THE MODULAR SYLLABLE: SINHALA[1]

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'The modular syllable' is the study of the role of the syllable in a modular theory of phonology. This study asks what modules are necessary in phonology, how they interact with each other and with other components of linguistic theory, and what their representational and computational resources are. This paper focuses on representations of the syllable at the morphology/phonology interface and their fate as they pass through the phonological modules. A Sinhala example illuminates the question of what happens to syllables in the phonology. (See Cairns and Raimy, in press.) This example is interesting because, on the surface, it appears that Sinhala exhibits contrastive syllabification: [ka.^{n}də] 'trunk; sg. def. nom.' vs. [kan.də] 'hill; sg. def. nom.' We will see that in fact this effect is an opaque interaction among three modules, the morphological, the phonological, and the phonetic modules. I justify the analysis of the nasal stop sequences as two distinct segments underlyingly (as opposed to a single "prenasalized" segment, which appears only on the surface) below.

In the minimalist theory proposed here, syllable boundaries are represented on a distinct syllable tier; there are no node labels nor constituent structure within syllables. I assume a Halle/Idsardian 3-Dimensional model (Halle and Idsardi 1995), with a number of half planes radiating from a common line which constitutes the timing tier. Word stress is represented on one of these planes (the metrical plane), features on another, syllables on yet another, and other linguistically relevant material on other orthogonal planes. X-slots, representing segments, are arrayed along the timing tier; the theory of Precedence Based Phonology (Raimy 2000) is used to represent the precedence relations among the X-slots (although that is not exemplified in this presentation). Lexical storage is in terms of the timing tier, complete with explicit precedence relations. Parameterized rules in the morphological module derive syllables, as well as other information on other orthogonal planes. Sonority features of segments are projected on the syllabic tier, where syllable boundaries are calculated. Metrical (stress) structure is represented on the metrical plane as a grid with constituents on Line 0, as well as on other lines. These 3-D representations are then handed over to the phonological module for a variety of operations. Following Calabrese 2005, the phonological component is itself a modular entity, comprising both idiosyncratic rules as well as constraints and repairs.

The example of the modular syllable presented here, from Sinhala (Feinstein 1977, 1979; Cairns and Feinstein 1982), shows that syllable boundaries inserted in the morphology are not (always) erased in the phonological component. The Sinhala phonological component imposes full assimilation on a glide in a sequence and degeminates the resulting geminate. Because there is no resyllabification, this gives rise to spectacular but illusory contrasts such as in (2), which look like examples of contrastive syllabification. In fact, the operation of the algorithm within the morphology that places the syllable boundary has been rendered opaque by the operation of the

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[1] Eric Raimy has provided much insight into the analysis adopted in this paper. Although I take full responsibility for any errors or misconceptions, Eric's suggestions have vastly improved this paper.

phonological module. (Note that the tautosyllabic nasal-stop sequence has been analyzed as a single segment, a prenasalized stop, by Davis 2003. Ringen and Vago (this conference) argue against this analysis, as I do at the end of this paper.

This analysis invokes three modules: the morphology, a set of phonological rules essentially similar to the lexical phonology, and a phonetic component that contains language particular information. The point of the following discussion of Sinhala is to demonstrate that syllable boundaries are inserted in the morphological module, which is independent of the phonological module. The phonology and phonetic modules do not change the morphologically inserted syllable boundaries; as a result of phonological operations, this modular arrangement gives rise to what appears to be contrastive syllabification. The success of this argument rests upon the representation of the so-called "prenasalized" segments, which Feinstein 1977, 1979 argued are really tautosyllabic nasal – oral stop sequences. This representation has been challenged by Davis 2003; I take a middle position, as we will see below.

The Basic Facts

There are three basic sorts of facts relevant to this analysis. First, Sinhala famously has "prenasalized stops," e.g. $-^{m}b-$, $-^{n}d-$, $-^{ŋ}g-$, that may appear only intervocalically. These contrast with heterosyllabic nasal stop sequences, which may or not be homorganic; our focus here is on the contrasts between prenasalized stops and homorganic sequences. For shorthand, we will use the terminology ^{n}d to indicate all prenasalized stops, and *nd* to indicate all homorganic nasal stop sequences, which are always heterosyllabic. Sinhala also has a lexical (and surface) contrast between singleton and geminate consonants. See Figure 2, below.

Second, all instances of *nd* appear in morphophonemic alternations with ^{n}d. Furthermore, the *nd* sequences are derived from an underlying sequence *–nd+G–*, where "G" stands for a glide, which appears as the first element of a suffix that appears overtly in other environments. (We will see below that in fact the G in question may be part of a root – the morpheme boundary is not necessary.) Some, but not all, geminates alternate with singletons in exactly the same morphological environments as do *nd* sequences with ^{n}d.

Finally, all nasals neutralize to velar point of articulation in word final position; word final ^{n}d neutralizes to [ŋ].

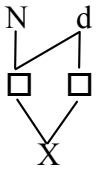
The preceding array of facts allow for three types of accounts. The first, adopted by Feinstein 1977, 1979 and Cairns and Feinstein 1982, treats all instances of ^{n}d as a tautosyllabic sequence of two segments. Feinstein argued that prenasalized stops do not exist in any language, and that such phenomena are universally a pair of segments squeezed into the onset of a single syllable. The morphological and phonological facts follow transparently from this analysis. The problem with this approach is that *nd* onsets are arguably not very natural; they would be the only complex onsets in Sinhala, which also does not allow codas of greater than one segment.

Davis 2003 adopts another approach: He argues that geminates and *nd* are really identical to singletons and ^{n}d, except they have a mora in underlying representation. That is, all instances of *nd* are geminated versions of ^{n}d, and geminates differ from singletons

by virtue of being attached to a mora underlyingly. There are three problems with this approach. First, this requires specifying the order of feature spell out below the level of the root node. Second, if ^{n}d is simply another nasal stop, we would expect it to neutralize to ^{ŋ}g in word final position, not simply *ŋ*. Why should the oral portion disappear? Finally, Davis' approach fails to capture the transparent alternation of the glide with geminates and *nd*, which means it is not descriptively adequate.

The current analysis incorporates features of both of the preceding analyses. Following Feinstein and Cairns and Feinstein, I posit an underlying nasal–stop sequence for every surface instance of ^{n}d. But, following Davis and departing from Feinstein and Cairns and Feinstein, surface occurrences of ^{n}d are analyzed as single, prenasalized segments: two root nodes of the feature tree are associated with one X-slot on the timing tier, as in (1). These segments are always derived, as we will see below.

(1) Representation of prenasalized stop, ^{n}d.



Recall that Sinhala allows heterorganic, heterosyllabic nasal–stop sequences. Such sequences clearly do not share any place features. I propose that the underlying representation of prenasalized stops is a placeless nasal followed by a homorganic stop, and that there is a lexical rule that produces (1) from such sequences.

(2) Contrast between Singletons and Geminates in Sinhala (refs to Feinstein '79)
All these are singular, definite inanimate nouns in the nominative case

	Simple		Complex	
a	potə	'book' (15b)	pottə	'core' (21a)
b	kadə	'shoulder pole' (1a)	reddə	'cloth' (21e)
c	kanə	'ear' (1b)	ginnə	'fire' (21b)
d	ka^{n}də	'trunk' (1c)	kandə	'hill' (1d)

(2) shows a contrast between "simple" and "complex" voiced and voiceless stops and nasals. Examples (2a-c) are clearly contrasts between singleton and geminate consonants; (2d), is the contrast mentioned above between ^{n}d and *nd.* The transparent morphophonemic contrast discussed above is illustrated in (3).

(3) Some Sinhala Verbs, all in the Present Indicative

	Noncausative		Causative		Root	Gloss
	Phonetic	Lexical	Phonetic	Lexical		
a.	yanəwa	ya na waa	yawənəwa	ya wa na waa	ya	Go
b.	kapənəwa	kapa na waa	kappənəwa	kap wa na waa	kapa	cut
c.	a^{n}dənəwa	anda na waa	andənəwa	and wa na waa	anda	put on

The data in (3) illustrate a productive alternation in Sinhala between /w/ and either the second half of a geminate or the second member of a heterosyllabic nasal – stop sequence. The morphological structure of these forms is in (4).

(4) Morphological Structure of Sinhala Verbs

Root (+ Causative) + Tense + Mood)

The tense (nonpast) morpheme is /na/, and /waa/ is the mood (indicative) marker. The phonology, which applies to the output of the morphology, reduces the vowel in /na/ to [ə] and shortens the vowel in /waa/; see below. Both these suffixes append to the last segment in the stem, which is vowel final in these examples. The Causative suffix /wa/ (which is also subject to reduction to [wə] in the phonological module), however, is suffixed to the last nonfinal consonant of the stem; this has the effect of "truncating" the stem final vowel. These operations crucially take place in the morphology.[2]

The theory proposed here is that syllable boundaries are inserted into sequentially ordered strings of phonemes in the morphology[3]. With the exception of some loan words, Sinhala syllables obey the strictures in (5); these constraints apply both in the phonology and in the morphology.

(5) Sinhala Syllabification

a. Locate every [- consonantal] segment that is a local sonority peak.
b. Place a left bracket in this environment: _____ (C) V, where V = sonority peak
c. Place a right bracket to the right of any right-adjacent, consonant (but do not pass a left bracket).

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[2] One might argue that the Causative is not underlying /wa/ and that the glide is the result of epenthesis, the typical Sinhala response to vowel hiatus. This analysis does not go through, however, because truly vowel-initial suffixes do not trigger the gemination and "de-prenasalization" effects demonstrated in (2).

[3] Actually, I propose below that there is an independent syllable plane which consists of a single line of elements, depicted by 'Δ's, projected from each 'X' on the X-tier, and containing only information about the sonority of the segment. The informal notation above suffices for our present purposes.

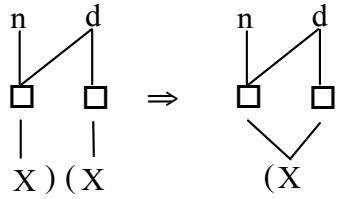
The Elsewhere Condition applies to (5b). A left-adjacent consonant, if present, is assigned to the beginning of a syllable; otherwise, a vowel-initial syllable is created. The algorithm in (5) produces syllables that may begin with one or no single consonant. Further, syllables may terminate with at most a single consonant, and long vowels may appear before a tautosyllabic consonant. This algorithm also allows for heterosyllabic nasal-consonant sequences that are not homorganic, as well as sequences of nasals followed by voiceless consonants. This successfully describes the syllable structure of Sinhala. (5), applied to the lexical forms in (2), yield the syllabification depicted in (6). The forms in (6) are created in the morphology and handed over to the phonology.

(6) The Forms in (2) after Syllabification

	Noncausative	Causative	Root	Gloss
a.	(ya)(na)(waa)	(ya)(wa)(na)(waa)	ya	Go
b.	(ka)(pa)(na)(waa)	(kap)(wa)(na)(waa)	kapa	cut
c.	(a)(nda)(na)(waa)	(an)d(wa)(na)(waa)	anda	put on

(7) Some Phonological Rules of Sinhala

a[4]



This (informal) rule says that if a stop is in an onset and shares features with a nasal to its left, the X-slot associated with the nasal deletes, and the root nodes of the nasal and of the stop share the X-slot.

b Vowel Reduction: short /a/ → [ə] in noninitial, open syllables.

Note: Stress is not relevant to Vowel Reduction. E.g. [kapə́te] from /kapa + ta/ 'to cut, present participle.'

c Vowel Shortening: Word final long vowels shorten.

This rule applies under somewhat mysterious circumstances, see below.

d Glide Vocalization: A glide becomes a vowel in a sonority peak.

e Glide Assimilation: A glide assumes all the features of a consonant to its left.

f Stray C Deletion: Unsyllabified consonants are not phonetically interpretable.

g Nasal Neutralization: Word final nasals neutralize to [ŋ].

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[4] I thank Eric Raimy for suggesting this analysis.

(8) Derivation of (6c) by the rules in (7)

	Noncausative	Causative
øutput of morphology	(an)(da)(na)(waa)	(an)d(wa)(na)(waa)
(7a)	(a)(^{n}da)(na)(waa)	Not applicable
(7b)	(a)(^{n}də)(nə)(waa)	(an)d(wə)(nə)(waa)
(7c)	(a)(^{n}də)(nə)(wa)	(an)d(wə)(nə)(wa)
(7e)	Not applicable	(an)d(də)(nə)(wa)
(7f)	Not applicable	(an)(də)(nə)(wa)
Phonetic Output	(a)(^{n}də)(nə)(wa)	(an)(də)(nə)(wa)

This successfully captures the difference between the prenasalized stop and the heterosyllabic nasal–stop sequence. Observe that the /w/ alternates overtly with the second half of this sequence.

We now examine the apparent syllabic contrasts in (2). These nouns have a definite suffix, /a/, which is subject to vowel reduction. The plurals of these nouns are in (9).

(9) Plurals of the nouns in (2), Nominative Case

	Simple		Complex	
a	pot	'books'	potu	'cores'
b	kad	'shoulder poles'	redi	'cloths'
c	kaŋ	'ears'	gini	'fires'
d	kaŋ	'trunks'	ka^{n}du	'hills'

Nouns in this morphological class do not take a plural suffix. Therefore, in the nominative, the bare stem emerges, subject to phonological rules. Following Feinstein 1977, 1979, we posit an underlying glide in final position for these forms. Virtually no further rules are required. The quality of the final glide is predictable: it assumes the backness of the preceding vowel. Accordingly, the final segment in these forms is specified merely as [- consonantal]. The underspecified glide archiphoneme assumes the features of the preceding vowel (Feature Spread), and glides vocalize early in the phonology when forced into a sonority peak (7d, Glide Vocalization). Observe the derivations of the words in (9d), shown in (10).

(10) Some Sample Derivations ("G" = underspecified glide)

MORPHOLOGY

	kand 'trunk, plu'	kandG 'hill, plu'	kandG+a 'hill, sg.'
Lexical	kand	kandG	kandG+a
(5)	(kan)d	(kan)(dG)	(kan)d(G+a)

PHONOLOGY (and phonetics, in the same module for expository purposes only)

(7a)	Not applicable	(ka)(^{n}dG)	Not applicable
(7b)	Not applicable	Not applicable	(kan)d(Gə)
(7d)	Not Applicable	(ka)(^{n}dI)	Not Applicable
(7e)	Not applicable	Not applicable	(kan)d(də)
(7f)	(kan)	Not applicable	(kan)(də)
(7g)	(kaŋ)	Not applicable	Not applicable
Feature spread	Not applicable	(ka)(^{n}du)	Not applicable

The main point of the preceding exposition of Sinhala is that the apparent contrastive syllabification exhibited in (2d) is an opaque result of the modular interaction between the morphological and phonological components. The morphology inserts syllable boundaries into strings of phonemes. These strings are handed over to the phonology, which is here conceptualized as containing at least two components, roughly a lexical phonology and a phonetic component. The phonological component causes a glide that immediately follows a consonant to absorb all that consonant's features. If that consonant is syllabified as the last consonant of the preceding syllable, a geminate emerges. If that consonant is unsyllabified and follows a syllabified nasal consonant, then it deletes in the phonetic component, and a heterosyllabic nasal–stop sequence emerges. Crucially, both prenasalized stops and heterosyllabic nasal–stop sequences are permitted in Sinhala phonology; therefore the phonological and phonetic components have no "incentive" to change syllable boundaries.

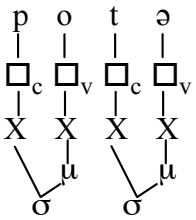
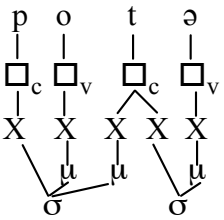
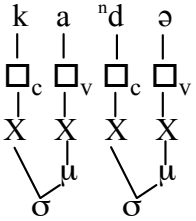
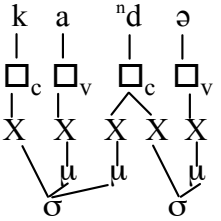
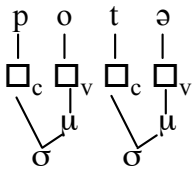
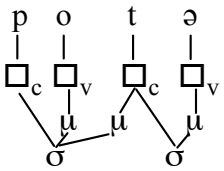
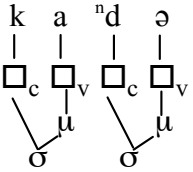
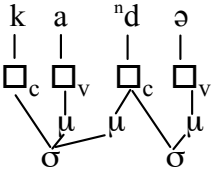
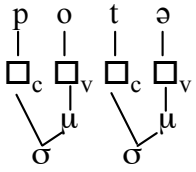
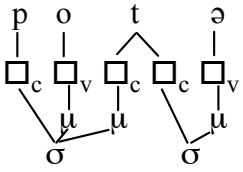
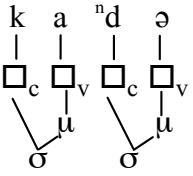
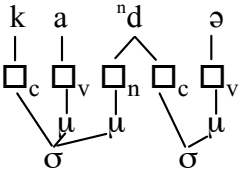
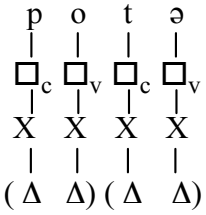
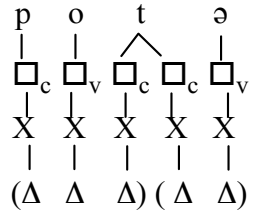
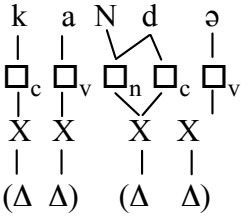
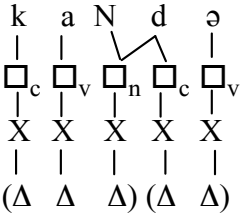
Although the main point of the preceding analysis is to demonstrate the modular syllable, it is pertinent to Davis's 2003 argument that all homorganic nasal-stop sequences in Sinhala are single segments, prenasalized stops; those that I have analyzed as a tautosyllabic sequence are singletons (and here we agree), and those represented as heterosyllabic sequences are lexically mora bearing. Davis' analysis is based only on the nominal data and ignores the verbal paradigms, where there are overt alternations between glides and the consonants that are part of both derived geminates and heterosyllabic nasal–stop sequences. His approach fails to explain why the heterosyllabic nasal–stop sequences are always morphologically derived, whereas this is not true of true

geminates; stem internal geminates abound, but there are no stem internal …VN.DV… sequences.

Davis explains the word final vowels in these plurals with the claim that they are a result of epenthesis in the service of preserving underlying mora count; see Davis 2003 for details. However, it seems that /a/ (= [ə]) is the vowel typically chosen for epenthesis in Sinhala, not a high vowel. For example, the noun in (2b) takes the plural suffix /wal/; Glide Assimilation (7d) does not apply to this suffix, presumably due to morphological marking of some kind. Since stop-glide sequences are avoided in Sinhala, epenthesis of /a/ (which always yields phonetic [ə] in noninitial, open syllables) applies, yielding [kadəwal]. It is unclear how productive this rule is, or if it applies in the morphology or phonology; the epenthesis that occurs in loan words is not consistent (see Feinstein 1979; p. 256, note 5), and in any case does not offer robust support for the hypothesis that a high vowel is the productive choice for epenthesis. Furthermore, there is nothing in Davis' published analysis that explains why an underspecified high vowel is selected for epenthesis as opposed to, say, /a/.

Davis's analysis is that it yields an incoherent representation of geminated prenasalized segments. Consider the possible representations in (11).

(11) Possible Representations of Plain and "Prenasalized" Segments

	PLAIN		PRENASALIZED	
	Simple	Complex	Simple	Complex
A				
B				
C				
D				

Recall that Davis 2003 says that the difference between geminates and singleton consonants is that the former are lexically stored with a mora; furthermore, he says that every homorganic nasal–stop sequence is one prenasalized segment. Therefore, the difference between the tauto- and heterosyllabic nasal–stop sequences is simply that the former do not have an associated mora, and the latter does. If his theory has both root nodes and X-slots on the timing tier, then he would presumably adopt representations like those in (11A); otherwise he would choose (11B). The problem with both of these is that there does not seem to be a coherent way of getting the nasal and oral portions of this segment to become correctly ordered. They violate what Selkirk 1990 called the No Feature Ordering Constraint:

(12) No Feature Ordering Constraint (Selkirk 1990)
Features dominated by the same root node are not phonologically ordered.

Alternatively, Davis might choose representation (11C), based on a theory that similarly eschews the distinction between root nodes and X-slots; however, this theory also fails to specify why the order of the geminated "prenasalized stop" is nasal–stop and not the other way around; an intervocalic …D.N… sequence is acceptable in Sinhala. So, aside from issues concerning descriptive adequacy, Davis's theory runs aground conceptually.

I propose (11D) as a possible theory of representation. Selkirk 1990 argued that the distinction between root nodes and X-slots is unnecessary; however, the modular perspective favors retaining this distinction on conceptual grounds.[5] The module concerned with features, which needs the root node, is independent of other modules, such as the syllable and metrical modules. They all share an interface, the timing tier; I have been tacitly assuming Raimy's theory of Precedence Based Phonology (Raimy 2000 et seq.), which posits that lexical items are stored in terms of the timing tier with explicit ordering relations among the X's. So, unless faced with empirical evidence that the X-slots and the root nodes should be merged, it appears conceptually cleaner to maintain the distinction.

The deltas in (11D) represent elements projected on a proposed independent syllable tier. These elements contain features that describe the sonority of the segments; in this sense, it is somewhat similar to CV syllable theory of Clements and Keyser 1983. Basically, UG would provide a rule that would project Δ's from elements on the X-tier; this rule would clearly need access to the feature tier. It is probable that there is minimal parametrization governing which sonority related features are projected. This theory is in the earliest stages of development, so I cannot go beyond speculation on this point.

A final word must be added regarding evidence that the mora does play a role in Sinhala phonology. Feinstein 1977, in an early application of the mora concept in generative phonology, drew attention to paradigms such as those in (13), illustrating that the Animate Definite marker is represented by a suffix that is variously /a/ or /aa/ (these facts are also in Feinstein 1979; a similar alternation is in the Genitive Suffix, as Feinstein 1977 mentions also).

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[5] Many thanks to Eric Raimy for helpful and, as usual, insightful email discussion of these points with me.

(13) Animate Singular Suffix in Sinhala (refs to Feinstein '79)
All these are singular, definite animate nouns in the nominative case

Phonetic output	Gloss	Stem
miniha	'the man' (18c)	minih
noona	'the woman' (18g)	noon
putaa	'the sun' (18b)	put

As Feinstein 1977, 1979 points out, the underlying form of this suffix is /aa/ (recall that the inanimate definite suffix is /a/); it shortens whenever it is affixed to a stem that is of greater weight than a single mora. Davis 2003, in referring to a similar alternation in the Genitive, takes this as evidence that the underlying difference between the "simple" and the "complex" forms illustrated in (2) is that the latter have an underlying mora whereas the former do not.

These facts suggest strongly that stems with more than one syllable, long vowels, and with a closed consonant in the stem constitute a natural class in Sinhala phonology; the mora is only one entity within phonological theory to define this class. Space does not permit a thorough exploration of this point in this poster. However, note that Vaux 1998 defends a rule of allomorphy that depends on whether or not the stem is greater than a bare CV syllable; this cannot involve a mora, because an unsyllabified consonant to the left of the syllable contributes to this rule. Although this point requires more investigation, these Sinhala phenomena may well involve some such process. Furthermore, there are multiple layers of opacity involved in this shortening process. For example, Slomanson, in an email to me, points out the form [demaupiyoo], 'parents,' to which the shortening rule does not apply.

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