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*Syllabic and moraic structures in Piro**

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0 Introduction

Syllable structure in Piro, an Arawakan language spoken in Eastern Peru,[1] exhibits properties that are of considerable interest. First, Piro allows three-consonant clusters in the syllabic onset (Matteson 1965) but a vowel-deletion rule is blocked to avoid such clusters, which makes it difficult to simply attribute the blocking to well-formedness constraints on syllable structure (cf. Kisseberth 1970a, b). Second, the onset consonant clusters are not governed by the Sonority Sequencing Principle (Selkirk 1984a, Clements 1990). The fact that all consonants except the prevocalic ones are described by Matteson (1965) as syllabic seems to obviate the need to posit complex onsets. However, these syllabic consonants do not participate in any phonological rules, including word stress and phrase-level rhythmic rules. If they are considered extrasyllabic throughout the phonology, they become exceptions to our general conceptions of extra-prosodicity, stray erasure and prosodic licensing (Itô 1986, 1989), since numerous such extrasyllabic consonants are not at the peripheral position of a well-defined domain but persist to be present throughout the derivation. Third, loss of an onset or unsyllabified consonant can lead to compensatory lengthening (henceforth CL), contradicting the moraic conservation account of CL (Hock 1986, Hayes 1989). Fourth, as Piro has no underlying long segments nor evidence for a heavy closed syllable, it becomes a counterexample to the typological prediction that CL occurs only in languages that have a pre-existing vowel-length contrast (de Chene & Anderson 1979) or syllable-weight contrast (Hayes 1989).

This study examines how syllabic and moraic structures interact with segment deletion and CL in Piro, and proposes that Piro has only CV syllables, all other consonants are extrasyllabic but moraic, vowel deletion is blocked by a constraint motivated by prosodic well-formedness, and CL in Piro is a moraic conservation phenomenon. The proposal has several theoretical implications: (i) the mora is a genuine prosodic unit capable of licensing a segment (Hyman 1985, Bagemihl 1991, Zec 1994), (ii) the typology of CL languages has to include those that make a distinction between moraic and non-moraic segments and (iii) stray erasure (Steriade

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1982, Itô 1986, 1989) may not be a valid phonological concept (Rubach 1996).

This paper is organised as follows. §1 examines the phonological and phonetic aspects of syllable structure, vowel deletion, CL and stress in Piro, and identifies the problems to be solved. After specifying the theoretical assumptions in §2, I present a proposal to account for Piro's prosodic structure, segment deletion and CL (§3). §4 compares the proposal with several conceivable alternatives, and touches on issues regarding prosodic licensing and stray erasure. A brief conclusion is given in §5.

1 The data and the problems

1.1 Syllable structure and syllabic consonants

The vowels and consonants in Piro are given in (1) (Matteson 1965).[2]

(1) vowels	i	u	e	o	a
stops	p	t			k
affricates		ts	tš	tx	
fricatives		s	š	x	
nasal spirant					h
flaps		l	r		
nasals, glides	m	n		y	w

Piro has no vowel-initial words, nor words ending in consonants. With the exception of a few monoconsonantal affixes, all morphemes begin with one or two consonants and end in a vowel.[3] On the basis of phonological distribution and phonetic observations, Matteson maintains that Piro has only open syllables, which allow up to three consonants in the syllable onset:

> In a sequence one syllable may be phonetically closed by the onset of the initial consonant of the following syllable. The degree of closure fluctuates from zero to complete closure with rearticulation of the consonant as a part of the following syllable. The latter extreme does not occur in normal speech, but in slow, exaggerated, hypostatic utterance... all consonants are treated as belonging to the same syllable as the following vowel because (1) the closure of syllables is freely fluctuating; (2) the patterns CV, CCV and CCCV occur word-initially and so must be described whether or not closed syllables are also described; and (3) the consonant invariably shares part of the muscular movement of the syllable pulse that produces the following vowel.
>
> (1965: 23–24)

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(2) a.	CV	te.no	'tall'	ki.ni.ma	'bead bracelet'
b.	CCV	slo.ta	'clam'	tla.hwa	'toad'
c.	CCCV	nkno.ya.te	'my turtle'	ra.su.ka.mtna	'they ran'

The distribution of three-consonant clusters is limited, however: they result only from morphological concatenations that involve monoconsonantal affixes (Lin 1987, 1997a):

(3) a. n-knoyate → nkno.ya.te 'my turtle'
my-turtle
b. hasuka + m + ta + kaka → ha.su.ka.mtka.ka 'cause to run' (79)
to flee-TRANSITORY-THEME CLOSURE-CAUSATIVE

As noted in Lin (1987, 1993), one important aspect of Piro syllable structure is that no sonority constraints are placed on the combinations of consonants. The examples in (4) show that any two consonants can occur in either order. Word-initial geminate clusters are also allowed, as shown in (4g). All permissible consonant clusters occur in both word-initial and word-medial positions.

(4) a.	tpa	'curve'	pto	'...'s group'
b.	mwenutu	'cheap'	wmahatya	'we lack'
c.	wyoptota	'we receive'	ywalitxa	'hip'
d.	ksu	'tube'	skota	'lower abdomen'
e.	tmennu	'flaw'	mtenotu	'short'
f.	smota	'blunt point'	msa	'empty corn cob'
g.	nnika	'I eat'	wwuhene	'our child'

The only exceptions to such considerable freedom of consonant clustering are certain combinations of obstruents that are similar in place and/or manner of articulation:[4]

(5) a. *rr, *rl, *ll, *lr, *nl
b. *pp, *tt, *kk, *t-ts, *t-tš, *t-tx
c. *fricative-fricative
d. *affricate-affricate
e. *ts-s, *ts-š, *ts-x, *tš-s, *tš-š
f. *x-ts, *x-tš

These cooccurrence restrictions can be accounted for by filters, motivated by the Obligatory Contour Principle (e.g. Mester 1986, McCarthy 1986, Yip 1988 and references therein), rather than by sonority constraints. The first member of a non-permissible cluster cannot be syllabified and is deleted (§1.3). Except these non-permissible clusters, all other consonant combinations, including sonorant geminates, are syllabified as part of the onset (Lin 1987).

Another important aspect of Piro syllable structure is that every consonant not in prevocalic position surfaces either as a syllabic consonant or has to be followed by a very short epenthetic vowel (Matteson & Pike 1958, Matteson 1965: 129–134), e.g. /pto/ [pᵊto] '...'s group', /pimri/

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[piṃri] 'another', /šwamkalo/ [šʷaṃkalo] 'spider'.[5] Such segments are not phonemic, and their main function is to facilitate the transition from consonant to consonant in a cluster. The two forms, Ç and C^{v}, are considered allophones of the corresponding underlying C (Matteson 1965: 33), and the choice between Ç and C^{v} is rule-governed (Lin 1993, 1997b). Although Matteson describes the non-prenuclear consonants as 'syllabic', she does not treat them as independent syllables. Rather, she argues that all consonants are onset elements. Phonetically, such a 'syllabic' consonant produces a weak pulse, which is in contrast with the strong pulse produced by a phonemic nuclear vowel:

> A syllable consisting of CCV or CCCV is initiated by a weaker, controlled syllable pulse or pulses with at least partial release(s) following each vocoid or syllabified consonant, with continued build-up even during the release, and with reinforcement by a strong pulse initiating the final syllabic unit. (Matteson 1965: 23)

It is clear that Matteson considers syllabicity of consonants to be different from that of phonemic vowels. Based on a survey of various languages exhibiting excrescent vowels, Levin (1987) has argued that Piro consonant syllabicity involves low-level universal and language-particular coarticulation effects. I have also suggested elsewhere (1993) that these 'syllabic' consonants do not constitute phonological syllabic peaks, since they are never sensitive to any syllable-related phonological processes (cf. §§1.2, 1.4, 4.2.1). Therefore, what is described as a 'syllabic' consonant is best treated as a phonetic phenomenon.[6]

1.2 Boundary vowel deletion

Piro has a boundary vowel deletion rule that removes the final vowel of each lexical root and derived stem at each stage of suffixation:

(6) *Boundary Vowel Deletion* (BVD)
$$V \rightarrow \emptyset \,/\, __ \,]_{stem} +$$

BVD, however, fails to apply under two circumstances. First, there is a morphological condition that arbitrarily marks some suffixes as non-triggers. Second, there is a phonological condition that prohibits creation of three-consonant clusters during the derivation; BVD is therefore consistently blocked if its application would yield a cluster of more than two consonants.

BVD crucially refers to internal morphological bracketing and exhibits the inside-out cyclic effect: it applies within the innermost morphological domain first before proceeding to the next larger domain (cf. §3.2). The examples given in (7) illustrate that the morphological and phonological derivations of a previous cycle determine the applicability of BVD on the next cycle.[7] (The suffixes that do not trigger BVD are given in capitals, the

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boldfaced vowels indicate those that fail to delete and the underline indicates the location of vowel deletion.)

(7) a. koko + yma + ru + NE 'those with uncles' (106)
uncle-with-ENTITY-PL
cycle 1 koko + yma → kok**o**yma
cycle 2 kokoyma + ru → kokoym**a**ru
cycle 3 kokoymaru + NE → kokoymar**u**ne

b. nika + ya + waka + lu 'to eat it there' (84)
to eat-LOC-place-it
cycle 1 nika + ya → nik_ya
cycle 2 nikya + waka → niky**a**waka
cycle 3 nikyawaka + lu → nikyawak_lu

In (7a) BVD is blocked on the first and second cycles to avoid the creation of a three-consonant cluster; no vowel is deleted on the last cycle because /NE/ does not trigger BVD. In (7b) the final vowel of the stem /nika/ is deleted; the derived consonant cluster [ky] has the effect of blocking BVD on the second cycle.[8] In generative phonology, rule blocking of this type is usually attributed to derivational constraints on syllable well-formedness (Kisseberth 1970a, b). However, in a traditional derivational account, where constraints are inviolable, it is a mystery why there is a constraint against such clusters if triconsonantal clusters are permissible.

Even if we stipulate a derivational constraint *CCC, the problem is that this constraint is not always enforced. In this study we consider only the case where fricative consonant clusters fail to block BVD.[9] Two examples are given in (8a, b). Compare these two examples with (7b) and (8c, d), where the newly created clusters block BVD on the next cycle. Notice that in (8), non-permissible clusters (cf. (5)) are created by BVD; the first member of such a cluster is later deleted, with CL of the preceding vowel (§1.3).

(8) a. kna + mtasa + xe + kaka 'lanky' (158*)
pole-hollow-always-COLLECTIVE
cycle 2 knamtasa + xe → knamtas_xe
cycle 3 knamtas**x**e + kaka → knamtas**x**_**k**aka (→ knamta:xkaka)

b. ptso + tsotaxi + xi + hima 'a little bit' (172*)
size-a little-small member-POSTPOSITIVE
cycle 2 ptsotsotaxi + xi → ptsotsotax_xi
cycle 3 ptsotsota**x**xi + hima → ptsotsota**x**x_**h**ima
(→ ptsotsota:xhima)

cf.

c. kawa + kaka + ka + na 'bathe themselves' (144*)
to bathe-CAUSATIVE-PASS-them
cycle 2 kawkaka + ka → kawkak_ka
cycle 3 kawka**k**ka + na → kawka**k**kana (→ kawka:kana)

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d. haluka + ka + lu + RU 'that can be desired' (224*)
to desire-PASSIVE-ENTITY-INDIVIDUAL
cycle 2 haluka + ka → haluk_ka
cycle 3 halu**kk**a + lu + RU → halu**kka**luru (→ halu:kaluru)

What is curious is that some non-permissible clusters block BVD ([kk] in (8c, d)) while others do not (fricative clusters in (8a, b)). Moreover, if one assumes that the first member of a non-permissible cluster cannot be properly syllabified (§1.1) and hence deleted, then CL in these cases results from deletion of a presumably moraless unsyllabified consonant.

1.3 Compensatory lengthening

The examples in (9) and (10) show how long segments are derived in Piro. Consonant deletion applies to non-permissible clusters, as shown in (9a) and (10a). In comparison, word-initial identical sonorant clusters in (9b) are not subject to degemination. Word-internally, consonant deletion leads to CL of the preceding vowel, as in (10a, b); the examples in (10b) are cases where consonant deletion and CL are optional. Examples without CL involve the permissible identical nasal clusters, as in (10c). The generalisations are summarised in (11).

(9) a. *Prefixation with C deletion*

p-pawata you-make a fire	→ pawata	'you make a fire' (33)
t-tšiyahata she-to weep	→ tšiyahata	'she weeps' (33)

b. *Prefixation without C deletion*

n-nika I-to eat	→ nnika	'I eat' (33)
w-wuhene our-child	→ wwuhene	'our child' (34)
m-mahata + KA + tu NEG-lack-NOMINAL-INDIVIDUAL	→ mmahatikatu	'one which does not lack' (M & P)

(10) a. *Suffixation, BVD, C deletion and CL*

∅-nika + ka he-to eat-PASS	→ nikka	→ ni:ka	'he is eaten' (28)
hira + re-TA drink-RELATIONAL-THEME CLOSURE	→ hirreta	→ hi:reta	'to drink' (34)
hitsrukate + tši ...'s chief-ABS	→ hitsrukattši	→ hitsruka:tši	'chief' (33)
kose ... TA + xe to pull-always	→ kosxeta	→ ko:xeta	'to always pull' (33)
xitxi + tši ...'s foot-ABS	→ xitxtši	→ xi:tši	'foot' (33)

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b. *Suffixation, BVD, optional CL*

wane + YA + yi → waneyyi ~ wane:yi 'you have' (34)
there-to-you

rawa + wu → rawwu ~ ra:wu 'he takes us' (34)
he takes-us

ruhi ... TA + hima → ruhhimata → ru:himata ~ ruỹhimata
he answers-it is said 'it is said that he answers' (34)

c. *Suffixation, BVD, no C deletion, no CL*

xema + maka → xemmaka 'he would hear' (34)
he hears-SUBJUNCTIVE

hina + ne → hinne 'rain' (89)
rain-GEN

(11) a. *Obligatory deletion (and obligatory CL word-medially)*
Non-permissible clusters as given in (5)

b. *No deletion word-initially; optional deletion and CL word-medially*
yy, ww, hh

c. *No deletion and no CL*
mm, nn

Although Matteson treats all long segments as phonemic, my investigation into Piro phonology and morphology as provided by Matteson has revealed that Piro has no underlying length contrast: all surface geminate consonants are derived by morphological concatenation and/or vowel deletion, and all surface long vowels occur as a result of consonant deletion followed by CL.[10]

In his typological study of CL, Hayes (1989) makes two important claims. First, since CL processes conserve mora count (moraic conservation), CL never results from the loss of a moraless segment. Second, CL is confined to languages that have a pre-existing syllable-weight contrast. Therefore, only deletion of a syllable nucleus or a moraic coda segment can trigger CL.

The first problem posed by Piro is that if all permissible clusters are syllabified as part of the onset and the first member of a non-permissible cluster cannot be syllabified (§1.1), CL in Piro results from the loss of an onset consonant (10b) or an unsyllabified segment (8) and (10a).[11] The second problem is that Piro has no pre-existing syllable-weight contrast. Since Piro does not have an underlying length contrast, there is no syllable-weight contrast based on underlying quantity distinctions. In Piro the only source that might evidence a syllable-weight contrast comes from the stress system. However, stress in Piro is quantity-insensitive, as shown in the next section.

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1.4 Stress

The stress rules as given in (12) apply across the board to phonological words, which are isomorphic with morphological words, i.e. the output of the lexical phonology (Matteson 1965: 20–22, 70).[12] In (13), where stressed syllables are indicated with an accent, we can see that this is a quantity-insensitive syllabic trochaic system (see also Hayes 1995: 102).[13] Moreover, stress clash is avoided, as indicated in (12b) and (13).

(12) *Piro stress* (Matteson 1965: 21)
- a. Primary stress on the penultimate syllable, secondary stress on the initial syllable.
- b. Tertiary stress on alternating syllables counting from the initial syllable, but in stress groups with an odd number of syllables, two unstressed syllables before the primary stress.

(13) a. sá.lwa.ye.hká.kna 'They visit each other' (21)
- b. tá.pa.lú.ška.ná.wa.thí.ma.ná.nu.mtá.na.tná.ka
  'It is said that his canoe alone was going along again' (21)
- c. poyehi + haxi → poyeh_haxi → póye:háxi 'sad, grieving' (118)
  firm-...'s heart
- d. kaxruka + kaka + hima + NA + TA + tka + na
  'They were joking together then, it is said' (21*)
  to joke-RECIPROCAL-it is said-PROG-THEME CLOSURE-then-they
  → kaxruk_kak_himanatatkana
  → ká.xru:.ká.khi.má.na.ta.tká.na
  → ká.x^{i}ru:.ká.k^{ə}hi.má.na.ta.ta.t^{ə}ká.na

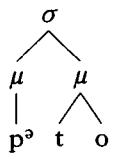
The derivations in (13c, d) illustrate stress assignment in relation to BVD and CL (cf. Lin 1993), showing that stress assignment is insensitive to derived long vowels and phonetic 'syllabic' consonants.

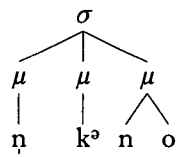
1.5 The problems

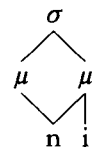
The Piro data examined above pose several problems. First, the onset consonant clusters are not governed by the Sonority Sequencing Principle (Selkirk 1984a), which requires that the segments in the onset have increasing sonority values towards the nucleus. Second, if the so-called 'syllabic' consonants are tautosyllabic with the following CV syllable, as Matteson claims, and if syllabic and geminate consonants are moraic (Hyman 1985, Hayes 1989), odd and perhaps universally unattested syllable types would be produced, as shown in (14).[14] On the other hand, if the first mora of each syllable in (14) and those consonants that cannot be properly syllabified due to violations of the occurrence restrictions or sonority constraints remain unsyllabified throughout the phonology, we

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run counter to the contention that unlicensed segments should be stray erased in the lexicon (Itô 1989).

(14) a. 

b. 

c. 

Third, the derivational constraint *CCC that is needed to block BVD cannot be motivated on the basis of syllable well-formedness if three-consonant clusters form legitimate onsets. Moreover, this constraint sometimes holds and sometimes does not. Fourth, CL results from deletion of a presumably moraless unsyllabified consonant or an onset consonant, contradicting Hayes' claim that loss of a moraless consonant cannot lead to CL. Finally, Piro is a counterexample to the claim that CL occurs only in languages that have a pre-existing vowel-length contrast (de Chene & Anderson 1979) or syllable-weight contrast (Hayes 1989).

Before presenting a proposal to solve these problems, I first lay out my theoretical assumptions.

2 Theoretical assumptions

I assume the basic principles of Optimality Theory (henceforth OT; Prince & Smolensky 1993, McCarthy & Prince 1993a, b, 1995). In OT, the candidate outputs generated by a set of universal operations (Gen) are evaluated against a ranked set of universal constraints, and the one that best satisfies the constraints is selected as the actual output. I follow McCarthy & Prince's (1995) Correspondence Theory in allowing operations of deletion in Gen[15] and interpreting the Faithfulness constraints between an input and output in terms of input–output correspondence. The Faithfulness constraints require that each element in the input has a correspondent in the output and *vice versa*:

(15) a. MAX-IO: Every element in the input has a correspondent in the output.
b. DEP-IO: Every element in the output has a correspondent in the input.

A MAX constraint penalises deletion and a DEP constraint penalises insertion.[16] Aside from Faithfulness, the set of universal constraints include various output well-formedness constraints as well as the Alignment constraints that match boundaries of phonological and morphological categories. Alternations and distributional restrictions then occur

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as a result of Faithfulness being overridden by other higher-ranked constraints.

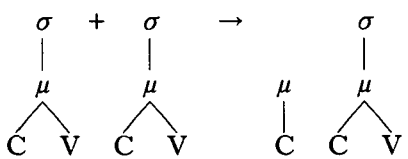
In this study, I also assume the distinction of lexical and postlexical components as in Lexical Phonology (Kiparsky 1982, 1985, Mohanan 1986). Although in OT all derivational rules are abandoned in favour of parallel constraint evaluation, it seems that we still have to posit a limited number of levels for some languages. For example, in their study of Axininca Campa, McCarthy & Prince (1993a) postulate three distinct levels, in each of which the constraint ranking differ. More recently, Booij (1996) also argues that constraints must be evaluated at more than one stage.

I follow moraic phonology (Hyman 1985, McCarthy & Prince 1986, Hayes 1989, Zec 1994) in eliminating skeletal C/V or X slots and classifying segments into moraic and non-moraic elements. An onset consonant is non-moraic, while a syllable nucleus is moraic. A coda consonant becomes moraic by the language specific Weight-by-Position rule if there is a distinction between a heavy CVC syllable and a light CV syllable (Hayes 1989). Alternatively, the coda consonant can be assumed to be moraic by default unless there is evidence showing that CVC must be light (Hyman 1985).

The degrees of underlying morification vary among different theories of moraic representation: in Hyman (1985) every segment is assigned a mora underlyingly; in McCarthy & Prince (1986) only long vowels and geminate consonants are underlyingly moraic; in Hayes (1989) contrastive short and long vowels are represented by one and two moras respectively, non-geminate consonants have no underlying moraic structure and underlying geminates are marked with a single mora. We are concerned most with how moraic conservation in CL can be captured in an OT account. Since there are no intermediate derivational steps between the input and the output at a given level, the simplest way is to make use of the correspondence constraint MAX-μ that preserves the input moras in the output. Vowel and consonant deletions in Piro can then lead to CL if MAX-μ is ranked high enough to preserve the input moras maximally. I therefore assume with Hyman that all segments are moraic underlyingly.[17]

In the moraic representation of syllable structure, non-moraic onset segments are either linked to the syllable node (Hayes 1989) or to the nearest tautosyllabic mora (Hyman 1985, Hayes 1994, Zec 1994). I adopt the latter representation since it conforms to strict layering (cf. §3.1.2) and naturally captures the suggestion that an onset consonant can directly inherit the mora vacated by the deleted vowel and become an extrasyllabic moraic consonant (§3.1.1):

(16)



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3 The proposal

In this section, I first propose that Piro has a CV syllable template and allows extrasyllabic moraic consonants (§3.1.1) and then provide an OT account of Piro's prosodic structure (§3.1.2). Based on the proposed syllabic and moraic structures, BVD and CL are analysed (§3.2). The typology of CL language is discussed in §3.3 and a concluding summary is given in §3.4.

3.1 Syllable structure and prosodic licensing

3.1.1 *The simple syllable hypothesis and moraic licensing.* Central to the notion of prosodic licensing as defined in (17) is the contention that only licensed units can be phonetically realised.

(17) *Prosodic licensing* (Itô 1986, 1989)
Every phonological unit (segment, syllable and foot) must be dominated by higher prosodic structure.

On the assumption that syllabification is continuous and exhaustive, segments have to be licensed by the syllable or subject to stray erasure. Stray erasure therefore functions to remove unlicensed elements from the representation, accounting for the lack of phonetic realisation of these elements. Extraprosodicity, epenthesis and resyllabification are language-particular devices to help prevent stranded segments from being stray erased. If no such devices are available in a language, stray erasure as a universal device intervenes to remove all unsyllabified segments.

Drawing evidence from Bella Coola phonology and morphology, Bagemihl (1991) argues for the simple syllable hypothesis as in (18a) and claims that some consonants must be left unaffiliated to a syllable phonologically. He then proposes the notion of moraic licensing as in (18b) and suggests that in some languages unsyllabified consonants may persist throughout the derivation and be exempt from stray erasure if they are moraic: that is, only a moraless unsyllabified consonant is subject to stray erasure.

(18) a. *Simple syllable hypothesis*
No incorporation or adjunction of extensive series of consonants or of consonants that violate sonority constraints.
b. *Moraic licensing*
In the marked case, an unsyllabified segment is licensed if it is linked to a mora; segments unlinked to a mora are stray erased. (In the unmarked case, a segment is unlicensed if it is not linked to a syllable.)

In a moraically licensed language, one expects that CL may occur as a result of deletion of an extrasyllabic moraic consonant. I suggest that Piro is one such language:[18]

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(19) a. Syllable template: CV
b. All other consonants are unsyllabified but licensed by moras.
c. Deletion of an extrasyllabic moraic consonant leads to CL.

If Piro has only CV syllables and allows unsyllabified moraic consonants, no sonority constraints are violated, and CL in Piro becomes a natural consequence of moraic conservation. Moreover, the fact that phonetic syllabification of these consonants fluctuates greatly (§1.1) raises questions about the need to assign these consonants to the preceding or following syllable. Therefore, they seem to be best treated as extrasyllabic consonants.

Phonetically the extrasyllabic consonants are 'syllabic', but the fact that they are ignored by all phonological rules (including BVD and word stress, cf. §§1.2 and 1.4) and even by the phrasal level rhythmic rules (Matteson 1965: 13–20) suggests that they do not constitute syllables by themselves. What Matteson labels as a 'syllabic consonant' appears to be a consonant released with a clearly audible pulse for the purpose of phonetic transition, rather than a true syllabic consonant that functions as the nucleus of a syllable; in addition, the epenthetic excrescent vowel appears to be part of the release of the consonant it follows (§1.1). That is, in each consonant cluster, except identical sonorant clusters, the release of the first consonant precedes the closure of the second consonant.[19] The reason that these preconsonantal consonants are transcribed as 'syllabic' can be attributed to their greater phonetic salience. Following Hayes' (1994) suggestion that moraic segments have greater phonetic strength, these consonants are best treated as being moraic. We can then distinguish three types of consonants in terms of their syllabic and moraic status: (i) regular non-syllabic consonants are syllabified into an onset or a coda; they are non-moraic as an onset and can be moraic or non-moraic as a coda; (ii) real syllabic consonants, such as the syllabic sonorants in English, are moraic and syllabified as syllable nuclei; (iii) phonetically 'syllabic' consonants like those in Piro are moraic but unaffiliated with any syllable.[20]

Extraprosodic elements have been argued to observe the Peripheral Condition that restricts them only to the peripheral position within the relevant domain (e.g. Hayes 1982, Harris 1983, Buckley 1994 and references therein). However, the unsyllabified consonants in Piro are not necessarily at the edge of the relevant prosodic domain and hence cannot be treated as invisible extraprosodic elements that can escape stray erasure. The suggestion that they are moraically licensed explains why they can be phonetically realised.[21]

Two questions then arise. First, it is curious why a language would allow such a vast number of extrasyllabic moraic consonants. Note that many of these consonants are derived from deletion of a vowel. While CL is a process that conserves the mora left by a deleted moraic segment, Piro appears to also require an onset consonant to preserve a mora left behind by a deleted vowel.[22] One may further question why those non-derived

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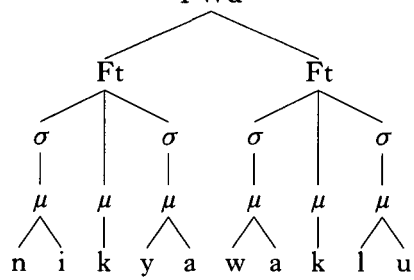
extrasyllabic consonants are also moraic, e.g. /š/ and /m/ in /šwamkalo/ [šᵊ.wa.m̩.ka.lo] 'spider'. A comparison of the basic vocabulary of Proto-Arawakan in Noble (1965) and that of Piro in Matteson (1965) indicates that, historically, non-derived extrasyllabic consonants also resulted from vowel deletion:

(20) Proto-Arawakan CV CVCV
Piro C CCV

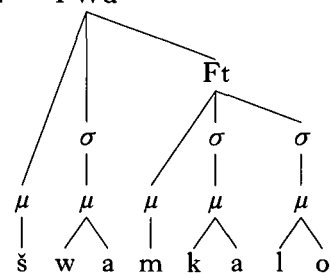
I then suggest that the mora count in Piro has been and is still maximally maintained; moras are lost only when a consonant is syllabified as an onset or when a stop of a non-permissible cluster is deleted in word-initial position where no vowel is available to preserve the mora as in e.g. (9a).

The second question is how these moraic consonants are organised at higher prosodic levels. If all phonological units must be prosodically licensed, the extrasyllabic moras eventually have to be dominated by a higher prosodic unit. I suggest that they are linked to the foot or the prosodic word, since they appear to have loose connection with the syllable but constitute part of the foot and the prosodic word that play a role in determining stress and phrasal rhythmic grouping (Matteson 1965: 13–22). The examples in (21) show that an unsyllabified mora is in principle licensed by the foot unless it is adjacent to unfooted syllables.[23]

(21) a.



b.



Zec (1994) has argued convincingly that the mora is a genuine prosodic unit capable of licensing segments because it clearly has prosodic properties. The evidence is based on the important role the mora plays in related prosodic phenomena, such as sonority restrictions, syllabic organisation, minimal word effects and foot construction. In addition to Bella Coola, Gokana (Hyman 1985) and Bulgarian (Zec 1994) are two other cases reported in the literature that require the treatment of the mora as a licenser of segments. The moraic licensing proposal then not only captures the phonological and phonetic aspects of Piro prosodic structure and CL but is also supportive of the treatment of the mora as a prosodic licenser.

3.1.2 *Prosodic licensing, weak layering and moraic conservation.* In this subsection, I provide an OT analysis of the proposed prosodic structure, demonstrating the interaction of prosodic licensing constraints, pres-

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ervation of input moras and well-formedness constraints on syllable and foot structures.

In the prosodic hierarchy generally assumed (e.g. Selkirk 1978, 1984b, McCarthy & Prince 1986, Nespor & Vogel 1986, Inkelas 1991), the mora is dominated by the syllable, the syllable by the foot, and the foot by the phonological word. The Strict Layer Hypothesis (Selkirk 1984b) holds that every prosodic constituent must be exhaustively dominated by the next higher constituent. The general prosodic licensing constraint is given in (22), and the licensing constraints that capture strict layering are given in (23) (cf. Itô & Mester 1992).[24]

(22) PROSODIC LICENSING (PROLIC)
Every phonological unit is licensed by a higher prosodic unit.

(23) a. RT/μ: Every segment is licensed by a mora.
b. μ/σ: Every mora is licensed by a syllable.
c. σ/FT: Every syllable is licensed by a foot.
d. FT/PWD: Every foot is licensed by a prosodic word.

Strict layering is violable, however. When a unit is not dominated by the next higher prosodic unit but licensed by another higher prosodic unit, we have a weak layering structure. Examples for weak layering include appendix consonants or non-moraic coda consonants (Goldsmith 1990, Hayes 1989, Lamontagne 1993), unfooted syllables (Itô & Mester 1992, Hayes 1995) and non-moraic epenthetic vowels (Piggott 1995).

In the case of Piro, RT/μ and FT/PWD are undominated, but μ/σ and σ/FT must be dominated by other constraints, since not every mora is licensed by a syllable, and not every syllable by a foot. The syllable structure constraints in (24a–c) (cf. Prince & Smolensky 1993) are all undominated and never violated. The combination of CONSPEAK (24c) (Rosenthall 1994: 214), ONSET and NOCODA accounts for the existence of extrasyllabic consonants. Since a degenerate foot is allowed only in a monosyllabic word, the foot structure constraint FTBIN (24d), which rules out degenerate feet (cf. Prince & Smolensky 1993), should be high-ranking. Weak layering in Piro then occurs as a result of ranking the constraints in (24) higher than μ/σ and σ/FT.

(24) a. ONSET: Onset is obligatory.
b. NOCODA: Coda consonants are prohibited.
c. CONSPEAK: Consonants cannot serve as syllable peaks.
d. FTBIN: Feet must be binary at the level of the syllable.

In addition, the constraint in (25), which accounts for moraic conservation, is violated when a prevocalic consonant becomes an onset, as required by the undominated ONSET constraint. Among the constraints proposed so far, MAX-μ, μ/σ, σ/FT and FTBIN may be violated, while all other constraints are undominated.

(25) MAX-μ: Every mora in the input has a correspondent in the output.

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The tableaux in (26) and (27) use the example given in (21b) to illustrate how the output with extrasyllabic moraic consonants is selected. For expository clarity, I focus on the moraic and syllabic levels in (26) and on foot and prosodic word levels in (27). The tableau in (26) shows that candidate (26b) is the winner since it violates only the lower-ranked constraints. Outputs that allow syllabic consonants (26a), codas (26d) and syllables without onsets (26a, e) are ruled out by the undominated syllable structure constraints, and (26f) fails because it violates the undominated RT/μ constraint. MAX-μ must dominate μ/σ so that (26b) can win over (26c); (26c) then fails by incurring more MAX-μ violations than (26b). Note that candidate (26e) preserves all the input moras, completely satisfying MAX-μ, but it violates the undominated ONSET constraint.

(26)

	ONSET NOCODA	CONSPEAK RT/μ	MAX-μ	μ/σ
š w a m k a l o μ μ μ μ μ μ μ μ				
a. š w a m k a l o μ μ μ μ μ σ σ σ σ σ	*!*	*!*	***	
☞ b. š w a m k a l o μ μ μ μ μ σ σ σ			***	**
c. š w a m k a l o μ μ μ σ σ σ			****!*	
d. š w a m k a l o μ μ μ σ σ σ	*!		*****	
e. š w a m k a l o μ μ μ μ μ μ μ μ σ σ σ	*!**			*****
f. š w a m k a l o μ μ μ σ σ σ σ σ		*!*	*****	

In (27), the extrasyllabic consonants are licensed either by a foot or the prosodic word. Candidate (27a) is ruled out because it has a degenerate foot; we also see that FTBIN must rank higher than σ/FT, so that candidate (27b) can win over (27a). In candidate (27c) the unsyllabified consonants remain unlicensed by a foot or the prosodic word, violating the un-

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dominated PROLIC constraint. Candidate (27d) fails because it incurs more violations of σ/FT than the optimal candidate (27b), which illustrates that violation of licensing constraints should be minimal.

(27)

	PROLIC	FTBIN	σ/FT
a. š[wa]$_\sigma$m [ka]$_\sigma$[lo]$_\sigma$ (Ft Ft; PWd)		*!	
☞ b. š[wa]$_\sigma$m [ka]$_\sigma$[lo]$_\sigma$ (Ft; PWd)			*
c. š[wa]$_\sigma$m [ka]$_\sigma$[lo]$_\sigma$ (Ft; PWd)	*!*		
d. š[wa]$_\sigma$m [ka]$_\sigma$[lo]$_\sigma$ (PWd)			**!*

3.2 BVD and CL

3.2.1 *BVD.* As suggested in Lin (1997a), to account for the BVD patterns that regularly avoid a sequence of more than two consonants, we need an Alignment constraint (cf. McCarthy & Prince 1993b, Cohn & McCarthy 1994, Kenstowicz 1995), the BASE-IDENTITY (BASE-ID) constraint (Kenstowicz 1996), and a constraint that prohibits three-consonant clusters.[25]

The ALIGN constraint given in (28a) accounts for BVD, and (28b) is an output well-formedness constraint against three-consonant clusters. The inside-out cyclic nature of BVD can be captured by BASE-ID in (29), with recursive constraint evaluation.

(28) a. ALIGN(Stem-R, C-R): Every stem ends in a consonant.
b. *CCC: Three-consonant clusters are prohibited. (*tentative*)

(29) BASE-ID: Given an input structure [X Y], output candidates are evaluated for how well they match [X] and [Y] if the latter occur as independent words. (Kenstowicz 1996: 370)

The tableau in (30) shows that ALIGN must rank higher than BASE-ID, and the tableau in (31), using the example (7b), shows that *CCC is ranked higher than ALIGN, so that candidate (31c), which incurs no ALIGN violation, can be ruled out.[26]

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(30)

nika + ya	ALIGN	BASE-ID
☞ a. nik_] ya		*
b. nika] ya	*!	

cf. [nika]

(31)

nika + ya + waka + lu	*CCC	ALIGN	BASE-ID
a. nika] ya] wak_] lu		**!	**
☞ b. nik_] ya] wak_] lu		*	*
c. nik_] y_] wak_] lu	*!		**
d. nika] y_] wak_] lu		*	**!*

cf. [nikyawaka]

The immediate constituents of the word in (31) are [nikyawaka] and [lu], so BASE-ID compares an output candidate with the immediate constituent that can stand as a word, i.e. [nikyawaka] 'I eat there'. For example, excluding the suffix /lu/, candidate (31b) differs from [nikyawaka] in lacking one vowel, but candidate (31d) incurs two additional violations because it has a vowel between [ky] and no vowel after [y]. If we do not adopt BASE-ID, candidates (31b) and (31d) would be tied. The difference between the two candidates is that (31b) deletes the vowel of the stem on the inner cycle, while (31d) deletes the vowel on the second cycle. The fact that BVD should apply to the inner stem first illustrates the inside-out cyclic effect, which is accounted for by BASE-ID.

3.2.2 **CCC.* To account for BVD, the constraint *CCC is crucial. However, positing *CCC is problematic since it counts the number of segments. One could imagine a situation in which four-consonant or five-consonant sequences are allowed, although a three-consonant sequence is prohibited. Therefore, what is really prohibited is not the three-consonant sequence but a sequence of more than two successive consonants. As pointed out by two anonymous reviewers, the question is why no more than two successive moraically licensed consonants are allowed.

I suggest two possible explanations: a phonetic one and a formal one. Let us assume that the release burst or phonetic salience of a moraically licensed consonant serves to preserve maximal perceptual cues of the consonant in the absence of a following vowel that can help encode some of these cues in format transition (cf. note 19). A more demanding perceptual requirement that helps the hearer to decode the unsyllabified consonant imposes more articulatory efforts. Producing two such consonants in a row without the help of a vowel is articulatorily even more demanding and hence avoided.

A more formal explanation may lie in restrictions on a weak layering structure. In OT, an optimal output is one that incurs violations

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minimally. Since violations of strict layering are compelled only when some of the licensing constraints in (23) are dominated by other constraints (§3.1.2), one expects that the number of units not licensed by their next higher categories should be minimised. Therefore, more than one unsyllabified consonant in a given domain is disfavoured. Moreover, there seems to be some disharmony requirement of strict layering violations. For example, in ternary stress systems, two unfooted syllables are found to be worse than two non-adjacent unfooted syllables (Alderete 1997).

If the above explanations are on the right track, what is characterised as *CCC may well be the conjunction of several constraints. For ease of exposition, I suggest WEAK LAYERING WELL-FORMEDNESS (WLWF) as in (32) to replace the problematic *CCC constraint.

(32) WLWF (*replacing* *CCC)
No two adjacent phonological units unlicensed by their next higher category are allowed, e.g. no two adjacent unfooted syllables, no two adjacent extrasyllabic moras.

3.2.3 *CL.* To account for CL, we need a set of OCP constraints on some adjacent obstruents ((5), §1.1), for example:[27]

(33) a. OCP_f: Adjacent fricatives are prohibited.
b. OCP_{st}: Adjacent identical stops are prohibited.

In addition, MAX-μ, introduced in §3.1.2 to preserve the moras of vowels and non-onset consonants, also accounts for moraic conservation of the CL phenomenon.[28]

Consider first the tableau in (34) for the CL example taken from (8a) (=(35a) below).[29] Candidate (34b) is ruled out by OCP and WLWF and (34c) by OCP. MAX-μ eliminates the candidate that violates moraic conservation, i.e. (34f). After the evaluation of ALIGN, two candidates, (34e, g), survive; BASE-ID then eliminates (34g), and (34e) is selected as the optimal output.[30]

(34)

...mtasa + xe + kaka	OCP_f	WLWF	MAX-μ	ALIGN	BASE-ID
a. mtasa] xe] kaka				**!	**
b. mtas_] x_] kaka	*!	*			**
c. mtas_] xe] kaka	*!			*	*
d. mta:_] xe] kaka				**!	
☞ e. mta:_] x_] kaka				*	*
f. mta_ _] x_] kaka			*!	*	*
g. mtasa] x_] kaka				*	**!*

cf. [...mta:xe]

Consider now the different behaviour of the fricative clusters and the identical stop clusters given in (35a, b) (=(8a, c)). Note that the vowel of [xe] in (35a) deletes while the vowel of the passive suffix [ka] does not.

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(35) a. kna + mtasa + xe + kaka 'lanky' (158*)
pole-hollow-always-COLLECTIVE
→ knamtas_x_kaka → knamta:xkaka
b. kawa + kaka + ka + na 'bathe themselves' (144*)
bathe-CAUSATIVE-PASS-them
→ kawkak_kana → kawka:kana

Tableau (34) already accounted for (35a). Tableau (36), however, shows that the constraint ranking established so far fails to select the correct output for (35b).[31]

(36)

...kaka + ka + na	OCP_{st}	WLWF	MAX-μ	ALIGN	BASE-ID
a. kaka] ka] na				**!	**
b. kak_] k_] na	*!	*			**
c. kak_] ka] na	*!			*	*
√ d. ka:_] ka] na				**!	
☞ e. ka:_] k_] na				*	*
f. ka_ _] k_] na			*!	*	*
g. kaka] k_] na				*	**!

cf. [...ka:ka]

By comparing (36) with (34), we can see that there is a ranking paradox: in order to select the actual attested output (36d), BASE-ID should be ranked higher than ALIGN, which is opposite to the ranking that is needed to select (34e). The ranking paradox indicates that it may be necessary to have constraint evaluations at more than one stage (cf. §2).

In a derivational account, a successful solution is to delete the first member of the fricative cluster and apply CL right after BVD on the same cycle in the lexical phonology; BVD on the next cycle is thus not blocked because no three-consonant cluster would be created (cf. Lin 1995):

(37) *cycle 2* knamtasa + xe → knamtas_xe → knamt**a**:xe
cycle 3 knamta:**xe** + kaka → knamta:x_kaka

On the other hand, degemination of [kk] must not apply in the cyclic component since it still functions to block BVD on the next cycle:

(38) *cycle 2* kawkaka + ka → kawkak_ka
cycle 3 kawka**kka** + na → kawka**kka**na
postlexical kawka**kk**ana → kawk**a:k**ana

If consonant deletion and CL are persistent rules (cf. Myers 1991), triggered by the OCP constraints, the constraint against fricative clusters then holds in the lexical component, but the constraint against [kk] operates postlexically. The difference in behaviour of these two groups of non-permissible clusters can then be attributed to the point in the derivation when the constraints are in effect.

In OT terms, we can rank OCP_f high but OCP_{st} low at the lexical level. OCP_{st}, however, should be ranked high at the postlexical level to account

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for the total surface absence of identical stop clusters.[32] Therefore, the output of the lexical level contains [kk], which is removed postlexically.

Tableaux (39) and (40) show how the example in (35b) can be correctly analysed. In (39), we can see that OCP_f has no effect on the [kk] sequence, and three candidates, (39c, e, g), survive after the evaluation of ALIGN. BASE-ID then eliminates (39e, g).[33] Note that OCP_{st} should be ranked lower than BASE-ID; otherwise, (39e) would be incorrectly selected as the output. The lexical output (39c) then becomes the input for postlexical constraint evaluation. Tableau (40) shows that OCP_{st} and MAX-μ at the postlexical level obtain the CL effect for the [kk] sequence. This postlexical ranking, on the other hand, has no effect on the lexical output of tableau (34) since it contains no OCP violation.

(39) *Lexical level*

...kaka + ka + na	OCP_f	WLWF	MAX-μ	ALIGN	BASE-ID	OCP_{st}
a. kaka] ka] na				**!	*	
b. kak_] k_] na		*!			*	*
☞ c. kak_] ka] na				*		*
d. ka:_] ka] na				**!	*	
e. ka:_] k_] na				*	*!*	
f. ka_ _] k_] na			*!	*	**	
g. kaka] k_] na				*	*!*	

cf. [...kakka]

(40) *Postlexical level*

...kakkana	OCP_{st}	MAX-μ
a. kakkana	*!	
☞ b. ka:kana		
c. ka_kana		*!

Tableau (41) shows that the proposed ranking also succeeds in selecting the correct output for the BVD example without CL analysed earlier in (31):

(41)

nika + ya + waka + lu	OCP_f	WLWF	MAX-μ	ALIGN	BASE-ID
a. nika] ya] wak_] lu				**!	**
☞ b. nik_] ya] wak_] lu				*	*
c. nik_] y_] wak_] lu		*!			**
d. nika] y_] wak_] lu				*	**!*
e. ni_ _] y_] wak_] lu			*!	*	***

Consider now those CL examples involving other non-permissible clusters. I have not been able to find crucial examples similar to those in

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(35) for other non-permissible clusters. It is therefore unclear if the restrictions on clusters other than fricative clusters and [kk] hold of lexical or postlexical level.[34] Let us examine both possibilities using an example taken from (10a): /xitxi/ + /tši/ → [xi:tši].

If, like OCP_{st}, the OCP constraint against affricate clusters, i.e. OCP_{af}, is ranked low at the lexical level, then [xitxtši] would be the optimal lexical output, as shown in (42). At the postlexical level, the high ranking OCP_{af} bans the affricate cluster and the output with CL surfaces.

(42) *Lexical level*

xitxi + tši	MAX-μ	ALIGN
a. xitxi] tši		*!
b. xi:_] tši		*!
c. xi_ _] tši	*!	*
☞ d. xitx_] tši		

On the other hand, if OCP_{af}, like OCP_{f}, is high-ranking at the lexical level, then we have to add another Alignment constraint. As shown in tableau (43), BASE-ID is irrelevant in this case because the bare root [xitxi] cannot stand as an independent word. As a result, candidates (43a, b) are tied, but (43b) is the actual attested output.

(43)

xitxi + tši	OCP_{af}	MAX-μ	ALIGN	BASE-ID
☜ a. xitxi] tši			*	
☞ b. xi:_] tši			*	
c. xi_ _] tši		*!	*	
d. xitx_] tši	*!			

*[xitxi]

Since the second mora of a long vowel comes from a moraic consonant and only short vowels are targeted by BVD, the generalisation here seems to be that a stem that ends in a long vowel fares better than one that ends in a short vowel. Zec (1994) suggests that within a heavy syllable, the first mora, which dominates a nucleus segment, is the strong mora, while the second mora, which dominates either a moraic coda or the second phase of a long vowel, is the weak mora. We can formulate the second Alignment constraint as in (44). This constraint can then correctly eliminate candidate (43a).[35]

(44) ALIGN(Stem-R, μ_w-R): Every stem ends in a weak mora.

Finally, to account for the examples with optional CL in (10b), I suggest that the OCP constraint against identical glide clusters, OCP_g, is ranked low and is hence inactive at the lexical level. The surface free variation can be attributed to variable or undetermined ranking of OCP_g at the postlexical level: when OCP_g is ranked high, we get the CL effect, but when it is ranked low, we keep glide geminates on the surface.

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3.3 What languages allow CL?

I have proposed that the simple syllable hypothesis together with moraic licensing provides a satisfactory analysis of syllable structure, BVD and CL in Piro. CL in Piro turns out not to be an exception to the moraic conservation account. However, Piro still remains a counterexample to Hayes' prediction about the types of languages that may exhibit CL: Piro has no pre-existing weight contrast. Piro also constitutes a counterexample to other typological predictions about CL. For example, de Chene & Anderson (1979) argue that CL does not occur in languages with no pre-existing vowel-length contrast, and CL cannot be the source of an emerging vowel-length contrast. Piro has no underlying vowel-length contrast and the only long vowels that potentially can lead to an emerging length contrast are derived by CL. Hayes (1989) has suggested that the factor determining a possible CL language lies not in the vowel-length contrast but the syllable-weight contrast, because CL is reported to occur in languages that have no underlying long vowels but have heavy closed syllables (Hayes 1989: 290). Even Bella Coola, a language that is forcefully argued to observe moraic licensing and can exhibit CL (note 18), has a syllable-weight contrast since heavy closed syllables are attested. Piro then presents an interesting case that requires a redefinition of possible CL languages.

To accommodate the case of Piro, I propose to replace Hayes' typological generalisation with the following: a language that has the moraic and non-moraic contrast among consonants or the monomoraic and bimoraic contrast among vowels can exhibit CL. Any language that has a syllable-weight contrast can be subsumed under the proposed generalisation. Assuming that all languages have the CV syllable type where C is non-moraic and V is moraic, the prediction made here is that CL is possible in languages that have at least one of (45). Type (45a) is also predicted by Hayes and (45d) by both de Chene & Anderson and Hayes.

(45) CL is possible in languages that have
  a. heavy CVC
  b. extrasyllabic moraic C
  c. syllabic C
  d. CVV

In a language that makes a weight contrast between CV and CVC syllables, there is also a contrast of moraic and moraless (coda and onset) consonants. Many canonical CL cases are of this type. In a language like Piro, where no syllable-weight contrast is evident but moraic licensing is observed, the contrast between extrasyllabic moraic consonants and the moraless onset consonants makes it possible to exhibit CL. My proposal also makes the prediction that CL is possible in a language that has syllabic consonants. As this type of language often overlaps with the other three types, the true test case must be one that has only CV and syllabic C syllables, which may not be easy to find. It therefore remains an empirical question whether the prediction about (45c) can be borne out. Under the present proposal, the condition for a pre-existing vowel-length contrast as

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argued by de Chene & Anderson is translated into moraic terms: monomoraic *vs.* bimoraic vowels. The point is that whenever there is a pre-existing contrast in moraic structure among consonants or vowels, CL is possible.[36] Hayes has made it clear that it is the moraic structure, not simply the vowel inventory of a language, that appears to be relevant to CL. Although I have abandoned Hayes' idea that syllable-weight contrasts determine CL, the present proposal retains the important insight that the contrast in moraic structure is the key to the understanding of the CL phenomenon.

3.4 Summary

The proposal presented in the previous sections solves all the problems identified in §1.5. First, there are no massive violations of sonority constraints. Second, phonetically 'syllabic' consonants are moraic but independent from the core syllable, so no odd syllable types are created. In addition, these extrasyllabic consonants are prosodically licensed and phonetically realised. Third, the constraint *CCC is replaced by WLWF, which is motivated by prosodic well-formedness. Fourth, different constraint rankings at the lexical and postlexical levels account for the contrast between those examples where BVD is blocked and those where BVD applies unexpectedly. Moreover, CL in Piro no longer constitutes a counterexample to the moraic account of CL. It also provides a case of CL that is predicted to exist by the moraic theory of CL and moraic licensing. Finally, the suggestion that CL may occur in languages that have a moraic contrast among consonants or vowels leads us to believe that it is the general moraic structure of a language, not simply its syllable-weight contrast, that determines whether CL may occur.

4 Comparison with alternative analyses

4.1 The coda hypothesis

One clear alternative way to solve the CL problem is to allow word-internal codas in Piro. Piro would then have a typical CL process that results from deletion of a coda segment (e.g. Steriade 1982, Wetzels & Sezer 1985). However, we have no independent evidence for a coda in Piro. If one assumes that the language-particular Weight-by-Position rule applies only when there is evidence for heavy CVC syllables, then it is not clear if the putative coda consonant is necessarily moraic. In the following two subsections, I examine two potential analyses in which word-medial moraic codas are postulated.

4.1.1 *Heavy closed syllables by default.* If one assumes that all CVC syllables are universally heavy unless there is evidence indicating otherwise, then the putative word-medial coda consonant is moraic by default. Although an assumption like this is not unreasonable (Tranel 1991), especially under Hyman's moraic theory, there are still reasons to believe

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that positing a coda in Piro is less desirable on both phonological and phonetic grounds.

First, since generalisations of syllable structure to a large extent are based on the distribution of consonant clusters in morphemes and words, the disregard of these distributional facts signals the weakness of the coda hypothesis. Besides, there is no evidence showing that word-initial and word-medial clusters behave differently with respect to either phonological or phonetic rules.

Second, even if we allow word-medial CVC syllables, we still have to posit extrasyllabic consonants in the language, because after CVC syllabification, additional word-initial consonants (including first halves of geminates) and some word-internal consonants in triconsonantal clusters cannot be exhaustively syllabified and still need to be moraically licensed:

(46) a. [n.ni.ka] 'I eat'
[šʲ.waṃ.ka.lo] 'spider'
b. [h̃a.su.kaṃ.tʲ.ka.ka] 'cause to run' ((3), note 9)
c. kna + mtasa + xe + kaka 'lanky' ((8a), (35a))
→ k.nam.tas.x.ka.ka → [kʲ.naṃ.ta:.x̣.ka.ka]

Third, Hudson (1995) suggests that syllable-final consonants should be marked as unreleased, and the Maximal Onset Principle (Selkirk 1982) follows from the maximisation of consonant releases. Although phonetically not all coda consonants are universally unreleased, there is indeed a cross-linguistic tendency for a coda consonant to be unreleased or weakened, but the putative coda consonants have strong releases. The phonetic salience exhibited by these consonants suggests that they are more likely to be independent units or more akin to the following rather than the preceding prosodic unit.

Furthermore, the general lack of complete closure of syllables (§1.1) seriously undermines the appeal of the coda hypothesis. Recall that a complete closure of syllables is unnatural and when it does happen, it crucially requires rearticulation of the 'coda' consonant for the transition to the next syllable; that is, some sort of gemination is necessary if a complete syllable closure occurs. In contrast, the present proposal captures the fact that phonetic syllable closure is highly fluctuating since the extrasyllabic consonants do not belong to any syllable.

4.1.2 *Limited closed syllables.* One could also suggest an analysis as follows: (i) all the non-permissible clusters are assumed to be some sort of linked geminates; (ii) only the first half of a 'geminate' can close the preceding syllable; (iii) these 'geminates' are moraic and degemination naturally leads to CL.

This analysis, however, runs into problems. First, non-geminates still have to be licensed; that is, we still need moraic licensing. Second, while in many languages a partial geminate such as a homorganic nasal–stop cluster behaves like a true geminate, many non-permissible clusters in

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Piro are not geminates in the usual sense, e.g. *[sx], *[xš], *[tstx], *[tsš], *[rl]. The question is: what clusters are considered partial geminates and hence moraic? Let us assume that the palatal fricative [x] and affricate [tx] are coronals and that affricates are both [−continuant] and [+continuant]. If we define 'geminates' in Piro as clusters sharing at least the same place or stricture features, clusters such as *[tts], *[sx], *[xš], *[tstx], *[rl] correctly fall within this definition. However, numerous permissible clusters, which are supposed to be non-geminates, would be incorrectly treated as 'geminates', e.g. [nt], [st], [nr], [mn]. If a geminate is more strictly defined as one in which both the place and stricture features have to be doubly linked, many non-permissible coronal clusters such as *[sx], *[sš], *[tstx], *[ttx] cannot be 'geminates' since the consonants in these clusters have different terminal place features and are not truly homorganic. In addition, this stricter definition still includes some permissible clusters: e.g. [pm], [mp], [nt], [tn]. It turns out that we cannot define 'geminates' in such a way to include sonorant geminates and all non-permissible clusters and exclude all permissible clusters.

4.2 Alternatives to moraic licensing

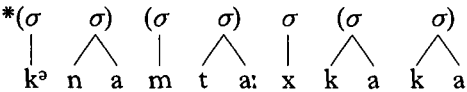
There are a few common solutions to account for extrasyllabic segments without resorting to moraic licensing, e.g. setting different syllabic templates/constraints at different levels (e.g. Borowsky 1986, Mohanan 1989, Clements 1990); positing a phonetically null nucleus (Kaye *et al.* 1990), degenerate syllables (McCarthy & Prince 1990, Repetti 1994) or weightless syllables (Piggott 1995); linking these consonants to the phonological word (Rubach & Booij 1990); dismissing stray erasure as a UG concept (Gussmann 1992, Rubach & Booij 1992, Cook 1994, Kenstowicz 1994) or a valid phonological concept (Rubach 1996). In what follows, I discuss three alternatives as they apply to Piro.

4.2.1 *Degenerate syllables.* One may suggest that the moraic consonant in Piro is syllabified as a degenerate syllable. This solution retains exhaustive syllabification (i.e. strict layering) and has only the syllable to serve as the licenser of segments. However, the simplest analysis of Piro's quantity-insensitive trochaic stress system is to count only syllables (cf. Hayes 1995). Positing degenerate syllables then produces incorrect stress patterns, as shown in (47). The problem is that the putative degenerate syllables, [kʰ], [m] and [x], would be included for foot construction and yet they must be invisible to stress assignment.

(47) *Stress foot: QI syllabic trochee*

[kʰnàm̩taːx̩káka]

*[k̀ʰ.na.m̩.taː.x̩.ká.ka]



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One anonymous reviewer has suggested that a moraic consonant occupies the nuclear position of a syllable but stress applies only at the vowel projection. A stress system in which foot construction is not based on syllables or moras is much less common, so this alternative not only posits a marked syllable type, i.e. an onsetless syllable with a consonant as syllable peak, but also has a less straightforward analysis of the stress system. On the other hand, in my analysis, the syllable structure is the least marked type and the stress system remains normal.

Furthermore, Piro need not make any reference to syllables except in the analysis of stress.[37] If foot construction is based on vowel projection, the status of the syllable in Piro becomes suspect. One could also suggest that stress applies only to CV syllables (branching σ's), thereby skipping degenerate C syllables (non-branching σ's). However, we can achieve the same result if we simply make reference to branching *vs.* non-branching moras. What is ironic about an analysis that complicates the otherwise simple analysis of Piro stress in order to retain exhaustive syllabification is that there is then no reason to posit any syllable at all in Piro.[38]

4.2.2 *Prosodic word licensing.* Another alternative is to license the extrasyllabic consonant directly by the prosodic word, as suggested by Rubach & Booij (1990) for Polish. The extrasyllabic consonants in Piro are similar to those in Polish, in that when they are in word-medial position, their phonetic affiliation with the preceding and following syllables is freely fluctuating. However, these consonants in Piro are moraic, as they are phonetically salient and may trigger CL. Moreover, some of the extrasyllabic consonants are internal to the foot, as (21) illustrates, and hence cannot be directly linked to the prosodic word. If OT is the correct model to characterise phonology, since minimal violation is the central tenet in such a constraint-based model, licensing these consonants with a lower prosodic unit produces less deviation from the prosodic hierarchy. The mora rather than the prosodic word then appears to be the most appropriate licenser of the extrasyllabic consonants in Piro.

4.2.3 *Lack of stray erasure.* One could also claim that Piro does not have stray erasure, which explains why unsyllabified consonants surface. There are however reasons to believe that a moraic licensing account is preferable.

As mentioned in §3.1.1, from both the synchronic and the diachronic perspectives, the onset consonant retains the mora left by the deleted nuclear vowel to maintain the original moraic structure of the morpheme/word. This explains the resistance to forming a coda, the freedom of consonant combinations and the need for elaborated phonetic transition rules. In a language enforcing maximal moraic conservation, the mora appears to function as a genuine prosodic unit capable of licensing all segments.

There are also theoretical considerations to favour a moraic licensing account. First, even if stray erasure is absent, there is still the question of licensing. That is, the lack of stray erasure does not necessarily exempt a

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language from the universal principle of prosodic licensing. Although stray erasure and prosodic licensing have often been considered two sides of the same coin, phonetic realisation of a segment primarily depends on proper licensing, while stray erasure functions more like a housekeeper, to remove unlicensed units from the representation. Therefore, an unsyllabified segment that remains in the representation because of the lack of stray erasure should still be properly licensed in order to be representationally well-formed and phonetically realised. Claiming that phonological units can be phonetically realised as long as stray erasure is inactive distorts the fundamental essence of prosodic licensing.

Furthermore, if phonology is viewed as interaction of universal constraints that results in optimal representations as in OT, then stray erasure, which is clearly rule-oriented, is not needed; on the other hand, as is demonstrated by the OT analysis in §3.1.2, licensing alone can determine what phonological unit can surface. For an extrasyllabic consonant to be realised and yet not counted as a syllable for foot construction, allowing the mora, the lowest prosodic unit, to ensure its phonetic realisation is the most satisfactory solution since it incurs minimal violation of the universal constraints on prosodic hierarchy and licensing. Therefore, stray erasure can be dispensed with while prosodic licensing should remain the main force accounting for prosodic organisation and phonetic realisation of phonological units.

In terms of the general concept of licensing, since it is often suggested that features must be licensed by the root node (e.g. Yip 1992) or other features (e.g. Itô *et al.* 1995), the root node (i.e. the segment) should similarly be licensed by the mora and the mora by the syllable or another higher prosodic unit. On the other hand, stray erasure as a universal phonological concept has recently been challenged (Gussmann 1992, Rubach & Booij 1992, Cook 1994, Kenstowicz 1994, Rubach 1996). Given the continuing important role played by licensing in phonological theory, and the possibility of removing stray erasure as a general phonological concept, the choice of moraic licensing in the analysis of Piro appears to be a correct one.

5 Conclusion

I have argued that Piro has only CV syllables and the extrasyllabic consonants are licensed by the mora. Deletion of these consonants can then lead to CL, thereby retaining support for the moraic conservation account of CL.[39] Piro is therefore suggested to be a language that enforces stronger moraic conservation than other languages. For a typological characterisation of a language that can exhibit CL, I have proposed that such a language must have a contrast of moraic structure among consonants or vowels. This proposal covers not only the CL case of Piro but also the observations made in the literature concerning other types of CL languages.

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Alternative analyses to the moraic licensing account have either been rejected or considered less desirable on empirical and theoretical grounds. The conclusion then is that the mora is a prosodic unit capable of licensing a segment and exhaustive syllabification is not required. I have also suggested that stray erasure can be dispensed with as a phonological concept, and prosodic licensing alone, with the mora as a legitimate licenser, ensures proper prosodic organisation of a phonological string and its phonetic realisation.

NOTES

* An early analysis of Piro syllable structure and vowel deletion was presented at the 17th Conference of the North East Linguistic Society at MIT in 1986 and appeared in the proceedings (Lin 1987). The first analysis of Piro compensatory lengthening was presented at the 1988 Linguistic Society of America Annual Meeting in New Orleans. A revised analysis was presented in 1994 at the 13th West Coast Conference on Formal Linguistics at the University of California, San Diego, and published as Lin (1995). The issues on moraic licensing and stray erasure were presented at the 1st Mid-Continental Workshop on Phonology held at Ohio State University in 1995. I thank the audiences at these conferences for their comments. At the early stages in the development of my work on Piro, I benefited from discussions with Juliette Blevins, John Kingston and Armin Mester. I am especially grateful to three anonymous reviewers of *Phonology* for their valuable comments and suggestions, which led to considerable improvement in both the content and the presentation of the paper.

[1] The data are taken from Matteson (1965), which is a complete grammar of Piro that contains sections on phonetics/phonology, morphology/syntax, texts and a Piro–English/English–Piro lexicon. As Piro is a mildly polysynthetic language, words combining long sequences of morphemes are common and often obligatory. In the book, only the morphology section provides examples with detailed morphemic breakdown. Fortunately, the detailed description of the morphology and the complete vocabulary lists make it possible to analyse the morphological structure of those words taken from other sections. In this paper, page numbers of Matteson (1965) are given for all polymorphemic examples, and an asterisk indicates that the morphological structure of the example is analysed by the present author. Examples taken from Matteson & Pike (1958) are indicated by M&P.

[2] The vowel /u/ is a high back unrounded vowel; /x/ is the non-sibilant palatal spirant [ç]. Matteson (1965: 25) also lists five long vowels and four long consonants as phonemes: [i: u: e: o: a: m: n: w: y:]. The long segments are in fact derived (see §1.3). The nasal spirant [h] patterns with nasals and glides, and can be treated as a placeless nasal glide with a default dorsal specification (Trigo 1988).

[3] The only monomorphemic word that may contain three consonants is [phya] 'vapour', which, however, has an alternative pronunciation [phe].

[4] This list has some minor differences from that given by Matteson (1965: 30). See Lin (1997b) for details.

[5] The quality of the epenthetic vowel varies systematically depending on the surrounding consonants, e.g. it is voiceless between voiceless consonants and becomes [i] next to palatal consonants such as [x] and [y].

[6] The issue of how to formally distinguish phonological and phonetic syllabicity, raised by three anonymous reviewers, is discussed in §3.1.1.

[7] To apply BVD non-cyclically, one has to assume that there is no bracket erasure of internal morphological brackets at the word level, and stipulate that BVD applies from left to right. In addition, such non-cyclic application cannot derive those examples that allow three-consonant clusters at some point of the derivation

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(cf. (8a, b) and §3.2.3) or on the surface (note 9). See Lin (1997a) for more details about BVD.

[8] Note that the transitional vowels (§1.1) do not participate in BVD, which confirms that they are not syllabified as syllabic nuclei, at least in the lexical phonology. If they were considered regular nuclear vowels, incorrect results would obtain. Assuming cyclic resyllabification, compare the derivations in (i) and (7b):

(i) ni.ka + ya → ni.k_.ya → ni.ki.ya + waka → ni.ki.y_.wa.ka → ni.ki.y̥.wa.ka + lu → ni.ki.y̥.wa.k_.lu → *ni.ki.y̥.wa.kə.lu

[9] Another group of exceptions to *CCC is quite productive and involves the transitory affix /-m/, which is the only monoconsonantal suffix in Piro. The form given in (3b) is one such example. See Lin (1997a) for more data and an analysis.

[10] The only exceptions are long vowels in a dozen exclamation and onomatopoeic words, e.g. [su:su:] (sound of ghost) (348), [špo:] (exclamation of agitation) (353), which I assume are not part of the core phonology of the language.

[11] One obvious alternative is to allow word-internal codas. I argue against the coda hypothesis in §4.1.

[12] Throughout the book, Matteson does not mark stress, as stress assignment is regular and predictable. She therefore gives the general rules, fourteen examples illustrating word stress (1965: 21) and six examples illustrating phrasal level stress (1965: 22).

[13] Hayes cites Piro stress as an example of a quantity-insensitive trochaic system. Kager (1993, 1995), however, questions the validity of a trochaic system that completely disrespects quantity. My analysis of Piro stress favours Hayes' position (see also §4.2.1).

[14] See Hayes (1989) for a discussion of the moraic representation of word-initial geminates.

[15] The earlier principle of Containment in OT, which is abandoned in Correspondence Theory in McCarthy & Prince (1995), requires that every element in the input must be contained in the output; therefore, a deleted element is one that is unparsed to a prosodic unit and hence cannot be realised phonetically.

[16] The earlier OT constraint against deletion was PARSE, and the earlier constraint against insertion was FILL (Prince & Smolensky 1993). In McCarthy & Prince (1995), the Faithfulness constraints have been expanded to include correspondence between the base and the reduplicant and correspondence among morphologically related outputs (cf. BASE-ID in §3.2.1).

[17] In OT, the extent to which prosodic structure is present underlyingly is still unclear (see Golston 1996 for some discussion). An OT analysis of Piro CL would require positing at least underlying moraic vowels. Choosing Hyman's representation for the present analysis is consistent with Lexicon Optimisation (Prince & Smolensky 1993), which selects an underlying representation that deviates least from the actual output. If only vowels are underlyingly moraic (cf. Pulleyblank 1994), my analysis would not be crucially affected since only the output that properly licenses all consonants would be optimal (see §3.1.2).

[18] Bagemihl (1991: 641) also shows an example in Bella Coola in which deletion of an unsyllabified moraic glottal stop leads to CL.

[19] Other languages that have clear consonantal releases and/or transitional vowels in consonant clusters include Imdlawn Tashlhiyt Berber and Tsou (an Austronesian language of Taiwan). Dell & Elmedlaoui (1996) argue that the non-syllabic transitional vowels in Imdlawn Tashlhiyt Berber result from the lack of overlapping of consonant articulators. Tsou is similar to Piro in that consonant clusters are not subject to universal sonority restrictions. A CC cluster, especially a stop + stop cluster, is often transcribed with a transitional vowel between the consonants. In his acoustic study of Tsou, Wright (1996) has shown that there is no actual vowel in such a cluster but a clear release burst for the purpose of retaining the perceptual cues of the first consonant.

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[20] An anonymous reviewer asks what 'syllabic' [y] and [w] really are. Under the interpretation proposed here, they are not nuclear [i] and [u], but non-nuclear glides with audible releases. Note also that [u] in Piro is unrounded (note 2) and as far as I know there is little evidence for vowel/glide alternations in Piro.

[21] In the literature there have been other solutions to account for extrasyllabic segments that can be phonetically realised. For example, Cook (1994) has argued against Bagemihl's moraic licensing account and suggested that Bella Coola has no stray erasure. It is beyond the scope of this paper to reexamine the case of Bella Coola, but in §4.2, I compare the moraic licensing proposal with other alternatives as they apply to Piro.

[22] Schwa deletion in French provides a similar case (Rialland 1985). Thanks to an anonymous reviewer for bringing Rialland's work to my attention.

[23] In (21b), I link [m] to the following foot, but it could be linked to the prosodic word. On the other hand, in (21a), it is technically not possible to link the extrasyllabic consonants to the prosodic word since they are foot-internal segments.

[24] If onset consonants are linked directly to the syllable (§2), we have to split (23a) into two constraints: VRT/μ (every vowel root node is licensed by a mora) and CRT/σ (every consonant root node is licensed by a syllable). This works fine for onset consonants but creates complications for the proposed unsyllabified consonants that should be licensed by the mora.

[25] Some modifications of these constraints are required in order to account for the systematic exceptions to BVD such as the examples in (8a, b), those cases involving /-m/ (note 9) and non-triggering suffixes (§1.2). The examples in (8) are discussed in §3.2.3, and the other two cases are discussed in Lin (1997a).

[26] Assuming that ALIGN (28a) refers only to a stem followed by a suffix, I do not place a stem bracket at the end of the prosodic word, so the retention of the word-final vowel does not violate the constraint. We can also posit another constraint that requires the right edge of the prosodic word to end in a vowel.

[27] See Lin (1997b) for the OCP constraints in Piro.

[28] In this subsection, for presentational clarity and to highlight the CL effect, I do not mark violations of MAX-μ caused by the mora loss of onset consonants.

[29] For ease of presentation, I show only the last three morphemes, and assume that BASE-ID is assessed at the segmental level. If BASE-ID involves also matching of moras, we still obtain the correct result. Moreover, I assume that there is no extrasyllabic vowel and the second mora of a long vowel is linked to the preceding syllable, so (34d, e) do not violate WLWF.

[30] In §3.2.1, we already established the ranking: WLWF (= *CCC) $\gg$ ALIGN $\gg$ BASE-ID. The OCP constraints are never violated on the surface, but WLWF and MAX-μ may sometimes be violated (cf. (3) and §3.1.2), so I assume that an active OCP constraint is ranked higher than WLWF and MAX-μ. The ranking of MAX-μ, however, cannot be crucially determined since the winning candidate (34e) and the candidate that fails to preserve the mora (34f) are tied with respect to all constraints except MAX-μ. Here I group it together with WLWF so that we can easily eliminate (34f) and focus on other candidates. The ranking is therefore: OCP $\gg$ WLWF, MAX-μ $\gg$ ALIGN $\gg$ BASE-ID.

[31] The pointing hand indicates actual attested output; the downward pointing hand the expected optimal output based on the constraint ranking.

[32] I have not found examples like (35b) for [pp] and [tt] but assume that the stops pattern together (cf. note 34).

[33] Since the grammar is divided into two levels, the recursive evaluation of BASE-ID at the lexical level would compare candidates with their immediate constituents that are legitimate lexical outputs, rather than with the final outputs of the postlexical level. An independent word for the purpose of BASE-ID evaluation then may differ from the actual surface output due to postlexical constraint evaluation. Therefore, for this example, (39c) incurs no BASE-ID violation since the immediate constituent that can stand as an independent lexical output is

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[kawkakkana], although the phonological form of this output is further modified at the postlexical level.

[34] Matteson (1965: 28) mentions that the occurrence of CL must be quite recent and the Manchineri dialect of Piro still has long stops without CL. It is likely that most non-permissible clusters, like long stops, are removed only postlexically.

[35] The constraint in (44) should be ranked lower than BASE-ID; otherwise, for the example involving [kk] in tableau (39), candidate (39c) would be incorrectly ruled out. In addition, one may be tempted to replace the original ALIGN constraint in (28a) with (44). This can be done if one assumes that a weak mora is equivalent to a non-nuclear mora (see Steriade 1990 for nuclear *vs.* non-nuclear moras). This move, however, would incorrectly select candidate (39e) as the optimal output because (39e) incurs no violation of (44) and therefore would win over all other candidates.

[36] I have limited my discussion to moraic *vs.* non-moraic consonants and mono-moraic *vs.* bimoraic vowels. If the moraic contrast of segments in general determines whether a language may exhibit CL, we also predict that CL may occur in a language that has a contrast between moraic and non-moraic vowels, e.g. a language that has weightless syllables (Piggott 1995). Further investigation is needed to bear out this prediction.

[37] One case of allomorph selection in Piro appears to provide the same type of evidence. As shown in (i), when the stem has at least three syllables, the allomorph /maka/ is selected (i.a); on the other hand, when the stem has fewer than three syllables, the allomorph /mka/ is selected (i.b). Note that (i.c) patterns with (i.b), which indicates that the stems in (i.c) have only two syllables rather than three. If this generalisation is correct, /w/ and /y/ in (i.c) cannot be syllables in their own right.

(i) maka ~ mka 'SUBJUNCTIVE, OPTATIVE, FRUSTRATIVE'

a.	n-pinita + maka I-to give medicine to	→ npinitmaka	'I would have given medicine to him' (74)
	kšinikanu + maka intelligent	→ kšinikanmaka	'very intelligent, but without the desired result (118)
b.	hi + mka NEG	→ himka	'although, perhaps' (123)
	hapo + mka trail	→ hapomka	'that which was to have been a trail' (97)
c.	powra + mka clean	→ powramka	'supposed to be clean' (118)
	seyni + mka but	→ seynimka	'but rather than that which might have been' (125)

[38] One question then arises: does Piro need syllables? One reviewer comments that one could refer to syllables *vs.* non-syllables as branching *vs.* non-branching moras, as Hyman (1985) does in his analysis of Gokana. This observation is correct, but the stress system has to refer to the internal structure of moras, and Piro becomes a marked system with no syllables. In an effort to minimise marked systems and structures, it seems preferable to keep the CV syllable for Piro.

[39] For a different view, claiming that skeletal timing slots are still needed to account for CL, see Schmidt (1992) and Rialland (1993).

REFERENCES

Alderete, John (1997). Dissimilation as local conjunction. *NELS* **27**. 17–32.

Bagemihl, Bruce (1991). Syllable structure in Bella Coola. *LI* **22**. 589–646.

Booij, Geert (1996). Lexical Phonology and the derivational residue. In Durand & Laks (1996). 71–98.

Borowsky, Toni (1986). *Topics in the lexical phonology of English*. PhD dissertation, University of Massachusetts, Amherst.

https://doi.org/10.1017/S0952675798003455 Published online by Cambridge University Press

Buckley, Eugene (1994). Persistent and cumulative extrametricality in Kashaya. *NLLT* **12**. 423–464.
Clements, George N. (1990). The role of the sonority cycle in core syllabification. In John Kingston & Mary Beckman (eds.) *Papers in laboratory phonology I : between the grammar and physics of speech*. Cambridge: Cambridge University Press. 283–333.
Cohn, Abigail C. & John J. McCarthy (1994). Alignment and parallelism in Indonesian phonology. Ms, Cornell University & University of Massachusetts, Amherst.
Cook, Eung-Do (1994). Against moraic licensing in Bella Coola. *LI* **25**. 309–326.
De Chene, Brent & Stephen R. Anderson (1979). Compensatory lengthening. *Lg* **55**. 505–535.
Dell, François & Mohamed Elmedlaoui (1996). Nonsyllabic transitional vocoids in Imdlawn Tashlhiyt Berber. In Durand & Laks (1996). 219–246.
Durand, Jacques & Bernard Laks (eds.) (1996). *Current trends in phonology : models and methods*. Vol. 1. Salford: ESRI, University of Salford.
Goldsmith, John (1990). *Autosegmental and metrical phonology*. Oxford: Basil Blackwell.
Golston, Chris (1996). Direct optimality theory: representation as pure markedness. *Lg* **72**. 713–748.
Gussmann, Edmund (1992). Resyllabification and delinking: the case of Polish voicing. *LI* **23**. 29–56.
Harris, James (1983). *Syllable structure and stress in Spanish : a nonlinear analysis*. Cambridge, Mass.: MIT Press.
Hayes, Bruce (1982). Extrametricality and English stress. *LI* **13**. 227–296.
Hayes, Bruce (1989). Compensatory lengthening in moraic phonology. *LI* **20**. 253–306.
Hayes, Bruce (1994). Weight of CVC can be determined by context. In Jennifer Cole & Charles Kisseberth (eds.) *Perspectives in phonology*. Stanford: CSLI. 61–79.
Hayes, Bruce (1995). *Metrical stress theory : principles and case studies*. Chicago: University of Chicago Press.
Hock, Hans Henrich (1986). Compensatory lengthening: in defense of the concept 'mora'. *Folia Linguistica* **20**. 431–460.
Hudson, Grover (1995). Consonant release and the syllable. *Linguistics* **33**. 655–672.
Hyman, Larry (1985). *A theory of phonological weight*. Dordrecht: Foris.
Inkelas, Sharon (1991). *Prosodic constituency in the lexicon*. New York: Garland.
Itô, Junko (1986). *Syllable theory in prosodic phonology*. PhD dissertation, University of Massachusetts, Amherst.
Itô, Junko (1989). A prosodic theory of epenthesis. *NLLT* **7**. 217–260.
Itô, Junko & Armin Mester (1992). Weak layering and word binarity. Ms, UCSC.
Itô, Junko, Armin Mester & Jaye Padgett (1995). Licensing and underspecification in Optimality Theory. *LI* **26**. 571–613.
Kager, René (1993). Alternatives to the iambic-trochaic law. *NLLT* **11**. 381–432.
Kager, René (1995). Review of Hayes (1995). *Phonology* **12**. 437–464.
Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud (1990). Constituent structure and government in phonology. *Phonology* **7**. 193–231.
Kenstowicz, Michael (1994). *Phonology in generative grammar*. Oxford: Basil Blackwell.
Kenstowicz, Michael (1995). Cyclic *vs.* non-cyclic constraint evaluation. *Phonology* **12**. 397–436.
Kenstowicz, Michael (1996). Base-Identity and uniform exponence: alternatives to cyclicity. In Durand & Laks (1996). 365–395.
Kiparsky, Paul (1982). Lexical phonology and morphology. In I.-S. Yang (ed.) *Linguistics in the morning calm*. Seoul: Hanshin. 3–91.
Kiparsky, Paul (1985). Some consequences of Lexical Phonology. *Phonology Yearbook* **2**. 85–138.

https://doi.org/10.1017/S0952675798003455 Published online by Cambridge University Press

Kisseberth, Charles (1970a). On the functional unity of phonological rules. *LI* **1**. 291–306.
Kisseberth, Charles (1970b). Vowel elision in Tonkawa and derivational constraints. In Jerrold N. Sadock & Anthony L. Vanek (eds.) *Studies presented to Robert B. Lees by his students*. Edmonton: Linguistic Research. 109–138.
Lamontagne, Greg (1993). *Syllabification and consonant cooccurrence conditions*. PhD dissertation, University of Massachusetts, Amherst.
Levin, Juliette (1987). Between epenthetic and excrescent vowels. *WCCFL* **6**. 187–201.
Lin, Yen-Hwei (1987). Theoretical implications of Piro syncope. *NELS* **17**. 409–423.
Lin, Yen-Hwei (1993). Sonority and postlexical syllabicity in Piro. *CLS* **28**. 333–344.
Lin, Yen-Hwei (1995). Extrasyllabic consonants and compensatory lengthening in Piro. *WCCFL* **13**. 93–105.
Lin, Yen-Hwei (1997a). Cyclic and noncyclic affixation in Piro. In G. E. Booij & J. M. van de Weijer (eds.) *Phonology in progress – progress in phonology*. The Hague: Holland Academic Graphics. 167–188.
Lin, Yen-Hwei (1997b). Piro affricates and edge effects. Ms, Michigan State University.
McCarthy, John J. (1986). OCP effects: gemination and antigemination. *LI* **17**. 207–263.
McCarthy, John J. & Alan S. Prince (1986). Prosodic morphology. Ms, University of Massachusetts, Amherst & Brandeis University.
McCarthy, John J. & Alan S. Prince (1990). Prosodic morphology and templatic morphology. In Mushira Eid & John J. McCarthy (eds.) *Perspectives on Arabic linguistics : papers from the 2nd symposium on Arabic linguistics*. 1–54.
McCarthy, John J. & Alan S. Prince (1993a). *Prosodic Morphology I: constraint interaction and satisfaction*. Ms, University of Massachusetts, Amherst & Rutgers University.
McCarthy, John J. & Alan S. Prince (1993b). Generalized alignment. *Yearbook of Morphology 1993*. 79–153.
McCarthy, John J. & Alan S. Prince (1995). Faithfulness and reduplicative identity. In Jill N. Beckman, Laura Walsh Dickey & Suzanne Urbanczyk (eds.) *Papers in Optimality Theory*. Amherst: GLSA. 249–384.
Matteson, Esther (1965). *The Piro (Arawakan) language*. Berkeley: University of California Press.
Matteson, Esther & Kenneth L. Pike (1958). Non-phonemic transition vocoid in Piro (Arawak). *Miscellanea Phonetica* **3**. 22–30.
Mester, R. Armin (1986). *Studies in tier structure*. PhD dissertation, University of Massachusetts, Amherst.
Mohanan, K. P. (1986). *The theory of Lexical Phonology*. Dordrecht: Reidel.
Mohanan, Tara (1989). Syllable structure in Malayalam. *LI* **20**. 589–625.
Myers, Scott (1991). Persistent rules. *LI* **22**. 315–344.
Nespor, Marina & Irene Vogel (1986). *Prosodic phonology*. Dordrecht: Foris.
Noble, G. Kingsley (1965). *Proto-Arawakan and its descendants*. Bloomington, Indiana: Indiana University Research Center in Anthropology, Folklore, and Linguistics.
Piggott, G. L (1995). Epenthesis and syllable weight. *NLLT* **13**. 283–326.
Prince, Alan & Paul Smolensky (1993). *Optimality Theory : constraint interaction in generative grammar*. Ms, Rutgers University & University of Colorado, Boulder.
Pulleyblank, Douglas (1994). Underlying mora structure. *LI* **25**. 344–353.
Repetti, Lori (1994). Degenerate syllables in Friulian. *LI* **25**. 186–193.
Rialland, Annie (1985). Schwa et syllables en français. In Wetzels & Sezer (1985). 187–226.
Rialland, Annie (1993). L'allongement compensatoire: nature et modèles. In Bernard

https://doi.org/10.1017/S0952675798003455 Published online by Cambridge University Press

Laks & Annie Rialland (eds.) *L'architecture et la géometrie des représentations phonologiques*. Paris: CNRS. 59–92.
Rosenthall, Sam (1994). *Vowel/glide alternation in a theory of constraint interaction*. PhD dissertation, University of Massachusetts, Amherst.
Rubach, Jerzy (1996). Nonsyllabic analysis of voice assimilation in Polish. *LI* **27**. 69–110.
Rubach, Jerzy & Geert Booij (1990). Edge of constituent effects in Polish. *NLLT* **8**. 427–463.
Rubach, Jerzy & Geert Booij (1992). Resolutions of extrasyllabicity in Slovak. *Linguistics* **30**. 699–729.
Schmidt, Deborah (1992). Compensatory lengthening in a segmental moraic theory of representation. *Linguistics* **30**. 513–534.
Selkirk, Elisabeth (1978). *On prosodic structure and its relation to syntactic structure*. Indiana University Linguistics Club.
Selkirk, Elisabeth (1982). The syllable. In Harry van der Hulst & Norval Smith (eds.) *The structure of phonological representations*. Part 2. Dordrecht: Foris. 337–383.
Selkirk, Elisabeth (1984a). On the major class features and syllable theory. In Mark Aronoff & R. Oehrle (eds.) *Language sound structure*. Cambridge, Mass.: MIT Press. 107–136.
Selkirk, Elisabeth (1984b). *Phonology and syntax: the relation between sound and structure*. Cambridge, Mass.: MIT Press.
Steriade, Donca (1982). *Greek prosodies and the nature of syllabification*. PhD dissertation, MIT.
Steriade, Donca (1990). Moras and other slots. *Proceedings of Formal Linguistics Society of Midamerica* **1**. 254–280.
Tranel, Bernard (1991). CVC light syllables, geminates and moraic theory. *Phonology* **8**. 291–302.
Trigo, Loren (1988). *On the phonological derivation and behavior of nasal glides*. PhD dissertation, MIT.
Wetzels, Leo & Engin Sezer (eds.) (1985). *Studies in compensatory lengthening*. Dordrecht: Foris.
Wright, Richard (1996). *Consonant clusters and cue preservation in Tsou*. PhD dissertation, UCLA.
Yip, Moira (1988). The obligatory contour principle and phonological rules: a loss of identity. *LI* **19**. 65–100.
Yip, Moira (1992). Prosodic morphology in four Chinese dialects. *Journal of East Asian Linguistics* **1**. 1–35.
Zec, Draga (1994). *Sonority constraints on prosodic structure*. New York: Garland.

https://doi.org/10.1017/S0952675798003455 Published online by Cambridge University Press