Strength relations between consonants: a syllable-based OT approach

Karen Baertsch and Stuart Davis

1. Introduction

This paper examines strength or sonority relations between consonants within and across syllable boundaries with a specific focus on the relationship between onset clusters and codas on the one hand, and the relationship between onset clusters and syllable contact sequences on the other.

Let us first consider the relationship between onset clusters and codas. While there is an abundance of work that examines the nature of onset clusters and codas (both within individual languages and across languages) very little research has examined the relationship that exists between onset clusters and codas. Kaye and Lowenstamm (1981) proposed an implicational universal based on theoretical grounds that the presence of a complex onset in a language implies the presence of a coda in that language. Both the empirical evidence for this proposal and the consequences of this proposal for syllable phonology have largely gone unexamined. One implication of Kaye and Lowenstamm’s proposal for syllable typology is that maximal syllable types would be as in (1a–c) while (1d) would be ruled out (contra Blevins 1995).

(1) Maximal syllable types under Kaye and Lowenstamm’s proposal
   a. CV   b. CVC   c. CCVC   d. *CCV

While there are indeed languages that do have CCV as their maximal syllable (e.g. Fongbe, Lefebvre and Brousseau 2002), its relative infrequency suggests that Kaye and Lowenstamm’s implicational universal may at least be a real typological tendency. Another type of example illustrating the relationship between onset clusters and codas concerns parallel diachronic developments affecting both of these. Davis and Baertsch (2005a) discuss the development of Pali from Sanskrit (Zec 1995; Wetzel and Hermans 1985) and Middle Indic from Sanskrit more generally (Vaux
1992). Sanskrit allowed coda consonants in a fairly unrestricted way and true onset clusters (i.e. obstruent + sonorant clusters), but Pali has tight restrictions on the coda and does not allow onset clusters. They also discuss the development of Campidanian Sardinian (Bolognesi 1998) from Latin where historic /l/ has changed to /r/ both in coda position and as the second member of an onset, but remains /l/ as a single onset. Davis and Baertsch (2005a) maintain that such diachronic changes affecting both onset clusters and coda segments are connected and are not independent developments.

Another relationship that we will consider in this paper is that between onset clusters and syllable contact sequences (i.e. a consonant sequence over a syllable boundary). Consider, for example, the comparison of Standard Bambara which is a CV language (ignoring a possible coda nasal which some consider as syllabic) with Colloquial Bambara. Through vowel syncope, Colloquial Bambara has developed onset clusters and syllable contact sequences as seen in (2) below (data from Diakite 2006).

(2) Standard versus Colloquial Bambara

<table>
<thead>
<tr>
<th>Standard</th>
<th>Colloquial</th>
</tr>
</thead>
<tbody>
<tr>
<td>buu.ru</td>
<td>[bru]</td>
</tr>
<tr>
<td>mo.ri.ba</td>
<td>[mor.ba]</td>
</tr>
<tr>
<td>ma.ri.fa</td>
<td>[mar.fa]</td>
</tr>
<tr>
<td>ba.ra.ma</td>
<td>[bra.ma] or [bar.ma]</td>
</tr>
<tr>
<td>fa.ra.ti</td>
<td>[fra.ti] or [far.ti]</td>
</tr>
<tr>
<td>kabila</td>
<td>[ka.bl]</td>
</tr>
<tr>
<td>melekuya</td>
<td>[mel.ku.ya]</td>
</tr>
</tbody>
</table>

The above examples not only show the simultaneous development in Bambara of onset clusters and syllable contact sequences, but they also show a link between the nature of the coda and the second member of the onset cluster: namely, both are consonants of high sonority. The high sonority preference for these positions has been noted by various researchers as a cross-linguistic tendency. Some researchers such as Clements (1990), Zec (1988), and Orgun (2001) have noted the preference for coda consonants to be of high sonority and have suggested constraints on coda sonority that give preference to high sonority codas. Other researchers such as Gouskova (2001), Smith (2003), and Green (2003) have focused on onset clusters, positing constraints on sonority distance or compound/conjoined constraints that have the effect of favoring a high sonority consonant as the second member of an onset cluster. The connection between these two
positions has also been observed in the phonological acquisition literature by such researchers as Levelt and van de Vijver (1998), Levelt, Schiller, and Levelt (1999), and Lleó and Prinz (1996). But none of these researchers formally propose to connect the high sonority preference for these two positions in the syllable. In §2 of this paper, we will offer a model of the syllable, the split margin approach, which formally relates the second member of the onset with a coda and will pursue some of the implications of this. In §3 of the paper, we will briefly discuss the analysis of onset clusters under the split margin approach. In §4 of the paper, we will explore the formal links between onset clusters and codas by examining their patterning in Campidanian Sardinian and Bambara. §5 explores the formal links between onset clusters and syllable contact sequences. §6 concludes the paper with directions for future research.

2. The split margin approach to the syllable

In §1, we noted Kaye and Lowenstamm’s (1981) proposed implicational universal that the presence of an onset cluster in a language implies the presence of a coda. We also noted links between onset clusters and codas such as the high sonority preference for both the coda consonant and the second member of an onset cluster. In this section we will offer a formal way of understanding these links through a presentation of the split margin approach to the syllable, originally developed in Baertsch (2002) and Baertsch and Davis (2003ab). After presenting the split margin approach we will briefly consider an application of it to developmental phonology and to a synchronic problem in Winnebago (Hocank).

The split margin approach to the syllable expands on Prince and Smolensky’s (1993) Margin Hierarchy which gives preference to consonants of low sonority in all margin positions within the syllable. While this captures very well the preference for single onset segments, it says little about the preference for high sonority in other margin positions. The split margin approach views the margins of a syllable as being composed of two types of structural positions rather than Prince and Smolensky’s one. This provides us with the theoretical construct to account for the behavior of each position individually as well as the interaction between positions within and across syllables.

In Baertsch’s (2002) split margin approach to the syllable, Prince and Smolensky’s (1993) Margin Hierarchy expressed as optimality-theoretic constraints is augmented so as to distinguish between structural positions
that prefer low sonority (a syllable-initial consonant) and those preferring high sonority (codas and the second member of an onset cluster). Prince and Smolensky’s Margin Hierarchy is retained in this approach as the $M_1$ hierarchy, given in (3), which addresses the low sonority preference for singleton onsets and the first segment of onset clusters.

(3) The $M_1$ hierarchy

*\(M_1/[-\h]\) >> *\(M_1/[+\h]\) >> *\(M_1/r\) >> *\(M_1/l\) >> *\(M_1/Nasal\)

The $M_2$ hierarchy given in (4) addresses the preference for high sonority in singleton codas and in the second segment of onset clusters. In this way, the $M_2$ hierarchy is similar to Prince and Smolensky’s Peak Hierarchy as far as sonority is concerned.

(4) The $M_2$ hierarchy

*\(M_2/Obstruent\) >> *\(M_2/Nasal\) >> *\(M_2/l\) >> *\(M_2/r\) >> *\(M_2/[+\h]\)

>> *\(M_2/[+\l]\)

We retain Prince and Smolensky’s Peak Hierarchy and note that while the $M_2$ hierarchy in (4) appears to allow and even prefer ([+\l]) vowels in what would be margin positions, these segments are also subject to the Peak Hierarchy which draws such segments into peak position rather than allowing them to surface as coda segments. The $M_1$ hierarchy interacts with the Peak hierarchy in a similar way, preventing vowels from surfacing in onset position, as we see in (5).

(5) The $M_2$ hierarchy in competition with the Peak hierarchy

<table>
<thead>
<tr>
<th></th>
<th>*(M_2/[+\h])</th>
<th>*(M_2/[+\l])</th>
<th>*(P/[+\h])</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ui/</td>
<td>(\approx) (i_{\l})</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>(i\text{er})</td>
<td>*1</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>(i\text{id}2)</td>
<td>*1</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>(i\text{is}2)</td>
<td>*1</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

In this rather simplified example, subscripts indicate the surface position of the underlying high vowel. The second candidate, in which the second high vowel is parsed as a coda consonant is rejected in favor of the first candidate which parses both vowels in peak position. The third candidate, in
which the first high vowel is parsed as an onset consonant is likewise re-
jected.  

Under the split margin approach, the structure of a syllable and the con-
straint hierarchies that are active in each structural position are shown in
(6), which depicts a language that allows both complex onsets and coda
segments.

(6) Syllable-internal structure

\[ \sigma \]

\[ \text{Onset} \quad \text{Rhyme} \]

\[ \text{Nucleus} \quad (\text{Coda}) \]

\[ M_1 \quad (M_2) \quad P \quad M_2 \]

This construct also allows us to examine the relationship across a syllable
boundary – the syllable contact relationship. The syllable contact environ-
ment is shown in (7)

(7) Syllable contact environment

\[ \omega \]

\[ \sigma \]

\[ \text{Onset} \quad \text{Rhyme} \quad \text{Onset} \quad \text{Rhyme} \]

\[ \text{Nucleus} \quad (\text{Coda}) \quad \text{Nucleus} \quad (\text{Coda}) \]

\[ M_1 \quad (M_2) \quad P \quad M_2 \]

At the syllable juncture, a syllable-final \( M_2 \) segment (a coda) is adjacent to
a syllable-initial \( M_1 \) segment (an onset or the first segment of an onset clus-
ter). Note that in the syllable-internal situation in (6), a consonant cluster

\[ ^1 \text{However, there may be language-specific rankings in some languages that give} \]

\[ ^1 \text{preference to one of the other candidates in (5). In general, we will not discuss the} \]

\[ ^1 \text{patterning of glides in this paper. They can either surface as margin segments or} \]

\[ ^1 \text{peak segments depending on the language, a fuller discussion of which is beyond} \]

\[ ^1 \text{the scope of this paper.} \]
consists of an M₁ segment adjacent to an M₂ segment as well. The difference between the two situations is that within the syllable (complex onset), the adjacent segments under discussion are dominated by a syllable node. In the syllable contact situation, the adjacent segments are not dominated by a syllable node, but rather by a higher domain (the phonological word in this example).

This theoretical approach affords us a number of advantages in syllabification. The M₁ hierarchy encodes the preference for low sonority segments in singleton onset position and in its interaction with faithfulness constraints allows for a ‘maximum sonority level for singleton onsets’ beyond which segments will simply not be parsed as onsets. In some cases, this maximum level may be very high (non-high vowels are absolutely banned from onset position in English) or lower on the sonority scale (as in Yakut, where rhotic consonants along with any segments more sonorous than rhotics are banned (Baertsch 2002)). The same (M₁) hierarchy interacts with the M₂ hierarchy and the Peak hierarchy to determine which segments are (dis)preferred in onset position in comparison with other syllable positions.

The M₂ hierarchy encodes the preference for high sonority segments in singleton coda position and its interaction with faithfulness constraints determines a ‘minimum sonority level’ for codas. In interaction with the M₁ hierarchy and the Peak hierarchy, the M₂ hierarchy determines which segments prefer to be in coda position as opposed to the other available positions. The interaction of the M₁ and M₂ hierarchies can determine the outcome of a single intervocalic consonant. If the segment is on the high sonority end of the sonority scale, as the flap is in English, it may be syllabified as a coda segment followed by an onsetless syllable (VC,V) in violation of the Maximal Onset Principle. If, on the other hand, the segment is on the low sonority end of the scale, it will certainly be syllabified as an onset (V.CV) in accord with the Maximal Onset Principle.

The split margin approach to the syllable provides us with a theoretical explanation for some previously puzzling facts as well. For example, in acquisition, it is possible for children to display an asymmetrical pattern of segmental acquisition in onset vs. coda position. Fikkert (1994) describes such a child, Jarmo, who, at about two years of age, had acquired obstruents and nasals in onset position (as singleton onsets). This acquisition pattern is in accord with the split margin approach in that he began acquiring onsets on the low sonority end of the scale and was working his way up from that point. At the same point in time, he had also begun to produce some coda segments in word-internal position. We focus here on the word-
internal coda position primarily because of the question of whether word-final consonants are codas or are adjoined to the word (see Piggott 1999 for a detailed discussion of this phenomenon). In word-final position Jarmo’s production was somewhat more erratic, however, in word-internal position he produced only laterals and rhotics as singleton codas. This is also consistent with the split margin approach in that he began acquiring codas on the high sonority end of the scale and was working his way toward the low sonority end of the scale. What surprised Fikkert and seemed not to fit well into the sequence of acquisition predicted by the theory at that time, was that Jarmo had also begun to produce some onset clusters consisting of obstruent plus liquid at that time. This was difficult to explain in the framework Fikkert was employing primarily because the expectation was that the segments that surfaced in onset clusters (whether in first or second position) should be segments that are also produced as singleton onsets.

Under the split margin approach, the acquisition pattern just discussed is expected to occur. Under this approach, the acquisition of the onset position itself will be accomplished by the demotion of *M₁/Obstruent below FAITH followed by the additional demotion of *M₁/Nasal below FAITH to produce the onset inventory Jarmo displayed. The acquisition of the coda position is independent of the acquisition of onsets and proceeds by the demotion of *M₂/[r] below FAITH (while *P/[r] continues to dominate FAITH) followed by the demotion of *M₂/[l]. Because the second onset position is also an M₂ position, the ranking FAITH >> *M₂/[r] along with the demotion of *COMPLEXONSET below FAITH as shown in the diagram in (8) is sufficient for onset clusters consisting of an obstruent plus rhotic to surface in the child’s speech even though he has not yet acquired rhotics as singleton onsets at this point in time.

(8) Constraint ranking for acquisition

```
*M₁/[r]          *M₂/Obstruent
    |              |
*M₁/[l]      *M₂/Nasal
    |    |    |    |    |    |
FAITH  *M₁/Nasal *COMPONS  *M₂/[l]    |
          |    |          |
*M₁/Obstruent  *M₂/[r]
```
This constraint ranking allows for obstruents and nasals as single onsets (i.e. *M₁/Nasal and *M₁/Obstruent are ranked below FAITH); it allows for laterals and rhotics to be single codas (i.e. *M₂/[l] and *M₂/[r] are ranked below FAITH), and it allows for complex onsets of obstruent-plus-liquid (i.e. *COMPLEXONSET is ranked below FAITH), thus accounting for Jarmo’s acquisition pattern.

An additional application of the split margin approach to the syllable comes from Dorsey’s Law in Winnebago (Hocank). Dorsey’s Law breaks up potential obstruent-sonorant onset clusters by inserting an epenthetic vowel between these two segments as we see in (9). (The Winnebago data are from Miner 1979, 1992, 1993 and Hale and White Eagle 1980.) Alderete (1995) observes the apparent oddity of Dorsey’s law since it acts to break up potential obstruent-sonorant onset clusters which are the most preferred clusters cross-linguistically.

(9) Dorsey’s Law in Winnebago (Hocank)

/hipres/ [hi.pe.res] ‘know’
/krepnâ/ [ke.re.pä.nâ] ‘unit of ten’
/sgaα/ [sgaa] ‘white’
/kšee/ [kšee] ‘revenge’
/haracab-ra/ [ha.ra.cab.ra] ‘the taste’
/ha-ku-ru-gas/ [ha.ku.ru.gas] ‘I tear my own’
/pšoopšoc/ [pšoo.pšoc] ‘fine’

What we see in the data in (9) is that two obstruents can occur word-initially or syllable-initially as long as one is a strident, as shown by the words for ‘white’ and ‘fine’ in (9) above. These are clusters we would analyze as adjunct clusters along with s-clusters in English. Over a suffix boundary, Hocank allows a sequence of an obstruent followed by a sonorant in separate syllables as in ‘the taste’ in (9) above. But morpheme-internally, no obstruent-sonorant onset clusters occur (Alderete 1995, based on Susman 1943 and Miner 1993).

A phonetic explanation has been proposed for this phenomenon arguing that the audible release of the obstruent before the sonorant is misperceived as a vowel. The vowel is perceived to be colored by the post-sonorant vowel because of anticipatory articulation of vowel gestures and is then phonologized since the inserted vowel counts for stress placement and can be stressed (see Blevins 2004 and Fleischhacker 2002 for a discussion of the phonetics of the phenomenon and Hale and White Eagle 1980 and Halle and Vergnaud 1987 among others for formal analyses of the interaction of
Dorsey’s Law with stress). The difficulty we see with this phonetic explanation is that it does not explain why the “misperception” occurs in Hocank but not in English (or other languages) where the same underlying sequences occur as onset clusters with no vowel epenthesis. Thus we note Alderete’s (1995) query – Why would Dorsey’s Law break up potential obstruent-sonorant onset clusters when they are cross-linguistically the most preferred complex onsets?

Alderete’s (1995: 48) answer is that a syllable contact constraint is active in Hocank such that there cannot be a sonority rise of greater than one sonority interval over a syllable boundary. Consequently, in Alderete’s analysis Dorsey’s Law occurs so as to break up bad syllable contact (i.e. rising sonority over a syllable boundary). The difficulty with this analysis is that it seems to predict that word-initial clusters like the one shown in the word meaning ‘unit of ten’ in (9) should not be broken up because syllable contact is not at issue word-initially. Alderete’s (1995: 49) analysis suggests that words that begin with such a cluster initially actually begin with a “silent vowel” so that the syllable contact constraint would apply to them. However, there is no independent evidence for the silent vowel (e.g. it does not interact with stress as the epenthetic vowel does and has no reflex diachronically).

Our proposed explanation for the Dorsey’s Law facts in Hocank is that Dorsey’s Law occurs due to language-internal pressure for obstruent-sonorant sequences (and other sonority-governed clusters) not to surface. The salient observation about Hocank is that the language disallows sonorant consonants in coda position as well. While this observation may seem unconnected to Dorsey’s Law, under the split margin approach to the syllable, it is crucially connected. Given the M₂ hierarchy, if a language does not allow sonorant consonants in coda position, then the entire M₂ hierarchy (abbreviated as *M₂ in (10)) dominates FAITH (DEP being the faithfulness constraint violated by the winning candidates in Hocank), while most of the M₁ hierarchy (abbreviated as *M₁) is dominated by FAITH. Thus, CVC reduplication as in (10) results in the epenthesis shown in candidate (b) motivated not by a syllable contact restriction but by the dispreference in Hocank for parsing a rhotic in coda position.

(10) **Hocank** /R⁺šara/ [šarašara] ‘bold in spots’

<table>
<thead>
<tr>
<th>/šar⁺šara /</th>
<th>*M₂</th>
<th>DEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. ša.ra.ša.ra</td>
<td>*</td>
<td>*M₁/Obs, *M₁/Obs, *M₁/[r], *M₁/[r]</td>
</tr>
</tbody>
</table>
Given the high ranked nature of the *M₂ hierarchy in Hocank, it follows that complex onsets (which include an M₂ position) are disallowed as well. Under the split margin approach to the syllable, a language will not allow onset clusters unless at least a portion of the M₂ hierarchy (along with the *COMPLEXONSET constraint) is dominated by FAITH. In fact, even if the *COMPLEXONSET constraint itself is dominated by FAITH, complex onsets will be disallowed unless the relevant M₂ constraints are also dominated by FAITH, as we see in (11).

(11) **Hocank** /krepanied/ [ke.re.pä.nä] ‘unit of ten’

<table>
<thead>
<tr>
<th>/krepanied/</th>
<th>*M₂</th>
<th>DEP</th>
<th>*M₁</th>
<th>*COMP périod</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. krepanied</td>
<td><strong>!</strong></td>
<td>*</td>
<td>**</td>
<td>*</td>
</tr>
<tr>
<td>b. kre.pä.nä</td>
<td>*</td>
<td>*</td>
<td>***</td>
<td>*</td>
</tr>
<tr>
<td>c. ke.re.pä.nä</td>
<td>**</td>
<td>****</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This analysis thus far provides a principled analysis of the epenthesis in Hocank without resorting to structures for which there is no overt evidence. However, there is one remaining issue outstanding in Hocank and that is the analysis of stem-final consonants. Recall the word meaning ‘the taste’ in (9) repeated below in (12). Here we see that Dorsey’s Law does not apply over a stem-final boundary and the obstruent-sonorant sequence surfaces.

(12) **Lack of Dorsey’s Law over a stem-final boundary**

/ha.racia ра/ [ha.ra.cab ра] *[ha.ra.ca.ba ра] ‘the taste’

Here we suggest that stem-final codas that are not word-final may, in fact, surface as an M₂ element compelled by a high ranked alignment constraint requiring a stem-final element to be syllable final, i.e. AlignR (stem, syllable), namely that the right edge of the stem aligns with the right edge of the syllable. The /b/ in (12) is in stem-final position. This alignment constraint prevents Dorsey’s Law from applying to (12), as shown in (13).

(13) **/ha.racia ра/ [ha.racia ра] ‘the taste’**

<table>
<thead>
<tr>
<th>/ha.racia ра/</th>
<th>AlignR(stem, syllable)</th>
<th>*M₂</th>
<th>DEP</th>
<th>*M₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.  ha.racia ра</td>
<td>*M₂/Obs</td>
<td>****</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. ha.ra.ca.bra</td>
<td>*</td>
<td>*M₂/r</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>c. ha.ra.ca.ba ра</td>
<td>*</td>
<td>*</td>
<td>****</td>
<td></td>
</tr>
</tbody>
</table>
We thus understand Dorsey’s Law epenthesis as providing evidence for the
relation between onset clusters and codas and for the split margin approach
to the syllable more generally. There is internal pressure from within the
phonology of Hocank for the sonorant not to surface as a second member
of the onset since Hocank does not permit sonorants to surface in coda
position.

3. Onset clusters

In this section we consider the strength or sonority relation within a com-
plex onset by a consideration of how onset clusters are analyzed within the
split margin approach to the syllable. We will show that our optimality-
theoretic analysis of onset clusters has implications for syllable typology.

In the split margin approach, onset clusters are accounted for in an op-
timality-theoretic grammar by the local conjunction of the M₁ constraints
in (3) with the M₂ constraints in (4), repeated below for convenience (and
where the parentheses indicate vocalic elements that are typically realized
in syllable peaks by the Peak constraints and so will not be at issue in the
discussion here).

The M₁ hierarchy
(*M₁/[+lo] >> *M₁/[+hi]) >> *M₁/r >> *M₁/l >> *M₁/Nasal
>> *M₁/Obstruent

The M₂ hierarchy
*M₂/Obstruent >> *M₂/Nasal >> *M₂/l >> *M₂/r >> (*M₂/[+hi]
>> *M₂/[+lo])

The conjoined constraints are intrinsically ranked with respect to each
other (reflecting the ranking of the component M₁ and M₂ hierarchies).
Given this, a cluster of an obstruent followed by a rhotic will be the fa-
vored onset cluster. This is because *M₁/Obs is the lowest ranking M₁ con-
straint and *M₂/r is the lowest ranking (relevant) M₂ constraint. As a con-
sequence, the conjunction [o*M₁/Obs&*M₂/r would be the lowest ranking
of the conjoined *M₁&*M₂ constraints (where we use [o to indicate the
domain of the local conjunction as the beginning of the syllable, i.e. the
syllable onset). Consider the Spanish data in (14). As these data show,
Spanish allows for obstruent-sonorant onset clusters but not obstruent-
obstruent ones. An underlying obstruent-obstruent cluster that could potentially surface in syllable-initial position (14c), actually surfaces with a prothetic vowel (a violation of the constraint DEP), but the underlying obstruent-sonorant sequences of (14ab) are allowed to surface as complex onsets.

(14) Exemplification from Spanish
a. /blanka/ [blan.ka] ‘white’
b. /pronto/ [pron.to] ‘soon’
c. /sposa/ [es.po.sa] ‘wife’

The patterning of (14) reflects the constraint ranking in (15) with the relevant tableaux shown in (16) and (17). The Spanish analysis in (15)–(17) shows how the split margin approach neatly accounts for onset clusters, especially the preference for obstruent-sonorant onset clusters.

(15) Constraint ranking for Spanish
\[ \sigma * M_1 / \text{Obs} & * M_2 / \text{Obs} \gg \text{DEP} \gg \sigma * M_1 / \text{Obs} & * M_2 / \text{l} \gg \sigma * M_1 / \text{Obs} & * M_2 / t \]

(16) /bla/ [bla]

<table>
<thead>
<tr>
<th>/bla/</th>
<th>[\sigma * M_1 / \text{Obs} &amp; * M_2 / \text{Obs}] DEP</th>
<th>[\sigma * M_1 / \text{Obs} &amp; * M_2 / l]</th>
<th>[\sigma * M_1 / \text{Obs} &amp; * M_2 / t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. \text{sr} bla</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. \text{gb} la</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

(17) /spo/ [es.po]

<table>
<thead>
<tr>
<th>/spo/</th>
<th>[\sigma * M_1 / \text{Obs} &amp; * M_2 / \text{Obs}] DEP</th>
<th>[\sigma * M_1 / \text{Obs} &amp; * M_2 / l]</th>
<th>[\sigma * M_1 / \text{Obs} &amp; * M_2 / t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. spo</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. \text{sr} es.po</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

What is interesting is that this approach provides a natural explanation for Kaye and Lowenstamm’s proposed implicational universal discussed in §1 that the presence of a complex onset in a language implies the presence of codas in that language. Given the logic of constraint conjunction, a conjoined constraint must dominate the individual conjuncts for it to be active in a language. If the conjoined constraint \[\sigma * M_1 / \text{Obs} & * M_2 / t\] is ranked low enough (below the relevant faithfulness constraints) so as to allow for on-
set clusters (as in Spanish) then it must follow that rhotics be allowed as single codas given that a conjoined constraint outranks each of the single conjuncts. This is shown in (18).

(18) \[
\begin{array}{c}
\text{FAITH} \\
\text{*M}_i/\text{Obs} \land \text{*M}_j/r \\
\text{*M}_i/\text{Obs} \land \text{*M}_j/r
\end{array}
\]

The consequence of this ranking is that if a language allows for an onset cluster, it also allows for the presence of a coda, thus giving a formal explanation for Kaye and Lowenstamm’s observation that the presence of a complex onset implies the presence of a coda. (It should be noted, though, that Kaye and Lowenstamm do not make predictions on the relationship between the complex onset and the coda.) If we then consider syllable typology, we would expect to find languages whose maximal syllable is CV (constraint ranking 19a), CVC (19b), and CCVC (19c).

(19) Accounting for syllable typology
   a. ranking for a CV language
      \[ \alpha \text{*M}_i/\text{Obs} \land \text{*M}_j/\text{Son} >> \text{*M}_j/\text{Son} >> \text{FAITH} \]
   b. ranking for a CVC language
      \[ \alpha \text{*M}_i/\text{Obs} \land \text{*M}_j/\text{Son} >> \text{FAITH} >> \text{*M}_j/\text{Son} \]
   c. ranking for a CCVC language
      \[ \text{FAITH} >> \alpha \text{*M}_i/\text{Obs} \land \text{*M}_j/\text{Son} >> \text{*M}_j/\text{Son} \]

However, a language whose maximal syllable is CCV with the hypothetical ranking in (20) is problematic given the role of constraint conjunction. First, it would require a conjoined constraint to be lower ranked than one of the individual conjuncts. And second, a surface obstruent-sonorant onset cluster (CCV) incurs violations of both \text{*M}_j/\text{Son} (ranked above \text{FAITH}) and the conjoined constraint. The violation of \text{*M}_j/\text{Son} would be fatal.

(20) Hypothetical ranking of a CCV language
    \[ \text{*M}_j/\text{Son} >> \text{FAITH} >> \alpha \text{*M}_i/\text{Obs} \land \text{*M}_j/\text{Son} \]
Even though it was noted earlier following (1) that some CCV languages
do occur, such as Fongbe, we suggest here that such languages have a rank-
ing for a CCVC language as in (19c). Their lack of codas has more to do
with the lack of potential codas in input sequences. While this issue is a
subject for future research, it is interesting to note that Haitian Creole,
which some researchers consider to reflect the grammar of its primary Af-
rican substrate language Fongbe (Lefebvre 1998), maintains coda conso-
nants. This makes sense if Fongbe is a covert CCVC language with the
ranking of (19c). The lack of apparent codas in Fongbe may be due to the
nature of the input sequences.

In the next section we consider diachronic implications of the split mar-
gin approach. If a CCVC language (19c) starts to lose or restrict its coda
consonants it should also lose or restrict its onset clusters accordingly.
Relatedly, if a CV language (19a) starts to acquire onset clusters it should
also acquire coda consonants. As far as we are aware, this diachronic link
has not been previously noted by others.

4. The diachronic link between onset clusters and coda

Having developed a formal analysis of onset clusters within the split mar-
gin approach to the syllable, we analyze in this section two cases that ex-
emplify the diachronic link between onset clusters and codas. In §4.1, we
consider Campidanian Sardinian, a daughter of Latin in which codas and
onset clusters become more restrictive than in Latin. In §4.2, we will con-
sider a formal analysis of the difference between Standard and Colloquial
Bambara where syllable structures have become less restrictive in the col-
loquial language. In both Campidanian Sardinian and Colloquial Bambara,
constraints have acted upon the coda and the second member of an onset in
a parallel way reflecting a link between these two positions.

4.1. Campidanian Sardinian

Campidanian Sardinian (Bolognesi 1998; Alber 2001; Smith 2003; Frigeni
2003, 2005) descends from Latin, a CCVC language (ignoring the issue of
s-clusters and certain cases of complex codas) in which basically any con-
sonant (regardless of sonority value) could be a single coda. Latin codas
can be accounted for by the constraint ranking in (21) where the entire M₂
hierarchy is dominated by FAITH.
(21) Ranking of the M₂ Hierarchy in Latin
FAITH >> *M₂/Obstruent >> *M₂/Nasal >> *M₂/l >> *M₂/r ...

Latin allows for onset clusters consisting of an obstruent followed by a
sonorant. This means that the relevant conjoined constraints are also
ranked below FAITH as in (22).

(22) Ranking permitting obstruent-sonorant onset clusters in Latin
FAITH >> [ œ*M₁/Obs&*M₂/l >> [ œ*M₁/Obs&*M₂/r >> …
>> *M₂/l >> *M₂/r

Campidanian Sardinian (henceforth Sardinian), on the other hand, has a
syllable structure that is more restricted than in Latin both with respect to
the nature of the coda and the onset clusters. Moreover, the language dis-
tinguishes initial syllables which allow onset clusters from non-initial syl-
lables which lack them for the most part. (See Alber 2001 on the impor-
tance of the initial syllable in Sardinian.) We focus on the initial syllable.
In Sardinian, the only (unassimilated) singleton coda allowed is the rhotic.
Coda laterals from Latin have rhotic reflexes in Sardinian as exemplified in
(23). (The lateral can occur syllable-initially in Sardinian, a position gov-
erned by the M₁ hierarchy.)

(23) ALBUS > arba ‘white’
   (ORKU > orku ‘ogre’)

We can account for this by the ranking in (24) whereby the relevant faith-
fulness constraint, ID[MANNER], is ranked below *M₂/l. ID[MANNER] is
violated if a lateral liquid changes to a rhotic liquid or vice-versa. The rele-
vant tableau is shown in (25) where we assume (given richness of the base)
an input lateral.

(24) Ranking for Sardinian
   *M₂/l >> ID[MANNER] >> *M₂/r

(25) /alba/ [ar.ba] ‘white’

<table>
<thead>
<tr>
<th></th>
<th>/alba/</th>
<th>*M₂/l</th>
<th>ID[MANNER]</th>
<th>*M₂/r</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>al.ba</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>ar.ba</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>
In comparison to the ranking in Latin (26), the Sardinian ranking in (24) ranks the FAITH constraint ID[MANNER] below *M₃/l disallowing lateral codas but still above *M₃/r thus permitting rhotic codas.

(26) Ranking for Latin
ID[MANNER] >> *M₃/l >> *M₃/r

What is interesting in Sardinian and what previous researchers have noted but have viewed as an independent change is the loss of the lateral when it is the second member of an onset cluster as in (27a). Rhotics in clusters remained (27b).

(27) Onset clusters

<table>
<thead>
<tr>
<th>Latin</th>
<th>Sardinian</th>
<th></th>
</tr>
</thead>
</table>
| a. plus | prus      | 'more'
| clave   | krai      | 'key'
| (longus | longu     | 'long') |
| b. primu| primu     | 'first'
| cras    | krazi     | 'tomorrow'

The change follows naturally from the ranking in (24) under the split margin approach, as we see in the tableau in (28).

(28) /plus/ [prus] 'more'

<table>
<thead>
<tr>
<th>/plus/</th>
<th>*M₃/l</th>
<th>ID[MANNER]</th>
<th>*M₃/r</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. plus</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. prus</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

We show the fuller ranking with the relevant conjoined constraints in (29) along with a more detailed tableau in (30). What (29) shows is that the domination of ID[MANNER] by *M₃/l also entails its domination by *M₃/Obs&*M₃/l. Thus, it is expected that if Latin /l/ has become [r] in coda position in Sardinian then it should do the same as the second member of a complex onset. And given the ranking in (29), Latin obstruent-rhotic onset clusters remain unchanged in Sardinian, in (31). Thus, our analysis under the split margin approach formally connects the historical change in the coda (23) with the change in onset clusters (27a).
(29) Fuller ranking for Sardinian
\[ \sigma^*M_1/Obs&*M_2/l \gg *M_2/l \gg ... \]
tableaux shown for Sardinian in examples like (25) and (30) reflect the synchronic state. We do not show the stages by

(30) /plus/ [prus] ‘more’

<table>
<thead>
<tr>
<th>/plus/</th>
<th>[\sigma^*M_1/Obs&amp;*M_2/l]</th>
<th>[\sigma^*M_1/Obs&amp;*M_2/l]</th>
<th>ID[MANNER]</th>
<th>[\sigma^*M_1/Obs&amp;*M_2/l]</th>
<th>[\sigma^*M_1/Obs&amp;*M_2/l]</th>
</tr>
</thead>
</table>
| a. plus | ! | * | * | | *
| b. \(\sigma\) prus | | | | * | *

(31) /primu/ [primu] ‘first’

<table>
<thead>
<tr>
<th>/primu/</th>
<th>[\sigma^*M_1/Obs&amp;*M_2/l]</th>
<th>[\sigma^*M_1/Obs&amp;*M_2/l]</th>
<th>ID[MANNER]</th>
<th>[\sigma^*M_1/Obs&amp;*M_2/l]</th>
<th>[\sigma^*M_1/Obs&amp;*M_2/l]</th>
</tr>
</thead>
</table>
| a. \(\sigma\) primu | | | * | | *
| b. plimu | ! | * | * | | |

There are other interesting details of Sardinian codas discussed in Davis and Baertsch (2004) and in our work in progress that we do not discuss here. Nonetheless, as reflected in our analysis presented in (24)–(31), Sardinian provides a clear illustration of the diachronic link between onset clusters and codas such that a restriction that has developed on codas (i.e. the restriction against laterals) is mirrored in the second position of onset clusters because both are M_2 positions. The parallel nature of the restriction is neatly captured in the split margin approach.

---

2 Sardinian codas are more complicated than is implied here in that, in addition to the sonority constraint that only allows the highly sonorous rhotic as a single (un-assembled) coda, Sardinian has also witnessed the rise of the Coda Condition (in the sense of Itô 1986, where a coda shares place features with a following onset) in comparison to Latin. Specifically, with the exception of a singleton coda [r], as in arba ‘white’ in (23), Sardinian obeys the coda condition. This means that Sardinian codas may include an obstruent only if it is the first part of a geminate (ignoring certain problems regarding the syllabification of s-clusters) or if it is homorganic to a following onset. While we do not analyze this here, one would need to reference a coda condition constraint in addition to the \(\sigma^*M_2\) constraints. Details are worked out in Davis and Baertsch (2005ab). Sardinian thus offers an interesting interplay of coda (M_2) constraints that reference high sonority (Zec 1988) and the classic Coda Condition (Itô 1986).

3 That said, it should be made clear that the tableaux shown for Sardinian in examples like (25) and (30) reflect the synchronic state. We do not show the stages by
4.2. Bambara

In the previous section, we detailed how a language becomes more restricted in its syllable structure with respect to both codas and second members of onsets in a parallel way, reflecting the M₁ position of the syllable. In this section, we will consider the opposite case where a language becomes less restrictive in its syllable structure with respect to these two positions. We will exemplify this with a consideration of the comparison of Standard Bambara with Colloquial Bambara. We make an assumption here that the former is a more conservative variety while the latter develops from it.

Recall from the Bambara data in (2) repeated below as (32) the difference between Standard Bambara and the colloquial language. (The data and discussion here are based on Diakite 2006, the author being a native speaker linguist.)

(32) Standard versus Colloquial Bambara

<table>
<thead>
<tr>
<th>Standard</th>
<th>Colloquial</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[bʊuˈru]</td>
<td>[bru]</td>
<td>‘bread’</td>
</tr>
<tr>
<td>[mo.ɾi.&quot;ba]</td>
<td>[mor.&quot;ba]</td>
<td>a name</td>
</tr>
<tr>
<td>[ma.&quot;ɾi.&quot;fa]</td>
<td>[mar.&quot;fa]</td>
<td>‘gun’</td>
</tr>
<tr>
<td>[ba.&quot;ɾa.&quot;ma]</td>
<td>[bra.&quot;ma]  or [bar.&quot;ma]</td>
<td>‘pot’</td>
</tr>
<tr>
<td>[fa.&quot;ɾa.&quot;ti]</td>
<td>[fra.&quot;ti]  or [far.&quot;ti]</td>
<td>‘carelessness’</td>
</tr>
<tr>
<td>[kabila]</td>
<td>[ka.&quot;bla]</td>
<td>‘tribute’</td>
</tr>
<tr>
<td>[melekuya]</td>
<td>[mel.&quot;ku.&quot;ya]</td>
<td>‘literature’</td>
</tr>
</tbody>
</table>

As the comparison between the Standard and Colloquial Bambara data reveals, the colloquial language has a syncope process that preferably deletes a non-final high vowel, though a non-high vowel can be deleted if there are no target high vowels. The effect of this is to make syllable structure less restrictive in Colloquial Bambara than in Standard Bambara

which the rankings for Latin as reflected in (21) and (22) evolved into the Sardinian ranking in (29). We do predict that the change from *l to [r] in the onset cluster either occurred simultaneous with or prior to the change of *l to [ɾ] in the coda. Under our theory we would not expect the change of lateral to rhotic in the coda to occur prior to that change in the onset cluster. Evidence that the *l-to-[ɾ] change occurred first in the onset cluster comes from Catalan dialects discussed by Pons (2008) where laterals have become rhotics as a second member of an onset but not in coda position. We leave the details of this matter for future research.
which is basically a CV language (ignoring the issue of a possible coda nasal in Bambara which some analyze as syllabic). Through syncope, Colloquial Bambara has developed both complex onsets and codas, so that CVC and CCV syllables are allowed in addition to CV syllables. What is noteworthy is that syncope in Bambara either creates a complex onset in which the second member is a sonorant (e.g. [bra.ma] ‘pot’, [ka.bla] ‘tribute’) or a coda in which the single coda consonant is a sonorant (e.g. [mar.fa] ‘gun’, [mel.ku.ya] ‘literature’). In other words, the result of syncope leaves a sonorant in M₂ position; it never results in an obstruent in that position. Consider, for example, the words given in (33) taken from Diakite (2006: 6).

(33) Standard Colloquial

[safunɛ] [sa.fne] (*[sfa.ne]) ‘soap’
[kalabâci] [kla.bæ.ci], [kal.bæ.ci] (*[ka.lab.ci]) ‘hypocrite’

The examples in (33) make clear that the result of syncope does not leave an obstruent in M₂ position. Given this, we can account for the difference between Standard and Colloquial Bambara by a difference in the ranking of the *M₂ constraints. Under the assumption that Standard Bambara is a CV language, all the *M₂ constraints would be high ranking. Colloquial Bambara, on the other hand, witnesses the demotion of *M₂/sonorant (collapsing *M₂/r, *M₂/l, and *M₂/nasal) below a constraint (or series of constraints) that favor syncopated outputs (which we will call SYNCOPE here and leave the details for further research). Standard Bambara would have the constraint ranking in (34) with a relevant tableau in (35). Here we focus on the analysis of codas.

(34) Ranking for Standard Bambara

*M₂/Obs >> *M₂/Son >> SYNCOPE >> *M₁/Son >> *M₁/Obs

(35) /moriba/ [mo.ri.ba] a name

<table>
<thead>
<tr>
<th>/moriba/</th>
<th>*M₂/Obs</th>
<th>*M₂/Son</th>
<th>SYNCOPE</th>
<th>*M₁/Son</th>
<th>*M₁/Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. mo.ri.ba</td>
<td></td>
<td>*</td>
<td>**</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. mor.ba</td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

The winning candidate in (35a) violates SYNCOPE in that it does not undergo syncope. The losing candidate in (35b) respects SYNCOPE, but this results in a violation of the higher ranked *M₁/Son constraint since it has
[r] in coda position. The winning candidate has no codas thus respecting the higher ranked *M₂ constraints. Turning to Colloquial Bambara, we can analyze it by the demotion of the *M₂/Sonorant constraint below SYNCOPE. The ranking for Colloquial Bambara is given in (36) with the relevant tableau in (37). (Note that the ranking in (36) between *M₂/Son and *M₁/Son is not crucial, just as long as *M₂/Son is ranked below SYNCOPE.)

(36) Ranking for Colloquial Bambara

*M₂/Obs >> SYNCOPE >> *M₂/Son >> *M₁/Son >> *M₁/Obs

(37) /moriba/ [mor ба] a name

<table>
<thead>
<tr>
<th>/moriba/</th>
<th>*M₂/Obs</th>
<th>SYNCOPE</th>
<th>*M₂/Son</th>
<th>*M₁/Son</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. mo.ri.ba</td>
<td>*!</td>
<td></td>
<td>**</td>
<td>*</td>
</tr>
<tr>
<td>b. йor.ba</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

The winning candidate in (37b) has a sonorant in its coda. The demotion of *M₂/Son below SYNCOPE in Colloquial Bambara allows for a sonorant in coda position.

We now consider the fuller ranking with the relevant conjoined constraints in (38) accounting for the nature of the complex onset. In Standard Bambara complex onsets are not allowed. What (38) shows is that the domination of SYNCOPE by *M₂/Son also entails its domination by [т ᵐ₁/Obś & *M₂/Son. Thus, just as possible forms with a coda consonant cannot surface in Standard Bambara neither can a possible form with a complex onset. This is shown by the tableau in (39).

(38) Ranking for Standard Bambara with conjoined constraints for complex onsets

[т ᵐ₁/Obś & *M₂/Son >> *M₂/Son >> SYNCOPE >> *M₁/Son >> *M₁/Obs

(39) /kabila/ [ka.bi.lа] ‘tribute’

<table>
<thead>
<tr>
<th>/kabila/</th>
<th>т ᵐ₁/Obś &amp; *M₂/Son</th>
<th>*M₂/Son</th>
<th>SYNCOPE</th>
<th>*M₁/Son</th>
<th>*M₁/Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Ṇ ka.bi.lа</td>
<td></td>
<td>*</td>
<td>*</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>b. Ṇ ka.blа</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td>**</td>
</tr>
</tbody>
</table>
Candidate (39b) violates the *M₂/Son constraint because of [l] being the second member of a complex onset. Candidate (39a) is thus the winner since it does not violate *M₂/Son even though it violates Syncope, but that is not a fatal violation since it is lower ranked than *M₂/Son. (Note that a possible candidate like [kab.la] for (39) would be ruled out by *M₂/Obs which is necessarily higher ranked than *M₂/Son given the *M₂ hierarchy in (4).)

For Colloquial Bambara, just as the demotion of the *M₂/Sonorant constraint below SYNCOPE as given by the ranking in (36) was able to account for the syncopated output in (37b) with a coda consonant, the further de-
motion of the conjoined constraint [ₐ*M₁/Obs&*M₂/Son below SYNCOPE as shown by the fuller ranking in (40) is able to account for the output with a complex onset as seen by the tableau in (41).

(40) Ranking for Colloquial Bambara with conjoined constraints for complex onsets
SYNCOPE >> [ₐ*M₁/Obs&*M₂/Son >> *M₂/Son >> *M₁/Son >> *M₁/Obs

(41) /kabila/ [ka.blə] ‘tribute’

<table>
<thead>
<tr>
<th>/kabila/</th>
<th>SYNCOPE</th>
<th>[ₐ*M₁/Obs &amp;*M₂/Son</th>
<th>*M₂/Son</th>
<th>*M₁/Son</th>
<th>*M₁/Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ka.bi.la</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>b. ≠ka.blə</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td>**</td>
</tr>
</tbody>
</table>

(Note that a possible candidate like [kab.la] for (41) would still be ruled out by *M₂/Obs since that would be higher ranked than the conjoined constraint [ₐ*M₁/Obs&*M₂/Son though this would not be an intrinsic ranking.)

Our detailed analysis of the different varieties of Bambara accounts for the parallel emergence of both onset clusters and codas in Colloquial Bambara. Along with the Campidanian Sardinian case discussed in §4.1 it provides strong evidence for the link between onset clusters and codas that is insightfully captured by the split margin approach.

5. Syllable contact

In this section, we first show how the split margin approach to the syllable can be extended to account for strength or sonority relations between con-
sonants in syllable contact position (i.e. when two consonants are adjacent over a syllable boundary). We then show how our analysis using the split margin approach to the syllable makes predictions regarding the relationship between clusters that comprise complex onsets and clusters that can appear over a syllable boundary.

In §2 of this paper, we briefly introduced the diagram in (7), repeated below as (42), that illustrates the syllable contact environment under the split margin approach to the syllable. The syllable contact environment in (42) is where the M₂ (coda) of the first syllable comes into contact with the M₁ (initial onset consonant) of the second syllable.

(42) Syllable contact environment

\[
\begin{array}{c}
\omega \\
\sigma \\
\text{Onset} \\
M₁ (M₂) \quad \text{Nucleus} \quad \text{Rhyme} \\
\text{P} \quad \text{(Coda)} \quad \text{M₂} \\
\text{Onset} \\
M₁ (M₂) \quad \text{Nucleus} \quad \text{Rhyme} \\
\text{P} \quad \text{(Coda)} \\
\end{array}
\]

\footnote{Here we do not detail the background literature on syllable contact. We note here the seminal work of Vennemann (1988) which builds on Hooper (1976) and Murray and Vennemann (1983). Vennemann (1988: 40) states the Syllable Contact Law as follows, “A syllable contact ASB is the more preferred, the less the consonantal strength of the offset A and the greater the consonantal strength of the onset B.” Given the split margin approach to the syllable we state syllable contact in terms of sonority. Informally, we view syllable contact as the avoidance of rising sonority over a syllable boundary and the preference for sonority fall. Davis (1998) and Baertsch and Davis (2005) give a detailed review of the use of syllable contact constraints in Optimality Theory. They note that most previous research uses a syllable contact constraint along the lines of Bat-El (1996: 304) that states, “The onset of a syllable must not be of greater sonority than the last segment in the immediately preceding syllable.” What we show in the present paper is that there is no constraint along the lines of Bat-El (1996), rather the preference for falling sonority of syllable contact is an automatic consequence of the split margin approach to the syllable.}
In examining the syllable contact environment in (42) there are two matters of consequence. Firstly, in the syllable contact situation, the coda of the first syllable is governed by the M₂ hierarchy in (4) and the adjacent initial onset consonant of the second syllable is governed by the M₁ hierarchy in (3). Given that the preferred M₂ consonant is one of high sonority and the preferred M₁ consonant is one of low sonority, then the preferred syllable contact sequence (i.e. M₂, M₁) is one with falling sonority. Secondly, a syllable contact situation is similar to that of a complex onset since in both situations a consonant cluster consists of an M₁ segment adjacent to an M₂ segment. The difference between the two situations is that within the syllable (complex onset), the adjacent segments under discussion are dominated by a syllable node. In the syllable contact situation, the adjacent segments are not dominated by a syllable node, but rather by a higher domain – the phonological word, as shown in (42). This construct also allows us to examine the relationship across a syllable boundary – the syllable contact relationship. We can analyze this relation between a syllable-final M₂ segment (a coda) and the adjacent syllable-initial M₁ segment (an onset) by a conjoined margin constraint that references the phonological word (rather than the syllable) as its local domain.

In order to make clear the difference between a conjoined margin constraint that has the phonological word as its local domain versus one that has the syllable as its local domain, let us consider the specific example of Modern English obstruent-plus-nasal sequences and Modern English nasal-plus-obstruent sequences. As is well-known, obstruent-nasal sequences are not allowed as a syllable onset (ignoring here the separate problem of a word-initial /sn/ cluster) so that there are no syllables that begin with pronounced [kn] in Modern English. On the other hand, there are many words of Modern English that have a word-internal nasal-obstruent sequence as in ‘bamboo’ where the nasal obstruent sequence occurs over a syllable boundary. With respect to the split margin approach to the syllable a possible syllable-initial obstruent-nasal cluster is similar to a word-internal nasal-obstruent cluster in that with both cluster types there is an obstruent in M₁ position adjacent to a nasal in M₂ position. This is shown in (43) where (43a) represents a case with the domain as syllable onset and (43b) as the phonological word as the domain.

(43) a. [σ k  n] [σ b]  
im ⫸  
M₁ M₂  
b. [m σ ] [σ b]  
im ⫸  
M₂  
M₁
The onset cluster illustrated in (43a) does not occur in Modern English while the syllable contact cluster in (43b) does, as exemplified by the cluster in the word ‘bamboo’. We can capture the occurrence of (43b) and the nonoccurrence of (43a) by the ranking in (44) using two similar conjoined margin constraints that differ only in their domain of application.

(44) Modern English ranking with local domains indicated

\[
[\sigma*M_l/\text{Obs} & *M_j/\text{Nasal}] \gg \text{FAITH} \gg [*M_l/\text{Obs} & M_j/\text{Nasal}]_{\text{sd}}
\]

As seen by the tableaux in (45) and (46) this ranking disallows onset clusters of onset-plus-nasal while allowing for a nasal-plus-onset over a syllable boundary.

(45) /knut/ [kɪ.nʌt] ‘Cnut’ (name of an 11th century English king)

<table>
<thead>
<tr>
<th></th>
<th>/knut/</th>
<th>[\sigma*M_l/\text{Obs} &amp; *M_j/\text{Nasal}]</th>
<th>DEP</th>
<th>[*M_l/\text{Obs} &amp; *M_j/\text{Nasal}]_{\text{sd}}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>knut</td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>*kɪ.nʌt</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(46) /bæmbu/ [bæm.ˈbu] ‘bamboo’

<table>
<thead>
<tr>
<th></th>
<th>/bæmbu/</th>
<th>[\sigma*M_l/\text{Obs} &amp; *M_j/\text{Nasal}]</th>
<th>DEP</th>
<th>[*M_l/\text{Obs} &amp; *M_j/\text{Nasal}]_{\text{sd}}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>bæm.ˈbu</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

If we consider the tableaux in (45) and (46) in more detail we note that the winning candidate in (46a) violates the conjoined constraint \[\sigma*M_l/\text{Obs} & *M_j/\text{Nasal}\]_{\text{sd}} because of the nasal-obstruent cluster, but this is not a fatal violation since the constraint is lower ranked than the DEP constraint which the losing candidate in (46b) violates. Note that the winning candidate (46a) does not violate high ranked \[\sigma*M_l/\text{Obs} & *M_j/\text{Nasal}\]. Now compare (46a) with (45a). Here we see that when a candidate like (45a) violates \[\sigma*M_l/\text{Obs} & *M_j/\text{Nasal}\] because of its [kn] cluster in the syllable onset, it necessarily also violates \[*M_l/\text{Obs} & *M_j/\text{Nasal}\]_{\text{sd}} because the onset cluster is also within the phonological word thus incurring a violation of both conjoined constraints. Thus, we see that under the split margin approach to the syllable, syllable contact sequences can be captured by the same types of conjoined margin constraints that account for the occurrence of onset clusters with the difference that the conjoined constraints account-
Strength relations between consonants

For syllable contact sequences do not have the syllable as its domain, just the phonological word.

An intriguing prediction emerging from the split margin analysis given here, that has gone unexpressed (and unobserved) in other approaches, is that there is a close relationship between the clusters that can appear in a complex onset and those that can occur in syllable contact. Since as shown in (45a), a violation of the conjoined constraint within the syllable (onset) entails a violation of the conjoined constraint within the phonological word, then the possible onset clusters in any language should be a subset of the possible mirror-image clusters allowed in the situation of syllable contact. For example, if [bl] is permitted as a possible onset, then [lb] should occur over a syllable boundary. Consider English which allows complex syllable onsets such as [bl] in blue, [dr] in dream, and [kl] in clear; we note that English also allows the mirror-image clusters in syllable contact such as [lb] in el.bow, [rd] in ar.dent, and [lk] in tal.cum. The relationship between these cluster types is demonstrated by the tableaux in (47) and (48) with the English words blue and elbow, where the \([\sigma \ *M_1/\text{Obs} \ &*M_2/\text{nasal}]\) constraint is ranked low enough so that /bl/ onset clusters are allowed.

(47) /blu/ [blu] blue

<table>
<thead>
<tr>
<th>/blu/</th>
<th>([\sigma \ *M_1/\text{Obs} \ &amp;*M_2/\text{nasal}]) DEP</th>
<th>([\sigma \ *M_1/\text{Obs} \ &amp;*M_2/l])</th>
<th>([*M_1/\text{Obs} \ &amp;*M_2/l]_{\text{wd}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\not\rightarrow) blu</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b. bl.lu</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(48) /elbo/ [el.bo] elbow

<table>
<thead>
<tr>
<th>/elbo/</th>
<th>([\sigma \ *M_1/\text{Obs} \ &amp;*M_2/\text{nasal}]) DEP</th>
<th>([\sigma \ *M_1/\text{Obs} \ &amp;*M_2/l])</th>
<th>([*M_1/\text{Obs} \ &amp;*M_2/l]_{\text{wd}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (\not\rightarrow) el.bo</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. el.bo</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In (47a) we see that the winning candidate violates \([\sigma \ *M_1/\text{Obs} \ &*M_2/l]\) and \(*M_1/\text{Obs} \ &*M_2/l]_{\text{wd}}\), but these constraints are both ranked below the relevant faithfulness constraint DEP. As can be inferred from the comparison (47a) with (48a), if (47a) with an onset cluster [bl] is allowed to surface, then the syllable contact cluster [l.b] in (48) must surface as well because, in a real sense, the [l.b] cluster with a lateral coda followed by an obstructing is less marked (i.e. has less constraint violations) than the [bl]
onset cluster. Thus we formally account for the observation that possible onset clusters should be a subset of the possible mirror-image clusters allowed in the situation of syllable contact. This relationship is predicted for any language that allows both onset clusters and clusters in syllable contact.

The tableaux shown in (45)–(48) neatly account for the syllable structure for a language like English that has both complex onsets and codas. Different rankings of the conjoined margin constraints can account for languages with other syllable types. For example, many Turkic languages allow for consonantal sequences over a syllable boundary but do not have complex onsets. This can be accounted for by the tableaux in (49) and (50) where the maximal syllable would be CVC. (We use DEP as the relevant faithfulness constraint that militates against vowel insertion.)

(49) /CVCCV/ [CVC.CV]

| /CVCCV/ | [σ *M₁&*M₂] | DEP | *M₁&*M₂|wd |
|---------|-------------|-----|---------|
| a.      | σ CVC.CV   |     | *       |
| b.      | CV.Ci.CV   |     | !       |

(50) /CCVCV/ [Ci.CV.CV]

| /CCVCV/ | [σ *M₁&*M₂] | DEP | *M₁&*M₂|wd |
|---------|-------------|-----|---------|
| a.      | CCV.CV     |     | *       |
| b.      | σ Ci.CV.CV |     | !       |

Similarly, the ranking shown in (51) and (52) with all the conjoined constraints being high ranked would account for a language with no onset clusters or syllable contact clusters. That is, the ranking in (51) and (52) would be applicable to a language whose maximal syllable was CV.

(51) /CVCCV/ [CV.Ci.CV]

<table>
<thead>
<tr>
<th>/CVCCV/</th>
<th>[σ *M₁&amp;*M₂]</th>
<th>*M₁&amp;*M₂</th>
<th>wd</th>
<th>DEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>CVC.CV</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>σ CV.Ci.CV</td>
<td></td>
<td>!</td>
<td></td>
</tr>
</tbody>
</table>

(52) /CCVCV/ [Ci.CV.CV]

<table>
<thead>
<tr>
<th>/CCVCV/</th>
<th>[σ *M₁&amp;*M₂]</th>
<th>*M₁&amp;*M₂</th>
<th>wd</th>
<th>DEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>CCV.CV</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>σ Ci.CV.CV</td>
<td></td>
<td>!</td>
<td></td>
</tr>
</tbody>
</table>
Notice that the various rankings of the conjoined constraints in (47)–(48), (49)–(50), and (51)–(52) account for the syllable typology mentioned in (19) where the ranking in (47)–(48) accounts for a language whose maximal syllable is CCVC, the ranking in (49)–(50) accounts for a language whose maximal syllable is CVC, and the ranking in (51)–(52) accounts for a language whose maximal syllable is CV. What is of note is that no ranking of these constraints can produce a language with onset clusters but lacking a consonant sequence over a syllable boundary. This is shown by the tableaux in (53) and (54) with the ranking of the conjoined margin constraints referencing the phonological word being higher ranked than DEP with the conjoined margin constraints referencing the syllable onset being lower ranked than DEP.

(53)  /CVCCV/ [CVC.CV]

<table>
<thead>
<tr>
<th>/CVCCV/</th>
<th>*M₁&amp;*M₂</th>
<th>₁</th>
<th>DEP</th>
<th>[σ*M₁&amp;*M₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. CVC.CV</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. * CV.CV</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

(54)  /CCVCV/ [Ci.CV.CV]

<table>
<thead>
<tr>
<th>/CCVCV/</th>
<th>*M₁&amp;*M₂</th>
<th>₂</th>
<th>DEP</th>
<th>[σ*M₁&amp;*M₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. CCV.CV</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. * Ci.CV.CV</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Crucial is the candidate in (54a) that has an onset cluster. As shown in (54), this candidate violates both conjoined margin constraints and so cannot surface as the winner under the ranking shown in (53)–(54). The ranking in (53)–(54) allows for only CV syllables as with the ranking shown in (51)–(52). The result of this discussion on syllable typology under the split margin approach to the syllable is the implication that if a language has onset clusters then it should have syllable contact clusters as well with the specific prediction that the permitted onset clusters are a subset of the possible mirror-image clusters allowed in syllable contact. This is similar to Kaye and Lowenstamm’s (1981) implicational universal discussed earlier in this paper that the presence of an onset cluster in a language implies the presence of a coda in that language, but is not exactly the same since our discussion of codas has been restricted to word-internal codas (i.e. codas in a syllable contact situation) and we view the patterning of word-final codas as a separate issue (especially in light of Piggott 1999).
6. Conclusion

This paper has discussed strength or sonority relations between consonants within and across syllable boundaries from a formal optimality-theoretic perspective incorporating the split margin approach to the syllable.

In the first part of the paper we considered the relation of the consonants within the syllable, specifically analyzing the link between consonant clusters and codas under the split margin approach to the syllable. The formal relationship demonstrated between a second member of an onset and a coda, both $M_2$ positions under the split margin approach to the syllable, allowed us to offer an understanding of a range of synchronic and diachronic phenomena such as the acquisition pattern of Jarmo discussed in §2 as well as a new explanation for Dorsey’s Law in Winnebago (Hocank).

After discussing the formal nature of onset clusters in §3, we then considered the diachronic implications of the split margin approach by showing how changes in one of the $M_2$ positions can have an effect on the other. We specifically considered the case of Campidanian Sardinian which has a syllable structure more restricted than in Latin in a way that affects the coda and the second member of a complex onset in a parallel manner. We also considered the case of Colloquial Bambara that has developed both complex onsets and codas in a parallel manner. We have shown how these diachronic developments are closely connected formally and are not independent developments.

In §5 we showed how the split margin approach to the syllable can be extended to account for strength or sonority relations between consonants over a syllable boundary (i.e. in syllable contact position). We then showed how our analysis makes specific predictions regarding the relationship between consonant clusters that comprise a complex onset and those that can occur over a syllable boundary. As far as we are aware, such predictions have not been formally observed previously. An intriguing prediction is that the permitted onset clusters in a language are a subset of the possible mirror-image clusters allowed in syllable contact. This is an empirical issue that needs further exploration.

There are many other issues that emerge from our analysis that we leave for future research such as the status of coda clusters, word-final codas, the analysis of exceptional $s$-clusters and other types of adjunct clusters, and accounting for languages that seem to have CCV as their maximal syllable. Nonetheless, we conclude that the split margin approach to the syllable developed here from an optimality-theoretic perspective makes intriguing
predictions about the relationship between consonants within and across syllable boundaries.

References

Alber, Birgit

Alderete, John

Baertsch, Karen

Baertsch, Karen, and Stuart Davis


Bat-El, Outi

Blevins, Juliette


Bolognesi, Roberto

Clements, George N.
Davis, Stuart  

Davis, Stuart, and Karen Baertsch  


2005b The connection between onset clusters, coda consonants, and syllable contact: The split margin approach to the syllable. Colloquium talk, University of Southern California, April 22.

Diakite, Boubacar  
2006 The synchronic link between onset clusters and codas in Bambara. Unpublished Ms., Indiana University.

Fikkert, Paula  

Fleischhacker, Heidi  

Frigeni, Chiara  


Gouskova, Maria  

Green, Tonio  

Hale, Ken, and Josie White Eagle  

Halle, Morris, and Jean-Roger Vergnaud  

Hooper, Joan  
Strength relations between consonants

Itô, Junko

Kaye, Jonathan, and Jean Lowenstamm

Lefebvre, Claire

Lefebvre, Claire, and Anne-Marie Brousseau

Levett, Clara C., and Ruben van de Vijver

Levett, Clara C., Niels O. Schiller, and Willem J. M. Levett

Lleό, Conxita, and Michael Prinz

Miner, Kenneth

Murray, Robert, and Theo Vennemann

Orgun, Cemil O.

Piggott, Glyne
1999 At the right edge of words. The Linguistic Review 16: 143–185.

Pons, Claudia
2008 Regarding the sonority of liquids: some evidence from Romance. Paper presented at the 38th Linguistic Symposium on Romance Languages, University of Illinois, April 4–6.
Prince, Alan, and Paul Smolensky  
Rutgers Optimality Archive. Published 2004, Malden, MA:  
Blackwell.

Smith, Jennifer  
2003 Onset sonority constraints and subsyllabic structure. Rutgers Opti- 
mality Archive.

Susman, Amelia  
1943 The accentual system of Winnebago. Ph.D. dissertation, Colum- 
bia University.

Vaux, Bert  
1992 Gemination and syllable integrity in Sanskrit. The Journal of  
Indo-European Studies 20: 283–303.

Vennemann, Theo  
1988 Preference Laws for Syllable Structure. Berlin/New York: Moun- 
ton de Gruyter.

Wetzels, Leo, and Ben Hermans  
1985 Aspirated geminates in Pali. In Linguistics in the Netherlands,  
Hans Bennis and Jacob Hoeksma (eds.), 212–223. Dordrecht:  
Foris.

Zec, Draga  
1988 Sonority constraints on prosodic structure. Ph.D. dissertation,  
Stanford University.