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ABSTRACT

This paper proposes a set of underlying vowels, alternate to those of Chomsky and Halle, to account for vowel alternations. This phonetic representational system, which is to a degree an extension of Chomsky's and Halle's basic framework, is demonstrated in the Laxing Rule and the Vowel Alternation Rule for all vowel variables. An appendix contains a summary of rules; a bibliography of references is also included. Research was supported by a grant from the Office of Education, Department of Health, Education, and Welfare to PALI (Pacific and Asian Linguistics Institute) of the University of Hawaii. (DD)

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UNDERLYING VOWELS IN MODERN ENGLISH

Robert Krohn

Much of the current work in generative phonology assumes, incorrectly I believe, that the underlying vowels of Modern English are similar to those that existed in Middle English times. Chomsky and Halle (1968, hereafter SPE) have attempted to demonstrate that these particular abstract underlying representations and a set of rules will account for the alternating vowels in related words such as *divine-divinity*, *extreme-extremity*, *sane-sanity*, *curious-curiosity*, *pronounce-pronunciation*, etc. It is the purpose of this paper to extend Chomsky and Halle's work on English vowels by demonstrating that the vowel alternations can also be accounted for if a less abstract set of underlying vowels is posited.

The alternate system of underlying vowels is displayed in Figure 1. In the top row are listed three (true) diphthongs of English /a^I ɔ^I a^U/, as in *fight*, *boy*, and *house*.¹ Since, in the production of the e sounds, the tongue moves from a lower to higher position, they are assigned the features [+low, +high].²

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	[+front, -round]	[+front, +round]	[-front, -round]	[-front, +round]
[+low, +high]	/a ^I / <i>high</i>	/ɔ ^I / <i>boy</i>		/a ^U / <i>how</i>
[-low, +high]	/i/ <i>feat</i> /ɪ/ <i>fit</i>	/y ^u / <i>beauty</i>		/u/ <i>booty</i> /ʊ/ <i>look</i>
[-low, -high]	/e/ <i>bait</i> /ɛ/ <i>bet</i>		/ʌ/ <i>luck</i>	/o/ <i>loan</i>
[+low, -high]	/æ/ <i>bat</i>		/ɑ/ <i>father</i>	/ɔ/ <i>lawn</i> /ɒ/ <i>hot</i> (RP)

FIGURE 1: The Underlying Vowels of English.

The alternations of front vowels that must be accounted for in a description of English are [a^I-I], as in *divine-divinity*, [i-ε], as in *extreme-extremuity*, and [e-æ], as in *sane-sanity*. To account for the second member of each pair, i.e. *divinity*, *extremuity*, and *sanity*, two rules operate on underlying /a^I i e/, rewriting them as [I ε æ], respectively. The first of the two rules is Chomsky and Halle's Laxing Rule.

(1) LAXING RULE (See SPE:172, 180 for a formal version.)

$$V \quad [-\text{tense}] / _ C \quad \left\{ \begin{array}{l} C \\ (C) \text{ } i\text{ } e \\ (C) \text{ } ish \\ (C) \check{V} (C) V \end{array} \right\}$$

In undergoing Rule 1, underlying /a^I i e/ are laxed to [ä^I I ε], respectively. The output of this rule is the input to the Vowel Alternation Rule (2), which rewrites [ä^I I ε] as [I ε æ], thereby providing the phonetic representations of the vowels as in *divinity*, *extremuity*, and *sanity*.

In the Vowel Alternation Rule given below, the variables α and β on the left of the arrow may be either + or -, but the α on the right must agree in its specification (+ or -) with the α on the left, and -β on the right has a specification opposite to that of β on the left.

(2) VOWEL ALTERNATION RULE

VOWEL	
αlow	-βlow
βhigh	αhigh
-tense	
+Rule VA	

The feature [+Rule VA], where VA represents the number of the rule, restricts the application of Rule 2 to lexical items that have been specially marked with the feature. This marking is necessary in order to prevent the rule from applying to [-tense] vowels such as those in *pin*, *dish*, *pet*, *pen*, etc. Rules that have 'plus' rule features, such as [+Rule VA], are called minor rules and contrast with major rules, which do not have such features. This classification may be considered as a hypothesis concerning the relative productivity of a rule. Major rules characterize the highly productive processes of a language, minor rules some of the less productive processes, such as the vowel alternations we have been discussing here (Krohn 1970).

In addition to accounting for the alternations of front vowels, Rules 1 and 2 also play a role in the description of the alternations of back vowels. One of these alternations--[o-a]--occurs in the following pairs of related words:

- [o-a] *verbose-verbosity*
- atrocious-atrocity*
- cone-conic*
- locate-locative*
- mediocre-mediocrity*

The first part of the derivation is parallel to that of the front vowels (cf. SPE:187):

	<i>verbose-verbosity</i>	
Underlying vowel	o	o
(1) Laxing		ø
(2) Vowel Alternation		ɔ

For British Received Pronunciation and for certain varieties of American English, the derivation will stop at this point. For most varieties of American English, however, our description requires an additional rule, Rule 3 below, which unrounds [ɔ̃] to [a].

(3) LAX NONHIGH VOWELS ARE NOT ROUNDED

VOWEL	
-high	[-round]
-tense	

Rule 3 expresses an important generalization. In many varieties of English, the only lax rounded vowel that occurs at the level of systematic phonetics is the high vowel [U] as in *good*; lax nonhigh rounded vowels, such as [ɔ̃] or [ɔ̃̄], do not exist at this level. Thus Rule 3, which states that all lax nonhigh vowels are not rounded, is in effect a statement concerning allowable vowel types. Such statements are called surface phonetic constraints.³

In all of the examples of vowel alternations discussed so far, the underlying vowels have been assumed to be tense. However, in the case of *Canada-Canadian*, *algebra-algebraic*, and a few other pairs, Chomsky and Halle (SPE:179-80) have argued that the under-

lying representations of the alternating vowels must be lax. (If the vowels were tense, stress would be incorrectly assigned according to the stress rules they have formulated.) They have also asserted that the members of each pair must be related by the rules of the phonological component. If we wish to claim, in agreement with Chomsky and Halle, that the alternating vowels of *Canada-Canadian*, etc. have the same underlying representation, it will be necessary to determine whether it is possible to account for these alternations within the framework of the alternative analysis presented here. Actually all of these alternations can be accounted for without the addition of any ad hoc rules. One example--*Canada-Canadian* will be discussed here. The others are presented in Krohn 1969.

The derivation of *Canada-Canadian* includes Chomsky and Halle's Tensing Rule (SPE:181, Rule 20b) and their Vowel Reduction Rule (SPE:110-1, Rule 103). Rule 4 is an informal version of the Tensing Rule.

(4) TENSING

$$\left[\begin{array}{l} \text{VOWEL} \\ -\text{high} \end{array} \right] \rightarrow [+tense] / _ \text{C} \left\{ \begin{array}{l} i \\ I \\ e \\ \varepsilon \end{array} \right\} \text{V}$$

The Vowel Reduction Rule is a low-level rule that states that lax unstressed vowels are realized as [ə] (or one of its variants).

(5) VOWEL REDUCTION

$$\left| \begin{array}{l} \text{VOWEL} \\ \text{-tense} \\ \text{-stress} \end{array} \right| \rightarrow \text{ə}$$

The derivation of *Canada-Canadian* is as follows:

Canada-Canadian

Underlying Vowel	ɛ	ɛ
(4) Tensing		e
(5) Vowel Reduction	ə	

Some additional examples of related words with lax underlying representations for their alternating vowels are the following pairs:

[ə -o] *harmony-harmonious*
colony-colonial
custody-custodian
felony-felonious
Newton-Newtonian

The derivation of *harmony-harmonious* and *harmonic* is straightforward, largely in terms of the rules that have already been presented. The first step in the derivation--stress assignment--is made according to the familiar rules of Chomsky and Halle (cf. SPE:186):

	<i>harmony-harmonious-harmonic</i>		
Underlying Vowel	ø	ø	ø
Stress Assignment		ø̌	ø̌
(4) Tensing		ó	
(2) Vowel Alternation	õ		õ̌
(3) Lax nonhigh vowels are not rounded	a		á
(5) Vowel Reduction	ə		

The derivation of *harmonic* is similar to that of *verbosity*. The only difference is in the source of the tenseness of the vowel. It is an underlying feature in *verbosity*, but must be added by rule in the case of *harmonic*.

It is quite reasonable, in the case of *harmony-harmonious-harmonic* to assume, as is done here, that the underlying alternating vowel is /ø/. First of all, in accordance with the present vowel quality rules, only /ø/ or /o/ can underlie the [o] of *harmonious*. Secondly, since only unstressed lax vowels reduce to [ə], the vowel must be lax in order to account for the derivation of *harmony*. Hence the underlying segment is /ø/. Consider now pairs which are similar to *harmony-harmonic* except that they do not have related forms containing [o].

[ə -a]	<i>curious-curiosity</i>
	<i>generous-generosity</i>
	<i>monstrous-monstrosity</i>
	<i>frivolous-frivolity</i>
	<i>demon-demonic</i>
	<i>period-periodic</i>
	<i>aristocrat-aristocracy</i>
	<i>democrat-democracy</i>

Here it is less clear what that underlying vowel is. In fact, there are three possible candidates, namely /*ǒ Ǔ a*/. Accordingly, there are three possible derivations:

	<i>curi<u>o</u>us</i>	<i>curi<u>o</u>sity</i>
	1 2 3	1 2 3
Underlying Vowel	<i>ǒ Ǔ a</i>	<i>ǒ Ǔ a</i>
Stress assignment		<i>ǒ Ǔ á</i>
(2) Vowel alternation	<i>Ǔ</i>	<i>Ǔ</i>
(3) Lax nonhigh vowels are not rounded	<i>a a</i>	<i>á á</i>
(5) Vowel reduction	<i>ə ə ə</i>	

In derivations 2 and 3, the underlying vowel is not marked with the feature [+Rule VA], and consequently the Vowel Alternation Rule does not apply.

Notice that no matter which of the three vowels is posited as the underlying one, the number of rules in the grammar remains the same. This is because these rules were all proposed in order to account for derivations of lexical items other than those we are considering now. That is, they are needed to account for *verbose-verbosity*, *harmony-harmonious-harmonic*, etc. Consequently, our choice of an underlying representation for the alternating vowel of *curios-curiosity* cannot affect the complexity of the phonological component. We cannot reduce the number of rules nor simplify them in any way by choosing one solution rather than another.

The various choices do, however, have certain definite consequences. If alternative 1, i.e. /ɔ̃/ is chosen, the derivation of *curious-curiosity* will be exactly parallel to that of *harmony-harmonic*. Moreover, such a derivation might ultimately be extended throughout the vocabulary of English to cover all instances of phonetic [a] (or [ɔ̃]), with the result that the inventory of underlying segments of English would not contain phonological /a/ (or /ɔ̃/).

If alternative 2 is chosen, the underlying vowel will be /ɔ̃/. In comparing solutions 1 and 2, we notice that fewer rules are required to derive [a] from /ɔ̃/ than from /ɔ̃/. Thus /ɔ̃/ as the underlying vowel is closer to the corresponding phonetic realization than /ɔ̃/ is. Furthermore, with alternative 2 (as with 1) it is still possible to derive the other dialectal variants. In other words, if /ɔ̃/ (or /ɔ̃/) is chosen, the lexical representation of pairs such as *curious-curiosity* will be the same for all dialects.

If, on the other hand, /a/ is posited as the underlying vowel, it will no longer be possible to account for the [ɔ̃] variants with the available rules. That is, we have no rules that will derive British [ɔ̃] from an underlying /a/. Instead, the British variant will have to be derived from an underlying /ɔ̃/. Thus the lexical representation of *curious-curiosity* will differ from dialect to dialect, some having underlying /a/, and others /ɔ̃/. However, this means that for each dialect the relationship of phonological and phonetic representations is as close as possible.

An examination of these alternatives suggests three principles, each corresponding to one of the three possible solutions:

1. [õ]. The Principle of Maximum Use of Available Rules, known informally as the Free-Ride Principle.
2. [õ̃]. The Principle of Maximum Dialect Coverage with Minimum Use of Available Rules.
3. [a]. The Principle of Minimum Use of Available Rules.

According to (1) the Maximum Use Principle, rules are utilized to their fullest extent. For example, *stop* and *curiosity* would have the following parallel derivations:

	<i>stop</i>	<i>curiosity</i>
Underlying vowel	ɔ	ɔ
(2) Vowel alternation	õ	õ
(3) Lax nonhigh vowels are not rounded	a	a

If the Maximum Use Principle is accepted, /a/ will not appear in the inventory of underlying segments, since phonetic [a] will be represented by /õ/ in all items in which it occurs. Thus the result of applying the Maximum Use Principle is to reduce the number of segment types in the phonological inventory of a language.

According to (2) the Principle of Maximum Dialect Coverage with Minimum Use of Available Rules, a linguistic description must have underlying forms sufficiently abstract so that various dialectal variants can be accounted for without positing additional rules.

Principle 2 allows the linguistic description to account for both American and British variants without any otherwise unmotivated rules.

The Minimum Use Principle (3) is self-explanatory. It requires that as few rules as possible be used to derive any particular item. Thus the distance between underlying representations and the corresponding phonetic realizations will be kept as small as possible. According to this principle, the vowel that underlies the *curious-curiosity* alternation is [a]. Furthermore, the Minimum Use principle dictates that rules, such as Vowel Alternation Rule, whose sole raison d'être is to account for alternations, not be used at all in the derivation of items that do not have alternate forms, as for example, *stop*, *cot*, *John*, *lock*, *lot*, *mop*, *hot*, etc. Kiparsky (1968) has proposed a similar principle--the Alternation Condition, which requires that 'if a form appears in a constant shape, its underlying representation is that shape, except for what can be attributed to low-level, automatic processes.' However, since Kiparsky considers Chomsky and Halle's Vowel Shift Rule to be a low-level, automatic process, it is difficult to assess the implications of the Alternation Condition. Who is to decide whether a given rule is low-level or not? Allowing the Vowel Shift Rule to operate on nonalternating forms as Kiparsky does means favoring the Free-Ride Principle, thereby contradicting the intent of the Minimum Use Principle. For further discussion of Minimum Use, see Krohn 1969:24-28.

In addition to /a^I ə^I a^U/, English has a fourth true diphthong, namely /Y^u/, as in *beauty*, which differs from the others in that it is an increasing rather than a diminishing diphthong (terminology used by Heffer (1959:111)). Like other true diphthongs, /Y^u/ contains a movement from one distinctive position to a second within the limits of a single syllable, beginning with the tongue in the [+front] position and ending with the lips in a [+round] position. In order to specify the characteristics of this diphthong adequately, the distinctive features [+front, +round] are assigned to its underlying representation.

The distinctive features of /Y^u/, as in *beauty*, *feud*, *fuel*, *mute* can be compared with those of /u/, as in *booty*, *food*, *fool*, *moot*:

	Y ^u	u
low	-	-
high	+	+
round	+	+
front	+	-

Since the phonetic realization of the feature [+front] and the feature [+round] are not simultaneous,⁴ the grammar must contain a rule that sequences them:

(6) FRONT-ROUND SEQUENCING RULE

VOWEL	→	SATELLITE	VOWEL
-low			-low
+high			+high
+front		+front	
+round			+round
+tense			+tense

Features that are unspecified in the matrices to the right of the arrow will be supplied by rules that supply predictable features (as suggested in SPE:419-20).

The rule for the front-round diphthong is not the only sequencing rule in English. The features [+low, +high] of the true diphthongs /a^I o^I a^U/ are also sequenced by rule.⁵

The diphthong /Y^U/ participates in several alternations with other vowels. For example, Chomsky and Halle's analysis makes the claim that the underlying representations of the second vowel in *sulfur-sulfuric* is the same. With an underlying [+front, +round] vowel, the derivation is as follows:

	<i>sulfur-sulfuric</i>	
Underlying vowel	Y ^U	Y ^U
Stress assignment		Y ^U
(7) <i>yu</i> -Tensing		Y ^U
(6) Front-round sequencing		y ^U
(5) Vowel reduction	ə	

The *yu*-Tensing Rule tenses lax [^YU] when it is followed by a vowel which may or may not be preceded by a consonant:

(7) *yu*-TENSING RULE

$$YU \rightarrow [+tense] / _ (C) V$$

This rule is a revised version of one proposed by Chomsky and Halle (SPE:195, Rule 52).

The /^YU/ of *sulfur* is neither stressed nor tensed at any place in its derivation, and consequently it reduces to [ə].

In some dialects, the second vowel of *sulfuric* will be realized as lax [yU] rather than as its tense counterpart [yu]. Presumably there are general rules that determine the tenseness of vowels preceding [r], but they have not been worked out in this study.

The *yu*-Tensing Rule is also required in the derivation of *ambiguous-ambiguity*, which follows (cf. SPE:193-5):

	<i>ambiguous-ambiguity</i>	
Underlying Vowel	YU	YU
<i>yu</i> -Tensing	Yu	Yu
(6) Front-round sequencing	yu	yu

The reason that the underlying representation of the third vowel is lax is that if it were tense, the stress in the word *ambiguous* would be incorrectly assigned according to the stress rules formulated by Chomsky and Halle.

Next, let us consider briefly certain restrictions on the occurrence of the initial glide of /Yu/. In some dialects this glide does not occur when the diphthong is preceded by a dental or palato-alveolar consonant or by a liquid. These consonants-- [t d n θ ó s z š ž ǰ j l r]--are the ones that are marked [+coronal]. Some examples of items that have variant pronunciations are the following: *student, Tuesday, duty, endure, knew, enthusiasm, assume, suicide, issue, luxurious, chew, June, flew, brew* (all these examples from Kenyon (1950:215-6)). However, the glide is retained if the diphthong has not been stressed at some point in its derivation, e.g. *annual, valuable*. See Chomsky and Halle (SPE:231-2) for a detailed discussion and for the formal version of the Glide Deletion Rule given below (SPE:232, Rule 123):

(8) *yu*-GLIDE DELETION RULE

yu → u in certain environments

We can now examine the alternation that occurs in such pairs as *assume-assumption*, where [u] (or [Yu]) alternates with [ʌ].

[u-ʌ] *assume-assumption*
 consume-consumption
 presume-presumption
 deduce-deduction
 induce-induction
 reduce-reduction
 seduce-seduction
 produce-production

There are two possible derivations for the [u-Λ] alternations, the choice depending on whether we adopt principles 1 or 2, or principle 3 (cf. SPE:220).

	<i>ass<u>u</u>me-ass<u>u</u>mption</i>			
	1,2	3	1,2	3
Underlying vowel	Y _u	u	Y _u	u
(1) Laxing			Y _U	U
(2) Vowel alternation			Y _ø	ø
(8) <i>yu</i> -glide deletion	u			
(9) Round vowels are nonfront (This rule is discussed below)			ø	
(3) Lax nonhigh vowels are not rounded			Λ	Λ

The fact that the second vowel of *assumption* is not a front vowel is accounted for by Rule 9, which reflects a surface phonetic constraint.

(9) ROUND VOWELS ARE NONFRONT

$$\left| \begin{array}{l} \text{VOWEL} \\ +\text{round} \end{array} \right| \rightarrow [-\text{front}]$$

When rule 9 operates on [Y_ø], it rewrites this segment as [o]. For obvious reasons, this rule must be ordered after the Front-Round Sequencing Rule (6).

Another alternation that must be accounted for is that which occurs in the following pairs of related words:

[a^U-Λ] *abounl-abundant*
 denounce-denunciation
 profond-profundity
 pronounce-pronunciation

In order to account for the derivation of words such as *abundant*, *pronunciation*, it is necessary to add to our list of rules a statement about lax high rounded vowels:

(10) LAX HIGH ROUNDED VOWELS ARE NONLOW

VOWEL +high +round -tense	→	[-low]
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This rule operates on [ä^U], the output of the Laxing Rule, rewriting the diphthong as [U]. The complete derivation is given below (cf. SPE:187, 203).

		<i>pron<u>ou</u>nce-pron<u>un</u>ciation</i>	
Underlying vowel		a ^U	a ^Ü
(1) Laxing			ä ^U
(10) Lax high rounded vowels are nonlow			U
(2) Vowel alternation			ö
(3) Lax nonhigh vowels are not rounded			Λ

In the framework of contemporary generative phonology, it is customary to write rules for nearly every alternation. At present there are no generally-accepted distinctions made between rules that describe productive processes and those that describe fossilized alternations inherited from earlier stages of the language. For further discussion of this dilemma, see Maher 1969. In any case, within the context of contemporary linguistics, it becomes necessary to account for the vowel alternations in the following pairs.

[ɔ^I-Λ] *joint-juncture*
 point-puncture
 destroy-destruction

The features assigned to /ɔ^I/, i.e.

[+tense, +low, +high, +front, +round]

are rewritten as

[-tense, -low, -high, -front, -round]

via Rules 1, 10, 2, 9, and 3, respectively. The complete derivation is given below.

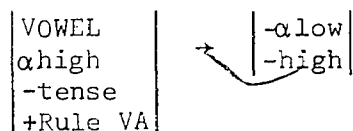
destroy-destruction

Underlying vowel	ɔ ^I	ɔ ^I
(1) Laxing		ɔ̃ ^I
(10) Lax high rounded vowels are nonlow		ʊ
(2) Vowel alternation		ø
(9) Rounded vowels are nonfront		œ
(3) Lax nonhigh vowels are not rounded		Λ

In contemporary generative phonology it would be customary to 'account for' the [k] in *destruction* by positing an underlying /k/ and then deleting it at the end of *destroy* (cf. discussions of *satisfy-satisfaction*, SPE:201; and *resign-resignation*, SPE:234, where hypothetical /k/ and /g/ are deleted). Although the *destroy-destruction* alternation is no more unusual than *satisfy-satisfaction*, the former is not treated by Chomsky and Halle (SPE).

According to the present formulation of Rule 10 (Lax high rounded vowels are nonlow), it will apply only to [ä^U] and [ɔ̃^I], as in the derivations of *pronunciation* and *destruction*. It is possible, however, to make the rule more general by removing the feature [+round] from the left of the arrow. In this form, the rule will apply also to lax /ä^I/, changing it to /I/, thereby rendering the operation of the Vowel Alternation Rule (2) unnecessary in the derivation of items such as *divine-divinity*. Consequently, we might ask whether it is not possible to simplify Rule 2. Actually this suggestion is perfectly feasible. We can reformulate this latter rule so that its output no longer includes high vowels, but only mid and low vowels. The final form of the rule, which has one feature less than the original formulation, is as follows:

(11) VOWEL ALTERNATION RULE (REVISED VERSION)



An important consequence of generalizing Rule 10 (Lax high [rounded] vowels are nonlow) and simplifying the Vowel Alternation Rule is that the [a^I - I] alternation (e.g. *divine-divinity*) is accounted for by a different rule than that which accounts for the [i - ε] alternation (e.g. *extreme-extremity*). Since the former rule is a general (i.e. major) rule while the latter is a nongeneral (i.e. minor) one, this analysis predicts that the [a^I - I] alternation is more productive than [i - ε]. (The differences between major and minor rules were discussed following the initial presentation of Rule 2.)

This prediction has been confirmed in a very interesting experiment conducted under the direction of D. Steinberg, where subjects were asked to coin new words, e.g. *Goldsteinian* [a^I - I] and *effetity* [i - ε] from *Goldstein* [a^I], and *effete* [i]. Although not fully productive, the [a^I - I] alternation is considerably more productive than [i - ε].

With the present set of rules it is also possible to derive the first vowels of *time-temporal* from the same underlying representation. The derivation is as follows:

	<i>time-temporal</i>	
Underlying vowel	a ^I	a ^I
(1) Laxing		ǣ ^I
(10 rev.) lax high vowels are nonlow		I
(11) Vowel alternation		ε

Although the [a^I - ε] alternation has not been treated by Chomsky and Halle, it is certainly no more unusual or obscure than those that have been discussed in generative phonology. An example of an alternation of low frequency mentioned by Chomsky and Halle is that which appears in *money-monetary* (SPE:213n).

If one wished to claim that the first vowel of *monetary*, i.e. [a], is derived from the same underlying representation as the first vowel of *money*, i.e. [Λ], then it is obvious that the vowel /Λ/ can be lowered to the position of [a] via the Vowel Alternation Rule. Even though they refer to this alternation, Chomsky and Halle have not specified the rules they would use to account for it, perhaps because the derivations of the back vowels are quite complex in their analysis. Take, for example, the nonalternating vowel in *long*, which Chomsky and Halle derive as follows: (Numbers refer to rules in SPE, Ch. 4.)

	<i>long</i>
Underlying vowel	ō
77b in the context 79	Λ
(78)	ā
Diphthongization	āw
(74) Glide vocalization	āu
Vowel shift	āō
Rounding adjustment	ōΛ

The above analysis of *long* differs greatly from the one that follows from the present study: The underlying representation of the vowel of *long* is /ɔ/; its phonetic realization is [ɔ]. And that is all. There are no ad hoc rules; in fact, no rules of any kind are involved in the derivation. On the other hand, a significant characteristic of Chomsky and Halle's analysis of *long* is the fact that it requires highly complex machinery to account for a very simple word.

When other derivations are compared in a similar manner, it is found that those of Chomsky and Halle require a greater number of rules, and that their rules are more complex than those proposed in the present study. It has been argued, however, that in one respect the present study is more complex than that of Chomsky and Halle. This is in the underlying representations of the true diphthongs /a^I ɔ^I a^U/, which have been assigned the features [+low, +high]. Since this analysis is sometimes misunderstood, perhaps it deserves some additional comment. (See also note 2 above, and the discussion in Krohn 1969, 1971a, 1971b.)

Assigning the features [+low, +high] to the same underlying segment reflects the fact that the tongue moves from a lower to a higher position during the production of [a^I], etc. This means that two features that might be regarded as simultaneous on the phonological level must be sequenced on the phonetic level. Such an analysis is no more complicated than what Chomsky and Halle have proposed for affricates, e.g. /tʃ/; prenasalized consonants, e.g. /ⁿd/; or

laterally released stops, e.g. /t^l/, all of which are considered as single segments. For example, Chomsky and Halle (SPE:317) have assigned the features [-continuant, +lateral] to the underlying representation of /t^l/. Obviously the body of the tongue is not so constructed that the features [-continuant] and [+lateral] are actualized simultaneously. Hence they are sequenced. Similarly the tongue is not so constructed that the features [+low] and [+high] are actualized simultaneously. They too must be sequenced.

Criticisms of the analysis of true diphthongs and Chomsky and Halle's analysis of affricates, etc. are based on the obviously true observation that a vocal organ can not be in two positions simultaneously. However, such criticisms suffer from the failure to see a fundamental distinction between phonology and articulatory phonetics. When linguists postulate phonological representations they are hypothesizing about mental representations. Many factors must be considered. Certainly no one will deny the importance of careful observations of the behavior of the tongue, lips, velum, etc. Nevertheless, statements about such observed behavior should not unduly restrict the linguist in his primary task of unraveling the mysteries of the mind. Certainly there is no reason to assume that the ability of the human mind to organize the facts of a natural language is strictly limited by the behavior of the vocal organs. The human mind is of much greater complexity than the body of the tongue.

The view that one must transcend mere observations of behavior if he wishes to make significant statements about mental structures and processes has been argued by Chomsky in many places (e.g. 1968: 12). Perhaps the analysis of vowels presented here can be regarded as additional evidence in support of his position. In any case, he must be given credit for having made this view a part of contemporary linguistics.

It should be noted that since this analysis of vowels has been carried out entirely within the theory of phonology developed by Chomsky and Halle, any validity that the present study might have provides additional support for their basic ideas. They have provided linguistics with a theoretical framework that permits the construction of abstract descriptions and significant explanations, and the evaluation of alternative solutions. Obviously, none of the work that has been presented here could have been completed without their pioneering effort.

In addition to extending and supporting some of the fundamental assumptions of Chomsky and Halle, this study has also attempted to show that it is possible within their framework to account for vowel alternations in Modern English without positing highly abstract underlying representations that resemble the corresponding phonetic representations that existed in Middle English. There is very little reason to believe that the high degree of abstractness entailed in the Middle English hypothesis is necessary in an analysis of Modern

English phonology. Although this study has not provided a definite answer to the question of how abstract underlying representations are, it does suggest strongly that they are somewhat closer to the surface, i.e. less abstract, than has generally been assumed in generative phonology.⁶

APPENDIX: Summary of Rules

Ref.:

1. Laxing

$$V \rightarrow [-tense] / _C \left\{ \begin{array}{l} C \\ (C)ic \\ (C)ish \\ (C) V (C) V \end{array} \right\} \quad (1)$$

2. Tensing

$$\left| \begin{array}{l} V \\ -high \end{array} \right| \rightarrow [+tense] / _C \left\{ \begin{array}{l} i \\ I \\ e \\ \epsilon \end{array} \right\} V \quad (4)$$

3. Lax high vowels are non low

$$\left| \begin{array}{l} V \\ +high \\ -tense \end{array} \right| \rightarrow [-low] \quad (10 \text{ rev.})$$

4. Vowel alternation

$$\left| \begin{array}{l} V \\ \alpha high \\ -tense \\ +\text{Rule VA} \end{array} \right| \rightarrow \left| \begin{array}{l} -\alpha low \\ -high \end{array} \right| \quad (11)$$

5. *Yu*-tensing

$$Y_U \rightarrow [+tense] / _(C) V \quad (7)$$

6. *Yu*-glide deletion

$$Y_U \rightarrow [-front] \text{ in certain env.} \quad (8)$$

7. Low-high sequencing

(n. 5)

$$\left| \begin{array}{l} +low \\ +high \\ \text{etc.} \end{array} \right| \rightarrow \left| \begin{array}{l} +low \\ \text{etc.} \end{array} \right| \left| \begin{array}{l} +high \\ \text{etc.} \end{array} \right|$$

8. Front-round sequencing

(6)

$$\left| \begin{array}{l} +front \\ +round \\ +tense \\ \text{etc.} \end{array} \right| \rightarrow \left| \begin{array}{l} +front \\ \text{etc.} \end{array} \right| \left| \begin{array}{l} +round \\ \text{etc.} \end{array} \right|$$

9. Rounded vowels are nonfront (9)

$$\left| \begin{array}{c} \text{V} \\ +\text{round} \end{array} \right| \rightarrow [-\text{front}]$$

10. Lax nonhigh vowels are not rounded (3)
(Add [-low] on the left of the
arrow for British Received Pron.)

$$\left| \begin{array}{c} \text{V} \\ -\text{high} \\ -\text{tense} \end{array} \right| \rightarrow [-\text{round}]$$

11. Vowel reduction: Unstressed lax vowels are reduced to schwa (5)

$$\left| \begin{array}{c} \text{VOWEL} \\ -\text{tense} \\ -\text{stress} \end{array} \right| \rightarrow \text{ə}$$

EXCURSUS

Since the input to Rule 3 (Lax high vowels are nonlow) is provided by Rule 1 (Laxing), we might ask whether or not it is possible to collapse the two rules. Actually this is a perfectly feasible suggestion. Rule 3 can be eliminated from the list of rules by adding two of its features to the Laxing Rule. These two features are enclosed in angled brackets.

REVISED LAXING RULE

$$\left| \begin{array}{c} V \\ \langle +\text{high} \rangle \end{array} \right| \rightarrow \left| \begin{array}{c} -\text{tense} \\ \langle -\text{low} \rangle \end{array} \right| / \text{---}^C \left\{ \begin{array}{l} C \\ (C) \text{ } i\text{c} \\ (C) \text{ } i\text{sh} \\ (C) \text{ } \bar{V} (C) V \end{array} \right\}$$

According to the convention for angled brackets, the revised Laxing Rule will apply first to [+high] vowels (as in *divine + ity*) rewriting them as [-low, -tense] vowels. Thus, for example, /a^I/, which is [+low, +high] will be rewritten as [I], which is [-low, +high, -tense]. By converting /a^I/ directly into [I], this formulation has eliminated the lax [ä^I] stage that was a part of the earlier derivation.

The reformulation of the rules suggested here produces some minor difficulties, namely it complicates the derivation of *vary-various-variety* (Krohn 1969:48-9), which requires that an underlying /ä^I/ (i.e. one that is not the output of the Laxing Rule) undergo Rule 3. The difficulty exists only because of the requirement (SPE: 179) that the second vowel in each word must be derived from the same underlying representation. If we remove this requirement, the difficulty will disappear.

NOTES

¹Diphthongs are vowels produced as the tongue and often the lips move from one distinctive vowel position to a second within the limits of a single syllable. These complex vowels are often called true diphthongs in order to distinguish them from diphthongized vowels, e.g. the nucleus of say, which may also include some tongue or lip movement, but not from one distinctive position to a second.

The differences between (true) diphthongs and other vowels are, of course, well-known and have often been discussed in the literature, e.g. Kenyon 1949 (209-10), Heffer 1950 (110-11), and Pike 1947. The spectrographic evidence of Lehiste and Peterson (1961: 274-7) and Lehiste (1964:4-6) shows that each of the two elements of a diphthong corresponds to a steady-state position. Between these two positions is a transition that is longer than either of the positions. However, other vowels, e.g. /e/ and /o/ as in say and so, contain only one steady-state position each. Thus the spectrographic evidence supports Pike's (1947) claim (and the one made here) that diphthongs are 'not structurally parallel' to vowels such as /e/ and /o/.

In the present study, diphthongs share the characteristic that certain features assigned to the same underlying segment are realized sequentially--not simultaneously--on the phonetic level. The diphthongs /a^I ɔ^I a^U/ each contain the sequence [+low, +high] and /y^u/ contains the sequence [+front, +round].

²Chomsky and Halle (SPE:408), however, have asserted that '... there can be no segments that are [+high, +low].' They claim (SPE: 305) that '...the phonetic characterization of "low" and "high" rules out sounds that are [+low, +high], for it is impossible to raise the body of the tongue above the neutral position and simultaneously lower it below that level.' However, merely noting--as Chomsky and Halle do--that the features [+low, +high] cannot be realized simultaneously on the phonetic level is surely not sufficient to rule out the hypothesis that the two features are simultaneous on the phonological level and sequenced on the phonetic, especially since a similar hypothesis is implicit in their analysis of affricates and certain other consonants (Krohn 1971a, 1971b). Furthermore to see how their argument about the tongue is contradicted by their treatment of the velum, we need only to examine their discussion of (single-segment) prenasalized consonants, such as /^mb n^d/:

...the velum... is *lowered* during the period of oral occlusion, [and] is *raised* prior to the release of the oral occlusion ... It would appear, therefore, that phonetically we have to recognize a feature that governs the timing of different movements *within the limits of a single segment*. [All italics mine--RK]. (SPE: 317)

Chomsky and Halle's suggestion to allow the features that correlate with different positions of the velum to be contained within the limits of a single underlying segment is, in principle, no different from the treatment of tongue height features proposed here; however, their suggestion is clearly inconsistent with their present restrictions on tongue features. To bring their treatment of the tongue in line with that of the velum, Chomsky and Halle will have to allow the lingual features that correlate with a sequencing from a lower to a higher position, i.e. [+low, +high], to be assigned to the underlying representation of single-segment diphthongs such as /a^I/. Certainly it is not unreasonable to assume that what is good for velum is also good for the tongue.

³For British Received Pronunciation and other varieties of English containing [ɔ̃], as in RP *hot*, this surface phonetic constraint must be stated differently:

(3a) LAX MID VOWELS ARE NOT ROUNDED

VOWEL	
-low	→ [-round]
-high	
-tense	

For a further discussion of surface phonetic constraints, see Shibatani (forthcoming).

⁴Features that are realized simultaneously in one language may be actualized sequentially in another. It is interesting to note that when Middle English absorbed loan words from French, the [+front, +round] monophthong /ü/ was replaced by a [+front, +round] diphthong, e. g. *cure* (Moore 1951:70).

⁵The rule that sequences the features [+low, +high] is as follows:

LOW-HIGH SEQUENCING RULE

VOWEL +low +high αfront <+round>	→	VOWEL +low αround	SATELLITE +high αfront
--	---	-----------------------------	----------------------------------

This rule is equivalent to two disjunctively ordered rules, the first with the features in brackets, the second without them. The first of these rules applies to the [+round] diphthongs /ɔ^I/ and /a^U/. For /ɔ^I/, which is [+front], [αround] of the first segment to the right of the arrow will be rewritten as [+round]. For /a^U/, which is [-front], [αround] will be rewritten as [-round]. The feature [αfront] of the satellite will be rewritten as [+front] for /ɔ^I/ and [-front] for /a^U/. Similarly, the sequencing of the features of /a^I/ is accounted for by the second rule, i.e. a rule that omits the features enclosed in brackets.

Features that remain to be specified on the right of the arrow will be added by rules that supply predictable features.

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The analysis presented here is a revision and extension of work presented in the first three chapters of my (1969) dissertation, English Vowels. The remaining five chapters deal with other alternations, such as in *fly-flew-flown* and other strong verbs, and with some questions regarding notational conventions.

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