Studies in African Linguistics
Volume 17, Number 2, August 1986

UNDERSPECIFICATION AND LOW VOWEL HARMONY IN OKPẸ*

Douglas Pulleyblank
University of Southern California

This paper examines the effect of [ATR] vowel harmony on low vowels in Okpẹ, an Ẹdoid language of Nigeria. The relevant facts can be summarized as follows: Low vowel stems condition [-ATR] forms on affixes. Low vowel affixes surface as [+low] in [-ATR] contexts and as [-low] when in [+ATR] contexts. Of particular interest is the additional fact that an underlyingly low vowel surfaces as [-low], [-*ATR*] in certain [+ATR] environments. To explain these alternations, it will be argued that low vowels are underlyingly unspecified for vocalic features. Redundancy rules, supplied for the most part by Universal Grammar, interact with the vowel harmony system and rules of syllabification to derive the non-low variants of underlyingly low vowels. By positing underspecified forms, it will be shown that no ad hoc rules need to be stipulated.

1. Introduction

The set of vowels that are active in vowel harmony alternations often constitutes only a subset of the complete set of vowels found in a particular language. For example, in Akan [Clements 1981], the vowels affected by [ATR][1] harmony are the non-low vowels; in Yoruba [Awobuluyi 1967, Bamgbose

---

*Many thanks to Diana Archangeli, Morris Halle, Mike Hammond, K.P. Mohanan, Russ Schuh, and Moira Yip for comments on an earlier draft. A version of this paper was presented at the 16th Conference on African Linguistics at Yale University in 1985.

[1]The feature [ATR] refers to "advanced tongue root" or "expanded pharynx". For a discussion of the phonetic parameters of this feature, see Lindau [1979]; for an illustrative example of the phonological use of the feature, see Clements [1981].

1967], the vowels affected by [ATR] harmony are the non-low, non-high vowels (that is, mid). Okpẹ, an Ẹdoid language of Nigeria, is particularly interesting in this regard. Phonetically, only non-low vowels appear in [+ATR]/[-ATR] pairs. Phonologically, however, there is evidence to show that low vowels do indeed participate in the system of vowel harmony. Specifically, the [-ATR] vowel [a] has a [+ATR] variant [e] in certain environments (as in the prefix of (1b)), and a [+ATR] variant [ẹ][2] in others (such as in the suffix of (1b)):

(1) a. [-ATR] stem: /a+sụ+a/ → [á !swá] 'we (inclusive) are singing'
    b. [+ATR] stem: /a+ru+a/ → [é !rwẹ́] 'we (inclusive) are doing'

The latter fact is particularly surprising since [ẹ] is a [-ATR] vowel. That is, a situation is created in an example like (1b) where a [-ATR] vowel patterns as the [+ATR] counterpart of a phonologically low vowel.

There are two basic approaches to be taken for this type of problem. On the one hand, one could assume that such facts simply represent an odd idiosyncracy of Okpẹ. Under such an approach, one would simply formulate two ad hoc rules whose specific functions would be to change an [a] into an [e] and an [a] into an [ẹ]. Alternatively, one could look for an explanation of the low vowel behaviour by examining the interaction of well-motivated language-particular rules of Okpẹ with general principles of Universal Grammar, attempting to avoid positing any special ad hoc rules specifically formulated to describe changes such as those observed above.

In this paper, I provide an account of the low vowel behaviour of Okpẹ that adopts the second strategy, with two sets of assumptions being crucial: (1) The theory of underspecification is adopted, and it is argued that low vowels are underlyingly unspecified for vocalic features in Okpẹ. The derivation of the particular phonetic form of such an underspecified vowel involves the interaction of a number of factors including the assignment of syllable

---

[2]Orthographic conventions used in this paper include the following: ẹ = [ɛ], ọ = [ɔ], ị = [ɩ], ụ = [ʊ], ˜ = Nasalization, ´ = H-tone, ` = L-tone and ! preceding a syllable = Downstep on that syllable.

structure and specifications of vowel harmony. (2) I assume a process of resyllabification for certain cases that violate syllabic constraints of Okpẹ. Crucially, such resyllabification involves two stages: (i) deletion of existing syllabic structure and (ii) reapplication of the regular rules of syllabification. These assumptions account for the structure-preserving nature of Okpẹ resyllabification, that is, for the fact that the syllable types created by resyllabification are the same as those created by the initial application of the regular rules.

It seems improbable that a theory of phonology should allow rules as unlikely as one which supplies a [-ATR] vowel as the [+ATR] counterpart for a low vowel. The fact that this paper accounts for such a surface alternation without requiring the positing of such an odd rule is interpreted as support for the basic assumptions that make such a result possible.

2. Harmony in Okpẹ: The Problem[3]

With respect to non-low vowels, Okpẹ has a straightforward system of root-controlled dominant [ATR] harmony. Stems belong to either the [+ATR] or the [-ATR] class, while affixes are generally unspecified for the feature [ATR], receiving their [ATR] specifications from the stem. For example, the infinitive prefix [e/ẹ] appears with its [+ATR] variant [e] in combination with a [+ATR] stem, as in (2), while it appears with its [-ATR] variant [ẹ] in combination with a [-ATR] stem, as in (3):

(2) a.	/i/	tí	'pull!'	ètyó	'to pull'
b.	/e/	sé	'fall!'	èsé	'to fall'

[3]In this paper, I sidestep the interesting rule of phonetic neutralization that merges [ị] with [e] and [ụ] with [o]. Such neutralization has been discussed by Hoffmann [1973] and the reader is referred to that paper. Note, however, that in a preliminary acoustic study of Okpẹ and the closely related language Uvwiẹ [Omamor 1973] there is some indication of a phonetic distinction between even the [+high, -ATR] and [-high, +ATR] pairs (the pairs that undergo neutralization), the distinction being more apparent in Uvwiẹ. Whatever the precise phonetic facts are, I abstract away from this issue here. This means that "surface" forms in this paper are one step away (at least) from phonetic reality.

	c.	/o/	só	'steal!'	èsó	'to steal'
	d.	/u/	rú	'do!'	èrwó	'to do, make'
(3)	a.	/ị/	rị́	'eat!'	ẹ̀ryọ́	'to eat'
	b.	/ẹ/	dẹ́	'buy!'	ẹ̀dẹ́	'to buy'
	c.	/ọ/	lọ́	'grind!'	ẹ̀lọ́	'to grind'
	d.	/ụ/	sụ́	'sing!'	ẹ̀swọ́	'to sing'

Note that in the above examples, a suffix [o/ọ] appears in addition to the prefix in all cases where the stem vowel is high (see section 4.4.1 below). As with the infinitive prefix, this suffix appears with its [+ATR] variant [o] if the stem belongs to the [+ATR] class and with its [-ATR] variant [ọ] if the stem belongs to the [-ATR] class.

Turning to the harmonic behaviour of the low vowel [a], the first observation to be made is that stems with the vowel [a] condition [-ATR] harmony:

(4)	a.	/a/	dá	'drink!'	ẹ̀dá	'to drink'
	b.	/ã/	dã́	'fly!'	ẹ̀dã́	'to fly'

In examples such as the above, where the absence of the infinitive suffix is accounted for by the non-high nature of the stem vowel, it is impossible for the [+ATR] variant of the infinitive prefix to appear: *[èdá], *[èdã́]. In a related manner, phonetic low vowels in prefixes cooccur only with [-ATR] stems, as in the example à dárị́ 'we (inclusive) drank'. When such a prefix occurs with a [+ATR] stem, it appears on the surface as [e], as in the following example: è tírí 'we (inclusive) pulled'. Hence we observe that the [+ATR] variant of [a] in prefixes is [e]. Note moreover that the vowel in such a case must be underlyingly low and not mid. The distinction between the pairs [e/ẹ] and [e/a] is neutralized for the [+ATR] variants; the [-ATR] variants, which remain distinct, show the underlying contrast to involve a [-low]/[+low] distinction.

The pattern just described changes, however, when dealing with a V-initial low vowel suffix. When such a low vowel suffix appears with a [-ATR] stem, e.g. sụ 'sing', the suffix is [a], as expected (5a); but when a low vowel suffix combines with a [+ATR] stem, e.g. ru 'do', then the suffix is [ẹ] (5b):

(5) a. á !swá 'we (inclusive) are singing'

b. é !rwẹ́ 'we (inclusive) are doing'

The process of resyllabification that changes the stem vowels in these cases into [w] is discussed in section 4.4.1 below. What is crucial for the present is the harmonic behaviour of the suffix. In (5a), the suffix appears as [a] because the stem it attaches to is of the [-ATR] class; in (5b), on the other hand, the suffix surfaces as [ẹ] because the stem is of the [+ATR] class. The essential problem is therefore that such vowels surface as [a] in [-ATR] contexts, while in [+ATR] contexts, they surface as [e] in a *prefix* and as [ẹ] in a *suffix*.

3. Theoretical Background: Underspecification

To account for the harmonic behaviour of low vowels in Okpẹ, I adopt the framework of underspecification proposed in Pulleyblank [1983] and Archangeli [1984]. This framework adopts as a point of departure the requirement that all redundancy be eliminated from underlying representations (see, for example, Kiparsky [1982]). In particular, only non-redundant feature values may be included in underlying representations; predictable feature values are filled in by redundancy rules—rules that are of a highly constrained nature. A central claim of this theory is that most redundancy rules are not language-specific rules; they are either (a) provided by Universal Grammar (DEFAULT RULES) or (b) derived by a general principle of Universal Grammar (COMPLEMENT RULES). It is claimed that Default Rules and Complement Rules do not exhibit language-specific idiosyncracies, their properties being derived by principles of Universal Grammar.[4]

3.1. Default and Complement Rules.

Several aspects of this theory are important for the following discussion. First, it is proposed that Universal

[4]For detailed discussion of such redundancy rules, and for the motivation of the various properties of redundancy rules discussed below, the reader is referred to Pulleyblank [1983], Archangeli [1984], and Archangeli and Pulleyblank [in prep].

Grammar provides a context-free default rule for every distinctive feature [Kiparsky 1982, Pulleyblank 1983]; such default values may, however, be supplanted by language-specific "complement" values, themselves determined in large measure by principles of Universal Grammar [Archangeli 1984]. As a simple illustration, consider a feature such as [high]. Let us make the substantive assumption that Universal Grammar supplies the value [+high] as the default specification of [high] for vowels. That is, any vowel that does not receive the value [-high], either from an underlying assignment through morphological concatenation or via phonological rule application, is assigned the value [+high] by default. The immediate implication is that the specification [+high] will not appear in underlying representations, since such a specification would be entirely redundant.

A second point concerns the notion of complement rules. Assume that in a given language, one must posit the value of [+high] as an underlying specification, for example because it occurs as a "floating" feature or because phonological rules crucially refer to that value prior to the stage of complete specification. In such a case, a complement rule would be established, assigning [-high] as the redundant value for the language in question and making it impossible for the value [-high] to appear underlyingly in that language. Such a complement rule would take precedence over the default rule otherwise provided by Universal Grammar. Note that the distinction between default rules and complement rules is essentially the distinction between "unmarked" and "marked" redundant specification.

3.2. Default ordering principles. Two potentially contradictory assumptions have been made in the past about the stage in the derivation at which redundancy rules apply. On the one hand, there is presumably no language whose phonology exploits the full set of distinctive features made available by Universal Grammar. Consequently, when features are not used contrastively in a language's phonology, they are often assumed to be assigned only at the stage where a phonological string is phonetically interpreted. For example, a feature such as [suction] [Chomsky and Halle 1968], necessary to distinguish plosives from implosives, plays no role in the phonology of a language like English. It seems fairly safe to assume, therefore, that the value [-suction] is redundantly assigned to all segments in the phonetic component of English. In fact, this is more than simply a "safe" assumption; it is necessary in order to account for the fact that such a feature is not only absent from underlying specifications, but that in addition, it is never referred to by phonological rules. This would be entirely accidental if the feature value [-suction] were supplied early on in the phonology of English. That is, features used contrastively are more likely to be used by the phonological rules of a language. A principle is required, therefore, that orders redundancy rules (such as the one assigning [-suction] in English) as late as possible in the grammar of a language, assigning them to the phonetic component unless there is evidence for an earlier assignment.[5] Phrasing this constraint in terms of the morphological and syntactic strata (levels) of lexical phonology, Pulleyblank [1983] makes the following claim:

(6) Redundancy rules begin their application in the latest possible stratum.

This requirement might be thought to contradict a somewhat different assumption about how redundancy rules must operate. Many earlier approaches, although implicitly assuming (6), explicitly require that redundancy rules apply in a block before all other rules of a language's phonology. This requirement, adopted for example in Chomsky and Halle [1968], was largely in answer to problems raised by Lightner [1963] and Stanley [1967] concerning the possible inadvertent development of a ternary feature system. It is not within the scope of this paper to discuss such problems, but the reader is referred to Kiparsky [1982] and Pulleyblank [1983] for a demonstration that the problems raised by Stanley and Lightner do not arise in the type of approach being taken here. Moreover, Pulleyblank [1983] shows that tonal default rules may apply as late as the post-lexical and even phonetic components even in cases where the features concerned *do* play a role in a language's phonology.

[5]Halle and Mohanan [1985] propose a general principle that preferentially assigns all phonological rules to the latest stratum possible. The late ordering of redundancy rules can plausibly be seen as a special case of this more general constraint.

What can be retained from the hypothesis of early application appears to be the following [Pulleyblank 1983]:

(7) Redundancy rules apply as early as possible *within* their stratum.

Because redundancy rules can apply both before phonological rules (as a result of (7)) and after phonological rules (as a result of (6)), it becomes possible for them to interact in a number of interesting ways. It is precisely such an interaction that will be shown to account for the behaviour of low vowels in Okpẹ.

3.3. The Redundancy Rule Ordering Constraint. In line with the general strategy of disallowing language-specific stipulations from being imposed on redundancy rules, it is argued that the types of interactions possible between redundancy rules and phonological rules are of a highly restricted nature. For example, Pulleyblank [1983] proposes that default rules can never be ordered by extrinsic language-specific stipulations. Where such rules are interspersed with language-specific rules, the relevant orderings involved are determined entirely by general principles. Of importance to this paper are cases involving the interaction of (6) and (7), which I refer to collectively as the Default Ordering Principles, with an additional principle, the Redundancy Rule Ordering Constraint. The Redundancy Rule Ordering Constraint (adapted from Archangeli [1984]) is given in (8):

(8) Redundancy Rule Ordering Constraint: A redundancy rule assigning [αF], where "α" is "+" or "-", is automatically assigned to the first component in which there is a rule that refers to [αF] in its structural description.

A basic effect of the Redundancy Rule Ordering Constraint is to divide derivations involving any given feature into two stages: (a) an initial, underspecified stage where phonological rules can distinguish between non-redundant specifications and the absence of specification and (b) a subsequent, fully specified stage where phonological rules can distinguish between "+" and "-" specifications. The Redundancy Rule Ordering Constraint rules out a stage in the derivation where, for some feature F, it would be possible to refer to a lack of specification for F while also being able to refer to both "+" and "-" values of F. To illustrate, consider the interaction of a redundancy rule such as (9) below (assuming for the sake of concreteness that [-ATR] is the default value assigned by Universal Grammar for [ATR])[6] with a language-specific rule that refers to [-ATR] in its structural description. Although the clause of the Default Ordering Principles given in (6) would assign the [-ATR] default rule (9) as late as possible, the Redundancy Rule Ordering Constraint would force it to be assigned to any stratum on which a language-specific rule referring to [-ATR] applies.

(9) Default [-ATR] Insertion:[7] [ ] → [-ATR]

Relevant to this effect of the Redundancy Rule Ordering Constraint is the notion of lexical "identity rules". Kiparsky [1982] suggests that the Strict Cycle Condition [Mascaro 1976] can be derived from the Elsewhere Condition [Kiparsky 1982] provided that lexical entries be interpreted as identity rules. This proposal has an interesting effect on the application of redundancy rules. If some feature value [αF] appears in an underived lexical entry, then the effect of Kiparsky's proposal is to have the feature in question appear in an identity rule that applies minimally on the first lexical stratum; by the Redundancy Rule Ordering Constraint, this means that any redundancy rule assign-

---

[6]For a markedness proposal along these lines (although phrased in a rather different framework), see Kaye et al. [1985].

[7]Because the representation of [ATR] is autosegmental, the rule formulation in (55) is interpreted as follows (where (X) indicates a skeletal position unspecified for [ATR]):

(X) → X
|
[-ATR]

The autosegmental interpretation of such a rule is an automatic consequence of the representation itself (thereby allowing the representation in (9) in the text); there is therefore no reason to encode such autosegmental properties into the formulation of the rule. This formulation embodies the claim that the redundant specification of a feature that is autosegmentally represented must itself be autosegmental [Pulleyblank 1983, Archangeli and Pulleyblank, in prep].

ing [αF] must therefore begin its application on the first lexical stratum.

3.4. Repeated application. As a final point, it should be noted that once redundancy rules have begun to apply, they apply at all stages of a derivation, whenever they can [Pulleyblank 1983]. This is a necessary assumption if we are to prevent the possibility of phonological rules *deriving* a representation that includes slots unspecified for F in addition to other slots specified for "+" and "-" values of F (ternary power).

To summarize, the Default Ordering Principles assign redundancy rules to the latest possible stratum, but require that they begin application as early as possible on the stratum to which they are assigned, after which point their application is automatic. The basic ordering determined by the Default Ordering Principles is supplemented by the Redundancy Rule Ordering Constraint, which can force redundancy rules to apply earlier than otherwise determined by the Default Ordering Principles.

Let us now turn to a discussion of how the above principles apply to the analysis of Okpẹ.

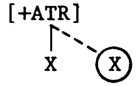
4. Analysis

4.1. [ATR] harmony. To begin with, I consider the lexical representation of the feature [ATR] and the basic account of [ATR] harmony. It is clear, of course, that there is an [ATR] contrast. Stems such as those in (2) above belong to the [+ATR] class while stems such as those in (3) belong to the [-ATR] class. In principle, the specified value could be either [+ATR] or [-ATR], with the unspecified value supplied by default. In fact, there is both language-internal and cross-linguistic evidence in favour of positing [+ATR] as the underlyingly specified value. For reasons of exposition, I postpone the presentation of such evidence until section 4.2.1 and proceed here with the analysis that follows from the decision to choose [+ATR] as the feature value represented underlyingly. The first implication is that the appropriate redundancy rule for [ATR] is as given in (9) above, that is, a rule assigning unspecified segments the value [-ATR].[8] [ATR] harmony is therefore the result

[8]I assume that (9) is in fact the default rule provided for the feature

of spreading an underlyingly present [+ATR] autosegment onto unspecified [ATR]-bearing units to its left or right. This can be formalized as follows:[9]

(10) [ATR] Harmony:



Conditions: 1. X = rime
2. mirror image

The first condition on (10), that the slots relevant to the rule must be rime slots, encodes the fact that ATR Harmony affects vowels, not consonants. Vowels are straightforwardly distinguished from consonants in Okpẹ because all syllables are open and only vowels occupy rime positions. Hence if some segment X is in a rime, then X is a vowel. Note that without information about syllable structure, the distinctive feature composition of a skeletal slot is insufficient to identify a slot as a vowel and therefore insufficient to determine whether the slot is an [ATR]-bearing unit. Vowels and their corresponding glides share general feature specifications as can be determined by the fact that vowels and glides alternate with each other in syllabically defined contexts (see below). The two segment types differ, however, in that vowels alone bear contrastive values for [ATR], that is, vowels alone are [ATR]-bearing units.

The second condition on [ATR] Harmony (10) serves to specify the bidirectional nature of [ATR] spreading in Okpẹ. That is, a [+ATR] autosegment

---

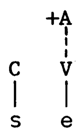
[ATR] by Universal Grammar (see also Kaye et al. [1985]). If this assumption is incorrect, however, the analysis presented here is completely compatible with (9) being interpreted as a complement rule introduced as a result of [+ATR] being the underlyingly assigned value for Okpẹ.

[9]As pointed out to me by Russ Schuh, it may well be the case that certain aspects of this rule do not need to be stipulated for Okpẹ, as they may constitute the unmarked case for harmony generally. For example, the bidirectional nature of harmony and the fact that harmony assigns [+ATR] to *rimes* might both be considered general properties of harmony systems. In addition, it is a common property of harmony rules that they be root-controlled, this point being captured not in the rule but in the underlying representations in the present analysis. But note that while these three properties are undoubtedly common, they are not required. For example, harmony is autosegmental and directional in Yoruba [Archangeli and Pulleyblank, in prep]; it involves more than just rime slots in Turkish [Clements and Sezer 1982]; it can be determined by affixes in Maasai [Levergood 1984].

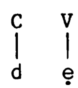
spreads to a free rime slot on either its right or left. Note that spreading is bidirectional but NOT automatic. It will be demonstrated below that spreading does not apply as the result of a general Well-Formedness Condition, as originally proposed by Goldsmith [1976], but applies in a rule-governed fashion at a particular point in the derivation. That is, the facts of harmony in Okpẹ are shown below to constitute an argument in favour of the version of the Association Conventions argued for in Pulleyblank [1982, 1983] in which autosegmental spreading is not governed by an automatic convention. One-to-one linking is the only automatic aspect of the conventions.

The rules of [ATR] Harmony (10) and Default [-ATR] Insertion (9) derive the basic harmonic properties of the [+ATR] and [-ATR] stem classes as follows: first, at the level of the stem, an underlyingly specified [+ATR] autosegment links to the stem vowel by left-to-right application of the autosegmental Association Conventions immediately after syllabification. In the following examples, èsé 'to fall' is representative of the [+ATR] class while ẹ̀dẹ́ 'to buy' is representative of the [-ATR] class; "+A" and "-A" are used in derivations to represent [+ATR] and [-ATR] respectively, and aspects of the phonological derivation other than those relating to harmony are ignored.

(11) a.



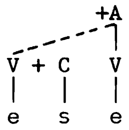
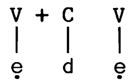
b.



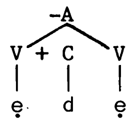
I analyze [ATR] Harmony in Okpẹ as applying on a non-cyclic stratum [Halle and Mohanan 1985] and assume, following Pulleyblank [in press], that rule application on a non-cyclic stratum consists of two phonological rule applications (the *Double Scan Hypothesis*), one at the level of the stem and a second after all affixation has taken place. Hence after affixation has taken place, syllabification and [ATR] Harmony apply to derive the following:[10]

---

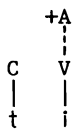
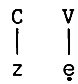
[10]Affixation in these examples would actually involve the addition of both a prefix and a suffix. The suffix, however, does not surface because of a process of vowel deletion that is discussed in section 4.4.1.

(12) a.  b. 

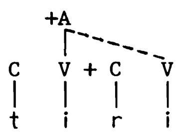
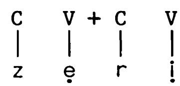
Application of Default [-ATR] Insertion in the [-ATR] case then completes the pair of derivations:

(13) b. 

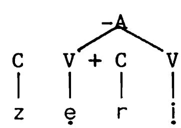
As two additional examples, consider the derivations of tírí 'pulled' and zẹ́rị́ 'ran', examples that illustrate stems of both harmonic classes in conjunction with a -CV suffix. In such examples, syllabification and the Association Conventions apply at the level of the stem:

(14) a.  b. 

After suffixation, syllabification and [ATR] Harmony (10) apply:

(15) a.  b. 

Finally, Default [-ATR] Insertion applies to assign the redundant specification [-ATR] to all unspecified vowels:

(16) b. 

4.2. <u>Feature representations</u>. Given the above outline of the paradigm cases of harmony, I now turn to a detailed consideration of the feature composition of Okpẹ vowels in order to explain the special properties of low vowels in harmonic contexts. In (17) below, I give the values of the features [back], [round], [high], [low], and [ATR] that are appropriate for fully specified (pre-neutralization) representations of the nine Okpẹ vowels:

(17) Fully specified feature values for vowels:

	i	ị	e	ẹ	a	ọ	o	ụ	u
BACK	-	-	-	-	+	+	+	+	+
ROUND	-	-	-	-	-	+	+	+	+
HIGH	+	+	-	-	-	-	-	+	+
LOW	-	-	-	-	+	-	-	-	-
ATR	+	-	+	-	-	-	+	-	+

Given the theory of underspecification sketched out in section 3 above, it is impossible to posit the representations given in (17) as underlying representations since they contain considerable redundancy. Redundant specifications must therefore be eliminated from such representations, to be filled in by redundancy rules (default rules and complement rules) at the appropriate point during the phonological derivation. To begin with, I assume the following context-free redundancy rules, where (18a, b, d) are default rules and (18c) is a complement rule:

(18) a. [ ] → [-back]
b. [ ] → [-round]
c. [ ] → [-high]
d. [ ] → [-ATR]

Eliminating such redundant specifications from the representations in (17) gives the following:

(19)

	i	ị	e	ẹ	a	ọ	o	ụ	u
BACK					+	+	+	+	+
ROUND						+	+	+	+
HIGH	+	+						+	+
LOW	-	-	-	-	+	-	-	-	-
ATR	+		+				+		+

The question of how to eliminate the redundancy in [low] specifications will be discussed shortly. Before addressing that question, however, I briefly motivate those aspects of the underspecified representation already given in (19).

4.2.1. [ATR]. Cross-linguistically, there is evidence to suggest that [+ATR] takes precedence over [-ATR]. For example, in Maasai [Levergood 1984], both stems and affixes may be dominant, in the sense that the ATR specification of a dominant morpheme prevails over the specification of a recessive morpheme. In such a case, it is the value [+ATR] that is associated with such dominant morphemes, with [-ATR] assigned only in cases having neither a [+ATR] stem nor a [+ATR] affix (that is, by default).[11]

With respect to Okpẹ, there are a couple of reasons other than cross-linguistic ones for positing [-ATR] as the redundant specification. First, this assumption allows the general redundancy rule assigning [-ATR] to apply to both low and non-low vowels; if [+ATR] were the redundant value, then a context-sensitive redundancy rule assigning [-ATR] to low vowels would have to be posited in addition to the general rule. The second reason has to do with the behaviour of mid and low vowels in [+ATR] harmonic contexts, behaviour that will be dealt with in detail in sections 4.3 and 4.4 below.

4.2.2. [back]/[round]. Two points are relevant here, namely which feature is selected for inclusion in underlying representations, and which value of that feature is selected. Examination of the feature specifications in either (17) or (19) shows that only one of the two features [back] and [round] is necessary to contrast the various vowels of Okpẹ, and in line with underspecification theory, only one value of the selected feature needs to be included underlyingly. I will first demonstrate below that the non-redundant value for [back] would have to be [+back], and the non-redundant value for [round] would have to be [+round]. Of these two, it will then be suggested in the section dealing with [low] (section 4.2.4) that the non-redundant feature for Okpẹ is [round].[12]

---

[11]See also Kaye et al. [1985] who propose [-ATR] as the unmarked value for [ATR] and develop a theory which (among other things) provides for the dominant nature of [+ATR] specifications.

[12]In adopting the proposal for the selection of [round] over [back], I incorporate certain suggestions made to me by Morris Halle and Moira Yip.

Consider examples such as the following, which involve suffixation of the past tense morpheme:

(20) a. tí-rí 'pulled'
b. sé-rí 'fell'
c. só-rí 'stole'
d. zẹ́-rị́ 'ran'
e. dạ́-rị́ 'drank'
f. wọ́-rị́ 'took a bath'

In the examples in (20), the past tense suffix harmonizes with the stem with respect to the feature [ATR] as expected. But if the stem vowel is [+high], then the suffix also agrees in backness and rounding with the stem:

(21) a. sụ́-rụ́ 'sang'
b. rú-rú 'did'

If the redundant values for [back]/[round] are [-back]/[-round], then the above distribution is straightforwardly accounted for. The [+back]/[+round] variants of the suffix are derived by a rule spreading the [+back]/[+round] specification of the stem if the stem is [+high]; if the stem is not [+high], then the suffix receives the default values [-back]/[-round]. If, on the other hand, one were to assume the redundant values to be [+back]/[+round], then the cases in (20) could only be accounted for by a non-assimilatory rule assigning the value [-back] in the following disjunctive environment: (i) after a [+high, -back/-round] vowel; (ii) after any [-high] vowel. Hence regardless of cross-linguistic considerations, the values [-back]/[-round] must be redundant in Okpẹ, with the values [+back]/[+round] appearing underlyingly and undergoing spreading.

Having motivated the feature values for [back]/[round] given in (19), the question remaining concerns which feature of the two should be included in underlying representations. I will return to this question immediately after considering the underlying representations of [high] and [low].

4.2.3. [high]. With respect to [high], there are two basic reasons for positing [+high] as the non-redundant value. First, as seen in (20) and (21) above, the rule of round assimilation crucially refers to the value [+high]. Second, the behaviour of vowels under glide formation (resyllabification—see section 4.4.1 below) also provides evidence for the presence of the specification [+high]. When a high vowel and a non-high vowel are adjacent and subject to glide formation, the loss of syllabic status for the high vowel does not result in the disappearance of the feature [+high]. On the contrary, the [+high] specification survives as a glide. The presence of rules crucially referring to [+high] and the absence of rules referring to [-high] suggest that [+high] is the underlyingly specified value.

4.2.4. [low]. Finally, turning to the feature [low], we observe in Okpẹ that the low vowel is particularly malleable. That is, it is particularly subject to environmental influences, surfacing as [e] or [ẹ] in particular contexts. It is only vowels that are phonologically low that manifest variation with respect to their specification for [low], as noted above in section 2. Such malleability is straightforwardly accounted for if the feature in question is not specified at the point in the derivation where the processes creating contextual variants apply. In other words, such surface variation in underlyingly low vowels suggests that the value [+low] is not present at the stage in the phonological derivation where rules such as ATR Harmony take place. I propose therefore that [a] is underlyingly unspecified for [low], receiving its [+low] specification by a context-free redundancy rule:[13]

(22) [ ] → [+low]

As it stands, however, this analysis would apparently require that all vowels except [a] be underlyingly specified as [-low]. But this is clearly unnecessary since many of the [-low] specifications on mid and high vowels are predictable, and therefore amenable to context-sensitive redundancy rules.

Three points are relevant. First, if a vowel is [+high], then it cannot be other than [-low] by virtue of the inherent content of the two features:

[13]The analysis presented in this section for redundancy rules involving the feature [low] owes much to discussion with Diana Archangeli.

(23) [+high] → [-low]

Second, if a segment is [+ATR], then it is [-low]:

(24) [+ATR] → [-low]

Kaye et al. [1985] proposes this as a universal constraint at the phonetic level; that is, no phonetically low vowel can be [+ATR]. Even if that claim should prove to be incorrect, (24) appears to express a correct markedness relation between the two features. The third type of case where a [-low] specification can be redundant is contingent on selecting [round] over [back] for inclusion in underlying representations. If [round] (specifically [+round]) is underlyingly specified, then the [-low] specification on [o] and [ọ] is redundant:[14]

(25) [+round] → [-low]

Apart from the fact that (25) is a correct generalization about Okpẹ, it is supported by the fact that round vowels being non-low seems to be the unmarked property for vowel systems in general.

With the adoption of the three rules in (23-25), the final set of underlying vowels in Okpẹ is as follows:[15]

(26) Minimal Vowel Specifications

	i	ị	e	ẹ	a	ọ	o	ụ	u
ROUND						+	+	+	+
HIGH	+	+						+	+
LOW				-					
ATR	+		+				+		+

[14]The feature value [-low] is doubly redundant in [o] because of both [+round] and [+ATR] specifications.

[15]It would be possible to obtain the same feature representations as in (26) by using a rule like [-round, -high, -ATR] → [+low] in conjunction with a context-free rule inserting [-low] (a suggestion made to me by Morris Halle) Following a suggestion by Diana Archangeli, I adopt the analysis given in the text because the rules proposed there all appear to constitute implications of an absolute or unmarked cross-linguistic character, unlike the rule for [+low] just mentioned.

Note that because [round] is used contrastively, [ọ] does not require a [-low] specification because it is [+round] (whereas [ẹ] must be underlyingly marked [-low]). If the feature [back] were used underlyingly instead of [round], an additional specification would be needed for [ọ], namely [-low]. Such a feature would be necessary since a redundancy rule for [-low] involving [back] (but not [round], e.g. a rule like [+back] → [-low]) could not be formulated so as to apply to [ọ] but not to [a]. Hence a final representation for Okpẹ vowels is selected that utilizes the features [high], [low], [round], and [ATR], with the feature values given in (26).

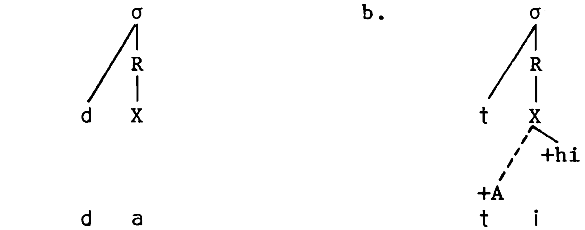
4.3. <u>The [a]/[e] alternation</u>. In this section, I consider how the proposals so far developed account for the problem of why the low vowel [a] takes [e] as its [+ATR] counterpart in prefixes. It is proposed that the occurrence of [e] is an automatic consequence of the application of the redundancy rules in conjunction with the independently motivated rule of ATR Harmony (10). Consider the derivation of forms such as à dárị́ 'we (inclusive) drank' and è tírí 'we (inclusive) pulled'. Underlyingly, the two stems appear as follows:[16]

```
(27) a.    d   X                    b.    t   X
                                               \
                                                +hi
                                          +A
           d   a                          t   ị
```

The vowel [a] in (27a) has no specifications at all underlyingly while [i] is underlyingly assigned [+high] and belongs to a stem with a [+ATR] autosegment. Syllabification followed by application of the Association Conventions results in the following (where "σ" indicates 'syllable' and "R" indicates 'Rime'):

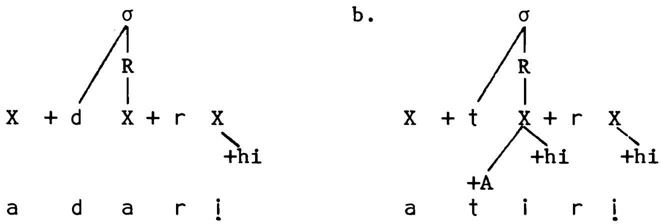
[16]For simplicity of exposition, I omit tone in the following examples and represent consonants by consonantal symbols as a short-hand for the actual autosegmental representation involving skeletal slots linked to distinctive feature matrices.

(28) a.



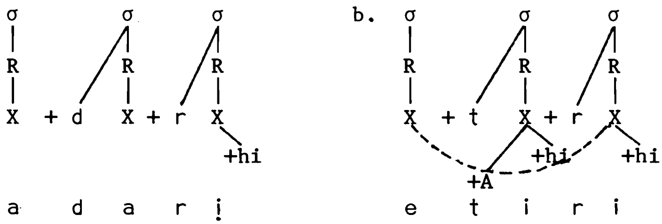
Affixation of the morphemes a 'we (inclusive)' and rị 'past tense' derives the following:

(29) a.



Syllabification then feeds the application of [ATR] Harmony (10):[17]

(30) a.



Consider now how the various redundancy rules apply to the two representations in (30), where for convenience of reference, the relevant rules have been reproduced below:

(31) a. [+round] → [-low]

b. [+high] → [-low]

---

[17]Note that the [+ATR] specification does not cross an association line in the derivation of (30b) because [ATR] and [high] are on different planes [Archangeli 1985].

c. [+ATR] → [-low]

d. [ ] → [+low]

e. [ ] → [-round]

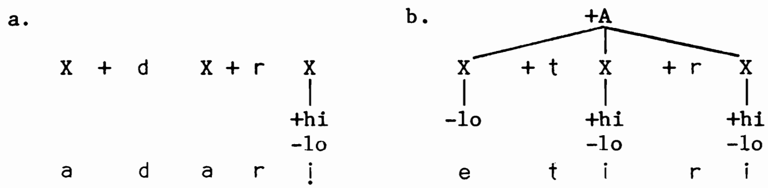
f. [ ] → [-high]

g. [ ] → [-ATR]

The three rules in (31a-c) must apply lexically for the following reason: [-low] specifications occur in underlying representations (see (26) above); by the Redundancy Rule Ordering Constraint (section 3.3 above), this means that any redundancy rule assigning [-low] must be assigned to the first lexical stratum. As regards the other redundancy rules (31d-g), however, no phonological rules have been posited that refer to the values that they insert. Hence the Redundancy Rule Ordering Constraint is not relevant, and (31d-g) begin their application as late as possible, i.e. post-lexically or phonetically, by virtue of the Default Ordering Principles (section 3.2 above).

Consider therefore the application of the redundancy rules to the forms given in (30) above, where for expository purposes, syllable structure has been suppressed. Lexically, of the rules in (31a-c), (31b) and (31c) are applicable, applying as follows:

(32)

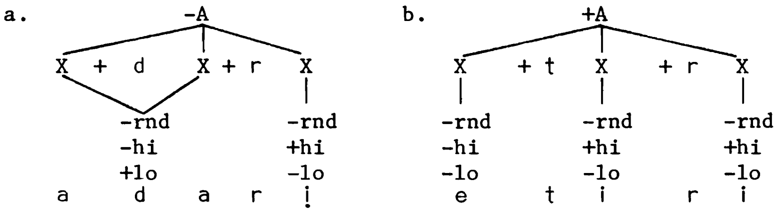


Post-lexically, all rules in (31) become applicable, filling out the above forms as follows:[18]

---

[18]As before, I assume that a single autosegment is inserted wherever possible (as in (33a)) because of the Obligatory Contour Principle, although nothing hinges here on that assumption. Two identical autosegments occur in (33b) because they are heteromorphemic. See McCarthy [1986].

(33)



The crucial aspect of these derivations concerns the applicability of the redundancy rules for [low]. The prefix of (33a), underlyingly low, does not meet the structural description of any of rules (31a-c) and is therefore assigned [+low] by the context-free rule (31d). The same underlying prefix in (33b), however, satisfies the structural description of (31c) because of its [+ATR] specification, the result of ATR Harmony. As a consequence, the prefix in (33b) receives a [-low] specification, thereby blocking the general redundancy rule (31d) and causing its vowel to surface as [e] .

To conclude this section, it has been argued that the change from [a] to [e] in [+ATR] contexts is the direct result of the interaction of the redundancy rules of Okpẹ with the rule of [ATR] Harmony. Application of the redundancy rules for [low] to a representation including the value [+ATR] results in the assignment of [-low], deriving [e] ; application of the same rules to a representation including the value [-ATR] results in the assignment of [+low], deriving [a] . No special rule is required to account for the "change" from [a] to [e] ; the apparent change simply falls out from the applicability or lack of applicability of particular redundancy rules.

4.4. The [a]/[ẹ] alternation. I propose to treat the alternation between [a] and [ẹ] in a manner basically analogous to that described above for [a]/[e] , where the appearance of a low vowel vs. a mid vowel depends on the redundant assignment of particular feature values. I argue that such a position is correct, in spite of an immediate problem: the reason that the phonologically low vowel surfaces as non-low in the cases discussed in the last section is specifically because such vowels are in [+ATR] contexts. The assignment of [+ATR] by [ATR] Harmony feeds the redundancy rule that assigns [-low]. The problem for the [a]/[ẹ] alternation is apparent. To become non-low, the vowel must be in a [+ATR] context; but the vowel which surfaces is [-ATR]. This paradox is resolved by an analysis which posits a derivation where V-initial low vowel suffixes of the type under discussion first undergo [ATR] Harmony (deriving the [+ATR] context needed to trigger the assignment of [-low]) and then undergo a rule of resyllabification, which has the result of removing the [+ATR] specification of the suffix. In the discussion that follows, I begin by looking at the process of resyllabification and then go on to demonstrate its interaction with the rules of harmony and redundancy already laid out above.

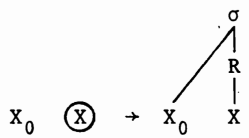
4.4.1. Resyllabification. The basic facts to be accounted for in this section concern configurations that result from the juxtaposition of vowels. Relevant data has already been seen in cases like (2) and (3) above, which I repeat below in a reorganized form:

(34)	a.	/e/	sé	'fall!'	èsé	'to fall'
	b.	/o/	só	'steal!'	èsó	'to steal'
	c.	/ẹ/	dẹ́	'buy!'	ẹ̀dẹ́	'to buy'
	d.	/ọ/	lọ́	'grind!'	ẹ̀lọ́	'to grind'
(35)	a.	/i/	tí	'pull!'	ètyó	'to pull'
	b.	/u/	rú	'do!'	èrwó	'to do, make'
	c.	/ị/	rị́	'eat!'	ẹ̀ryọ́	'to eat'
	d.	/ụ/	sụ́	'sing!'	ẹ̀swọ́	'to sing'

In these examples, the vowel of the infinitive suffix is deleted if it immediately follows a non-high vowel (34); but if the suffix vowel immediately follows a high vowel, then the high vowel becomes a glide and the suffix vowel survives. While it is clearly possible to produce such facts by positing two rules (one of deletion and one of glide formation), such an approach misses certain generalizations. First, the essential point seems to be that sequences of adjacent vowels are not desirable in Okpẹ. Such sequences are rearranged, but in a manner that depends on the segmental characterization of the vowels concerned. One point to be captured is that the undesirability of the sequence is independent of its segmental composition, and this point is completely missed in an approach that simply posits two independent rules. Second, it appears to be the case that the rules always apply together, i.e. one rule does not apply in certain environments to the exclusion of the other.

The relation between vowel deletion and glide formation can be straightforwardly captured in an account where *unsyllabified* skeletal positions are not pronounced. To determine the type of conditions that result in unsyllabified slots, let us first consider the types of slots that get syllabified. In Okpẹ, this is a fairly simple matter. All syllables are open; onsets consist of an optional consonant followed by an optional glide or [r]. Basic syllabification can be expressed by the following rule, where Ⓧ indicates an unsyllabified slot:[19]

(36) Syllabification:



An unsyllabified slot is assigned a rime node, with preceding slots incorporated as an onset. I assume that independent constraints determine precisely which segment types can occupy particular syllabic positions. That is, I assume constraints such as the following:

(37) a. Only slots specified for at least one of the vowel features [round], [high], and [low] are eligible to be made into a rime.

b. Consonant clusters are possible only if the second segment in the cluster is [+high] or [r].[20]

As illustration, consider the derivation of ẹ̀dẹ́ 'to buy' and ẹ̀swọ́ 'to sing'

---

[19]The precise details of the theory of syllabic structure are not crucial for the points being made about Okpẹ. Here and throughout, I follow Kaye and Lowenstamm [1984], Levin [1983], Archangeli [1984], etc. in assuming that the syllabic content of the skeletal ("CV") tier is derivative. See Archangeli for some discussion of the formalism I adopt here.

[20]Some examples of clusters involving [r] are: ìmrí 'fat', èvró 'to lose (something)', ẹ̀hrá 'to split up', òsòlóbrùghwẹ́ 'God'. I will not go into the feature specification of [r] (or other consonants) here, and therefore leave a more general statement of the restriction on clusters open.

At the level of the stem, syllabification produces the following:

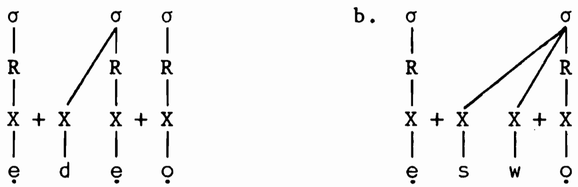
(38) a. b.

If the forms being derived were imperative, such syllabifications would be complete: dẹ́ 'buy!', sụ́ 'sing!'. But for the infinitive forms, further affixation would derive the following:

(39) a. b.

In (39a), when a rime is built on the suffix vowel, preceding material cannot be incorporated into the existing syllable since [ẹ] is not a possible onset; in (39b), on the other hand, the suffix vowel can form a single syllable with the two preceding segments since onsets can include a consonant plus glide sequence:

(40) a. b.



The representation in (40b) now gives the correct surface form ẹ̀swọ́ . But as it stands, the structure in (40a) predicts the incorrect form *ẹ̀dẹ́ọ́ . The problem with such a structure involves the vowel sequence ẹọ , ruled out since sequences of vowels are only possible in Okpe under quite restricted circumstances. Basically, a sequence of V-slots is possible only if linked to the same vowel matrix or if the first vowel is high; in both types of cases, there is a tonal requirement that the two vowels be on different tones:

(41) a. mìá !dá 'I am drinking'

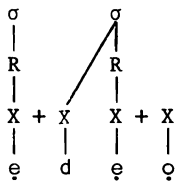
b. àrìé !rwẹ́ 'you are doing'

c. ìsáàgwẹ̀ 'groundnuts'

d. ìgyíìnì 'locally made gin'

Notice that whatever the precise factors are that allow a vowel sequence to persist, they do not exist in a case like (40a). As a consequence, a rule desyllabifies the second of the two vowels in contact, deriving the following:

(42) a.



Because the unsyllabified vowel cannot be syllabified into an existing syllable and because it cannot be syllabified by itself, it remains unsyllabified and does not surface phonetically.[21]

Consider now cases involving the underlyingly unspecified vowel, [a], such as ẹ̀dá 'to drink' and á !swá 'we (inclusive) are singing'. Prior to syllabification, such cases would appear as follows:

(43) a. b.

These cases pose a problem for syllabification—precisely because of the unspecified segments. It was proposed in (37) that a rime can be built on a skeletal slot in Okpẹ only if that slot dominates a specification of [high], [round], or [low], correctly allowing the syllabification of all cases except

[21]No problem would result if some rule were assumed to actually delete such an unsyllabified segment. The cases involving [a] (discussed below) demonstrate that such deletion could not replace the stage of desyllabification, however.

[a] .[22] In order to also allow the syllabification of [a] , there are two basic alternatives: (1) low vowels could be underlyingly syllabified; (2) the requirement just mentioned could be relaxed to the following:

(44) A slot is eligible for rime status provided that is it NOT specified for any feature other than [high], [round], or [low].

This revised requirement would allow the syllabification of [a] in cases like those in (43) because the vowels in question have no consonantal specifications.

Although either assumption would allow the correct syllabification of examples such as those in (43), I choose the first formulation (37) for two reasons. First, relaxing the condition on the configurations that allow rime construction has an undesirable effect, to be discussed directly. Second, assuming that low vowels are underlyingly syllabified (precisely because of their underspecified status) accounts automatically for their harmonic behaviour.[23]

Consider first the problem with relaxing the condition on rimes. As mentioned above, branching onsets are possible in Okpẹ only if the second member of the onset is [+high] or [r] , as in an example like (40b) above. If conditions on syllable structure are to be formulated along the lines of the revised rime condition just given, then the onset condition (37) should presumably be formulated as follows (where (45) does not take into consideration the onsets with [r] as second member):

(45) Consonant clusters are possible if the second segment in the cluster is NOT specified for any feature value other than [+high].

Unlike the revised requirement for rimes in (44), (45) provides incorrect results when involving [a] . Consider the syllabification for forms such as

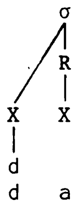
---

[22]Actually, [e] would also require underlying representation of syllable structure (as pointed out to me by Diana Archangeli), since [+ATR] (the only marker of [e]) only associates to rimes. This is entirely consistent with the distinction between [a] and [e] being simply the presence vs. absence of a [+ATR] specification, as argued here.

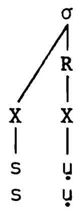
[23]For discussion of a comparable problem (and a comparable solution) involving completely unspecified segments in Japanese, see Grignon [1984].

ẹ̀dá and á !swá given in (43), where the revised conditions on syllabification (44) and (45) are assumed. On the stem cycle, syllabification would apply in both cases:

(46) a.

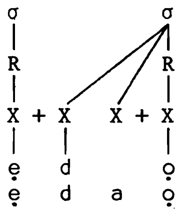


b.

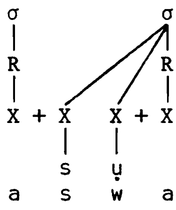


After affixation, and assuming the revised condition on clusters given in (45), syllabification would apply as follows:

(47) a.



b.

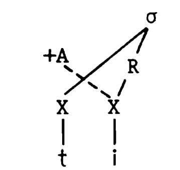


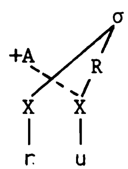
While application of the redundancy rules would correctly derive á !swá in the second case, an incorrect surface form would be derived in the first case. Although there is some question as to how the configuration in (47a) would acttually surface, it is clear that it would not be ẹ̀dá without some ad hoc rule of adjustment. The problem in this case is a direct result of reformulating the condition on consonant clusters as in (45). With the version of the condition given in (37), and if low vowels are underlyingly syllabified, then resyllabification of ẹ̀dá would have proceeded in a manner entirely analogous to ẹ̀dẹ́ (40), producing correct results.

In conclusion, I adopt the requirements for syllabification in (37). The condition in (37b) must be as formulated so as not to produce incorrect results such as those just considered, and the condition in (37a) is adopted in the interests of uniformity. That is, given the analysis here, conditions on syllable structure involving underspecification refer only to specified values, not to their absence.

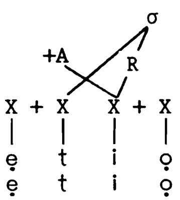
4.4.2. Automatic Dissociation. The examples seen in the preceding section all involve [-ATR] stems and are therefore relatively uninteresting as far as the application of the redundancy rules are concerned. In all cases, redundant values simply assign the feature values expected, given the underlying representation of the vowels in question. The assignment of redundant values becomes more interesting, however, when we consider cases where stems are [+ATR]. It is proposed here that the [-low], [-ATR] specification of an underlyingly low vowel in a case like é !rwẹ́ 'we (inclusive) are doing' results from the following sequence of rule applications: (1) [ATR] Harmony takes place, (2) the rule assigning [-low] to a [+ATR] vowel applies, (3) resyllabification takes place, triggering (4) a loss of [ATR]-bearing status.

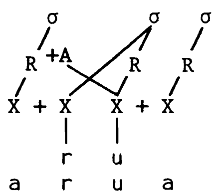
To illustrate this chain of events, I will contrast the derivation of ètyó 'to pull' (where a *non-low* suffix surfaces as [+ATR] as expected in a [+ATR] context) with é !rwẹ́ 'we (inclusive) are doing' (where a V-initial *low* suffix surfaces as [-ATR] in a [+ATR] context). At the level of the stem, two things happen: (i) syllabification takes place in a straightforward fashion in both cases, and (ii) the [+ATR] autosegment links to the newly created rimes. (Recall that it is rimes that constitute ATR-bearing units.)

(48) a.


b.


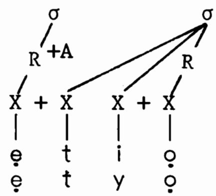
Affixation then creates the following configurations:

(49) a.


b.


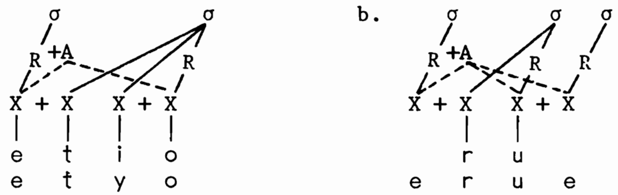
The crucial difference between the two cases involves the presence of underlying syllabification in (49b) because of the low-vowel affixes and the absence of underlying syllabification in the affixes of (49a). Since (49b) is completely syllabified, the syllabification rule in (36) is inapplicable; with (49a), on the other hand, syllabification derives the following:

(50) a.



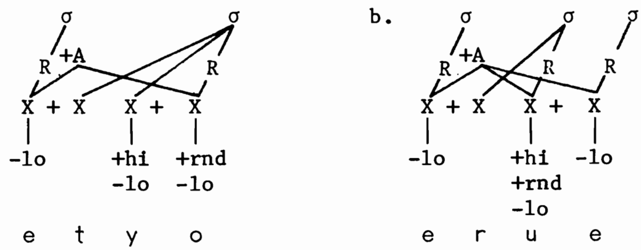
ATR Harmony applies in both cases to derive:

(51) a. b.



Recall from sections 3.2 and 3.4 that redundancy rules begin their application as early as possible on the stratum to which they are assigned, and they apply whenever they can from the point at which they begin to apply. This means that one of the times that the rule assigning [-low] to [+ATR] vowels (31c) is applicable (as well as the other rules assigning [-low]) is immediately after the rule of ATR Harmony. In cases like (51), this means the following (where for reasons of exposition only vowel specifications are indicated):

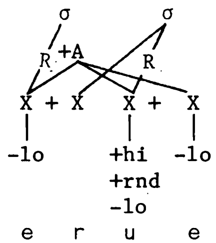
(52) a. b.



Since all the vowels in (52) are [+ATR] as a result of [ATR] Harmony, all vowels receive [-low] by the redundancy rule (31c) (Of course, they may also receive [-low] by virtue of being [+round] or [+high]).

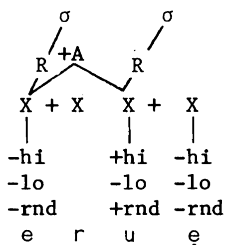
But there is a problem with the syllabification of (52b). Just as in (40a) above, (52b) contains an unacceptable sequence of adjacent vowels. As a result, the second rime must be deleted (just as in (40a)):

(53)



Loss of the second rime in (53), however, produces a situation where an [ATR] autosegment is associated to a skeletal position that is NOT a rime, that is, the final segment above. I assume, following Haraguchi [1977:290], that an autosegment is automatically delinked if the slot it is linked to ceases to be P-bearing.[24] Since the final segment in (53) is no longer ATR-bearing, this means that the [+ATR] autosegment delinks:

(54)

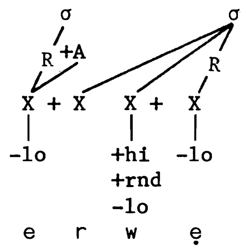


The parallel that has been drawn between a case such as that in (54) and a case such as ẹ̀dẹ́ (40a) now breaks down in one important sense. After loss of rime status, the suffix -ọ in ẹ̀dẹ́ cannot be resyllabified and therefore is not pronounced; in the case of é !rwẹ́ , however, loss of rime status in (54) feeds the reapplication of the regular syllabification rules producing

[24]Haraguchi actually formulates the constraint with respect to tone, hence the interpretation here is slightly generalized.

the well-formed configuration below:[25]

(55)



At this point in the derivation, one additional assumption guarantees the correct surface result, namely the assumption that spreading of autosegments is NOT automatic [Pulleyblank 1983]. If automatic spreading were assumed, as in Goldsmith [1976], then the [+ATR] autosegment present in (55) would be re-assigned to the final vowel after resyllabification, producing the incorrect surface form *é!rwé . If spreading is rule-governed rather than automatic, then it is inapplicable in (55) provided that ATR Harmony is ordered before resyllabification.[26] And if spreading does not take place, then the value [-ATR] is redundantly assigned to the final vowel in (55) producing the correct surface form é!rwẹ́ .

To summarize, this analysis makes crucial use of the following assumptions: (i) low vowels in Okpẹ are underlyingly unspecified, therefore requiring underlying syllabification to identify them as vowels; (ii) redundancy rules apply according to the general principles outlined in section 3; (iii) [ATR] autosegments are automatically dissociated from any skeletal position that ceases

[25]Note that in both (55) and (50), glide formation would (by Automatic Dissociation) cause the [+ATR] autosegment to delink. In (50), such delinking would be followed by reassociation by the automatic application of the Association Conventions (one-to-one linking), followed by [ATR] Harmony (since delinking in (50) is caused by initial syllabification). In (55), delinking would trigger no further rules since the [+ATR] autosegment would not be floating, and since [ATR] Harmony would already have applied (delinking being triggered by resyllabification).

[26]See Steriade [1982] for cases where rules adjusting syllabification are non-initial.

to be [ATR]-bearing; (iv) spreading of autosegments is not automatic. Given these assumptions, the surface manifestation of an underlyingly low vowel as [ẹ] in an appropriate [+ATR] context is derived without the postulation of any special rules.

5. Conclusion

This paper has argued that the changes observed when low vowels appear in [+ATR] harmonic contexts can be accounted for without positing special, ad hoc feature-changing rules. Cases where a low vowel surfaces as [e] have been shown to result automatically from the interaction of the redundancy rules with a general rule of [ATR] Harmony; cases where a low vowel surfaces as [ẹ] result from a comparable interaction of harmony and underspecification, in conjunction with an independently motivated rule of desyllabification.

It is to be expected that the various principles of a modular grammar (cf. Chomsky [1981]) will interact to produce a rich variety of surface representation. This has been argued to be the case for low vowel alternations in Okpẹ.

REFERENCES

Archangeli, Diana. 1984. "Underspecification in Yawelmani phonology and morphology." Ph.D dissertation, MIT.

Archangeli, Diana. 1985. "Yokuts harmony: evidence for coplanar representation in nonlinear phonology." *Linguistic Inquiry* 16:335-372.

Archangeli, Diana and Douglas Pulleyblank. in preparation. "The content and structure of phonological representations." ms., University of Arizona and University of Southern California.

Awobuluyi, A.O. 1967. "Vowel harmony and consonant harmony in Yoruba." *Journal of African Languages* 6(1):1-8.

Bamgboṣe, Ayo. 1967. "Vowel harmony in Yoruba." *Journal of African Languages* 6(3):268-273.

Chomsky, Noam. 1981. *Lectures on Government and Binding: The Pisa Lectures*. Dordrecht: Foris Publications.

Chomsky, Noam and Morris Halle. 1968. *The Sound Pattern of English*. New York: Harper & Row.

Clements, G.N. 1981. "Akan vowel harmony: a nonlinear analysis." In George N. Clements (ed.), *Harvard Studies in Phonology*, Vol. II, pp. 108-177. Bloomington: Indiana University Linguistics Club.

Clements, G.N. and E. Sezer. 1982. "Vowel and consonant disharmony in Turkish." In H. van der Hulst and N. Smith (eds.), *The Structure of Phonological Representations, Part II*, pp. 213-255. Dordrecht: Foris Publications.

Grignon, Anne-Marie. 1984. "Phonologie lexicale tri-dimensionelle du japonais." Ph.D dissertation, University of Montreal.

Halle, Morris and K.P. Mohanan. 1985. "The segmental phonology of Modern English." *Linguistic Inquiry*, 16:57-116.

Haraguchi, Shosuke. 1977. *The Tone Pattern of Japanese: An Autosegmental Theory of Tonology*. Tokyo: Kaitakusha.

Hoffmann, Carl. 1973. "The vowel harmony system of the Okpẹ monosyllabic verb." *Research Notes from the Department of Linguistics and Nigerian Languages* 6:79-111. University of Ibadan.

Kaye, Jonathan and Jean Lowenstamm. 1984. "De la syllabicité." In F. Dell, D. Hirst and J.-R. Vergnaud (eds.), *Forme sonore du langage*, pp. 123-159. Paris: Hermann.

Kaye, Jonathan, Jean Lowenstamm and Jean-Roger Vergnaud. 1985. "The internal structure of phonological elements: a theory of charm and government." *Phonology Yearbook* 2:305-328.

Kiparsky, Paul. 1982. "Lexical morphology and phonology." In The Linguistic

Society of Korea (ed.), *Linguistics in the Morning Calm*, pp. 3-91. Seoul: Hanshin Publishing Company.

Leben, William R. 1973. "Suprasegmental Phonology." Ph.D dissertation, MIT.

Levergood, Barbara. 1984. "Rule governed vowel harmony and the strict cycle." *Proceedings of NELS 14*, pp. 275-293. Amherst, MA: GLSA, UMASS, Amherst.

Levin, Juliette. 1983. "Reduplication and prosodic structure." ms., MIT.

Lightner, T.M. 1963. "A note on the formulation of phonological rules." *Quarterly Progress Report of the Research Laboratory of Electronics MIT*, 68:187-189.

Lindau, Mona. 1979. "The feature expanded." *Journal of Phonetics* 7:163-176.

Mascaro, J. 1976. "Catalan phonology and the phonological cycle." Bloomington: Indiana University Linguistics Club.

McCarthy, John J. 1986. "OCP effects: gemination and antigemination." *Linguistic Inquiry* 17:207-263.

Mohanan, K.P. 1982. "Lexical Phonology." Ph.D dissertation, MIT.

Omamor, Augusta Phil. 1973. "Uvwiẹ—a case of vowels merging." *Research Notes from the Department of Linguistics and Nigerian Languages* 6:113-143. University of Ibadan.

Pulleyblank, Douglas. 1982. "Tiv and the association conventions." In *Proceedings of ALNE 13/NELS 13*, pp. 211-228. Amherst: GLSA.

Pulleyblank, Douglas. 1983. "Tone in Lexical Phonology." Ph.D dissertation, MIT. [In press: Dordrecht: Reidel].

Pulleyblank, Douglas. 1986. "Tone and the morphemic tier hypothesis." Paper presented at the University of Milwaukee Morphology Symposium.

Pulleyblank, Douglas. in press. "Rule application on a non-cyclic stratum." *Linguistic Inquiry*.

Stanley, R. 1967. "Redundancy rules in phonology." *Language*, 41:294-302.

Steriade, Donca. 1982. "Greek prosodies and the nature of syllabification." Ph.D dissertation, MIT.

Steriade, Donca. 1984. "Glides and vowels in Romanian." ms., University of California, Berkeley.