-initial or intervocalic position, as shown in the tableaux in (17).

(17) Underlying /d/ in word-initial and intervocalic position, stage 1

<table>
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<th>Surface</th>
<th>M$_2$/Obs</th>
<th>M$_1$/r</th>
<th>M$_2$/r</th>
<th>Id[son]</th>
<th>M$_1$/Obs</th>
<th>CodaCond</th>
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</tbody>
</table>

At this stage, both *M$_1$/r and *M$_2$/r (governing rhotics in onset and coda positions, respectively) dominate Id[son], making it more harmonic to change the [sonorant] feature of an underlying /ɾ/ to [d] than to force [ɾ] to surface in either onset or coda position. It is this ranking that neutralizes the distinction
between /d/ and /ɾ/ in both word-initial and intervocalic environments, as the tableaux in (18) illustrate.

(18) Underlying /ɾ/ in word-initial and intervocalic position, stage 1

<table>
<thead>
<tr>
<th></th>
<th>/ra/</th>
<th>*M₂/Obs</th>
<th>*M₁/r</th>
<th>*M₂/r</th>
<th>Id[son]</th>
<th>*M₁/Obs</th>
<th>CodaCond</th>
</tr>
</thead>
<tbody>
<tr>
<td>→</td>
<td>[da]</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ra]</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ara/</td>
<td>*M₂/Obs</td>
<td>*M₁/r</td>
<td>*M₂/r</td>
<td>Id[son]</td>
<td>*M₁/Obs</td>
<td>CodaCond</td>
</tr>
<tr>
<td>→</td>
<td>[a.da]</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ad.a]</td>
<td>*!</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[a.ra]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ar.a</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

In both of the tableaux in (18), candidates with a segment faithful to the underlying /ɾ/ incur fatal violations of *M₁/r if parsed in onset position or *M₂/r if parsed in coda position. The winning candidate is the candidate that turns the /ɾ/ into an obstruent ([d]), regardless of environment.

At the next stage, *M₂/r has been demoted below Id[son], allowing [ɾ] to surface, but only in coda position, therefore it surfaces in intervocalic position but /ɾ/ remains [d] in word-initial position (where it cannot be parsed as a coda segment without incurring violation of some other very high ranked constraint such as Dep). We see this in the tableaux in (19).

(19) Underlying /ɾ/ in word-initial and intervocalic position, stage 3

<table>
<thead>
<tr>
<th></th>
<th>/ra/</th>
<th>*M₂/Obs</th>
<th>*M₁/r</th>
<th>Id[son]</th>
<th>*M₂/r</th>
<th>*M₁/Obs</th>
<th>CodaCond</th>
</tr>
</thead>
<tbody>
<tr>
<td>→</td>
<td>[da]</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ra]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>ara/</td>
<td>*M₂/Obs</td>
<td>*M₁/r</td>
<td>Id[son]</td>
<td>*M₂/r</td>
<td>*M₁/Obs</td>
<td>CodaCond</td>
</tr>
<tr>
<td>→</td>
<td>[a.da]</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ad.a]</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[a.ra]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>ar.a</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

This is the constraint ranking that corresponds to the syllable structure tree given in (14), above. Once the demotion of *M₂/r is completed, the violation

---

8 I follow Tesar and Smolensky (1998, 2000) in treating the change in the child’s constraint hierarchy as constraint demotion (in this case demotion of the *M₂/r constraint) rather than constraint promotion. However, because the changes at stage 3 and 5 both involve constraints that are demoted below Id[son], it gives the impression that the Id[son] constraint is moving up the hierarchy.
of Id[son] incurred by the candidate with [d] corresponding to /ɾ/ becomes fatal, leaving [aɾ.a] as the winning candidate. The demotion of *M₂/r has no effect on the realization of underlying /d/, shown in (20).

(20) Underlying /d/ in word-initial and intervocalic position, stage 3

<table>
<thead>
<tr>
<th></th>
<th>M₂/Obs</th>
<th>M₁/r</th>
<th>Id[son]</th>
<th>M₂/r</th>
<th>M₁/Obs</th>
<th>CodaCond</th>
</tr>
</thead>
<tbody>
<tr>
<td>/da/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>→</td>
<td>[da]</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>[ɾa]</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>/ada/</th>
<th>M₂/Obs</th>
<th>M₁/r</th>
<th>Id[son]</th>
<th>M₂/r</th>
<th>M₁/Obs</th>
<th>CodaCond</th>
</tr>
</thead>
<tbody>
<tr>
<td>→</td>
<td>[a.da]</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>[ad.a]</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[a.ɾa]</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[a.ɾa]</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

In what Ueda and Davis (2001, 2005) identify as stage 5 (the adult-like representation), the *M₁/r constraint has been demoted below Id[son], allowing [ɾ] to surface as an onset segment. It is at this stage that [ɾ] surfaces in word-initial position, as we see in (21).

(21) Underlying /ɾ/ in word-initial and intervocalic position, stage 5

<table>
<thead>
<tr>
<th></th>
<th>M₂/Obs</th>
<th>Id[son]</th>
<th>M₁/r</th>
<th>M₂/r</th>
<th>M₁/Obs</th>
<th>CodaCond</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ɾa/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>→</td>
<td>[ɾa]</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>/aɾa/</th>
<th>M₂/Obs</th>
<th>Id[son]</th>
<th>M₁/r</th>
<th>M₂/r</th>
<th>M₁/Obs</th>
<th>CodaCond</th>
</tr>
</thead>
<tbody>
<tr>
<td>[a.ɾa]</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

Note here, though, that the winning candidate for the intervocalic /ɾ/ is still the coda parse. This will continue to be the case either until *M₁/r is demoted below *M₂/r or until *M₁/r is demoted below CodaCond. At that point, the child’s grammar will be truly adult-like with respect to the syllabification of [ɾ].

In the case of Lama in section 3 above, the M₂ constraints are interacting with Faithfulness constraints in a similar way. Here, it is the high ranking *M₂/Obs which triggers the effects described. *M₂/Obs and MaxObs (‘Do not delete obstruents’) both dominate the Linearity constraint (‘No metathesis’, McCarthy & Prince 1995). This ranking allows metathesis of the /-ɾə/ suffix, which avoids parsing obstruents in coda position while retaining those obstruents in the surface realization, as we see in (22). Deleting the consonant of the
suffix is not a viable option as it would neutralize the distinction between this suffix and other inflectional suffixes (like the class 4 suffix /-ña/).

(22) Metathesis in Lama

<table>
<thead>
<tr>
<th>/waas+rə/</th>
<th>*M₂/Obs</th>
<th>Max[Obs]</th>
<th>*M₁/r</th>
<th>*M₂/r</th>
<th>Lin</th>
<th>*M₁/Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>[waas.ɾə]</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[waa.ɾə]</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[waar.ə]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[waat.ə]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When a stem is not obstruent-final, metathesis is no longer optimal, as we see in (23). The stem-final sonorant is deleted, avoiding violation of the *M₂ constraints, and the suffix-initial /r/ is strengthened to [ɾ], avoiding violation of *M₁/r and *M₂/r. In both metathesis and strengthening, the *M₂ constraints/coda constraints play a major role in the selection of the winning candidate.

(23) [ɾ] strengthening in Lama

<table>
<thead>
<tr>
<th>/məl+rə/</th>
<th>*M₁/r</th>
<th>*M₂/l</th>
<th>*M₂/r</th>
<th>Lin</th>
<th>Max[Son]</th>
<th>Id[son]</th>
<th>*M₁/l</th>
<th>*M₁/Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>[məl.ɾə]</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[məl.ɾə]</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[məl.ɾə]</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[məl.ɾə]</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Finally, in the case of Taimyr Pidgin Russian, it is the high ranking (essentially undominated) *M₁/r coupled with a low ranking *M₂/r that creates the unusual situation in which /r/ cannot be parsed as an onset segment while it does surface in coda position, as we see in (24). Note in this tableau that it is only the [ɾ] which is parsed as a coda. Other intervocalic consonants like the [b] in the final syllable are parsed as onsets following the maximal onset principle.

(24) Prothesis in TPR

<table>
<thead>
<tr>
<th>/ruba/</th>
<th>*Complex</th>
<th>*M₁/r</th>
<th>Dep</th>
<th>*M₂/Obs</th>
<th>*M₂/r</th>
<th>*M₁/Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ru.ba]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>[u.ru.ba]</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ur.ub.a]</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>
In TPR, it is the ranking *M₁/r >> Dep >> *M₂/r that forces [r] into coda position. This ranking, in conjunction with the ban on onset clusters (encoded in the constraint ranking as *Complex) motivates the epenthesis in consonant clusters with [r] as a second member, whether that cluster is word-initial as in (25) or word-medial.

(25) Epenthesis in TPR

<table>
<thead>
<tr>
<th></th>
<th>/brat/</th>
<th>*Complex</th>
<th>*M₁/r</th>
<th>Dep</th>
<th>*M₂/Obs</th>
<th>*M₂/r</th>
<th>*M₁/Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>[brat]</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>[ba.rat]</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>→</td>
<td>[bar.at]</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

In each of the three languages analyzed in this section, the role of the M₂ hierarchy has been an important one. *M₂/r is in each case dominated by *M₁/r, making a coda parse of a rhotic preferable to an onset parse, and *M₂/r is dominated by some active Faithfulness constraint. These are the conditions necessary to overrule the maximal onset principle in the OT analysis. In addition, if *M₁/r dominates Faith, rhotics will not be allowed in onset position at all.

6. Conclusion

While onset position is clearly important in the syllabification of underlying strings of segments, this paper has focused on effects motivated by sonority based coda restrictions. The maximal onset principle is indeed a strong preference but is not universal, even in the syllabification of VCV sequences, as the discussion of Taimyr Pidgin Russian has shown. In this case, prothesis and epenthesis provide syllable nuclei to which coda rhotics may attach. In the discussion of the acquisition of Japanese, the coda status of [ɾ] explains the neutralization of [ɾ] and [d] word-initially. In both cases, the primacy of parsing high sonority segments as codas overrides both the maximal onset principle and the principle that possible coda segments must be a subset of possible onset segments. While the argument here was made with languages in which clear-cut examples of onset rhotics were completely absent, one question to consider now is where the dividing line is in languages where the same high sonority segment can fill either onset or coda position. That is, in the VCV context, at what point does syllabification produce VC.V vs. V.CV? In Lama, the labial glide prefers coda position but can be coerced into onset position word-initially. Perhaps the English-speaking children discussed briefly in section 4 will continue to syllabify liquids as codas when possible and as onsets
only when necessary even after acquiring word-initial liquids. I leave this as one avenue for future research.

The optimality theoretic analysis provided here focuses on the two margin positions (onset and coda). Such an analysis captures the sonority preferences in both positions, accounts for the syllabifications discussed here, and predicts similar situations in other languages. But both margin hierarchies employed in this analysis interact with the peak hierarchy (governing nuclear position) as well. The focus in this paper has been on liquids rather than glides. Glides are more sonorous than liquids, thus we would expect them to be more susceptible to a coda parse. But it is at this point in the sonority scale where we see a three-way competition among peak, coda, and onset. Depending upon the ranking of the margin constraints vis-à-vis the peak constraints, a high vowel/glide may (but need not) always be pulled into peak position rather than coda position. Or it may be preferred in coda position over onset position. This is certainly another profitable area for future work.

Margin formation is not simply a matter of building appropriate onsets and peaks and leaving unparsed segments to fill coda slots. The analysis provided here argues for a much more active role for coda formation. The maximal onset principle is not universal, even for VCV sequences. Not all consonants must be available to a language as onset segments. We must be willing to consider the possibility that coda formation is responsible for at least some of the phonology we see.

References


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