

tic (cf. section 3). We suspect, however, that more examples will be found once we look for them. If this turns out to be the case we must be able to say not only that a particular sequence of x 's belongs to a domain D_i but also that a particular (sequence of) autosegment(s) belongs to this same D_i , without there being any underlying connection between both sequences. The following figure visualizes the overall conception of phonological representation that such a state of affairs presupposes:

6

[illegible]

The strongest claim is that autosegments within each domain are associated with their P-bearing units according to the same universal association conventions.

As an alternative to this view it might be proposed that autosegments are assigned to the nodes in the phonological hierarchy and that the autosegments *percolate* to the x slots. This is in fact the view of Hart (1981) who defends a version of the autosegmental theory that shares a number of properties with the present proposal. There are, however, several reasons for rejecting such an approach. First, it will be impossible, given the percolation device, to manipulate the connections between autosegments and P-bearing segments in the way that is familiar (and motivated) in many autosegmental studies. Secondly, it is unclear how opaque segments could be handled, and thirdly, it is equally unclear how the parts of whole melodies (e.g. tonal melodies) can percolate to the right P-bearing elements.

The model adopted here allows for the possibility that a given feature is represented as an autosegment at various levels simultaneously. We do not know at present to what extent this must be restricted. Hart adduces one example (concerning nasalization in Parintintin) in which a feature is present at three levels: the segmental level, the syllable level and the word level. We think that the data are not conclusive in this case and we therefore hypothesize that a given feature can occur at no more than *two*

3. THE SYLLABLE AS THE RELEVANT DOMAIN: EMPHASIS IN ARABIC

In all Arabic dialects whole syllables can be characterized by the presence or absence of a phonetic property referred to as *emphasis*, involving the secondary articulations of velarization or pharyngealization. In most dialects the presence of emphasis is conditioned by the presence of a particular emphatic consonant in the syllable. If one such consonant is present all segments in the same syllable are emphatic.

The following triggering segments, which Broselow (1979) terms *independent emphatics* occur in all major dialects: *T, D, S, Z, L, R* (and, although the sound is used rarely, *q*). "Furthermore, most of these dialects exhibit additional contrasting pairs, especially in the labial series" (Lehn 1963, 31). Next to the emphatic set there is a set of non-emphatic (plain) consonants, including the six plain consonants corresponding to the emphatic series above. For this phenomenon of emphasis the following treatment will be proposed.

Independent emphatics have a phonological representation consisting of two tiers. On one tier we find the 'feature' emphasis (or whatever set of features is necessary to characterize the corresponding phonetic property) and on the other tier we find all other features. The so-called true pharyngeals $\hat{h}$ and ζ are "inherently" emphatic, i.e. they are associated with [+E] at the segmental level and not at the syllable level. This then means that the true pharyngeals are formally *neutral* segments.

Using capitals to symbolize independent emphatics we get the following underlying representations (the examples, involving (near) minimal pairs, are taken from Lehn 1963, 32-3):

(7)				
	+	+	+	+
	—	—	—	—
	Rab	Tiin	Raakil	
	'lord'	'mad'	'man'	
	rab	tiin	raakib	
	'it sprouted'	'figs'	'passenger'	

+			
bukRa	'tomorrow'	fikra	'idea'
+			
RaaʕiD	(military rank)	raaʕiD	'sleeper'

To get the correct surface forms the autosegment [+E] must be spread to all other segments present in the syllable. This fact must be stipulated in the grammar by fixing the five parameters as follows:

(8) *Emphasis in Arabic*

- the set of P-bearing segments: all segments
- the set of P-segments: [+E]
- the set of neutral segments: *h*, *ʕ*
- the set of opaque segments: $\emptyset$
- the domain of association: the syllable

The result is as follows

- (9) a. $\begin{array}{c} + \\ | \\ \text{A} \\ \text{(Rab)}_{\sigma} \end{array}$ b. $\begin{array}{c} + \\ | \\ \text{A} \\ \text{(Tiin)}_{\sigma} \end{array}$ c. $\begin{array}{c} + \\ | \\ \text{A} \\ \text{(Raa)}_{\sigma} \end{array}$ d. $\begin{array}{c} + \\ | \\ \text{A} \\ \text{(buk)}_{\sigma} \end{array}$ e. $\begin{array}{c} + \\ | \\ \text{A} \\ \text{(Raa)}_{\sigma} \end{array}$ f. $\begin{array}{c} + \\ | \\ \text{A} \\ \text{(ʕiD)}_{\sigma} \end{array}$

Segments that are not associated with an autosegment will surface as non-emphatic, due to a redundancy rule. This move embodies a deviation from standard autosegmental phonology, but one that is convincingly motivated in Halle & Vergnaud (1982). The alternative analysis would involve assigning an autosegment [-E] to one of the consonants that constitute non-emphatic syllables. The choice of a particular consonant would be arbitrary, however. Avoiding such arbitrariness we could also assign [-E] to all consonants that do not belong to the set of independent emphatics. Such a move forces us to adopt one of the following rules:

- (10) a. [-E] $\rightarrow \emptyset$ / [+E]

or:

- (10) b. [-E] $\rightarrow$ [+E] / [+E]

The derivation would then involve two steps rather than one:

- (11) a. $\begin{array}{c} + \\ | \\ \text{A} \\ \text{(Rab)}_{\sigma} \end{array}$ $\rightarrow$ $\begin{array}{c} + \\ | \\ \text{A} \\ \text{(Rab)}_{\sigma} \end{array}$ b. $\begin{array}{c} + \\ | \\ \text{A} \\ \text{(Rab)}_{\sigma} \end{array}$ $\rightarrow$ $\begin{array}{c} + \\ | \\ \text{A} \\ \text{(Rab)}_{\sigma} \end{array}$

It seems to us that rules like (10a) or (10b) duplicate the effect of the universal association conventions and we therefore prefer to make use of the 'unmarked' feature value approach. Note, however, that we deviate here from Halle & Vergnaud in one respect. We cannot assume that all segments are segmentally specified with the unmarked feature value, since we have utilized segmental specification for the characterization of neutral segments. We therefore assume that segments not belonging to the set of independent emphatics are *unspecified* at the segmental level. Unmarked values are assigned by rule at the end of the derivation.

Lehn (1963) claims that there are dialects of Arabic in which the opposition emphatic versus non-emphatic has been extended to all consonant types. Given this type of situation it is arbitrary to assign the autosegment [+E] to any one of the consonants that constitute an emphatic syllable. It would be more straightforward to assign the autosegment to the syllable, without any underlying association line. Our model allows for such representations, as we have demonstrated in section 2, and it therefore predicts the possibility of the dialect difference that seems to be involved here.

We conclude that the above analysis represents a clear case of syllable domain association (cf. Selkirk 1980, 577).

4. THE FOOT AS THE RELEVANT DOMAIN: NASALIZATION IN APPLE-CROSS GAELIC

In Applecross Gaelic primary stress is assigned to the initial syllable of all except a few root morphemes. Affixes or clitic elements never receive primary stress. Compare the following examples:

- (12) a. /k^hən^yɪ/ 'meeting'
 /äjət/ 'angel'
 /má.r + iə/ 'mothers'
 /ʔa+éçk^yən^y/ 'seeing him'
 /k^ho+vīa.t/ 'how much'
 /k^hat^hriənə/ 'Catherine'

The type (12a) examples, which include as we have indicated the vast majority of monomorphemic words, and also their inflected forms, can be seen as constituting a single foot, i.e.:

- (13) a.  b.  c. 

Foot trees are left-branching in other words. The forms under (12b), which comprise for the most part prefixations and precliticizations, but also a very few monomorphemic words, appear as follows:

- (14) a.  b.  c. 

Pre-stress syllables are considered as extrametrical; they are joined as weak sisters to the feet in the word tree.

The occurrence of nasalization in Applescross Gaelic is subject to the following conditions (Ternes 1973):

- (15) a. "the centre of nasal assimilation lies in the vocalic nucleus of the stressed syllable of a stem . . . From the centre, nasalization extends in a forward and backward direction unless or until checked by one of the conditions below".
 b. "in the backward direction, nasalization comprises the consonantal onset of the stressed syllable, but never extends beyond". It is this restriction that is to be explained by the fact that nasal assimilation is *foot*-bound.
 c. "in the forward direction, nasalization extends as far as the end of the word, including suffixes . . ." All syllables following the stressed syllable will be included in the same foot as the stressed syllable.

- d. "nasality does not extend beyond stops" (in either direction).
 e. "the vowel phonemes /e, o, ə/ never function as the centre of nasalization. They are never nasalized, whether stressed or unstressed, nor does nasality extend beyond one of these phonemes".

Examples of nasalization are:

- (16) a. *Complete nasalization*
 /jēnɛ.vər/ → [jēnɛ.vāf] 'grandmother'
 /frīa.v/ → [frīā.ṽ] 'root'
 b. *Nasalization blocked by stop to the left*
 /t^hrīf ar/ → [t^hrīf̃i.jār] 'plate'
 /strāi.ɣ/ → [strīāi.ɣ̃] 'string'
 c. *Nasalization blocked by a stop to right*
 /sNān^yd^yan/ → [sNān^yd^yan] 'thread'
 /k^hōispaxk/ → [k^hōi^hspaxk] 'wasp'
 d. *Nasalization blocked by e/o/a*
 /šauLəxkən^y/ → [šāuLəxkən^y] 'to compare'
 /mā.riçən/ → [mā.ri^hçən] 'mothers'
 e. *Nasalization blocked by margin of foot*
 /k^ho + vīa.t/ → [k^ho + vīā.t] 'how much'

It is important to note that nasals themselves have nothing to do with nasalization synchronically. Compare the following contrast:

- (17) mūxk 'pig' – mur 'sea'
 mā.har 'mother' – māra.v 'dead person'

Hence we will assume that nasal consonants are associated with [+N] at the segmental level but not at the autosegmental level. Stops and high mid vowels will have an autosegment [-N] associated with them in the lexicon: this is the way in which *opaque* segments are characterized (cf. Clements & Sezer, this volume). The predictability of this will be captured in terms of redundancy rules.

All root morphemes can be lexically classified as [+N] or [-N]:

- (18) a. + – b. – c. – – + –
 | | | |
 mūxk mur k^hat^hriənə
 d. – e. – + – – f. +
 | | | |
 māra.v k^hōispaxk mā.har

The rule of nasalization can now be formulated as follows:

(19) *Nasalization in Applecros Gaelic*

- a. the set of P-bearing segments: all sonorants
- b. the set of P-segments: [+N], [-N]
- c. the set of neutral segments: nasal consonants
- d. the set of opaque segments: obstruents, e, o, ə
- e. the domain of association: the stress foot

The following examples show the result of the rule:

- (20) a. $\begin{array}{ccccccc} + & - & - & + & - & - & + \\ \text{N} & \text{N} & \text{N} & \text{N} & \text{N} & \text{N} & \text{N} \\ \text{(muxk)}_F & & \text{(k}^h\text{a)}_O & \text{(t}^h\text{rianə)}_F & & \text{(k}^h\text{ə ispaxk)}_F & \end{array}$
- d. $\begin{array}{c} + \\ \text{N} \\ \text{(ma.har)}_F \end{array}$

A technical problem must be dealt with here. The free autosegment must be so located that it can be associated with the mainstressed vowel, without violating the condition that lines may not cross.

For example in (18e) the floating [+N] must be placed 'above' the first vowel /ə/ and not above the /a/. However, if stress is predictable (as it in fact is in most cases), the information where to place the floating segment is not available in the lexicon. To solve this problem we suggest that lexical items are classified in terms of a *morphological feature* [±N]. After stress has been assigned a rule will introduce the appropriate autosegment at the appropriate place. It is important to note that it would be insufficient for such a rule to introduce the autosegment in the domain of the strongest (or unique) foot (as a floating autosegment) for such a foot may contain an opaque segment. In that type of situation the floating autosegment must be linearly ordered before or after the opaque segment, depending on the position of the stressed vowel with respect to the opaque segment. In other words, the rule would have to introduce the autosegment so that the stressed vowel is 'accessible' to it. It appears to be more straightforward then to assume that the rule simply says: associate the appropriate autosegment with the stressed vowel. The difference between the two possibilities is not insignificant for the following reason.

Once the autosegment has been introduced certain P-bearing segments are in the scope of two autosegments, which results in an ambiguity with respect to their association:

- (21) a. $\begin{array}{ccccccc} + & - & + & - & + & - & + \\ \text{N} & \text{N} & \text{N} & \text{N} & \text{N} & \text{N} & \text{N} \\ \text{muxk} & & \text{muxk} & & \text{muxk} & & \text{muxk} \end{array}$

Since only (21b) satisfies the actual form, we want to be able to rule out (21c) on principled grounds. Given (21a) as our point of departure we can assume (22) (as has been suggested in the autosegmental literature):

(22) *Precedence Convention I*

The spreading of a free autosegment takes precedence over the spreading of a bound autosegment.

(22) will not be any use, however, if we take (23) to be the representation that feeds the association conventions:

- (23) $\begin{array}{c} + \\ \text{N} \\ \text{muxk} \end{array}$

It will not be any help to say that in addition to (or in place of) (22) there is a second convention (as has also been suggested):

(24) *Precedence Convention II*

Rightward spreading takes precedence over leftward spreading

Though this will give the correct result in the case of (23) it will produce the wrong form in the case of (25):

- (25) $\begin{array}{c} - \\ \text{N} \\ \text{h}^h\text{at}^h\text{ə} \end{array}$

The /r/ must come out nasalized, and (24) would result in an oral sound.

The conclusion seems to be that we must prefer the first possibility, i.e. a rule that introduces the appropriate autosegment at the right spot, but without an association line. We will accept this conclusion for the moment, but return to the issue in section 5, where we will be confronted with the same problem in our analysis of nasalization in Guarani.

Let us note two other aspects of our analysis that deserve mention. Firstly, we could assume that nonnasal morphemes are simply unmarked and that they will surface with the unmarked value for the feature nasal, i.e. [-nasal]. This is, after all, the kind of approach we choose in the case of emphasis in Arabic (see section 3). It is indeed true that this is possible,

but it should be noted that this would not lead to any simplification in the analysis as far as the rule component is concerned. We will leave this issue undecided here.

Secondly, we could follow Halle & Vergnaud (1981) and say that opaque (i.e. lexically bound) segments are not subject to spreading. This would solve our ambiguity problem, without making use of any precedence convention whatsoever. We think, however, that it is incorrect to say that opaque segments need never spread. It will be shown that in the case of Guarani opaque segments do spread, and we also refer to Clements & Sezer this volume. We will come back to this issue in section 6.

5. THE STRESS GROUP AS THE RELEVANT DOMAIN: NASALIZATION IN GUARANI

The facts of nasalization in Guaraní have been analyzed by various authors both in metrical terms (Sportiche 1977; Vergnaud & Halle 1978) and in autosegmental terms (Goldsmith 1975; Hart 1981; Poser 1981, this volume). Standard segmental treatments have been offered as well in Lunt (1973), Rivas (1974). We will analyze the facts in autosegmental terms. At the appropriate points we will compare our analysis with other autosegmental treatments (especially that of Poser 1981, this volume).

The basic facts of nasalization in Guaraní, as reported in Gregores and Suárez (1967), are as follows. Each utterance can be partitioned into oral and nasal spans, which typically comprise several segments. Nasal spans consist of contiguous strings of sonorants, possibly interrupted by (voiceless) obstruents, which "remain unaffected by the opposition nasal versus nonnasal" (G&S, 67). Except for a few cases each nasal span contains either a nasal consonant ([m], [n] or [ɲ]) or a stressed nasalized vowel. Oral spans on the other hand always contain a stressed oral vowel.

Confining ourselves to monomorphemic utterances for the moment let us consider the following examples:

- (26)
- | | | |
|----|---|---------------|
| a. | [tupá] | 'god' |
| | [pū ^h ū ^h á] | 'navel' |
| | [mā ^h rō] | 'never' |
| c. | [mé ^h nā] | 'husband' |
| | [k ^w im ^b a ^h é] | 'man', 'male' |
| d. | [kū ^h mā ^d nā] | 'bean' |
- b. [tupá] 'bed'
[puru^há] 'to be pregnant'

Within the autosegmental framework we could assume underlying representations as in (27):

- (27)
- | | | | | | |
|------|---------------------|--|---------------------|-----|-------|
| a. | + + | + + | b. | - - | - - |
| tupa | puru [?] a | tupa | puru [?] a | | |
| c. | + + | + + | d. | + - | + + - |
| Máro | MeNa | k ^w iMa [?] e kuMaNa | | | |

The surface forms result from application of the general association convention supplemented by one language-particular rule to derive the prenasalized consonants (cf. the postalization rule in Goldsmith 1975):

- (28)
- (29)

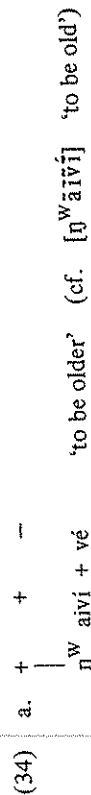
Obstruents are not affected by the nasality flow. They are specified as [-nasal] at the segmental level; they are thus *neutral*. Nasal consonants on the other hand are lexically bound to an autosegment; they are *opaque*.

We have to assume precedence convention I (see (22)): association with floating autosegments takes precedence over association with bound ones, as we have already seen in the case of Gaelic. It is, moreover, quite clear that opaque segments (i.e. nasals) *must* spread. Finally, one must note that the present approach toward the prenasalized consonants presupposes that both [+N] and [-N] are taken as autosegments.

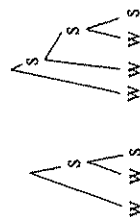
The rule of nasalization can now be formulated as follows:

- Nasalization in Guarani*
- (30)
- the set of P-bearing segments: all segments
 - the set of P-segments: $[-N]$, $[+N]$
 - the set of neutral segments: obstruents
 - the set of opaque segments: nasals
 - the domain of association: ?

Before we turn our attention to the domain specification we must first discuss one other aspect of the analysis proposed so far.

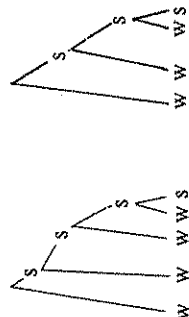


c.



se+tupá ore+tupá (cf. 33a)

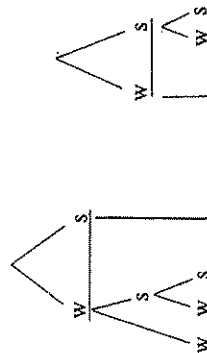
d.



(cf. 33 c. d)

ro+yo+pitivó te+re+puká

e.



w a i v +vé máro+vé (cf. 34a, 36)

Comparing the metrical structure of *máro* (in 37b) and *márové* (in 37e) one will see that the post-stress 'stray' syllable in *máro* becomes part of the second foot in *márové*.

If we now say that the domain of association in Guaraní is the foot, our spell-out rule can introduce *floating* autosegments into the appropriate foot domain (as in Applectross Gaelic). The ambiguity that we noted in (34) can no longer arise since the two floating autosegments will always belong to *different* feet. We also explain *why* the orality or nasality of the suffix only spreads into the stem if it has penultimate stress, as can be seen by examining the forms in (37e). All remaining cases where an ambiguity exists involve at most *one* floating autosegment. This means that we can appeal to precedence convention (22) for those cases. Of course we will also have cases in which two bound autosegments are involved (cf. 27d). It is not clear whether leftward or rightward precedence applies here since both will give the same result. Since rightward precedence is independently motivated on the basis of other languages and leftward

precedence is not, it is clear that we can dispense with the latter. This leads to the interesting result that we do not require to assume (as Poser does) that the precedence convention is parametrized.

We conclude that nasalization in Applectross Gaelic and Guaraní can be handled in the same terms *if* we assume that harmony in the latter language is not bound to the word domain, but to a smaller metrical domain, so far assumed to be the metrical foot. Let us now look somewhat more closely at the precise characterization of this metrical domain.

In our analysis it is the case that word final, post-stress syllables fall outside the scope of any foot; they are stray syllables that are adjoined in the word tree as weak sisters to the preceding foot. It turns out, however, that the sonorants in those post-stress syllables receive the same value for nasality as the sonorants belonging to the preceding foot. The domain of spreading is apparently the foot *plus* any following stray syllables. Let us call this constituent (following Gregores & Suárez) the *stress group*.

It is important to note the following. We claim that nasalization in Guaraní is bound to the *stress group* and we therefore put forward our analysis as an example showing the relevance of both metrical and autosegmental phonology for the treatment of harmony. Unlike the examples in the previous sections, however, association in Guaraní is not bound to one of the familiar metrical domains (such as syllable, foot etc.). The crucial point is that the span over which nasality spreads must be defined in terms of metrical structure: a stress group comprises of all syllables that are minimally governed by a stressed syllable.

Let us finally remark that our analysis arrives at the same interpretation of the domain of spreading as that of Gregores & Suárez. They say: "By delimiting the nasal spans in this way, their boundaries coincide with – and confirm – those of the stress groups delimited at the previous level". (p. 68). 'Stress groups' are defined as follows: "each stressed syllable in a macrosegment belongs in the same constitute with all the immediately preceding unstressed syllables, and – if it is the last stressed syllable in the macrosegment – with the following one (or more, up to three) syllables. A stressed syllable flanked by other stressed syllables stands, of course, alone. We may call each of these structural units a *stress group*; in it, the stressed syllable must be interpreted as the nucleus, and the unstressed syllables, in coordinate construction with each other, as the satellite". (p. 65).

6. PRECEDENCE CONVENTIONS, OPAQUE SEGMENTS AND LANGUAGE-SPECIFIC RULES

Our study of nasalization in Applectross Gaelic and Guaraní has affirmed

the claim (already extensively discussed in Goldsmith 1976) that the general association convention must be supplemented by general precedence conventions, since cases arise in which P-bearing segments are in the scope of more than one P-segment. We have made use of Precedence Convention 1, repeated here for convenience:

(22) *Precedence Convention 1*

The spreading of a free autosegment takes precedence over the spreading of a bound autosegment

In this section we will discuss some of the alternative approaches for dealing with the precedence facts. We will furthermore address a claim advanced by Halle & Vergnaud (1981), which involves a more radical version of (22):

(38) spreading conventions only apply to free autosegments

We will show that this claim cannot be upheld, referring to our analysis of Guarani, where opaque elements are spread due to the general association convention. In addition we will give an analysis of nasalization in two other languages (Capanahua and Sundanese) in which we make use of language-specific association rules that stipulate *unidirectional* spreading of opaque elements.

We found that (22) leads to the right result provided that nasalization in the two languages is bound to the foot and the stress group respectively. The possibility of generalizing over the two cases of nasalization does not crucially depend, however, on our decision to introduce *floating* autosegments. Earlier we expressed the opinion that it seemed more straightforward to associate such autosegments directly with the stressed vowels, not in the least because the spell-out rule that introduces floating segments must also locate the stressed vowel to guarantee accessibility. Suppose then that we select the more direct formulation of the spell-out rule, how could we in that case explain the precedence relations in the two cases. We suggest that then the following precedence convention is needed:

(39) *Precedence Convention IV*

The spreading of metrically stronger autosegments takes precedence over the spreading of metrically weaker autosegments

(39) predicts that the spreading of the autosegment that is associated with the stressed vowel takes precedence and this is precisely what happens in both Gaelic and Guarani. It is important to note that an

analysis that makes use of this convention still requires that nasalization in Guarani be bound to the stress group.

The alternative treatment of nasalization in Applescross Gaelic and Guarani shows that the interaction between autosegmental and metrical phonology is even more intricate than we have suggested thus far. We think, however, that a larger number of cases is required before we can decide whether (39) is really a principle of universal grammar. Assuming that (22) is independently motivated (for example by the analysis of tonal systems) we therefore favour the floating analysis at this point. Let us now address (38).

Halle & Vergnaud (1981) claim that harmony processes 'fall into two distinct types depending on whether the harmonic features propagate in one direction only, or whether the propagation occurs in both directions' (H&V, 1). They propose handling bidirectional harmony in autosegmental terms and unidirectional harmony in metrical terms. Apart from the directionality there is another difference between the two types of harmony systems. In bidirectional harmony systems 'a distinction is made between triggering and opaque elements. The general association convention only applies to the triggering element which must always be a floating autosegment. Opaque elements, i.e. autosegments that are lexically associated with a P-bearing unit are not subject to spreading. "No such distinction is made in the case of directional harmony: all triggering elements are opaque, and each opaque element induces a harmony of its own" (H&V, 9).

We do not agree with the distinction that H&V make. Take for example the case of Guarani. We have seen that opaque elements (the nasals) are subject to spreading. This would imply that the harmony is metrical in the framework of H&V. However, spreading in Guarani is bidirectional (see the forms in 29c & d where nasality spreads in both directions). Our analysis, moreover, makes use of floating autosegments, which would imply that the harmony is autosegmental. But this would be incompatible with the fact that opaque elements are subject to spreading.

If we conclude for this (and other) reason(s) that all harmony should be analyzed autosegmentally, it can no longer be upheld that opaque elements are not subject to spreading. It may be true though that there is a difference between opaque elements and floating elements in the sense that only the opaque elements may be referred to by language-specific association rules, whereas floating autosegments cannot.

Suppose language-specific rules can prescribe three kinds of behaviour for opaque elements: spread leftward, spread rightward or don't spread at all. In the absence of any language-specific rule the general association convention will guarantee that an opaque element spread in both directions. Let us furthermore assume that the general association convention

applies after the language-specific spreading rules (this follows from the Elsewhere Condition). We will now give two examples where a theory along these lines seems to be required to handle cases of nasalization in other languages than Applectross Gaelic and Guarani.

Our first example concerns nasal spreading in Capanahua. It is also discussed in H&V and in Anderson, this volume. In the descriptive source (Loos 1969) the following facts are reported.

A contiguous sequence of vowels and glides (*w*, *y*, *ɿ*, *ɿ*) is nasalized if it precedes a nasal consonant (*n*, *m*). Nasal consonants, however, are deleted before a continuant strident consonant, glide, liquid or word boundary. If a nasal is deleted the nasalization on the preceding vowels and glides remains, but, and this is the surprising feature, vowels and glides that stand after the deleted nasal are also nasalized. Consider the following example:

- (40)
- | | | | |
|----|------------------|--------------------|---------------|
| a. | /poyan/ | 'arm' | [pōyā] |
| | /bawin/ | 'catfish' | [bāwī] |
| | /ciʔin/ | 'by fire' | [ciʔī] |
| | /boon/ | 'hair' | [bōō] |
| b. | /waran/ | 'squash' | [warā] |
| | /ciponki/ | 'downriver' | [cipōnki] |
| c. | /bimi/ | 'fruit' | [bīmi] |
| | /banawi/ | 'plant it' | [banawi] |
| d. | /wiranwī/ | 'push it' | [wīrāwī] |
| | /wīranyāsaʔnwʔi/ | 'push it sometime' | [wīrāyāsāʔwī] |

The forms in (40a) show the non-local character of nasal spreading and the effect of nasal deletion before a word boundary. The forms in (40b) show the blocking character of consonants (i.e. *r* and *p* in this case). The forms in (40c) show spreading to the left. Finally, the forms under (40d) show the bidirectional nature of spreading following nasal deletion before a glide. We propose the following analysis.

All consonants are autosegmentally specified as [+N] or [-N] at the word level. There is a language-specific rule that prescribes the leftward spreading of [+N] and, ordered before this, a rule that deletes nasals before glides and word boundary, setting the [+N] autosegment afloat. We explain, given this analysis, why spreading is bidirectional after nasal deletion has applied: the language-specific spreading rule cannot apply to a floating autosegment (its SD is simply not met). Thereafter the general association convention takes over, leading to bidirectional spreading. In (41) we give some sample derivations:

- (41)
- | | | | | | | | | | | | | | | | | | | | |
|---------------|---|--------------|---------|--------------|---------|---|---|--|--|--|--|---------|---------|---------------|---------|--------------|---------|--------------|---------|
| a. | <table border="0"> <tr> <td>-</td> <td>+</td> <td>-</td> <td>+</td> <td>-</td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> <tr> <td>poyan</td> <td>n-del.</td> <td>poya</td> <td>spread.</td> <td>poya</td> </tr> </table> | - | + | - | + | - | | | | | | poyan | n-del. | poya | spread. | poya | | | |
| - | + | - | + | - | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| poyan | n-del. | poya | spread. | poya | | | | | | | | | | | | | | | |
| b. | <table border="0"> <tr> <td>-</td> <td>-</td> <td>+</td> <td>-</td> <td>-</td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> <tr> <td>ciponki</td> <td>spread.</td> <td>ciponki</td> <td>spread.</td> <td>ciponki</td> </tr> </table> | - | - | + | - | - | | | | | | ciponki | spread. | ciponki | spread. | ciponki | | | |
| - | - | + | - | - | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| ciponki | spread. | ciponki | spread. | ciponki | | | | | | | | | | | | | | | |
| c. | <table border="0"> <tr> <td>-</td> <td>+</td> <td>-</td> <td>+</td> <td>-</td> <td>+</td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> <tr> <td>wīranyāsaʔnwī</td> <td>n-del.</td> <td>wīranyāsaʔwī</td> <td>spread.</td> <td>wīranyāsaʔwī</td> <td>spread.</td> </tr> </table> | - | + | - | + | - | + | | | | | | | wīranyāsaʔnwī | n-del. | wīranyāsaʔwī | spread. | wīranyāsaʔwī | spread. |
| - | + | - | + | - | + | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| wīranyāsaʔnwī | n-del. | wīranyāsaʔwī | spread. | wīranyāsaʔwī | spread. | | | | | | | | | | | | | | |

The leftward spreading rule could also be an alpha-rule. The facts of Capanahua are not conclusive in this respect. Note in any case that the “-” value may be allowed to spread bidirectionally due to the general conventions.

The present analysis makes crucial use of a rule that stipulates leftward spreading (cf. Anderson, this volume). Let us now look at a case where we require rightward spreading: nasalization in Sundanese. Nasalization in Sundanese is discussed in Anderson (1972) in segmental terms. Hart (1981) gives an autosegmental analysis, that differs from the one we are going to propose. The descriptive source is Robins (1957) who reports the following facts.

A string of contiguous vowels, possibly interrupted by *h* or *ʔ*, is nasalized if a nasal consonant (*m*, *n*, *ɳ* or *ŋ*) precedes. The following examples serve as an illustration of this rightward nasal spreading:

- (42)
- | | | | |
|----|----------|------------|----------|
| a. | /ɳiər/ | 'to seek' | [ɳiār] |
| | /ɳaiən/ | 'to wet' | [ɳaiān] |
| b. | /māro/ | 'to halve' | [māro] |
| | /moekʔn/ | 'to dry' | [mōekʔn] |
| c. | /ɳaho/ | 'to know' | [ɳāhō] |
| | /bʔɳhār/ | 'to be' | [bʔɳhār] |

The forms in (42a) show the non-local character of spreading, those in (42b) the blocking character of supraglottally articulated consonants. The forms in (42c) show both the transparency of /*h*/ and (in the second form) the fact that spreading is not leftward. The analysis we propose is as follows.

All supraglottally articulated consonants are autosegmentally specified as [-N] or [+N] at the word level. There is a language-specific rule that prescribes the rightward spreading of [+N]. It is easy to see that this will give the desired result:

cf. *ɳiər*

660 b 2
shows
direction

- (43) a. $\begin{array}{c} + \\ | \\ \text{jaian} \end{array} \rightarrow \begin{array}{c} + \\ | \\ \text{jaian} \end{array}$
- b. $\begin{array}{c} + \\ | \\ \text{moekyn} \end{array} \rightarrow \begin{array}{c} + \\ | \\ \text{moekyn} \end{array}$
- c. $\begin{array}{c} + \\ | \\ \text{jaho} \end{array} \rightarrow \begin{array}{c} + \\ | \\ \text{jaho} \end{array}$

As in the case of Capanahua we will assume the spreading of [-N] is due to the universal spreading convention. Vowels that remain unassociated will be assigned the unmarked value, i.e. [-nasal]. There is, however, one seemingly complicating factor in the case of Sundanese that relates to the occurrence of infixes.

Robins (1957) mentions three infixes, one without a nasal (-ar-), and two containing a nasal (-im-, -in-). Both categories are extremely interesting for their own reasons. We will first look at forms of the first category (we have italicized the infix):

- (44) /*narai*an/ (cf. 42a) [naraian]
 /*maroek*yn/ (cf. 42b) [maroekyn]
 /*jarah*o/ (cf. 42c) [jaraho]

The surprising fact about the forms in (44) is that the vowels following the *r* of the infix are nasalized except for the first one. This is odd for two reasons. First we have seen that *r* blocks spreading (cf. the form in 42b) and secondly, even if the *r* of the infix were specified as neutral, why should the vowel immediately following it be nonnasal?

The explanation of these two facts leads us to assume that the rightward spreading rule applies cyclically and that there is a second rule that spreads [-N] to a tautosyllabic vowel. We cannot collapse this second rule with the rule that spreads [+N] precisely because this latter is not bound to the syllable domain but to the word domain. This shows that the word domain rule cannot be an alpha-rule, since this would result in denasalizing all vowels following the /r/ of the infix. We obtain the following derivations:

- (41) a. *1e cycle*
- $\begin{array}{c} + \\ | \\ \text{moekyn} \end{array} \rightarrow \begin{array}{c} + \\ | \\ \text{moekyn} \end{array} \xrightarrow{[-N]\text{-spread.}} \begin{array}{c} + \\ | \\ \text{moekyn} \end{array} \rightarrow \begin{array}{c} + \\ | \\ \text{moekyn} \end{array}$
- nasal*

- b. *2e cycle*
- $\begin{array}{c} + \\ | \\ \text{maroekyn} \end{array} \rightarrow \begin{array}{c} + \\ | \\ \text{maroekyn} \end{array} \xrightarrow{[-N]\text{-spread.}} \begin{array}{c} + \\ | \\ \text{maroekyn} \end{array} \rightarrow \begin{array}{c} + \\ | \\ \text{maroekyn} \end{array}$

The spreading rules are not crucially ordered. Applying them in the reverse order, or simultaneously will lead to the same result. The fact that at least [+N] spreading *must* be cyclically ordered also follows if we look at the second category of infixes, i.e. those containing a nasal:

- (42) a. gade 'to be big' [gade] → gumade [gumade]
 dyhys 'to approach' [dyhys] → dumyhyrs [dumyhyrs]
 b. pangih 'to find' [pangih] → pinapangih [pinapangih]

These forms illustrate that the vowels following the nasal of the infix must be nasalized. At first sight one might propose that this is due to the local rule (formulated as an alpha-rule). The second form in (42a) shows, however, that this cannot be true: nasal spreading after the nasal of the infix extends here over two syllables. This must be due then to the word domain rule (Anderson 1972 points out the significance of the crucial form in 42a).

We think that the two analyses given above clearly show the need for language-specific rules that stipulate the direction of spreading of opaque, i.e. lexically bound autosegments. This is an interesting conclusion given the claim advanced in Halle & Vergnaud that opaque elements do not spread. We have not given a crucial example showing the need to stipulate that an opaque element *must* not spread. The facts of Capanahua were seen to be inconclusive on this point. A possible example might be found in Mongolian vowel harmony (as discussed in Chinchor 1979), Chinchor argues that high round vowels block rounding harmony (coming from the left), but all vowels after the round blockers are themselves nonround. This example requires further study, however, so we will not discuss it in any detail here.

7. CONCLUDING REMARKS

We have addressed ourselves to two topics that relate to the spreading of autosegments. Firstly, we have shown that various prosodic categories constitute domains for such spreading, either as the result of general or language-specific association rules. It is of some importance to note that, though we have employed the metrical theory of phonological domains, nothing in our analyses depends crucially on the fact that phono-

logical domains have a binary branching structure in this theory, rather than an n-ary branching structure as suggested in Clements & Keyser (1981) and Leben (1982). Our findings are compatible with either approach to domain characterization.

Secondly, we have discussed the behaviour of opaque segments. We found that such elements are subject to spreading, either as a result of general or of language-specific rules.

The second part is somewhat more speculative than the first, but we hope that on the whole some progress has been made here towards the proper formal treatment of suprasegmental processes, in particular of those involving nasalization.

The Syllable

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English provides a particularly good illustration of the proposition that the syllable is a linguistically significant unit which must have its place in phonological theory. The reasons generally given in support of the syllable as a theoretical construct are threefold, and English provides pertinent evidence in each of these areas. First of all, it can be argued that the most general and explanatory statement of phonotactic constraints in a language can be made only by reference to the syllabic structure of an utterance. Second, it can be argued that only via the syllable can one give the proper characterization of the domain of application of a wide range of rules of segmental phonology. And third, it can be argued that an adequate treatment of suprasegmental phenomena such as stress and tone requires that segments be grouped into units which are the size of the syllable. The same three reasons leading to the postulation of the syllable can be shown to motivate the existence of privileged groupings of segments within the syllable which must be thought of as constituent-like linguistic units themselves.¹ The notion of the syllable that will emerge from this examination of English is therefore one of a hierarchical unit; an internally structured tree quite analogous to a tree representing syntactic structure.

1. THE REPRESENTATION OF THE SYLLABLE

1.1 In what follows, special attention will be given to the question of the representation of the syllable and especially to the hypothesis that the syllable is an element of a hierarchically organized prosodic struc-

*This article was written in 1978, and has been circulated informally since then. It was intended that it should form part of my book *Phonology and Syntax: The Relation between Sound and Structure*, forthcoming from MIT Press. I have decided to publish it separately now, unrevised, for it will not now fit in the book. My views on the nature of syllable structure have changed somewhat since 1978, as have the views of other scholars, but I feel that there is enough of value in the present piece to merit its publication at this time.