The Role of Metrical Structure in Segmental Rules

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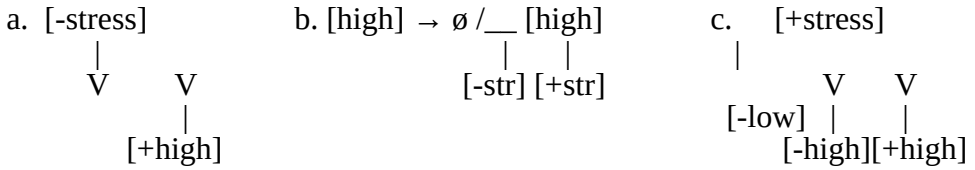
1. Introduction

Current practice in formulating stress-conditioned segmental rules, exemplified in (2), implicitly does not restrict reference to metrical structure. We will call this the 'free reference' hypothesis:

(1) The free reference hypothesis: all aspects of metrical structure may be referred to in all parts of a rule.

(2)



after: Vago (1988) McCarthy (1984) Calabrese (1986)

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When we consider assimilation rules, the free reference theory predicts that prominence conditions can be specified on the trigger and the target of the rule independently, thus leading us to expect a wide range of rules of the form exemplified in (2). The processes formulated there are assimilation of an unstressed vowel to a following vowel (2a), delinking of [high] from an unstressed vowel in the presence of a stressed high vowel (2b), and assimilation of a stressed vowel to a following vowel (2c). The full range of configurations of stress conditions predicted by the free reference hypothesis, allowing only for a binary stress distinction, is summarized in (3). If more levels of stress are distinguished (e.g. primary, secondary, unstressed) then the number of configurations increases rapidly.

(3)

Condition on trigger	Condition on target
+stress	+stress
+stress	-stress
+stress	none
-stress	+stress
-stress	-stress
-stress	none
none	+stress
none	-stress

Each rule configuration corresponds to a predicted pattern of assimilation, in which a feature spreads from a syllable that satisfies the condition on the trigger to syllables which satisfy the condition on the target. In fact the range of stress-influenced assimilation patterns is very restricted. As we shall see, there are only three, and only two are drawn from the set of patterns predicted by the free reference hypothesis. One of the major claims of this paper is that all the attested patterns can be analyzed without direct reference to stress. The next section presents the typology of stress-influenced assimilation, together with analyses of each type, showing that in each case, the process can be analyzed without reference to stress, as assimilation within the metrical foot.

2. Stress-conditioned assimilation

Attested instances of stress-influenced assimilation fall descriptively into the three patterns summarized in (4).

(4)
Pattern 1: A feature spreads from a stressed syllable to a sequence of unstressed syllables.

C V C V C V C V
|
[αF]

Pattern 2: A feature spreads from an unstressed syllable up to the stressed syllable.

C V C V C V C V
|
[αF]

Pattern 3: A combination of (i) and (ii).

C V C V C V or C V C V C V

[αF] [αF]

When metrical structure is considered we see that all of these patterns can be analyzed without reference to stress as autosegmental spreading within the metrical foot:

(5)
Pattern 1: [C V C V]φ [C V C V]φ
|
[αF]

Pattern 2: C V [C V C V C V]φ
|
[αF]

Pattern 3: C V [C V C V]φ or C V [C V C V]φ

[αF] [αF]

Thus the claim argued for in this section is that assimilation is never stress conditioned. The patterns described are analyzed as resulting from spreading of a feature [F] subject to a domain limitation of the type shown in (7). This constraint blocks spreading of [F] across a foot-boundary, so, given the assimilation rule (6), it will associate to all compatible segments within a foot.

(6) Assimilation: spread [F]

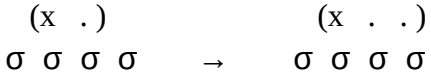
(7) [F] cannot associate to more than one position unless the positions are in the same foot.

2.1 Assumptions concerning foot structure

Before we turn to the example analyses, it is necessary to make some assumptions concerning foot-structure explicit. The metrical theory assumed here is standard in most respects, but we will make two crucial assumptions:

i. Stray syllables are adjoined to feet where possible, and
ii. The head of a foot is always at one edge of the foot.

Together these assumptions imply that stray syllables are adjoined to a foot as long as headedness is preserved. Thus in the configuration shown in (8), the final syllable is adjoined to the foot, but the initial syllable remains unfooted (Cf. Gussenhoven (forthcoming)).

(8)


2.1 Pattern 1: Nasal harmony in Guaraní

Pattern 1 is exemplified by Guaraní nasal harmony. In this pattern, a feature, in this case nasality, spreads leftwards from a stressed nasal vowel up to the next stressed vowel. Voiceless segments are reported not to be nasalized but do not block harmony (9) (all data are from Gregores and Suárez 1967).

(9)

tupá	/ tupá /	'bed'
tupa!	/ tupa!$ /	'god'
xaIxupIŸra⁄	/ xaIxupIŸra$⁄ /	

Unstressed syllables in an oral span following a stressed nasal vowel can be weakly nasalized, even across a word boundary. This is probably the result of coarticulation rather than phonological spreading (cf. Cohn 1990).

In outline, the analysis is that [nasal] spreads within the foot (cf. van der Hulst and Smith 1982). To justify this account, we must provide an analysis of the foot structure. The stress facts are as follows: Roots in Guaraní are generally stressed on the last syllable, otherwise on the penultimate syllable:

(10)

pI⁄pe	'within'
pIpe!	'broad'

When stressed morphemes are concatenated, the rightmost receives primary stress:

(11)

IvI⁄	'earth, ground'
ku/i⁄	'bits, shreds'
IvIŸku/i⁄	'sand'

Antepenultimate stress can result from the affixation of apparently stressless suffixes:

(12) /a!pe 'here'
/a!pevo'(moving) close to the speaker, toward here'

The basic pattern of morpheme-final stress can be analyzed as resulting from the construction of a right headed, unbounded foot on the right edge of the morpheme. Exceptional penultimate stress results from lexical marking of the final syllable as extra-metrical. After concatenation of morphemes, extrametrical syllables which are no longer peripheral are adjoined to the following foot (i.e. next to a weak syllable), in accordance with assumptions stated in section 2.1. The foot then consists of a stressed syllable and all unstressed syllables to its left, which is precisely the domain of harmony. Nasal harmony can then be analyzed as spreading nasal within the foot:

(13) Nasal harmony: spread [+nasal].

(14) Domain condition: [+nasal] cannot associate to more than one position unless they are in the same foot.

Spread onto voiceless segments is blocked by the cooccurrence condition in (15).

(15) *[+nasal, -voice]

According to this account, spread onto a stressed oral vowel is blocked by the foot boundary to the right of the vowel, thus no reference to stress is required. The apparent influence of stress is accounted for in terms of foot-bounding.

(16) [xaIxupIŸ}φ{ra!]φ
|
[nasal]

Other examples of pattern 1 assimilation are Eastern Cheremis harmony (Hayes 1979) and Southern Paiute voicing assimilation (Sapir 1930, Flemming 1993).

2.2 Pattern 2: Vowel harmony in Tudanca Spanish

In pattern 2, a feature spreads from an unstressed syllable up to a stressed syllable. This pattern is a priori unexpected in that a stressed syllable assimilates to a weaker unstressed syllable, but when we consider foot structure, we see that it is equivalent to pattern 1. In both cases assimilation is foot-bounded, the difference lies in whether the feature being spread originates in a stressed or unstressed syllable.

Pattern 2 is exemplified by Tudanca laxing harmony (Penny 1978). The surface vowel inventory of Tudanca is shown in (17).

(17)

	[+tense]		[-tense]	
[+high]	i	u	I	U
[-high] e	o	E	O	[-low]
	a		A	[+low]

Underlyingly high final vowels are lax, and laxness spreads up to the stressed vowel:

(18) Penultimate stress:

pÍntU	'male calf'	pínta	'female calf'
c&ÍkU	'boy'	c&íka	'girl'
sÉkU	'dry' (masc.)	séka	'dry' (fem.)'

(19) Antepenultimate stress:

antigwÍsImU	'very old'	rakÍtIkU	'rachitic'
orÉgAnU	'oregano'	kÁrAbU	'tawny owl'
pÓrtIkU	'portico'	pÚlpItU	'pulpit'

The domain of harmony is thus the stressed syllable together with any following unstressed syllables. Analysis of the stress pattern indicates that this is a foot.

As in standard Spanish, stress is penultimate or antepenultimate. Following Harris (1983), we can analyze this pattern as involving construction of a binary left-headed foot at the right edge of the word to yoield regular penultimate stress. Exceptional antepenultimate stress results from lexical extra-metricality of a final syllable. Assuming stray syllable adjunction as outlined in section 2.1, the foot consists of the stressed syllable plus any following unstressed syllables.

We can then analyze laxing harmony as spreading of [-tense] within the foot, following Hualde 1989. A sample derivation is shown in (22). Again, the crucial point is that no reference to stress is required in this analysis.

(20) Laxing harmony: Spread [-tense]

(21) Domain condition: [-tense] cannot associate to more than one position unless they are in the same foot.

(22)

anti[gwisi]φ<mu>	→	anti[gwisimu]φ	
|		|	
[-tense]		[-tense]	

Other examples of pattern 2 are Romance metaphony (Rohlfs 1949, Leonard 1978) and Old High German umlaut (Ellis 1953).

2.3 Pattern 3: Round harmony in Palestinian Arabic

Pattern 3, exemplified by Palestinian Arabic (PA) rounding harmony (Abu Salim 1987), is a combination of patterns 1 and 2. It is of considerable

significance here because not only is it not necessary to refer to stress in its analysis, but an account in terms of direct reference to stress is not possible.

THE ROLE OF METRICAL STRUCTURE IN SEGMENTAL RULES

The basic data (avoiding complications due to cyclicity) are shown in (23). Assimilation may be progressive or regressive. Progressive assimilation is observed in the spread of [round] onto epenthetic vowels, which are indicated by underlining in (23b).

(23) a. Regressive assimilation:

yí-fham	'he understands'	yú-drus	'he studies'
tí-lbis	'she wears'	tú-ktub	'she writes'

b. Progressive assimilation: (underlined vowels are epenthetic)

/ákil	'food'	fúrun	'oven'
òísir	'bridge'	?úrus	'wedding'

Abu-Salim (1987) pointed out the role of metrical structure in explaining some cases in which rounding harmony is blocked. With verbs having biconsonantal roots, the indicative prefix *bi-* fails to undergo harmony when adjacent to [u], although in other contexts this prefix harmonizes regularly:

(24)

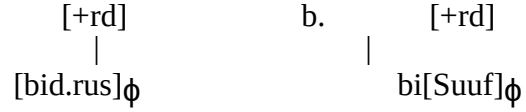
a. Harmony applies:		b. Harmony does not apply:	
bú-drus	'he studies'	bi-Súuf	'he sees'
bú-ktub	'to write (3sg.m.)'	bi-rúuÌ	'he goes'

The generalization here is that harmony does not apply to a pre-tonic vowel. The stressed prefixes in (a) undergo harmony, but the pretonic syllables in (b) do not. Stress placement differs in these forms due to the difference in the weight of the stems: those in (a) are heavy syllables, whle those in (b) are super-heavy (cf. Hayes in press). Feet are left headed in PA (Hayes in press), so we can account for the incidence of harmony in prefixes by restricting multiple association of [+round] to the metrical foot (25). The pre-tonic suffixes do not fall in the same foot as the stem [u], so harmony does not apply (27b). Rightward spread is trivially foot-bound because the foot extends to the edge of the word[1].

(25) Domain condition: [+round] cannot associate to more than one position unless they are in the same foot.

(26) Rounding harmony: spread [+round]

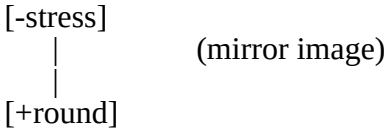
(27)



[1]This picture is complicated somewhat by the fact that suffixes do not undergo harmony, and that stress assignment in PA is cyclic (Brame 1974), leading to violations of the above generalizations at the word level. Thus a full analysis will require additional elements, however the basic dependence of rounding harmony on stress placement exemplified and analyzed here is unaffected by these complications.

No reference to stress is required in the analysis of this pattern. Furthermore, the pattern cannot be analyzed in terms of direct reference to stress. To account for the failure of pretonic vowels to harmonize in terms of stress

conditions on the trigger and target of the assimilation rule, we would need a rule like (28).

(28)


This rule will not spread [round] from a stressed vowel, and thus accounts for the failure of pretonic vowels to harmonize. But the harmony is bidirectional, as shown in (23), while this rule incorrectly predicts that rightward spread from a stressed vowel should not be possible either.

In conclusion, all three attested patterns of apparently stress-conditioned assimilation can be analyzed without reference to stress, in terms of foot-bounding, supporting the claim that stress does not condition assimilation. In the next section we will consider some phenomena which, judging from previous analyses, are problematic for this claim, and present evidence that they are not in fact counter-examples.

2.4 Potential counter-examples

2.4.1 Vowel harmony in Pasiego

The first case is Pasiego Spanish height harmony (Penny 1969a). Pasiego has the surface vowel inventory shown in (29).

(29)

	[+tense]		[-tense]	
[+high]	i	u	I	U
[-high] e	o		O	[-low]
	a		A	[+low]

Vowels in a word agree in height, with the exception of vowels in final unstressed syllables, which are not subject to harmony:

(30)	[+high]		[-high]
kumíd-a	‘lunch’	sosprés-a	‘surprise’
lubúk-us	‘young wolves’	belórt-a	‘hay-rake’
kUntÍnt-U	‘happy (count)’	Qók-us	‘a type of wooden footwear’
mInÚd-U	‘small (count)’		

/a/ can appear with high or mid vowels:

(31)	[+high]		[-high]
arín-a	‘flour’	kalór	‘heat’
trAnkÍl-u	‘quiet (count)’	AtOlOsÁ-U	‘hunchback’

This height harmony gives rise to alternations, exemplified here from verb paradigms:

(32)	‘drink’ ‘take’	‘feel’
inf.	beb-ér	kox-ér sint-ír
1sg. fut.	beb-eré	sint-iré
1pl. fut.		kox-erémus
1pl.pr.ind.	beb-émus	sent-émus
2pl.pr.ind.	bib-í:s	kux-í:s sint-ís
imp. ind.	bib-ía	sint-íu
1pl.pr.subj.	beb-ámus	kox-ámus
2pl.pr.subj		kox-áis sint-áis

Penny (1969b) concluded from these data that the height of the vowels in a word is determined by the height of the stressed vowel. Thus, for example, the stem of ‘drink’ is *beb* in forms with stressed *é*, but *bib* in forms with stressed *í* . McCarthy (1984) and Vago (1988) formulate this analysis in autosegmental terms using essentially the rules shown in (2) above.

Thus this process has been analyzed as sensitive to stress, yet obviously cannot be spreading within the metrical foot, because [high] spreads throughout the word. However, there is clear evidence against this stress-based analysis, showing that the stressed vowel does not govern harmony.

The first observation to make is that low and mid stressed vowels do not condition harmony. As shown in (33), a high stem does not lower to harmonize with a stressed mid suffix (barring two exceptions):

(33) Stressed mid vowels:

batid-ér-a	‘hoe’	lind-ér-a	‘hillside’
libr-ét-a	‘notebook’	inQim-ér-a	‘wall-stones’
urmigad-ér-a	‘itching’	batid-ór-a	‘hoe’
bibid-ór-a	‘principal house’	iskarpid-ór	‘comb’
istir-ón	‘thin person’	pisar-ós-us	‘penitent (pl.)’
marmux-ón	‘stammerer’	fug-ón	‘hearth’

As seen above, low vowels are neutral, and thus do not condition harmony:

(34) Stressed low vowels:

akolodrá-u	‘long and thin (udder)’	indux-áse	‘to enter the hive’
xorobá-u	‘hunch-backed’	urmigál	‘ant-heap’
intint-ár	‘to mark (sheep with ink)’	sinur-jár	‘to address as *usted*’

However, even when the stressed vowel is disharmonic with the stem, the vowels of the stem harmonize with each other, that is stems never contain a mixture of high and mid vowels. This fact is treated as coincidental in previous analyses.

(35) unattested forms:

*akoludrá-u	*ormigad-ér-a
*intent-ár	*bebid-ór-a

Thus Pasiego height harmony cannot be characterized as involving spread of [high] from a stressed vowel because harmony is operative even when the stressed vowel is disharmonic. An alternative analysis is presented in Flemming (1993), according to which the apparent effects of stress result from the fact that stress typically falls on a suffix, and high suffixes condition raising of stems. In any case, the key point is that stress is not relevant to the height harmony, so it is not a counterexample to the claim that stress does not condition assimilation.

2.4.2 Chamorro umlaut

Foot structure in Chamorro is clearly trochaic (Chung 1983) yet there is a rightward rule of vowel assimilation that is described by Topping (1968) and Chung (1983) as targetting stressed syllables.

Umlaut fronts vowels following certain particles containing front vowels:

(36)

nA⁄nA	'mother'	i nœ⁄nA	'the mother'
kA⁄ttœ	'letter'	ni kœ⁄ttœ	'the letter (obl.)'
hu⁄Nuk	'to hear'	inhi⁄Nuk	'we (excl.) heard'

Chung (1983)

If this process is assimilatory and it only targets stressed vowels, it is problematic for the current hypothesis. Any effects of stress cannot be analyzed as being due to foot-bounding because the assimilation applies across a foot boundary (37):

(37)

```
          x   .
    i [ n a . n A]φ
      |     |
[-back][+back]
```

However, data collected from a speaker of Chamorro cast doubt on the relevance of stress to umlaut, showing that umlaut can in fact apply to vowels in unstressed syllables:

(38)

a. Umlaut applies to an unstressed vowel:

tAsA!hus	'dried meat'	i tœsA!hus	'the dried meat'
kutsi !nu	'dirty person'	i kitsi !nu	'the dirty person'
kule!pblA	'snake'	i kile!pblA	'the snake'

b. Umlaut fails to apply to an unstressed vowel:

pulónnun	'trigger fish'	i pùlulónˆA	'his trigger fish'
mundóNgu	'cow's stomach'	i mùnduNgónˆA	'its stomach'

Furthermore, evidence from Costenoble (1940) shows that umlaut is synchronically morphological. Costenoble indicates that umlaut is triggered only by certain morphemes, and is subject to different restrictions with each. More importantly, umlaut can apply in the absence of any preceding front vowel in certain possessive constructions:

(39)

a. lu!gA ‘wall’ mA!∂og ligA!ˆA i gi !mA/ ‘the wall of the house hole wall (poss.) the house has a hole’

cf. mA!∂og i ligA!n i gi !mA/ (as above)

b. u!lu ‘head’ i!lun-gwi!hAn ini ‘they are fish-heads’
head(poss.)-fish this

cf. i i!lun i gwi!hAn ini (as above)

Thus it appears that umlaut is a process which fronts the first vowel of lexically marked words in certain morphological contexts. It is not synchronically phonologically conditioned. Since it does not involve assimilation, it does not bear on the claim that stress never conditions assimilation.

2.5 Summary

To summarize our findings so far:

1. Assimilation is never conditioned by stress. Allowing for this possibility predicts a wide range of unattested patterns of stress-conditioned assimilation.

2. The attested patterns of assimilation which appear to be influenced by stress can be analyzed in terms of autosegmental spreading bounded by a metrical foot.

3. The pattern of assimilation found in Palestinian Arabic cannot be given a straightforward analysis in terms of direct reference to stress

3. The role of stress in segmental phonology

Although stress does not condition assimilation (or dissimilation) there clearly are stress-conditioned segmental processes, e.g. vowel reduction. Thus any explanation for the absence of stress-conditioned assimilation must not rule out stress-conditioned segmental rules entirely.

The hypothesis advanced here is that stress affects segmental material only via conditions on the distribution of featural contrasts. That is, attested stress conditioned processes essentially involve the distribution of contrasts, being processes of neutralization of vowel and consonant contrasts or deletion. Examples are outlined in (40).

(40)
English vowel reduction: Vowels are reduced to schwa in unstressed syllables.
Italian vowel reduction: /e/ and /E/ are neutalized to [e] and /o/ and /O/ are neutralized to [o] in non-primary stressed syllables (Nespor and Vogel 1986:130).
Bernera Gaelic aspiration: Aspirated and unaspirated voiceless stops contrast in stressed syllables only (Børgstrom 1940:134).
Maltese Arabic Syncope: Unstressed vowels in non-final syllables are deleted (Brame 1972)

The generalization that emerges from consideration of these types of process is that stress conditions the distribution of contrasts, with a greater number of contrasts being permitted in stressed syllables. Thus reduction rules neutralize contrasts in unstressed syllables, and deletion eliminates all contrasts in a position.

This hypothesis concerning the role of stress can be reformulated in terms of licensing (Steriade 1993, cf. Goldsmith 1990):

(41)
Stress only affects segmental material through licensing conditions of the following form:

[F] must be licensed by membership in the head syllable of a foot/word.

Unlicensed features are automatically delinked, giving rise to alternations.

For example, the licensing conditions for English and Italian vowel distribution can be formulated as in (42):

(42)
a. Licensing of vowels in English:
The place features of a vowel must be licensed by association to a mora in the head syllable of a foot.
b. Licensing of [-tense] in Italian:
[-tense] must be licensed by association to a mora in the head syllable of a word.

Reduction follows from these distributional constraints because unlicensed features are delinked, as shown in the outline derivations below (43). In English, all vowel place feature contrasts must be licensed by association to a mora in a (primary or secondary) stressed syllable. Thus all vowel features are delinked from an unstressed vowel, yielding the placeless vowel, schwa. In Italian, only the feature [-tense] must be licensed by primary stress, and thus delinks in all other syllables to be replaced by default [+tense]. Deletion would result from statements requiring vowels to be licensed.

(43)

English: 'method'	Italian: tòstatóre	'toaster'
mE!QAd	to~stato!re	
	| |	
	[-tns] [+tns]	
		delinking of unlicensed features
mE!Q´d	to~stato!re	
	|	
	[+tns]	
		default rules
-	to~stato!re	
	| |	
	[+tns] [+tns]	

The licensing hypothesis predicts the lack of stress conditioned assimilation: licensing conditions can only induce delinking of unlicensed features, they cannot induce feature spreading. However, the hypothesis is sufficiently permissive to allow for attested stress-conditioned processes.

4. Conclusions: the role of metrical structure in segmental rules.

In this paper, I have argued for three primary conclusions:

(1) Prominence relations play no roles in assimilation processes. The attested patterns of stress-influenced assimilation can be analyzed without direct reference to stress.

(2) Metrical constituent structure can condition assimilation. The metrical foot can provide a domain of association. The primary function of prosodic structure lies in providing bounding domains for processes (Nespor and Vogel 1986, Hayes 1989). This conclusion thus follows naturally from regarding the metrical foot as a prosodic constituent on a par with the phonological word or phrase.

(3) The role of prominence with respect to segmental material is in conditioning the distribution of contrasts. Thus the form of a sound may depend on its prominence, but its interactions with other segments (assimilation, dissimilation) are not influenced in this way.

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