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# Syllable Structure and Markedness Theory

**1.** Linguistics have long been impressed with the fact that grammars of human languages are more or less likely to display certain phenomena, such as the presence of a certain kind of rule or category. In generative phonology the question of how to express these regularities arises with increased importance, since a formal evaluation metric does not correctly distinguish between processes such as, say, k → č and č→ k. While the first process is quite common, the second does not seem to be attested. Yet, the second one is formally simpler.

Discussing segmental systems of languages, Kean (1975) observed:

> ... The segments *t* and *a* are nearly ubiquitous in segmental systems; they are found at all stages of phonological representation in an overwhelming majority of languages, but the segments *kp* and ʉ only occasional enjoy a place in a segmental system...

Accordingly she sets the task of a theory of markedness as follows:

> ... As a first approximation the theory of markedness can be said to be a theory of the most likely intrasegmental conjunctions of specified features...

There is however a set of problems, which clearly call for a markedness rationale but do not seem to be directly amenable to the above formulation. Consider for instance processes such as Ø → X / Y__Z or X → Ø / Y__Z. Let us focus on an instantiation of the first type of process: Ø → Vowel / Y__Z. Such a process is observed again

and again *when Y and Z are consonants*. If Y and Z are vowels themselves, then that process is extremely unlikely: obviously one does not expect that a language will choose to resolve hiatuses by the insertion of yet another vowel!

In such cases the problem is not just how likely a certain set of specified features is; rather, what is also at stake here is the likelihood of a certain kind of segment juxtaposition.

This dual aspect of the task of markedness has been noticed in earlier research. With reference to their markedness conventions for the features [segment], [consonantal] and [vocalic], Chomsky & Halle (1968) state:

> ... Conventions (I) - (IV), which express the universal constraints on syllable structure, thus differ from the other marking conventions not only in their content but also in the principles governing their application...

Kean (1975) goes further towards formally distinguishing the domain over which conventions for major features and other features are defined:

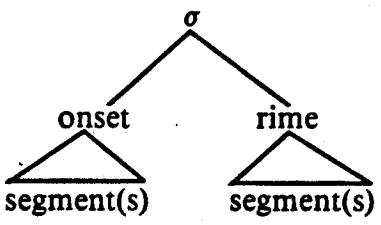
> ... The features [segment] and [syllabic] differ from the features discussed so far in two major ways. One obvious difference is that neither of these features has an articulatory definition. A second difference is that whether or not a unit is marked for either of these features depends on the place of that unit in a string and not solely on the other features of that unit (...). This is not surprising (...). in fact what would be surprising would be for (the) environments (of these) conventions not to be strings...

In the same spirit we wish to draw the distinction in even sharper fashion on the basis of our analysis of an implicational universal of syllable structure. Following Vergnaud & Halle (1978), we think of the syllable as a binary branching structure the terminal nodes[1] of which are the segments themeselves. Typically the syllable ($\sigma$) consists of two sister constituents: a lefhand constituent, the onset and a righthand constituent, the rime (1a), both of which may or may not branch; if the rime branches we many further distinguish, for easier

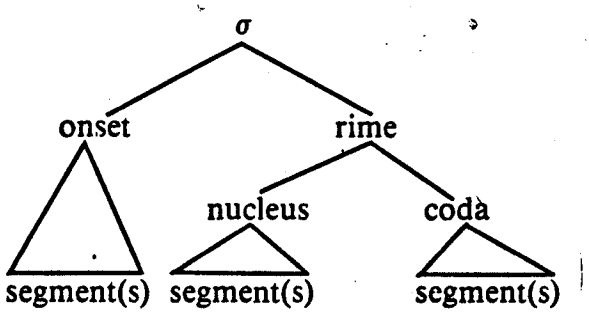
[1] Prosodic phenomena have recently received considerable attention. See for instance Liberman (1975), Kahn (1976), Liberman & Prince (1977), Vergnaud & Haile (1978), Kiparsky (1979), Selkirk (1979), as well as Fudge (1969).

reference, between its subconstituents: the nucleus and the coda (1b).[2]

(1) a.




b.




Since markedness conventions interpret lexical representations and since it has been argued that prosodic structure is associated with that level of representation[3] (an approach for which we will adduce additional support), we will propose that markedness conventions for major features be directly built into syllable structure. The hierarchical approach to prosodic structure provides a framework for the expression of such statements: specifically, we will argue that the domain over which these conventions are defined are constituents of $\sigma$. In this article we will restrict our attention to the feature [segment].

In sections 2 and 3 we will discuss the implicational universal which is the basis of our proposal. In sections 4 and 5 we state our proposal and discuss its implications for phonological theory. In sections 6 and 7 we touch upon the question of syllable structure assignment and sketch out directions for future research. Finally in section 8 we discuss the behaviour of loan words in light of our analysis of syllable structure.

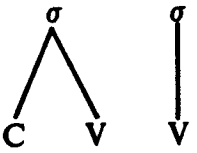
[2] At this point, however we wish to leave it an open question whether the latter categories have a theoretical status of their own, i.e. whether they are available for reference by rules etc.

[3] See for instance Selkirk (1979).

2. In this section we will first informally sketch the sorts of generalizations that a theory of markedness should account for. To begin this discussion we wish to make the following distinction between two types of syllable constraints: formal and substantive. Formal syllable constraints refer to the limitations on the shape of syllables that may occur in a given language. Thus a language like Desano and Maori are limited to syllables with non-branching rimes and non-branching onsets (i.e. only open syllables). Languages like English and Polish may have both branching rimes and branching onsets, and so on. These formal syllable constraints are to be distinguished from substantive constraints. In general English and Polish have similar formal syllable constraints. They differ, however, in terms of what phonological classes may occupy a given position whitin a syllable. Polish permits syllable onsets consisting of a stop followed by a nasal: *gmach* 'edifice', *dno* 'bottom' while such onsets are impossible in English.[4] The major portion of this article will be devoted to formal constraints and their status within a theory of syllable markedness.

It has generally been assumed that open syllables, CV and V are the least marked of the syllable types. CV syllables are found in every language and a significant number of languages have only syllables of this type. We define a first category of languages as those containing open syllables (non-branching rimes) and no syllable initial clusters (non-branching onsets). This is the least marked category in terms of syllable markedness

(2)

| | Category I | Syllable types | Examples |
|---|---|---|---|
| | |  | Desano, Dida, Maori |



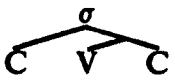
We shall also assume that CV is the optimal, least marked syllable and that V occupies a slightly higher position on the markedness scale.

While the existence of Category I languages and the associated

[4] Thorough discussions of such substantive constraints can be found in Greenberg (1963; 1965).

claim regarding the unmarked status of their syllables is hardly a new discovery, there exists a second category of languages that has, to our knowledge, escaped the notice of linguists. Category II languages have branching rimes but no branching onsets. These languages have closed syllables but lack syllable initial consonant clusters.

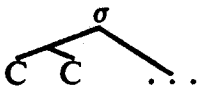
| (3) | Category II | Syllable types | Examples |
|---|---|---|---|
| | | Category I and CVC | Pre-contact Quechua, Hungarian, Wolof |




As we proceed up the scale of syllable markedness it should be noted that each category contains all the syllable types of the categories below it in the markedness scale. Thus, Category II languages are stipulated as having syllables of the type CVC. From their position on the markedness scale, it follows that they will also have syllables of the type CV and V.

The final and most marked category of languages have both branching rimes and branching onsets. Organizing languages in the markedness scale discussed above makes an interesting claim worth noting about what should be an impossible combination of syllables and syllable initial clusters. Expressed somewhat differently, we are claiming that in a language, the existence of syllables with branching onsets implies the existence of syllables with branching rimes.

| (4) | Category III | Syllable types | Examples |
|---|---|---|---|
| | | Category I, Category II and | English, Polish, Fox |




The above state of affairs is what we wish to capture with our theory of syllable markedness. We proceed to the formulation of such a theory in the next section.

**3.** Suppose we arrange two columns — one for onsets and one for rimes. These columns are arranged such that the least marked onset

and rime appear at the top of each column with the markedness increasing as we travel down each column. Such an arrangement is given below.

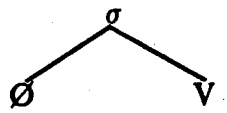
(5)

| Onset | Rime | Markedness |
|---|---|---|
| C | V | 0 |
| Ø | Ø | 1 |
| CC | VC | 2 |
| CCC | VCC | 3 |
| $C_1 \ldots C_n$ | $VC_1 \ldots C_{n-1}$ | n |

If we consider our optimal syllable to be CV, we consider that each of its constituents, the onset and the rime are the least marked of their respective categories. We noted above that we wished to consider syllables of the type V as being slightly more marked than CV syllables.

We assume that all syllables have the structure ONSET-RIME and are organized into a binary branching tree. If every syllable has such a structure, then V syllables are to be represented as in (6).

(6)




V syllables as open syllables with null onsets

Since we assume that V syllables are slightly more marked than CV syllables, we place Ø below C in the onset markedness scale. Note that we have also allowed for a null rime in (5). For the moment let us assume that it has been included to bring out the parallelism between the markedness scales of the onsets and the rimes. At level 2 we have a rime closed by a consonant. Following our earlier discussion we wish to assume that a branching rime (closed syllable) is more marked than a non branching rime. It is also quite natural to increase the markedness as the number of consonants closing the syllable increases. Thus a rime VCCCC is more marked than VCCC, and so on. We should point out that since we are dealing with strictly formal constraints, we should not be characterizing syllables as sequences of C's and V's. It is rather *the form* of the syllable trees that is crucial here. It must be understood that branching rimes may be found of the type VV (long vowels), VVC, VVCC and so on. In our theory these have exactly the same status as rimes whose second member is

non-syllabic. We shall say nothing further about this possibility but the reader is reminded that our discussion of formal constraints involves shapes of trees; sequences of C's and V's are used for mnemonic reasons only.

The markedness scale for onsets is established in the same way. We assume that syllables with branching onsets are more marked than those with non-branching onsets and further that markedness increases with the number of branches in a given onset.

In order to incorporate all these facts into a theory of syllable markedness, a further analytic step must be taken. We must assume that syllable markedness is non-cumulative, i.e. the markedness of a syllable is not the sum of the markedness of the onset plus the markedness of the rime. Indeed we wish to claim that there is no markedness level for syllables at all; rather, markedness is computed from onsets and rimes. The argument for the above claim goes as follows: suppose we wish to characterize languages in terms of their degree of syllable markedness and that we wish to do this by a single integer which will express the degree of markedness of entire syllables. We assume the following formula:

(7) $m(S) = m(0) + m(R)$

where m is a function expressing the level of markedness of its argument (S,O and R stand for syllable, onset and rime, respectively). The level is to be read off a table along the lines of (5). The syllable markedness index of a language would be a single integer whose value based on a calculation following (7) may not be surpassed by the language in question. Suppose, for instance, a language has a syllable markedness index of 2. From table (5) we can see that the language would have the following possible syllables:

(8)

| Onset | Rime | Markedness |
|---|---|---|
| C | V | 0 |
| Ø | Ø | 1 |
| CC | VC | 2 |

| Syllables | Onset | | Rime | | S-markedness |
|---|---|---|---|---|---|
| CV | 0 | + | 0 | = | 0 |
| ØV | 1 | + | 0 | = | 1 |
| CCV | 2 | + | 0 | = | 2 |
| CVC | 0 | + | 2 | = | 2 |

| | but not | | | | |
|---|---|---|---|---|---|
| *ØVC | 1 | + | 2 | = | 3 |
| *CCVC | 2 | + | 2 | = | 4 |

Syllables like CVC and CCV are possible in this framework, since an unmarked onset is combined with a marked rime or vice versa and the absolute limit for the entire syllable, viz. 2 is not surpassed.

Note, however, that syllables such as VC or CCVC are ruled out, which is not even consistent with the empirical evidence disucussed in Section 2.

In fact human languages simply do not exhibit such behaviour. Again, syllable markedness does not exist, rather onset markedness and rime markedness exist and are independent of each other in the following sense.

(9) Let {0} be the set of onsets of a language L. Let {R} be the set of its rimes. The set {S} is the set of all the syllables of L. $\{S\} = \{0 \times R\}$.

That is, the set of all syllables of a language is the cartesian product of the set of its onsets and the set of its rimes.[5]

In other words the total set of syllables of a language are obtained by combining every possible onset with every possible rime. To characterize the syllable markedness of a language two values must be given: the markedness of the onset and the markedness of the rime. Furthermore we want to obtain the set of implications shown in (10).

(10)

| Onset | | Rime | Markedness |
|---|---|---|---|
| C | ⊃ | V | 0 |
| ∩ | | ∩ | |
| Ø | ⊃ | Ø | 1 |
| ∩ | | ∩ | |
| CC | ⊃ | VC | 2 |
| ∩ | | ∩ | |
| CCC | ⊃ | VCC | 3 |
| ∩ | | ∩ | |
| $C_1 \ldots C_n$ | ⊃ | $VC_1 \ldots C_{n-1}$ | n |

The implications heading upwards are simply a reflection of the

[5] The independence of rimes and onsets as separate systems was also recognized by Greemberg (1965) although in the context of quite a different discussion.

organization of the columns. The presence of a given rime or onset in a language implies the presence of every rime or onset lower (higher on the chart) than it in the markedness scale. So, for example if a language has CC onsets, it will have onsets with Ø and C. The implications holding between onsets and rimes indicate the more fundamental role of the latter in determining syllable markedness. They say, in effect, that the presence of an onset of a given degree of markedness implies the presence of a rime of an equal degree of markedness in that language.

This may be expressed formally as in (11)

(11) v(L) = (m,n) where m is the maximum markedness value for the onsets and n is the maximum markedness value for the rimes; moreover $m \leq n$.

The set of syllables of a language may be read directly off the markedness index in the following way:

(12) if v(L) = (m,n) then

$$\{S\} = \left\{ \begin{matrix} m \\ m\text{-}1 \\ m\text{-}2 \\ . \\ . \\ . \\ m\text{-}q \end{matrix} \right\} \times \left\{ \begin{matrix} n \\ n\text{-}1 \\ n\text{-}2 \\ . \\ . \\ . \\ n\text{-}r \end{matrix} \right\}$$

where q = m
and r = n

Thus the syllable markedness index of a language is an ordered pair whose first member is the markedness specification of the onset and the second, the rime. We stipulate further that the maximum degree of markedness for rimes found in a language is always at least as great as the maximum degree of markedness of the onsets (Note that we are speaking of the entire inventory of syllables of a language. Obviously it is possible of a particular syllable to have an onset more highly marked than its rime, e.g. CCV.)

Conceptually, it makes perfect sense to recognize a kind of priority to rimes as opposed to onsets. Phonological processes sensitive to syllable structure are sensitive to the structure of the rime, e.g. branching or not. We know of no syllable structure sensitive

phonological process that is sensitive to the structure of the onset.[6] The stipulation that m is less than or equal to n yields the rightward implication of (10). Furthermore the three categories of languages discussed above fall out automatically from the formulation. Category I (open syllable) languages are specified (1,1) in syllable markedness. Interpreted as in (11), this yields the syllables CV, ØV, CØ, and ØØ. Let us leave aside the syllables with a null rime, CØ, and ØØ. The remaining syllables, CV, ØV are just the set of occuring syllables in these languages.

Category II languages such as Hungarian receive the index (1,2), allowing for the syllables CV, ØV, ØØ, CVC, and ØVC. Once again leaving aside the syllables with null rimes, we have CV, ØV, CVC and ØVC which correspond to the Hungarian inventory of syllables.

Finally, Category III languages would have indices of at least (2,2). Post-contact Quechua falls into this group. It has all the syllables of (1,2) languages plus the onset CC which may occur before any rime, yielding the additional syllables CCV, CCØ and CCVC. Different dialects of Arabic may be classed as (1.3) languages: syllables may be closed by up to two consonants or a long vowel followed by a single consonant but no branching onsets exist. Following this scheme French comes out as (3,3) and Yiddish and English as (3,4). Thai, which displays branching onsets of at most two consonants and long diphthongs (each member of which is long) in closed syllables, appears to be a (2,5) language.[7]

Earlier we noted that no language may have had branching onsets unless it also had branching rimes. This fact also follows from our formulation. If such a language existed it would have the onsets C, Ø, CC and the rimes V, Ø. This language would have the markedness index (2,1). This is excluded by our theory by virtue of the requirement that $m \leq n$.

**4.** We now wish to continue our formulation in rendering our theory compatible with an existing theory of markedness. Let us assume an

[6] Of course, this is begging a question, viz. what is a syllable sensitive rule? While we are not in a position to exhaustively answer such a question (or to assess its ultimate significance) we believe that some progress has been made toward this end. See for instance Kahn (1976) and our discussion thereof below.

[7] We are indebted to Panit Chotibut for valuable discussion of syllable structure in Thai.

extended standard theory of markedness along the lines of the one presented in Kean's contribution to this volume. We propose that certain marking conventions, namely the conventions for those features that have no direct phonetic interpretation, be stated in terms of constituents of the syllabic tree. To account for the formal syllable constraints discussed above we give the following rule for the feature [segment]. The environment for this rule is the categories O (onset) and R (rime).

(13) [u segment] → [+ segment] / [$_{O/R}$ ____]

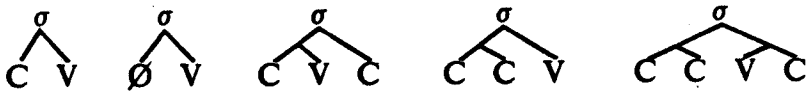
Rule (13) interpreted in accordance with Kean's (1975) complement convention is really a collapsing of four specifications show in (14)

(14) a. [u segment] → [+ segment] / [$_{O/R}$ ____]
b. [m segment] → [— segment] / [$_{O/R}$ ____]
c. [u segment] → [— segment] / ~ [$_{O/R}$ ____]
d. [m segment] → [+ segment] / ~ [$_{O/R}$ ____]

(14a) indicates that the unmarked value for segment is [+segment] in non-branching onsets or rimes. In the same context, [—segment] (i.e. null onsets and rimes) is the marked value of [segment]. In all other contexts, i.e. in all cases of branching onsets and rimes, the marked value of [segment] is [+segment] (14c).

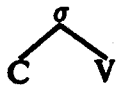
Let us now apply the rule (13) to various syllabic structures in order to show that it yields the desired results.

(15) Syllabic structures




In the above structures the middle line (C,V,Ø) is only a mnemonic device to keep track of the sorts of syllables we are dealing with. Since, for the moment we are only interpreting the feature [segment] our only choice is the presence or absence of an element. The universal syllable template to be discussed below as well as other marking conventions will yield the results indicated in (15). Beginning with the least marked syllable CV we note that neither the onset nor the rime are branching and that in both instances we have [u segment]. Applying (13) to this structure we get (16).

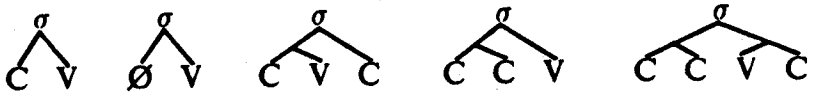
(16)




seg + +

Similarly the second structure of (15) contains no branching onset or rime. In this case however the onset is marked and following (14b) is interpreted as [—segment]: in other words a null onset. Thus V syllables are slightly more marked than CV syllables which is the desired result. The third structure has an unmarked non-branching onset and a branching rime both of whose members are marked (14a) will yield [+ segment] in the former case and (14b) will yield the same result for both members of the rime. Note that this structure is more marked than either CV or V syllables, again the desired result. We summarize the structures of (15) as interpreted by (13) below.

(17)




In terms of markedness a CCV syllable has the same level as a CVC syllable, viz. 2. We have stated above that the presence of a CCV syllable implies the presence CVC syllable in a given language. Since both syllable types have the same degree of marking this effect must be accounted for in some other way. In fact, it is our $m \leq n$ condition that does this, i.e. the most highly marked rime of a language must always be at least as highly marked as the most highly marked onset.

**5.** In order to fully understand the workings of this theory certain notions regarding the form of lexical representations must be made precise. We see that rule (13) operates on a phonological feature but depends crucially on syllable structure in order to function correctly. It follows that syllable structure must be present at the point at which marking conventions apply. Since this point is that of lexical representation, it follows that syllable structure must make up part of the lexical representation of a form. The phonological representation of a lexical item, has, then, two levels: the segmental level which is a matrix of features consisting of the values u and m, as in Kean (1975) and a syllabic level consisting of binary trees at least up to the

syllable level.[8] In very rough form we give the phonological representation of two lexical items in a hypothetical language. We supply only the values for the feature segment. In a complete representation, obviously all the features would be indicated. Note that the accompanying phonetic transcription is purely mnemonic.

(18) Entries (abbreviated) for "topi" and "kraspel"


Conceptually the idea of a two tiered phonological representation is not abhorrent. The quasi-independence of syllable structure from segmental structure may find some support in acquisition and aphasia studies. It is frequently the case that one completely botches the segmental structure of a word that one wishes to recall. It appears to be quite rare that the syllable structure is equally botched: in attempting to recall words that slipped one's mind the syllable structure is usually preserved even in a series of wrong guesses. No formal attempt will be made to justify this organization of lexical items other than that it is required by our theory. Research in the domains cited just above should provide interesting results for our claim.[9]

A second point must be raised concerning lexical representations, viz. at what level of representation is the syllable markedness index of a language to be fixed. Let us begin by considering some clear cases. Desano is, as we have said, a (1,1) language. Further no rules affecting syllable structure may create syllable structures that would otherwise not exist. Thus a rule converts a sequence CVV into CV (the segmental facts do not concern us here) but CV already exists. Thus, Desano is completely unrevealing as to at which level syllable markedness should be defined since the inventory of syllable types on both levels (underlying and surface) is identical. The Odawa dialect of Ojibwa is more useful in this regard. Odawa (like other Ojibwa dialects) is a (2,3) language with branching onsets limited to

[8] We leave open the question whether the organization into feet is done at this level, but see Kiparsky (1979), and Selkirk (1979).

[9] Brown and McNeil (1966) and Cutler and Fay (1977) have shown that prosodic structure is preserved in speech errors. In addition David Caplan has pointed out that prosodic structure is also preserved in the various sorts of aphasia.

those whose second member is a glide. The above characterization is valid only at the level of underlying representation. Odawa has a rule which in general stresses even numbered syllables starting from the beginning of the word, as well as all final syllables. A later rule deletes all unstressed vowels. Starting with a form like (19a) we derive (19b)

(19) a. /masina? ikan/ 'book'
b. [msin?ikan]

The inflected form (20a) yields (20b)

(20) a. /ni-masina?ikan/ 'my book'
b. [nmasna?kan]

The effect of the syncope rule is to create surface onsets that cannot exist at the level of underlying representation, e.g. *ms, nm*. External evidence (Kaye (1975), Kaye & Nykiel (1978)) indicates that the operative syllabic constraints are at the underlying level and not the surface level, i.e. *ms, ns* are not possible Odawa onsets. Given this situation the simplest possible theory has the following condition:

(21) All syllable constraints are defined at the level of lexical representation.

Note that we are not claiming that all operations which involve syllable structure operate on underlying syllable structure. A phonological rule sensitive to syllable structure may apply after a prior rule has altered the underlying syllable structure. Put another way, syllable sensitive rules may be fed or bled by other phonological rules. Hans Basbøll (personal communication) provides us with a typical example. Danish has a rule which raises *æ* to ɛ in a closed syllable.

(22) $ae \rightarrow \epsilon \; / \; \underline{\quad}\; \overset{R}{\underset{C}{\diagup\diagdown}}$

Another rule syncopates vowels in certain contexts. The syncope rule (which is optional) may feed rule (22) as the following derivation shows:

| (23) | 'America' | /aemerika/ | /aemerika/ |
|---|---|---|---|
| | Syncope | aemrika | _____ |
| | (22) | ɛmrika | _____ |
| | Output | [ɛmrika] | [aemerika] |

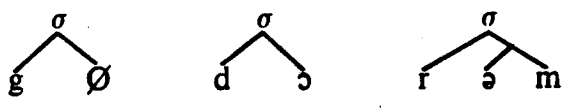
This and other examples show that phonological rules indeed apply to derived syllable structure. Our original claim (16) remains unaffected by this state of affairs. An interesting possibility would be to impose a « structure preserving » constraint on derived syllable structure; i.e. that no syllable sensitive rules may apply to a syllable that does not occur in lexical representation. In the Danish example above, the derived initial closed syllable which triggers (22) is a possible syllable in UR. This suggestion has far reaching consequences which we will discuss below.

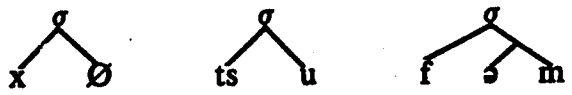
Another interesting situation arises in the case of Yiddish Epenthesis. A rule of epenthesis discussed in Lowenstamm (forthcoming) is exceedingly difficult to state in a non - syllabic framework. On the other hand, when reference to syllable structure is allowed, the rule can be stated in a maximally simple fashion, as in (24)

(24) $\emptyset \rightarrow$ ə /.C ——.

In other words, when a consonant is the sole member of a syllable, a schwa is inserted to its right. This rule converts underlying forms such as/gdɔrəm/ 'limitations', /xtsufən/ 'impudent persons' into [gədɔrəm] and [xətsufəm] respectively. Crucial to the operation of (24) is a syllabification such as /g.dɔ.rəm/ and /x.tsu.fəm/. Other conceivable syllabifications such as /gdɔ.rəm/ and /xtsu.fəm/ are ruled out on independent grounds for the dialects of Yiddish under discussion. This point is important because if such syllables were permitted, not only would we have to revert to complexity in the statement of (24), but more importantly for our hypothesis, we would have a syllable structure sensitive rule, (24) affecting a configuration which is not a possible syllable in the language. But our framework provides us with the possibility to maintain the well motivated underlying representation /gdɔrəm/ and /xtsufəm/, (24) as the statement of epenthesis *and* our hypothesis about the structure preserving nature of syllable sensitive rules. Indeed we construe all syllables as consisting of an onset and a rime so that lexical entries for the forms discussed here are as in (25) and epenthesis can be reformulated as (26):

(25) a.



b. 

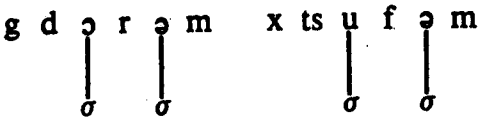

(26) 


In other words, if the left-most element of a rime is null, it gets realized as a schwa. Null rimes appear to be called for in Harari (Kenstowicz 1977, Halle and Vergnaud forthcoming) and for Tiberian Hebrew (Borer 1978). We see, then, that null elements play a crucial role in both the formal theoretical apparatus and in actual linguistic descriptions.

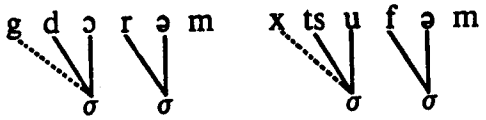
**Excursus**

It is worth noting that our conception of syllable structure is markedly different from that expounded in an important contribution, viz Kahn (1976). Kahn argues that syllable structure is assigned in the following way: there is a one-to-one relationship between the number of [+syllabic] segments and the number of syllables of a string; once all these segments have been spotted, as many [—syllabic] segments as can be observed word initially in the language are associated to the left of these peaks, then as many [—syllabic] segments can be observed word finally in the language are associated to the right of the same syllable peaks. One can readily see that Kahn's system will not provide the representations of (25 a,b) as the initial syllables lack a [+syllabic] segment. Rather, faced with the problem of assigning syllable structure to these forms, Kahn's algorithm would perform as follows:

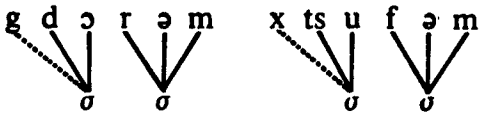
(27) a. 1st Step: Identification of syllable peaks




b. 2nd Step: Leftward association



c. 3rd Step: Rightward association




In (27) we have demonstrated the whole process of syllable structure assignement in Kahn's system for clarity of exposition. However, the process is in fact blocked as early as the second step (27b): the association of the 1st segment of each representation (representated in dottes lines) is actually illicit, no Yiddish word beginning with #gd or #xts. The fact that no Yiddish word displays such sequences is hardly surprising, these sequences being always separated by a schwa, as the result of epenthesis. As we see this system will not assign syllable structure to the underlying representation above thereby not providing an input to the syllable structure sensitive rule of epenthesis. We are of course making the assumption here that epenthesis is indeed syllable sensitive. What supports this view? This brings us to our second point: Kahn (op. cit) convincingly argues that rules of the form (28) are not natural rules in the sense of Chomsky and Halle (1968).

(28) a. $X \rightarrow Y / \left\{ \begin{matrix} C \\ \# \end{matrix} \right\} \_\_ Z$

b. $X \rightarrow Y / Z \_\_ \left\{ \begin{matrix} C \\ \# \end{matrix} \right\}$

In fact, he contends, these environments stand for syllable boundaries. As far as we know this argument constitutes the major motivation in the literature for the recognition of the syllable as a domain of rule application. As it turns out, Yiddish Epenthesis is just such a rule but, as we saw, Kahn's algorithm cannot analyze the input strings. One might object that Kahn's proposal is not really at fault and that it in fact works perfectly well for the low level generalization that he set out to capture in his thesis. This would be irrelevant: his argument for the introduction of the syllable is an argument about rule format and its validity extends beyond just late rules.

We just saw that significant generalizations about syllable structure in Yiddish can be captured with the notion of a null rime.

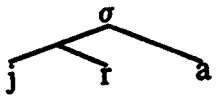
Even at that these null rimes may still appear somewhat « gimmicky ». There is some evidence that null rimes may somethimes surface in the same way as null onsets.

Dida, a Kru language, is basically of the type (1,1). Surface sequences of C-liquid do occur: *jrà* 'lion', *mlɛ̄* 'to leave' *ɓlɛ̀* 'cow'. What is interesting is that speakers of the language claim to hear a vowel between the consonant and the liquid and even to hear a tone on the vowel (a copy of the following tone). Thus jrà would have the syllable structure as in (29):

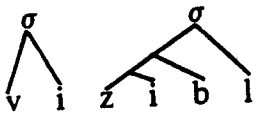
(29)


Note that if the syllable structure were not as in (29), a situation would exist directly contradicting our theory, i.e. Dida would have only open syllables and branching onsets. Given the structure preserving nature of syllable structure changing rules, it follows that *jrà* could not have the structure (30) at any level of representation:

(30)

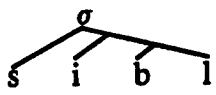



since branching onsets are excluded from UR. This provides us with an interesting contrast. French, like Dida[10] has a rule which among other contexts deletes a vowel between a consonant and a liquid (Schane 1968. 43) as in *visible* /vizibili/ cf. *visibilitè*. Note that in the case of words like *visible, visiblement* where a vowel has been deleted between the *b* and the *l*, the intuition of French speakers are markedly different from those of Dida speakers. There is no tendency to posit a reduced or abstract vowel (null rime) in words like *visible* by speakers of French as in done for Dida. Unlike Dida, French has underlying syllables of the form C-liquid, cf. *double, cible, simple, meuble,* etc. Thus, the rule that deletes the two final vowels in a form like /vɪzɪbɪlɪ/ may indeed change the syllable structure since the syllable structure created by such a deletion, i.e.




[10] Alternatively, it is possible that Dida has no vowel deletion rule (although the clusters were certainly created historically by a deletion rule) and has null rimes both on the surface and underlying representations.

exists independently, as in (31):

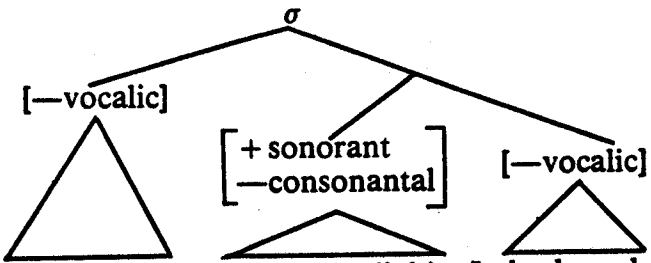
(31) 


*cible* 'target'

**6.** In this section we wish to address the question of how syllable structure is assigned. Quite surprisingly this question is generally left unattended (with the exception of Kahn (1976) and Vogel (1977), but see our discussion above). That is, current work 'assumes' syllable structure and, from there, analyses are carried out. While this is not incorrect as a strategy of research, the question cries for some attention from the part of linguists. Indeed phonological representations are not randomly associated with prosodic structure, rather some principles are at work behind the organization of strings of segments into prosodic units (for instance, in a linear framework, the existence of a certain rule inserting syllable boundaries, as in Hooper (1972), or rules for the construction of metrical structure as in Liberman & Prince (1977)). While a full treatment of syllable structure assignment would be beyond the scope of this article, we want to show what the proposal put forth in the preceding sections can contribute to such a system.

We assume that a theory of syllable structure assignment minimally incorporates (32ab), as part of universal grammar (UG).

(32) a. The Universal Syllable Template (UST)




Note that UST does not mention syllabic. Indeed we do not believe that this feature plays a role in grammar (see Lowenstamm (1979)). UST, which interprets phonological strings at all stages of a derivation has the following properties:

(i) it optionally dominates phonological material
(ii) it is to be interpreted according to Vergnaud's Per-

colation Convention (see Vergnaud (1979)).

b. A set of principles governing the application of UST to phonological strings (directionality (see our discussion in section 7., below), minimization of the number of strings in the analysis of a string, etc.).

Now, consider the following problem noted by Broselow (1976) in the context of her discussion of Hooper (1972). Broselow quotes the following form from Egyptian Cairene Arabic: *abyad* 'white'. This form is syllabified as *ab. yad*, as evidenced by the spread of pharyngealization (see Broselow, op. cit., for valuable discussion of Emphasis). On the other hand, Hooper's rule would yield *a.byad* (parallel to Spanish *a.lyen.to*). In a rather unconvincing discussion Broselow ends up by rejecting Hooper's approach and reverts to a conception of syllable structure as a language specific phenomenon. We believe this to be the wrong move. Indeed we sympathize with Hooper's general endeavor to keep syllable structure assignment as a universal process, thereby limiting the task of individual grammars to fixing parameters of UG.

In fact, in our framework we are able to isolate just what appears the relevant parameter: Arabic is a (1,3) language and the option of branching onsets is simply not available to it, which rules out *a.byad* as a possible analysis by UST. Syllable structure assignment is otherwise identical in Arabic and Spanish: UST applies in the same fashion in both languages (we assume left to right directionality and/or maximization of onsets).

Consequently, along with (32ab) we have to have (32c).

(32) c. Languages freely draw from the universally available syllable types *within the limits of (11)*.

(32c) in effect says that there is nothing necessary about the fact that a language has a given markedness index. This index has to be determined by the learner. Once this is done, the entire set of syllables of the language follows.

**7.** We now turn to the parsing strategies mentioned under (32b). While no parsing strategy seems to work adequately all the time, certain strategies appear able to account at least for the clear cases. The first proposed is given below.

(33) The Rightward Strategy

Scanning a word from left to right, make the first syllable as unmarked as possible. If the resulting syllable on the right conforms to the formal and substantive syllable constraints of the language, then there is a syllable boundary[11] at that point. If the resulting right syllable violates a constraint, move the syllable boundary over one segment to the right and try again. Repeat until the resulting right syllable is licit. After the first syllable boundary has been found, repeat the process for each successive syllable until the end of the string is reached.

The rightward strategy has the effect of minimizing the markedness of the *rimes* of a word at the expense of increasing the markedness of the onset. To illustrate (33) consider English which we assume uses this strategy. We apply (27) to the words *command, canteen, astute* and get the following syllabifications:

(34) co-mmand can-teen a-stute

In the first case *command* we attempt a cut after the least marked initial syllable, CV. Yielding kə-mænd. Since *mænd* is a legitimate English syllable, the syllabification is well formed and we have reached the end of the string. In the second case *canteen*, we again try the least marked initial syllable yielding *kæ-ntiyn*. But *nt* is not a possible English onset. We move our cut one segment to the right and try again. This time we get *kæn-tiyn*. *Tiyn* is a good English syllable and thus the cut holds up. In the third case, a syllable cut is attempted after the initial vowel, *-stuwt*. Since *stuwt* is a well-formed English syllable, this syllabification stands. These syllable cuts may be justified in two ways. Ideally one can find phonological processes that are sensitive to syllable structure and use them to determine syllable structure in unclear cases. Thus, for English stressed syllables initial voiceless stops are aspirated. The aspiration of *t* in a word like [kænt$^{h}$iyn] indicates that the syllable boundary falls between the *n* and the *t*. In the word *astute* no such aspiration occurs and we conclude that one syllable boundary follows the initial vowel. We shall see below that a procedure such as that described in Kahn (1976, 39ff.) is not a reliable way to determine syllabification. Kahn

[11] Syllable boundaries are no longer necessary in a metrical framework. We only refer to them informally in the sense of 'beginning or end of a syllable'.

bases syllable cuts on the distribution of onsets and rimes in word initial and word final position respectively. There are two principle reasons for rejecting Kahn's procedure in addition to the objections raised in section 5.: the exceptional nature of word initial, and to a lesser extent, word final syllables, and the possible existence of a leftward strategy to be discussed below.

Note that two languages may both employ a rightward strategy and yet because of differing formal or substantive constraints, similar phonological strings may be syllabified differently. Thus Ojibwa has strings similar to *astute* such as *miskosi* 'he is red' but the syllabification is mis-ko-si and not *mi-sko-si. Ojibwa does not permit branching onsets other than those whose second member is a glide. The example *mis-ko-si* does not show that Ojibwa has a rightward strategy. A form like *mi-kwan* « feather » syllabified *mi-kwan* shows that (33) is in effect.

In cases where no phonological processes sensitive to syllable structure are available, we must fall back on native speaker judgments as to where the syllable breaks occur. Of course these judgements are not always consistent or clear and care must be taken as to how much weight one should accord them. Such data is the basis for our discussion of Polish.[12]

Polish speakers generally agree that the syllabification of words like *wyspa* 'island, *ospa* 'smallpox', *tykwa* 'pumpkin', *stacja* 'station' is as in (35):

(35) wys-pa os-pa tyk-wa stac-ja

Given (33) we would expect syllabifications like **wy-spa*, **ty-kwa*, etc. Since sp-, ky-, and cj- are all possible onsets. A possible explanation for (35) may be that there is another parsing strategy such as (36):

(36) The Leftward Strategy

Scanning a word from right to left, make the last syllable as unmarked as possible. If the resulting syllable on the left conforms to the formal and substantive syllable constraints of the language, then there is

12 We wish to thank Grzegosz Dogil, Wiktor Gonet, Barbara Nykiel and Jerzy Rubach for their help in the analysis of the Polish data. What appears here does not necessarily represent their point of view.

a syllable boundary at that point. If the resulting left syllable violates a constraint, move the syllable boundary over one segment to the left and try again. Repeat until the resulting left syllable is licit. After the first syllable boundary has been found, repeat the process for each successive syllable until the beginning of the string is reached.

It is obvious that (36) is the mirror image of (33). It has the effect of minimizing the markedness of syllable *onsets* of a word at the expense of increasing the markedness of the rime. Applying (36) to the forms cited above we indeed obtain the syllabifications of (35). If we take the word *ospa* and make the final syllable as unmarked as possible, we get *os-pa*. Since *os* is a possible rime, the syllabification holds. If we had applied a rightward strategy, we would have obtained the syllabification *o-spa* which is either rejected out of hand or at least found less preferable by Polish speakers. The other forms of (35) present an interesting problem. Following the analysis of Gussmann (1978) these forms have an underlying vowel that breaks up the surface cluster as in wysEpa, tykEwa, etc. (cf *wysepka* 'island' (dim.). *tikiew* 'pumpkins' (gen. pl.)). At the level of UR wysEpa, would be syllabified by either a rightward or leftward strategy as *wysE-pa*. If we assume a rightward strategy as in English we could explain the surface syllabification *wys-pa* as a vestige of one of the original syllable breaks in UR and not as evidence for a rightward strategy. The case of *ospa* shows this cannot be the case. The *sp* cluster is organic - there is no underlying vowel separating the two consonants and yet *ospa* and *wyspa* are syllabified exactly alike. We tentatively propose a leftward parsing strategy for Polish. If it is indeed the case that some languages have leftward strategies while others have rightward ones, it is quite tempting to try to correlate this with another opposition in the Halle-Vergnaud metrical theory. They note that metrical trees may be left-branching in some languages and right-branching in others. It would be quite interesting if there were some connections between this distinction and leftward vs. rightward strategies. The last words have certainly not been said regarding these parsing strategies. In languages like Polish where we have been unable to find phonological processes sensitive to syllable structure, speakers' judgments become much less clear when cutting long sequences of word internal consonant sequences. People are far from complete agreement with the cuts furnished by our parsing strategies in those cases.

It is not always possible to determine if we are dealing with a rightward or leftward strategy. Obviously (1,1) open syllable languages will yield the same results in either direction. The same is true with a (1,2) language like Hungarian.[13] Given a sequence like *CVCCVCVC̆* both strategies yield the syllabifications *CVC-CV-CVC*. A language must be at least as marked as (2,2) (branching onsets) before directionality becomes crucial. For the less marked cases we assume that one of the two parsing strategies, say the rightward one, is the unmarked one and is found in the relatively unmarked languages.

Our discussion of parsing strategies obviously suffers from our failure to take several other factors into account. Ultimately we must distinguish stressed and unstressed syllables. We note that stressed syllables show a wider diversity of syllable types and stressed syllables may have a greater degree of markedness.[14] Compare the syllabification of English words like *distant, dis-tant* and *disdain, di-sdain*. Strong boundaries (i.e. #) in general as well as prefix boundaries in Indo-European languages influence syllabification and must figure in any adequate parsing strategy. The effects of prefix boundaries are obvious in English. Compare the syllabification of *distaste dis-taste* vs. *disdain di-sdain*. One cannot simple claim, however, that syllable boundaries and morpheme boundaries of any type always coincide, cf. French *arrivez* 'arrive 2nd pl', *prétendant* 'claiming', *sautons* 'let's jump', where the final vowel of the word is the initial element of a suffix (i.e. *—ez, —ant, —ons*) and the syllabification is as follows: *a-ri-vez, pré-ten-dant, sau-tons*.

Finally, word-initial and word-final syllables are generally weird. Word-initial syllables can usually be more marked than other syllables.[15] For example, in many (1,1) languages null onsets may only appear in word intial positions. The inventory of Polish syllable onsets is much more spectacular in word-initial syllables than elsewhere. Preliminary investigations of Dida indicate that long vowels occur only in word-initial and word-final syllables and never

[13] Thanks to Katalin E. Kiss for raising this point.

[14] We thank Manfred Bierwisch for this point. See Kahn (1976) for a discussion of these questions. See also Borer (1978) for a clear example of the relationship between stressed syllables and markedness.

[15] It will be important to eliminate stress as a possible factor giving this result. In our examples the tolerance for marked syllables shown by word initial position appears to be independent of stress.

elsewhere. Also in Dida glides may appear as syllable onsets only in word-initial syllables and not elsewhere.

Word-final syllables are more perplexing. At times they appear to allow more marked syllables like word-initial syllables. The case of Dida long vowels was mentioned above. Ojibwa glides may occur as syllable coda only in stem-final syllables, cf. *nēkāw* 'sand', *pakiw* 'gum, pitch'. In other languages word-final syllables support less marking than elsewhere in the word. Japanese must have a sonorant in word-final positions (a vowel or syllabic nasal). Word internal syllables are not subject to this constraint. Italian word final syllables may be closed only by, —*n*, —*l*, or —r. In other positions codas may contain a wider variety of non-syllabics.[16]

**8.** As a final note we wish to discuss loan word nativization with respect to our theory of syllable markedness. Considering first languages of the type. (1,1) we note that nonconforming syllables of the source language are adapted to the syllable structure of the target language. Thus, Portuguese *martelo* 'hammer' is borrowed into Desano as *barateru*. What is crucial here is that the initial syllable in the Portuguese source word did not correspond to a possible syllable in Desano: specifically it had a branching rime while such syllables are excluded from Desano. A similar example is provided by Lingala (Bantu), another (1,1) language. The nativized version of French *secrétaire* 'secretary' comes out as *sɛkɛlɛtɛlɛ*. In this example the nonconforming initial and final syllables of the source word are adapted to the native syllable structure by the insertion a vowel.[17]

At this point one may wonder if an influx of loan words may ever have an effect on the native system of syllable markedness. Below we shall present some evidence that this may indeed occur but only according to rather severe constraints. Our claim is presented in (28) below.

(28) Nativized loan words may not surpass the level of markedness of the *rimes* in the target language.

[16] We whish to thank Marina Nespor and Irene Vogel for sharing with us their insights into Italian syllable structure.

[17] This example is due to Susan Stucky. See Stucky (1976) for many other examples of this sort.

From (28) it follows that any (1,1) language may never introduce closed syllable via loan words, for to do so would be to increase the level of rime markedness from 1 to 2. Note that we have said nothing about syllable onsets in (28), however, it also follows that in (1,1) languages branching onsets will not be added to the syllabic inventory. This follows from our $m \leq n$ constraint defining possible syllabic systems. If, say, Lingala added syllable initial clusters the resulting system would be (2,1) (branching onsets, non-branching rimes) which is of course excluded in our model.

(28) does provide one situation where loan words may increase the syllable inventory of a language, viz., in just those cases where $m < n$. Since the constraint (28) is limited to rimes only, onsets may be increased in markedness due to loan words and this just in those cases where the language has a « marge de manoeuvre », i.e. where the onset markedness may be increased without going beyond the limit of the markedness of the rime. Examples from two, (1,2) languages, Quechua and Finnish, show just such a state of affairs. Both these languages allow for the influx of loan words with branching onsets. As a result post-contact Quechua and modern Finnish may now be classed as (2,2) languages. Quechua has incorporated a large number of Spanish loan words containing syllable initial Stop-Liquid clusters, e.g. *prisirinti* Sp, presidente 'president', *prufisur* Sp. profesor 'teacher', *triwul* Sp. trébol 'clover'.

Similarly Finnish had a syllable structure of the same type as Quechua and once again this structure has been modified by loan words entering the lexicon in a manner exactly parallel to the Quechua case. The following loan words illustrate this situation: *presidentti* 'president' *profiili* 'profile', *kroketti* 'croquet' *krapu ~ rapu* 'Cancer (Tropic of)', *plakaatti* 'placard'. Some speakers may surpress the initial consonant but the norm seems to be to pronounce the entire cluster.

It should be obvious that this theory and the constraint (28) does not exhaust all the things that can be said about loan word nativization. Adaptation involving substantive constraints are not dealt with here. Such constraints are involved in the rendering of Greek loan words such as *pterodactyl, pneumatic, psychology*, etc. in English where the initial consonant is lost. In general it appears that substantive constraints are less powerful forces leading to nativization than the formal ones. Note, for example that in French, which started out

with substative constraints similar to those of English, the initial consonant of the above Greek words was not lost in their French version. Obviously much work remains to be done in the area of syllable structure and loan words. The above account seems a promising line of research.

**9.** In this paper we have sketched a preliminary version of a theory of syllable markedness.

Given certain key notions such as the non-cumulative nature of syllable markedness, the primacy of rimes, and a marking convention sensitive to syllable structure which approaches maximal simplicity, we can account for a wide variety of facts. Evidently, there are many problems to be resolved. In particular, the status of null elements in complex symbols is an area that needs work. The exact role of stress, morphological boundaries and initial and final syllables in parsing procedures needs to be worked out. The « patching together » of words from stems and affixes, the possibly structure preserving nature of syllable changing rules and the problem of representation of morphemes which are ill-formed syllabically are directions we intend to pursue in future research. We believe that we have opened up an interesting source of future investigation: one that should lead to a marriage of the theory of segmental markedness along the lines of Kean's contribution to this volume, and a theory of syllable markedness. It may also be the case that certain types of syllable behaviour including directionality of parsing techniques may be related to the type of metrical structure allowed for in the work of Halle and Vergnaud. 78

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