The Phonology of Featureless Segments

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1. Introduction

The phonology of featureless segments is an interesting aspect of non-linear phonology. These featureless slots play an important role in accounting for a number of phonological phenomena, a role that is not possible within a linear framework. This paper will focus on the phonology of featureless vowels and examine their behavior.

Predictions concerning the behavior of featureless segments is obviously dependent on the theoretical framework adopted. This paper will consider two non-linear frameworks in which the status of featureless segments are quite strongly opposed. The first is particle phonology (Schane 1984). Within particle phonology there is only one featureless vowel: *ɨ*. Its emptiness is attributed to the fact that it is not specified by any of the three unary particle features, no palatality (frontness), labiality (rounding), nor aperture (openness). Thus when the vowel space is analyzed as being composed of these three features, the location of *ɨ* is at the zero point of the vowel space, a point represented by no values for any of these unary features. (With these features the heart of the system, particle phonology can make clear and testable predictions about vowel coalescence, diphthongization, and epenthesis.)

The second framework I will be considering, radical underspecification, (Archangeli 1984) maintains a very different conception of emptiness.This framework assumes that in every language there is one featureless vowel; the general diagnostic for the identification of this vowel is based in the language specific epenthetic vowel. Archangeli claims the unspecified vowel to be *e* in Spanish, *i* in Japanese, and *u* in Telugu even though these three languages possess identical underlying inventories of *a*, *i*, *u*, *e*, and *o*.

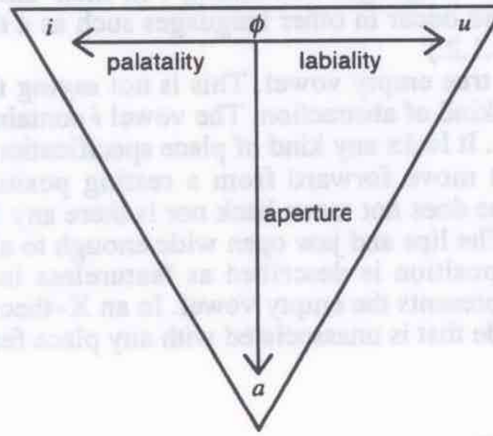
In this paper I will present evidence that the featureless vowel in particle phonology, *ɨ*, is in fact the true empty vowel and patterns in a manner that can only be attributed to its emptiness. I will also show evidence that the unspecified vowel in radical underspecification does not pattern as an empty vowel.

In the following sections I will briefly introduce the particle phonology and radical underspecification frameworks.

1.1 Particle Phonology

The particle phonology framework (Schane, 1984) makes use of the three features that specify the vowel space as indicated in figure (1):

(1)



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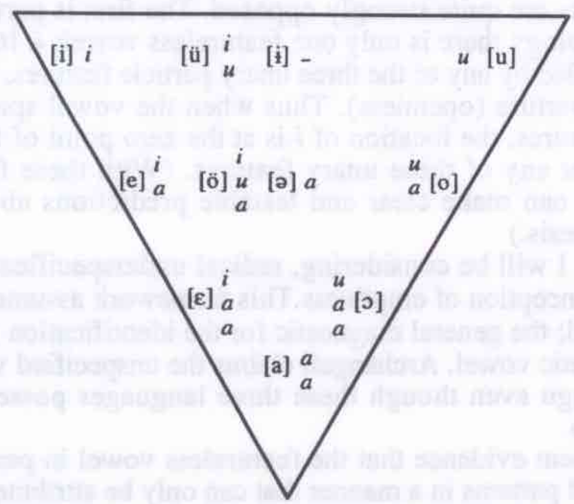
Each of these features is a unary particle and is indicated in derivations with a single letter, |i| corresponds to palatality, |u| to labiality, and |a| to aperture. At the center top of the vowel triangle there is a point that is not specified by any particle. This is the zero point from which the axes of the three particles extend. Palatality extends to the left of that point and is represented by the particle |i|. The most basic vowel specified by the particle |i| is [i]. To the right of the zero point is labiality, which encompasses both rounding and backness, and is represented by the particle |u|. The vowel [u] is the most basic vowel specified by |u|. The cover term to describe either of these particles is called tonality, which can be represented by |y|, but is not a particle in its own right.

The vertical axis represents the |a| particle (aperture) and extends in only one direction, downward. To indicate various degrees of aperture, there can be multiple occurrences of the |a| particle. The particle representations of some basic vowels are given in figure (2)[1]:

(2)



The system in (2) assumes a language containing three central vowels. In a language with two central vowels, *ə* and *a*, the *ə* is assigned zero particles and the *a* a single |a| particle. In a language with a single central vowel, that vowel is always an *a* and is assigned a single |a| particle.

It is not uncommon in languages with two central vowels for a stressed full vowel to alternate with an unstressed schwa. This phenomenon, found in languages like English, French, and German, is a simple process of complete particle deletion when unstressed. Although these alternations are interesting in their own right, and are completely compatible with the analysis that I am proposing, I will not consider them here. This paper will be primarily concerned with processes that target empty vowels such as vowel hiatus resolution and diphthongization, and the results of these processes. These occur in languages containing *ɨ* in their underlying inventory such as Korean and Turkish, but can also occur in other languages such as a diphthongization process in Chicano Spanish. (See section 2.1.2.)

I hypothesize that *ɨ* is the true empty vowel. This is not saying that it does not contain any acoustic information or is some kind of abstraction. The vowel *ɨ* contains sonority, voicing and can exist as the nucleus of a syllable. It lacks any kind of place specification. It is not composed of any palatality, the tongue does not move forward from a resting position to produce *ɨ*. Nor is it composed of labiality, the tongue does not move back nor is there any lip rounding. Similarly, *ɨ* is not composed of any aperture. The lips and jaw open wide enough to allow the passage of air, but no more. This neutral tongue position is described as featureless in particle phonology and I hypothesize that this position represents the empty vowel. In an X-theory framework this vowel is represented by a nuclear root node that is unassociated with any place feature. This structure will be more fully described below.

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1 In this diagram, particles are indicated by italics.

1.2 Underspecification

Underspecification theory relies on the exploitation of what Archangeli (1984) describes as asymmetries in the distribution of phonological features and rules. The asymmetry refers to the fact that phonological oppositions can often be described by making reference to only one feature. A simple and elegant analysis of tone in Japanese is proposed by Archangeli and Pulleyblank (1984) where only high tone is relevant throughout the derivation although both high and low tones actually surface. Low tones are assigned by redundancy rules to tone bearing units left unmarked for tone after the phonological derivations have finished.

The fundamental assumption of radical underspecification is that only the marked features are phonologically active. Redundancy rules fill in the unmarked features after the derivations.

Archangeli demonstrates the framework by comparing the vowel systems of three languages, Spanish, Japanese, and Telugu, all of which have a five vowel *a, i, u, e, o* inventory. In figure (3), the completely specified feature matrix for this vowel system is given, and it applies to all three languages.

(3)

	i	e	a	o	u
High	+	–	–	–	+
Low	–	–	+	–	–
Back	–	–	+	+	+
Round	–	–	–	+	+

To determine which features are to be left unspecified in underlying representation, the language specific epenthetic vowel must be determined. The features specifying the epenthetic vowel are considered redundant and removed from the underlying representation from all of the vowels in the system. The purpose for choosing this vowel to be completely unspecified is to facilitate the epenthesis process. In this scenario, the epenthetic vowel would be featureless due to its features being unspecified. Epenthesis would involve merely inserting the featureless vowel slot and allowing the redundancy rules to fill in the missing features. The following section will illustrate examples of underspecified matrices.

1.2.1 The Underspecified Matrix

Spanish has a five vowel system consisting of /i, e, a, o, u/. Because the epenthetic vowel is *e*, as is apparent in examples like *estereo* and *especial* in which word initial *sC* is not allowed, its features [-high], [-low], [-back], and [-round] are removed from all five vowels in the system. All of the features of *e* and any vowel sharing the same feature values as *e* are redundant feature values and are thus left blank. The results of this action are given in the matrix in figure (4):

(4)

	i	e	a	o	u
H	+				+
L			+		
B			+	+	+
R				+	+

One might notice that two of the segments that [+back] specifies are also specified by [+round]. This is due to the redundancy between the features [back] and [round], and between [back] and [low]. This allows us to remove one of them from the matrix. We will follow Archangeli and remove [back] from the underlying representation. This is possible because [back] can be completely specified instead by [low] and [round]; any segment that is either [+low] or [+round] is also [+back]. This final result in (5) is the system for Spanish in which all vowels are distinguished and *e* is maximally unspecified:

(5)

	i	e	a	o	u
H	+				+
L			+		
R				+	+

The set of redundancy and complement rules which fill in the values for a fully specified matrix are given in (6). Rule (6a) states, for example, 'for any segments unspecified for [high], insert [–high]'. This would specify *e*, *a*, and *o* as [-high]. Rule (4b) states 'for any segments unspecified for [low], insert [-low]'. This rule specifies *i*, *e*, *o*, and *u* as [-low]. By application of the rest of the rules in (6), all of the missing values are inserted.

(6)
a. [ ] ⇒ [-high]
b. [ ] ⇒ [-low]
c. [ ] ⇒ [-round, +back] / [____, +low]
d. [ ] ⇒ [-round]
e. [ ] ⇒ [α back] / [____, α round, - low]

One might notice that only plus values appear in the underspecified matrix in this case, but this is merely coincidence. When assigned a specification using these features, *e* ends up with a negative specification for all values. A language with a different epenthetic vowel will have different underlying values. The matrix that Archangeli derives for Japanese, for example, assumes an epenthetic vowel of *i*[2] and is given in (7). Although both Spanish and Japanese have the same underlying five vowel inventory, the underlying feature values describing them are quite different due to their different epenthetic vowels.

(7)

	i	e	a	o	u
H		-		-	
L			+		
B				+	+

One characteristic of the underspecification framework is that any epenthetic vowel value, both common epenthetic vowels and uncommon epenthetic vowels can be handled equally well. The framework does not predict nor provide an explanation for which vowels are more likely to be chosen as the epenthetic vowel cross linguistically. It is a general tendency for languages to assign the role of epenthesis to higher, more central vowels. The vowels *i*, *u* and *ə* are common epenthetic vowels cross linguistically. It is also the tendency among languages with an underlying *ɨ*, the most high and central vowel, to utilize *ɨ* as the epenthetic vowel. In Korean, Turkish, and Sarangani Manobo, all languages with *ɨ*, the epenthetic vowel is *ɨ*. A framework like radical underspecification which so crucially depends on the language specific choice of epenthetic vowel for its underlying representation might be expected to account for the cross linguistic tendencies of epenthesis, but it does not.

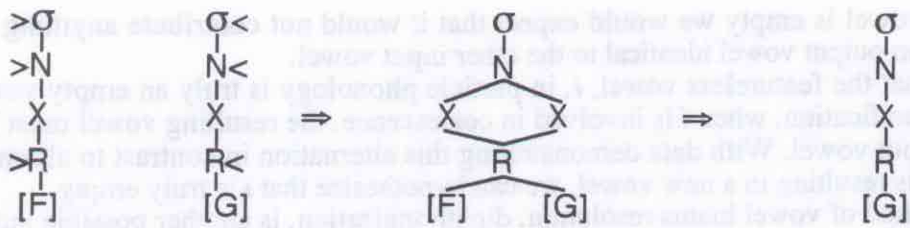
1.3 Vowel Hiatus Structures

In this section I will describe the vowel hiatus structures that will formulate the environment that I will use to test the hypothesis about empty vowels.

Languages tend to avoid vowel hiatus structures. Hiatus is the occurrence of two adjacent vowels belonging to separate syllables. Two vowel hiatus resolution processes are relevant to this study, coalescence and diphthongization. Vowel coalescence resolves hiatus by a process of fusion of the features of each vowel (Schane, 1987). This process is illustrated in (8):

2 Although I disagree with the choice of *i* for the Japanese epenthetic vowel, (*u* is more general) I will follow Archangeli's derivations. In neutral environments the epenthetic vowel is *u*, as in *kurisumasu* 'Christmas'.

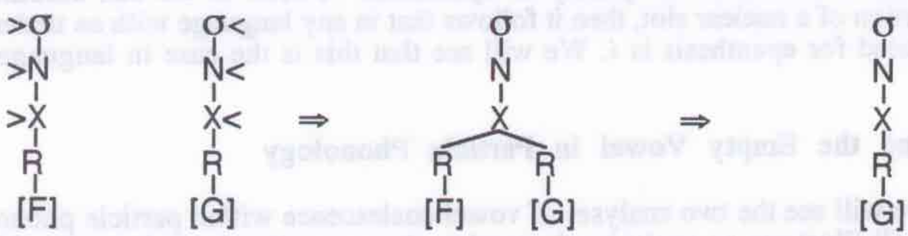
(8)[3]



We are interested in this process because of the information that is contained in the result. This is a set union process and thus certain predictions about empty segments can be tested in a coalescence environment. If, for example, a certain framework treats [F] as a featureless vowel, then we would expect the result of a coalescence of [F] and [G] to result in a vowel quality equivalent to [G] if the vowel specified by [F] is truly empty.

In cases in which vowel hiatus results in diphthongization through the non-fusion of root nodes, as shown in (9), I will draw similar conclusions. If [F] represents the empty set then I will hypothesize that the resulting structure in (9) is phonetically and phonologically equivalent to a monophthong with the features in [G]. These hypotheses will be tested in following sections.

(9)



1.4 Outline of this Study

When an empty segment is involved in vowel hiatus resolution, there are certain results that are expected. I will describe my predictions and proposals in section (2). In section (2.1) I will analyze the predicted results of coalescence in Sanskrit in a particle framework and compare them to the observed data. In section (2.2) I will make a similar analysis in a radical underspecification framework. We can test whether the set union hypothesis for vowel coalescence holds for Korean by analyzing the results of coalescence not involving *ɨ*. If it is a valid hypothesis, then we can test the emptiness of *ɨ* through its behavior during coalescence. In section (3.2) I will look at examples of vowel epenthesis in two languages with an underlying *ɨ*. In section (3.3) I will analyze a feature spread that targets only *ɨ*. I will present language internal evidence in section (3.4), that the *t* in Korean is the empty consonant. Extra evidence for the hypothesis that *t* is empty in Korean can be found in data demonstrating an alternation between *t* and *ɨ* in section (3.5). The final evidence in (3.6) comes from diphthongization data.

2. The Proposal

As previously mentioned in section (1.3) there are two methods of vowel hiatus resolution that could potentially have consequences for a hypothesis about empty vowels. One method, vowel coalescence, has been characterized as the set union of the featural specifications of each input vowel (Schane 1987). It thus follows that a vowel that is the result of vowel coalescence can supply information concerning the featural specifications of the input vowels.

3 In this X-theory structure (Schane 1993) σ represents the syllable node, and N represents the syllable nucleus, or vowel slot. The X is the timing slot, thus a long vowel would be associated with two X slots. The R is the root node which represents the segmental entity itself. A monophthong requires a single R node but a diphthong requires an R node to dominate the particles of each vowel element. Elements between > and < symbols undergo fusion which is the process of combining two units in the same tier into one unit.

If one of the input vowel is empty we would expect that it would not contribute anything to the process resulting in an output vowel identical to the other input vowel.

I hypothesize that the featureless vowel, *ɨ*, in particle phonology is truly an empty vowel. If this is the correct specification, when *ɨ* is involved in coalescence, the resulting vowel must be the same as the other input vowel. With data demonstrating this alternation in contrast to alternations with two non *ɨ* vowels resulting in a new vowel, we can hypothesize that *ɨ* is truly empty.

The second method of vowel hiatus resolution, diphthongization, is another possible indicator of empty vowel segments. The structure of rising diphthongs is an association of the two root nodes of the input vowels to a single X-slot. If either of these input vowels is empty then the the only contribution to the diphthong are the features of the other vowel. I will hypothesize that the resulting structure would be phonetically and phonologically equivalent to a monophthong thus there can be no such thing as a rising diphthong with *ɨ* as an element in any language. I will hypothesize that this distribution can be attributed to the invisibility of the empty root node. An empty root node which shares an X-slot with a non-empty root node is not only phonetically unrealized, but phonological systems will not recognize the existence of the empty root node in any kind of process. Thus a rising (short) diphthong with *ɨ* as an element is indistinguishable from a monophthong and it functions as such.

The third hypothesis concerns the quality of epenthetic vowels. If we can assume that epenthesis is the insertion of a nuclear slot, then it follows that in any language with an underlying *ɨ*, the vowel that is used for epenthesis is *ɨ*. We will see that this is the case in languages like Korean and Turkish.

2.1 Coalescence and the Empty Vowel in Particle Phonology

In this section we will see the two analyses of vowel coalescence within particle phonology. In section (2.1.1) I will illustrate an analysis of vowel coalescence data from Sanskrit. We can make comparisons to a radical underspecification analysis of the same data in section (3). In section (2.1.2) I present an analysis involving diphthongization and an empty vowel.

2.1.1 Coalescence in Sanskrit

This section presents evidence that the process of vowel coalescence is the set unionization of the features of the input vowel. Sanskrit has three short vowels *i*, *a*, *u*, and five long vowels *ī*, *ē*, *ā*, *ō*, and *ū* as the data (DeHaas, 1988) in (10) indicate. Two like vowels coalesce into a long vowel but the coalescence of *a* with either high vowel results in a new set of segments, *ē* and *ō*.

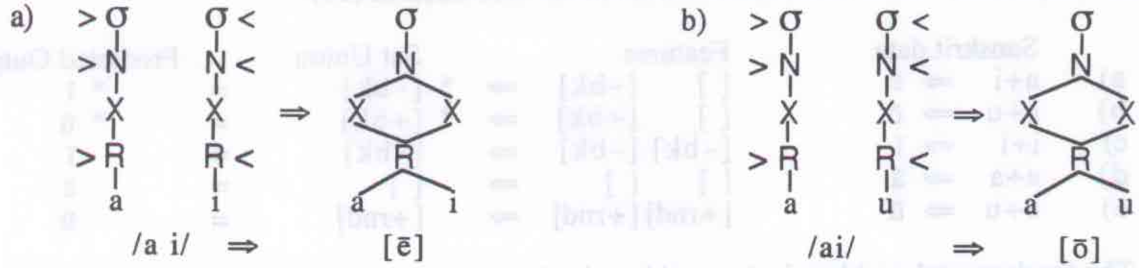
(10)	a+a	⇒	ā	sa ca aprajah ⇒ sa cā prajah	'and he, offspringless'
	i+i	⇒	ī	ati iva ⇒ atī va	'beyond like'
	u+u	⇒	ū	su uktam ⇒ sūktam	'well-spoken'
	a+i	⇒	ē	rāja indra ⇒ rājēndra	'lord of kings'
	a+u	⇒	ō	hita udēsah ⇒ hitōdēsah	'friendly advice'

The particle assignments (Schane 1987) for the Classical Sanskrit system is given in (11). The vowels *i* and *u* each are assigned a single tonality particle, *e* and *o* are assigned a tonality particle and one aperture particle, and *a* is assigned only a single aperture particle.

(11)	vowel:	*i*	*u*	*a*	*e*	*o*
	particle representation:	i	u		i	u
			a	a	a	

The Sanskrit coalescence process proceeds as in (8), the vowel nuclei and the root nodes are fused but the X nodes remain distinct to give the resulting long vowel outputs in (12):

(12)



The particles assigned to the input vowels, when fused, precisely specify the output vowels observed in the data. The particles represent the exact information necessary to account for vowel coalescence.

2.1.2 The Underspecified Matrix in Sanskrit

Because it is not clear which vowel is the Sanskrit epenthetic vowel, any of the three short underlying vowels can be assigned default status in the underspecified matrix. DeHaas (1988) tests a three matrices, each with a different default vowel. In the matrix in (13a), the vowel *i* is given the status of unspecified vowel. The other two vowels are each specified by a single feature. In (13b) *u* is the unspecified vowel and in (13c) the unspecified vowel is *a*. There is no particular impetus for choosing any vowel over the others as the underspecified vowel.

(13)

a.	i	a	u	b.	i	a	u	c.	i	a	u
hi		–		hi		–		hi			
bk				bk	–			bk			
rd			+	rd				rd			+

Testing (13a) by attempting to account for the Sanskrit coalescence data we find that some of the predicted outputs do not coincide with the actual data. The predicted results are given in (14):

(14)	Sanskrit data			Features		Set Union		Predicted Output
a)	a+i	⇒	ē	[-hi] [ ]	⇒	[-hi]	=	* ā
b)	a+u	⇒	ō	[-hi] [+rnd]	⇒	[-hi, +rnd]	=	ō
c)	i+i	⇒	ī	[ ] [ ]	⇒	[ ]	=	ī
d)	a+a	⇒	ā	[-hi] [-hi]	⇒	[-hi]	=	ā
e)	u+u	⇒	ū	[+rnd] [+rnd]	⇒	[+rnd]	=	ū

The Features column gives the features of the two vowels under coalescence. The Set Union column is just that, the two features are coalesced by set union. The Predicted Output is the segment that is specified by the features in the Set Union column.

We see that one of the derivations is not correct; (14a) predicts that the coalescence of *a* and *i* yields *a*, because *i* is specified as the featureless vowel. We might suspect that *i* is the wrong vowel and better predictions might be obtained with a different vowel. Testing the predictions of the matrix in (20b) in which the default vowel is assumed to be *u* we find the output in (15):

(15)	Sanskrit data			Features		Set Union		Predicted Output
a)	a+i	⇒	ē	[-hi] [-bk]	⇒	[-hi, -bk]	=	ē
b)	a+u	⇒	ō	[-hi] [ ]	⇒	[-hi]	=	* ā
c)	i+i	⇒	ī	[-bk] [-bk]	⇒	[-bk]	=	ī
d)	a+a	⇒	ā	[-hi] [-hi]	⇒	[-hi]	=	ā
e)	u+u	⇒	ū	[ ] [ ]	⇒	[ ]	=	ū

Again the results include an incorrect prediction, and again the segment involved is the one which was unspecified. A final attempt to find a working system from the matrix in (13c) in which *a* is the unspecified vowel also leads to errors in the derivation in (16).

(16)	Sanskrit data			Features			Set Union		Predicted Output
a)	a+i	⇒	ē	[ ] [-bk]	⇒	*	[-bk]	=	* ī
b)	a+u	⇒	ō	[ ] [+bk]	⇒	*	[+bk]	=	* ū
c)	i+i	⇒	ī	[-bk] [-bk]	⇒		[-bk]	=	ī
d)	a+a	⇒	ā	[ ] [ ]	⇒		[ ]	=	ā
e)	u+u	⇒	ū	[+rnd] [+rnd]	⇒		[+rnd]	=	ū

The fundamental problem is that at this point in the derivation the features needed to describe the coalescence are not available. One of the characteristics of the underspecification framework is the application of redundancy rules when the necessary features are not available underlyingly.

DeHaas attempts to insert features through application of the redundancy rules in (17) for the matrix in (13a).

(17)				
	a:	[ ]	⇒	[+hi]
	b:	[-hi]	⇒	[+lo]
	c:	[-hi]	⇒	[+bk]
	d:	[+hi]	⇒	[-lo]
	e:	[ ]	⇒	[-bk]
	f:	[ ]	⇒	[-rnd]

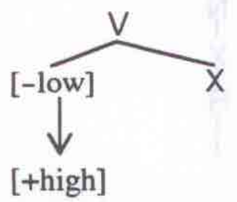
The missing feature required to uniquely specify *i* is [-bk]. This feature value is inserted by the rule in (17e) thus all the features above it must apply before it, in order. Thus (17c) will have already applied specifying *a* as [+bk]. When *i* is assigned [-bk] in [17e], *a* and *i* cannot coalesce because these are now specified by opposite values of the same feature [bk]. We are prevented from attempting to order (13e) before (13c) due to the Elsewhere Condition [4] which requires a more specific rule as in (13c) to be ordered before a more general rule as in (13e). Thus there is no rule ordering that will allow coalescence to proceed. Radical underspecification has failed to account for this simple coalescence data.

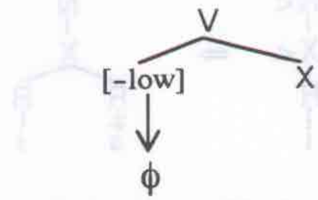
2.1.2 A Case of Diphthongization with an Empty Vowel

The first vowel element in Spanish diphthongs spoken in the Chicano dialect undergo a process whereby mid vowels raise and low vowels delete (Clements and Keyser 1983). Some of the relevant alternations are given in (18).

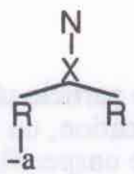
(18) UR	Standard Spanish	Chicano Spanish
i + u	i̯u	i̯u
i + a	i̯a	i̯a
u + i	u̯i	u̯i
u + a	u̯a	u̯a
e + u	e̯u	i̯u
e + o	e̯o	i̯o
e + a	e̯a	i̯a
o + i	o̯i	u̯i
o + e	o̯e	u̯e
o + a	o̯a	u̯a
a + i	a̯i	i
a + u	a̯u	u
a + e	a̯e	e
a + o	a̯o	o

Clements and Keyser propose the two rules in (19) and (20) to account for the Chicano Spanish data. In (14), the Mid Vowel Raising Rule accounts for the standard Spanish *e* and *o* as the first element in a diphthong raising to *i* and *u* respectively in Chicano Spanish. The rule in (20) accounts for the deletion in Chicano Spanish of the Standard Spanish *a* when it is the first element of a diphthong. The process formulating the Chicano Spanish surface form requires two rules which show no similarity or parallelism.

(19) 

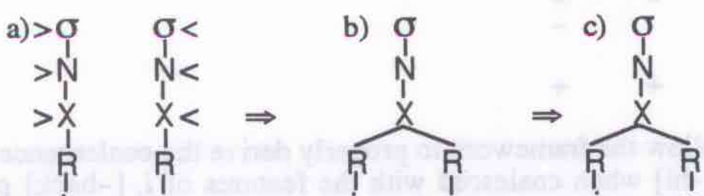
(20) 

The particle phonology framework can, however, capture the process that is occurring in this example. Within this framework, it is evident that the process affecting both low and mid vowels is actually the same process, and it can be described in its entirety with only one rule. This rule, which states 'remove an aperture particle from the first half of a rising diphthong' is given in (21):

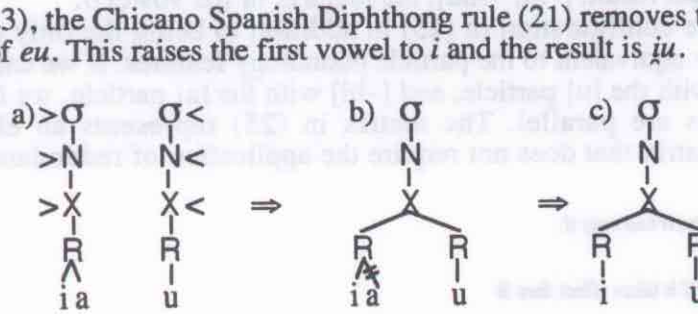
(21) 

This rule applies to any vowel in the first half of a diphthong, not just mid vowels. When the vowel is a high vowel, it applies vacuously because high vowels have zero |a| particles to start with. The rule raises mid vowels to high by the removal of the lone |a| particle. When the first vowel is an *a*, the removal of its aperture particle results in a branching X node dominating two R nodes, one of which is now empty. This structure, I hypothesize, is equivalent to a monophthong and the empty branch is effectively absorbed by the filled branch.

A derivation with an underlying high vowel is illustrated in (22). In (22a), vowels in hiatus trigger diphthongization by fusion down to the X nodes. This is the structure of standard Spanish. In (22b), the Chicano Spanish diphthong rule (21) applies but because the first element, *i*, has no |a| particles it applies vacuously. The resulting diphthong *i̯u* is unchanged from the standard form.

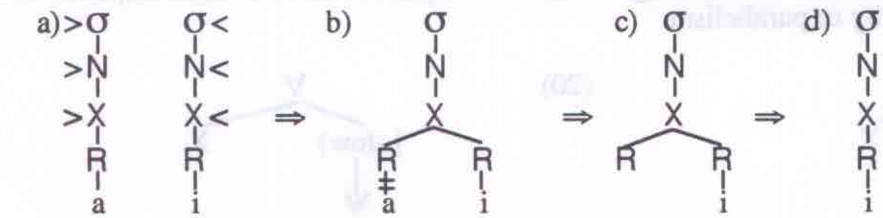
(22)
iu ⇒ i̯u 

In (23), the Chicano Spanish Diphthong rule (21) removes the aperture particle from the first element of *eu*. This raises the first vowel to *i* and the result is *i̯u*.

(23)
eu ⇒ i̯u 

In (24), after diphthongization in a), the application of the Chicano Spanish diphthong to the structure in b) results in the removal of the only particle from *a* leaving an empty root node sharing an X-slot with another root node in c). The resulting structure is functionally equivalent to the monophthong depicted in d).

(24)
ai ⇒ i



Particle phonology is able to capture the entire process smoothly by recognizing that what in a binary feature framework requires two rules is actually one process. This process makes crucial use of empty segments; it does not matter or whether not the empty segments actually surface in the language. We will see below in section (3) that in Korean, a language with an underlying *ɨ*, the generalizations are the same.

2.3 Constraining Radical Underspecification

In the analyses in section (2), we have seen how a constrained system like particle phonology can account for coalescence and diphthongization data. Radical underspecification, on the other hand is unconstrained in the sense that there are few advantages to having the unspecified vowel the epenthetic vowel when epenthesis is not involved. The feature specification of any particular vowel is bound to contain redundant features whose elimination from underlying representation is an advantage for the system. The danger is that non-redundant features may also be removed, as we saw in Sanskrit.

DeHaas attempts to resolve this problem by proposing a minimal underspecification matrix which does not require a completely unspecified vowel. In this framework, *i* would thus be specified for [-bk] underlyingly. Following DeHaas, we can discount Archangeli's radical underspecification framework and assume a less powerful minimal underspecification in which all vowels can be specified. By assuming the underlying values in (25), vowel coalescence is free to apply without requiring any redundancy rules.

(25)

	i	e	a	u	o
hi		-	-		-
bk	-	-			
rnd				+	+

These feature specifications allow the framework to properly derive the coalescence of *a* + *i* and of *a* + *u*. The features of *a*, [-hi] when coalesced with the features of *i*, [-back] properly derives [-hi, -back], the features of the vowel *e*. Similarly, the derivation of the coalescence of *a*, [-high] and *u*, [+rnd] gives the correct result, [-hi, +rnd], the features of the vowel *o*.

It is interesting to note that the configuration in (25) in addition to being the only one that yields the correct results, is actually equivalent to the particle phonology features. If we can equate [-bk] with the |i| particle, [+rnd] with the |u| particle, and [-hi] with the |a| particle, we find that the processes in both frameworks are parallel. The matrix in (25) represents an efficient, constrained feature specification matrix that does not require the application of redundancy rules

4 Elsewhere Condition:
Rules A and B in some component apply disjunctively, if and only if:
a. The output of A is a proper subset of the input of B
b. The output of A and B are distinct.
In that case A (the particular rule) applied first, and if it takes effect then B (the general rule) is not applied. (Kiparsky, 1984)

until the derivations are complete. Similar to the particle analysis of Chicano Spanish diphthongs, only a single rule in (26) is necessary to account for the alternations.

(26) $[\text{-hi}] \Rightarrow [\ ]$

An underspecification framework thus must utilize minimal underspecification in order to maximize its ability to remove only redundant features from underlying representation. It is then that the framework is functionally equivalent to the particle framework. It still must, however, insert redundant features through redundancy rules. The particle framework does not need anything like a redundancy rule; the framework is an inherently constrained type of underspecification.

3. A Case Study: Korean

In this section I will analyze the *ɨ* in Korean under a particle framework. I will perform tests to determine the type of coalescence that occurs in Korean and what happens when *ɨ* is one of the coalescing vowels. I will look at epenthesis in Korean and in Turkish to determine the value of the epenthetic vowel and how it is affected by harmony processes. There is consonant-vowel harmony process in Korean whereby *ɨ* assimilates to the place of the preceding consonant. I will present evidence that there is a counterpart to *ɨ* in the consonant space; *t* behaves as if it too is an empty segment. This is further corroborated by evidence that there is an alternation between *t* and *ɨ*. Finally, the structure of diphthongs in Korean and the behavior of *ɨ* in these structures is analyzed.

3.1 Vowel Coalescence

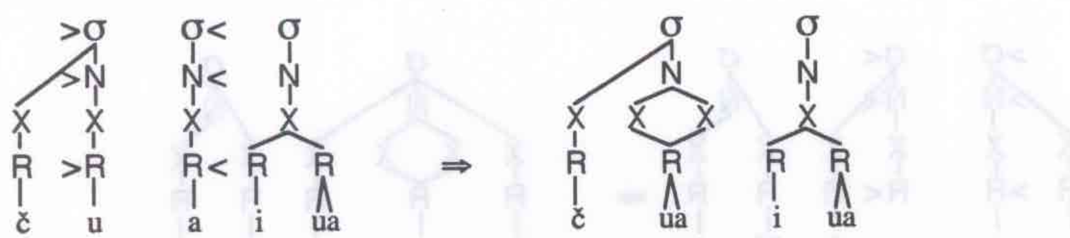
Figure (27) is a chart of the Korean vowel inventory and the corresponding particle representations.

(27)

ɨ	*i*	*u*	*ə*	*e*	*o*	*a*	*ɛ*	*ü*	*ö*
	i	u		i	u		i	i	i
			a	a	a	a	a	u	u
						a	a		a

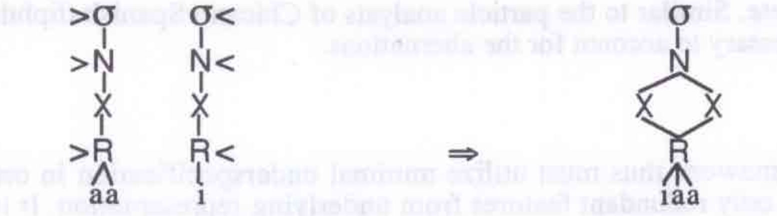
Similar to the Sanskrit data, there are cases of vowel hiatus resolution through coalescence. We find that the coalescence follows the feature fusion process of (8). In the example in (28), the vowels *u* and *a* are in hiatus and coalesce. The resulting vowel surfaces with the expected quality of combining both features of the input vowels, that is, *u a* ⇒ *o:*. In (31), the process is *a i* ⇒ *ɛ:* and in (32) *u i* ⇒ *ü:*. In each of these cases, the particle phonology approach accounts for the facts in a straightforward and principled way.

(28)



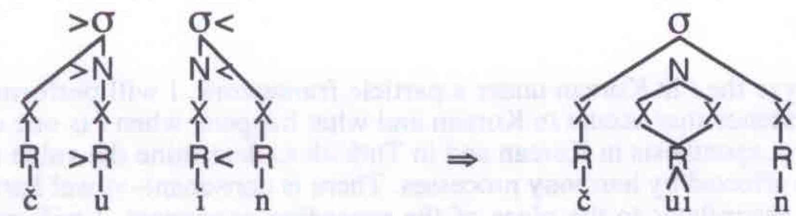
/čuəi̯o/ ⇒ [čo:i̯o] 'to give (polite)'

(29)



/ai/ ⇒ [ɛ:] 'child'

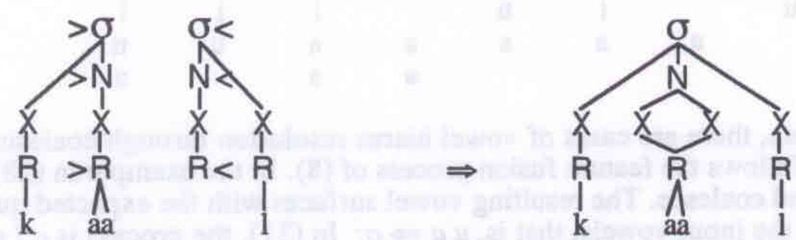
(30)



/čuin/ ⇒ [čü:n] 'owner'

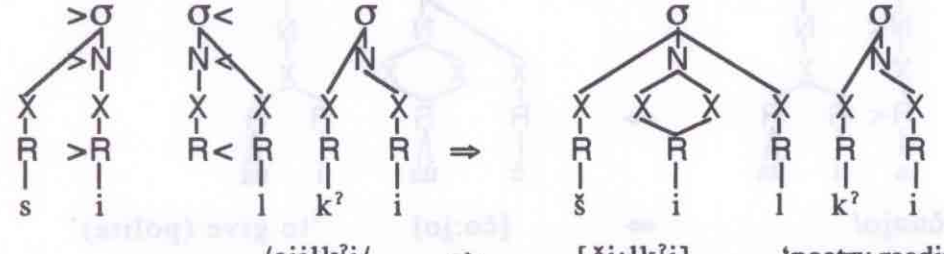
The following three derivations in (31–32) demonstrate the results of vowel coalescence with *ɨ* as an element. In all cases the result of coalescence with *ɨ* is a vowel with the same quality as the other input vowel. In (31) the coalescence involves *ɨ* and *a*. The resulting vowel is *a:* and not some mid vowel such as *ə:*. In (32) *i* and *ɨ* coalesce to derive the resulting *i:*. In (33) and (34) the coalescing pairs are *ɨ o* and *ɨ ɛ:* respectively, and in neither case is the result a vowel located midway between the two coalescing vowels, but is equal in quality to the other vowel. Data is from Kim-Renaud (1986).

(31)



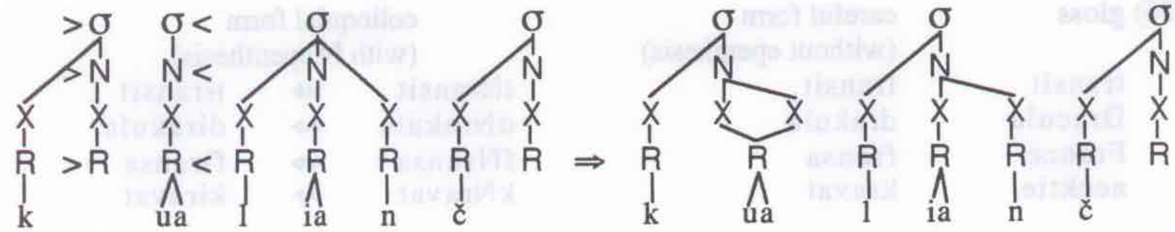
/kaɨl/ ⇒ [ka:l] 'autumn'

(32)



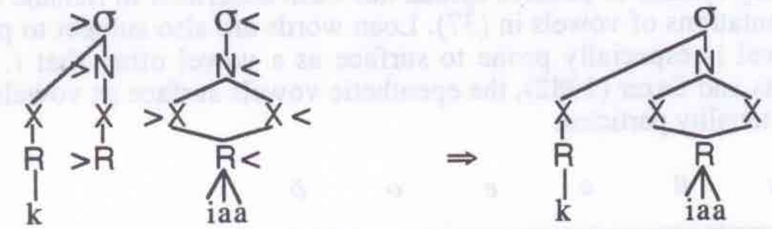
/siɨlk^{ʔ}i/ ⇒ [ši:lk^{ʔ}i] 'poetry reading'

(33)



/kɨ olenčɨ/ ⇒ [ko:lenči][5] 'that orange'

(34)



/kɨɛ:/ ⇒ [kɛ:][6] 'that child'

3.2 Epenthesis

In this section we will look at data demonstrating the tendency for languages with *ɨ* to utilize that vowel for epenthesis. In Turkish the epenthetic vowel is subject to subsequent vowel harmony rules. In Korean the epenthetic vowel by virtue of its emptiness is subject to harmonies that do not occur with any other vowels.

3.2.1 Nucleus Insertion

The Korean syllabification algorithm allows for CVC syllables with only *l*, nasals, and lenis stops in the coda. The Korean syllable is more restricted that the English syllable and any borrowings from English must be altered to fit the syllable structure. The most common violation is consonant clusters which are broken up by epenthesis. Figure (35) lists some English borrowings and the deep and surface forms. In all cases syllabification proceeds through the epenthesis of empty N (nuclear) slots which surface as *ɨ*.

(35) English source	Nucleus Insertion	Surface Structure
blues	pNllusN	pɨllusɨ
Christmas	k^{h}NlisNmasN	k^{h}ɨlisɨmasɨ
drive	tNlaibN	tɨlaibɨ
plastics	p^{h}NllasNt^{h}iksN	p^{h}ɨllasɨt^{h}iks$^?$ɨ
skate	sNk^{h}eit^{h}N	sɨk^{h}eit^{h}ɨ
smooth	sNmutN	sɨmutɨ
Sphinx	sNp^{h}iŋk^{h}NsN	sɨp^{h}iŋk^{h}ɨsɨ
strike	sNt^{h}Nlaik^{h}N	sɨt^{h}ɨlaik^{h}ɨ

We find similar patterns on Turkish, a *ɨ* language. The data in (36, next page) are examples of borrowings with epenthesis (Clements and Sezer, 1982). In colloquial speech, epenthesis breaks up illegal consonant clusters. As in Korean, the epenthetic vowel surfaces as *ɨ*.

5 The epenthetic vowel inserted word finally surfaces as *i* due to spread of features from *č*. This process is described in section (3.2).

6 Syllables with triple length vowels are not allowed, invoking fusion of the X-slots of the input long vowel.

(36) gloss	careful form (without epenthesis)			colloquial form (with N epenthesis)
transit	transit	tNransit	⇒	tɨransit
Dracula	drakula	dNrakula	⇒	dɨrakula
France	fransa	fNransa	⇒	fɨransa
necktie	kravat	kNravat	⇒	kɨravat

3.1.2 Vowel Harmony

The Turkish vowel harmony system of particle spread has been described in Schane (1984) and derives the particle representations of vowels in (37). Loan words are also subject to particle spread and the epenthetic vowel is especially prone to surface as a vowel other that *ɨ*. In the examples in (38) from Clements and Sezer (1982), the epenthetic vowels surface as vowels other than *ɨ* due to leftward spread of tonality particles.

(37)	*ɨ*	*i*	*u*	*ü*	*a*	*e*	*o*	*ö*
		i	u	i u	a	i a	u a	i u a

(38) gloss	careful form (without epenthesis)	colloquial form (with epenthesis)	particle spread
a) prince	prens	pirens	i
b) announcer	spiker	sipiker	i
c) Prussia	prusya	purusya	u
d) protest	protesto	purotesto	u
e) transit	transit	tɨransit	none
f) France	fransa	fɨransa	none

In each case, after an empty nuclear slot is inserted, a tonality particle from the closest underlying vowel spreads left into the epenthetic vowel. In (38 a and b) an |i| particle spreads left while in (38 c and d) it is a |u| that spreads. In (38 e and f) because the leftmost underlying vowel contains no tonality particle, the epenthetic vowel surfaces as *ɨ*.

3.3 Vowel and Consonant Harmony

Returning to Korean, we find that, in addition to loanwords, vowel epenthesis also occurs in verb conjugations. Consider the data in (39).

(39)	stem		polite	infinitive
a.	nanu~	'to divide'	nanuəi̯o	nanuta
b.	k^hi~	'to light'	k^hiəi̯o	k^hɨta
c.	k^h~	'to grow'	k^həi̯o	*k^hta ⇒ k^hɨta
d.	t^h~	'to break'	t^həi̯o	*t^hta ⇒ t^hɨta

In these examples the polite suffix *~əi̯o* and the infinitive suffix *~ta* are attached to the verb stems. However, the attachment of *~ta* to the stems in (39. and d.) results in an disallowed onset consonant cluster and is broken up by epenthetic *ɨ* [7].

7 We could have analyzed these alternations as the deletion of an underlying *ɨ* in derived environments adjacent to a vowel but this would leave the question as to why this hiatus resolution results in a short vowel whereas underlying *ɨ* hiatus results in a long vowel. With this analysis we can follow the observation (Kim, 1986) that *ɨ* never occurs morpheme finally in underlying representation (in native morphemes). There is a second parallel to this observation that *ɭ*, which I will analyze as the empty consonant in section (3.4), also rarely occurs morpheme finally.

The data in (40) however seem to refute the hypothesis that *ɨ* is the empty epenthetic vowel in Korean. We find *i* and *u* appearing in the epenthetic vowel insertion environment. We must rule out vowel harmony as an explanation to account for the apparent anomaly; the environments following the vowels in question are identical.

(40)	stem		polite	infinitive
a.	č~	'to carry'	čəi̯o	*čta ⇒ čita
b.	čʰ~	'to steam'	čʰəi̯o	*čʰta ⇒ čʰita
c.	pʰ~	'to scoop'	pʰəi̯o	*pʰta ⇒ pʰuta

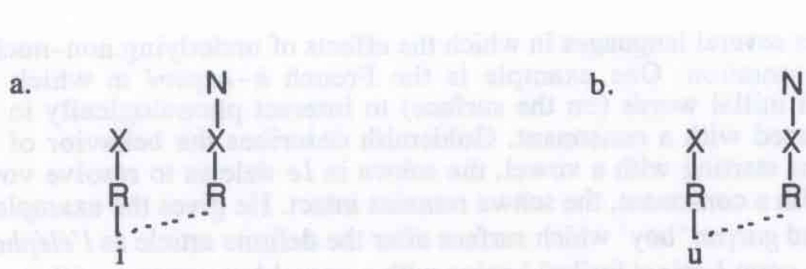
An analysis of the phoneme sequences of Korean reveals a surprising fact; *ɨ* rarely occurs following labial or palatal consonants in the native Korean lexicon. Is there something blocking *ɨ* from occurring after palatal and labial consonants? We cannot claim an OCP violation because *ɨ* has no feature to conflict with those of the consonant. We can claim, however, that the place feature from the consonant spreads to the empty epenthetic vowel slot. Thus palatality can spread from a consonant to an empty nuclear root node to convert it to /i/, and labiality can spread from a consonant to an empty nuclear root node to convert it to /u/.

Clements (1989, 1991) describes various interactions between consonants and vowels cross linguistically and proposes a set of features common to both consonants and vowels to allow straightforward accounting for this type of data. Among the features he proposes, his labial and palatal are of most interest to us here. Following Clements, I will claim that the feature specifying palatality for consonants and vowels is the same feature particle |i|, and similarly the feature specifying labiality for consonants and vowels is the same feature particle |u|. The data in (41) indicates that palatals only have interaction with /i/ and labials only have interaction with /u/. When these are paired with the opposite counterpart there is no interaction.

(41)	stem		polite	infinitive
a.	pʰi~	'to bloom'	pʰi̯əi̯o	pʰita
b.	ču~	'to steam'	čuəi̯o (čo:i̯o)[8]	čuta

The spreading rule on the next page in (42a. and b.) can account for the distribution of *ɨ* which occurs after all consonants except the palatal series / č, čʰ, čˀ / and the labial series / p, pʰ, pˀ, m /. An |i| or |u| particle spreads right into an empty nuclear root node. Notice that this rule spreads these particles only into empty slots, no other vowel besides *ɨ* is the target for this spread. This would preclude the sequence of labial consonant (*p, pʰ, pˀ, m*) followed by *ɨ* and the sequence of a palatal consonant (*č, čʰ, čˀ*) followed by *ɨ* from ever occurring in the native lexicon. Any underlying occurrence of this sequence would be masked by assimilation from the rightward spread of tonality particles into empty nuclear root node. In the modern language both sequences are rare in the native lexicon. The palatal + *ɨ* sequence is common in the Sino-Korean lexicon, however. In modern loanwords from English, the labial + *ɨ* sequence is common, but the palatal + *ɨ* sequence is not.

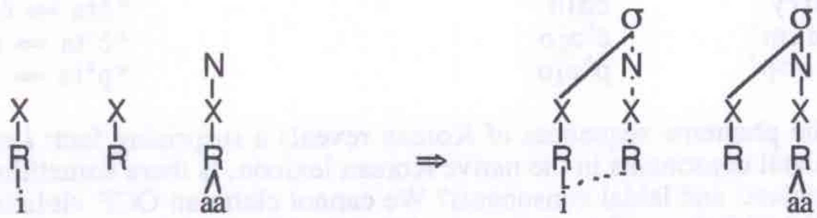
(42)



[8] For reasons that are still as yet unclear, palatals tend to trigger coalescence over diphthongization.

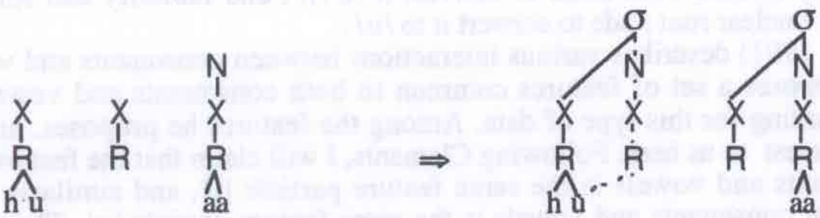
In (43) the derivation for [čita] is given. The consonant *č* is represented by the |i| particle under a non-nuclear X slot. The consonant *t* is represented by an empty X slot (to be discussed in the following section). The epenthetic nuclear slot is inserted to allow proper syllabification and particle spread follows. In (44) a similar derivation is given for [pʰuta]. The consonant *pʰ* is represented by a |u| particle and an aspiration |h| particle (see consonant particle chart in (49)).

(43)



/čta/ ⇒ [čita] 'to carry'

(44)



/pʰta/ ⇒ [pʰuta] 'to scoop'

(45)

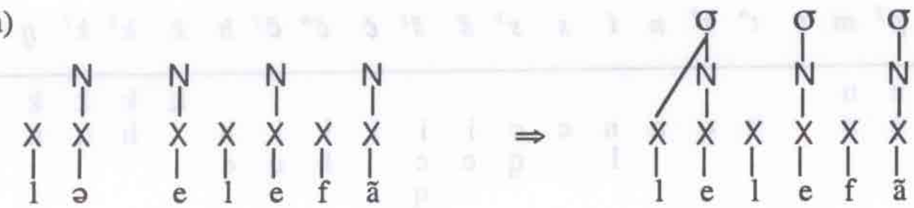
/olenč/ ⇒ [olenči] 'orange'

In (45) we can see evidence that |i|-spread to an empty nuclear slot is still an active process. An epenthetic vowel must be attached word finally in 'orange' for proper syllabification and that vowel surfaces as *i*.

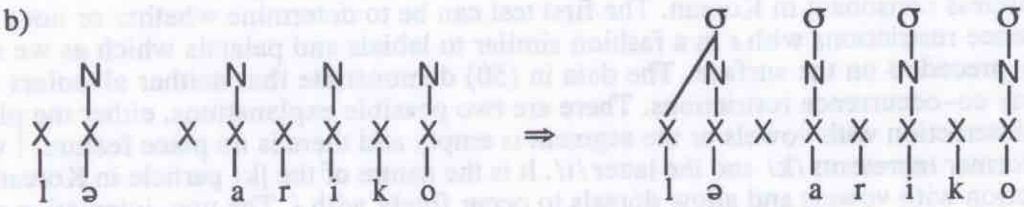
3.4 Empty non-nuclear slots

Goldsmith (1990) describes several languages in which the effects of underlying non-nuclear slots affect the surface representation. One example is the French *h-aspiré* in which the unassociated slot causes vowel initial words (on the surface) to interact phonologically in the language as if these words started with a consonant. Goldsmith describes the behavior of the definite article *le*. Before nouns starting with a vowel, the schwa in *le* deletes to resolve vowel hiatus. Before nouns starting with a consonant, the schwa remains intact. He gives the example of the nouns *éléphant* 'elephant' and *garçon* 'boy' which surface after the definite article as *l'éléphant* and *le garçon* respectively. The noun *haricot* [ariko] begins with a vowel but patterns with nouns beginning with a consonant in its surface form after a definite article *le haricot*. He argues that there is an empty consonant slot located between the vowels preventing hiatus and thus preventing the schwa from deleting.

(46 a)



b)



In French this unassociated slot does not surface with any phonetic content. In Korean, however, there is evidence that an empty non-nuclear slot does actually surface with phonetic content. In a manner parallel to the vowel feature structure, I will argue that there is a consonant that exists without any features in the center of the Korean consonantal space, namely *t*.

3.4.1 Empty Underlying Consonants

Previous analyses of Korean consonants under an underspecificational approach (Iverson and Kim, 1987; Kim, 1987; Sohn, 1987; Chung, 1990) have reached a similar conclusion but must resort to redundancy rules to respecify the features of *t*. I will claim, however, that in a unary particle feature framework, it can be shown that *t* is in fact underlyingly empty and surfaces as a different segment only in the case when it is the target of particle spread.

The chart in (47) represents the Korean consonantal phonemes. The distinctive features that are assigned are given in (48). These are all unary features, loosely based on Clements (1991). In continuing with the spirit of particle phonology I assign single letter representations. Each consonant and its particle representation is given in (49, next page).

(47)[9]

	labial	alveolar	palatal	dorsal
lenis stops	p	t	č	k
aspirated stops	p^h	t^h	$č^h$	k^h
glottalized stops	$p^?$	$t^?$	$č^?$	$k^?$
nasals	m	n		ŋ
liquid		l		
continuants		h, s, $s^?$	š, $š^?$	

(48)

lenisity	=	(null)	labiality	=	u
aspiration	=	h	alveolarity	=	(null)
glottalization	=	q	palatality	=	i
nasality	=	n	dorsality	=	k
liquidity	=	l			
continuancy	=	c			

9 The segments *š* and *š*$^?$ are not underlying and occur only as the result of left |i| spread from *i* or *į*.

(49)[10]

p	p^h	$p^ʔ$	m	t	t^h	$t^ʔ$	n	l	s	$s^ʔ$	$š$	$š^ʔ$	$č$	$č^h$	$č^ʔ$	h	k	k^h	$k^ʔ$	$ŋ$
u	u	u	u														k	k	k	k
	h	q	n		h	q	n	n	c	c	i	i	i	i	i	h		h	q	n
								l		q	c	c		h	q	c				
												q								

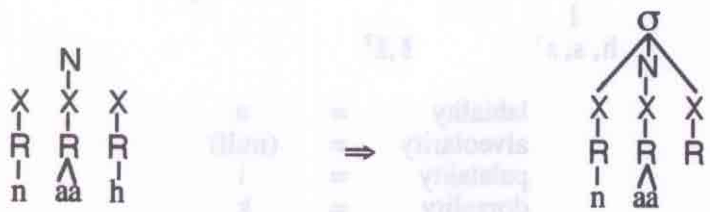
There is ample internal phonological evidence that can be found that points to the conclusion that *t* is a featureless consonant in Korean. The first test can be to determine whether or not *t* has any co-occurrence restrictions with *ɨ* in a fashion similar to labials and palatals which as we saw do not directly precede *ɨ* on the surface. The data in (50) demonstrate that neither alveolars nor dorsals have any co-occurrence restrictions. There are two possible explanations, either the place feature has no interaction with vowels or the segment is empty and there is no place feature. I will claim that the former represents /k/ and the latter /t/. It is the nature of the |k| particle in Korean to have no interaction with vowels and allow dorsals to occur freely with *ɨ*. The non-interaction of *t* with *ɨ* is attributed to the emptiness of both segments.

(50) tɨtta	'to listen'	nɨkɨshata	'to be enough"
$t^ʔ$ɨtta	'to copy'	$s^ʔ$ɨta	'to write'

The set of obstruents that can occur in the syllable coda on the surface is limited to *p*, *t*, and *k*. The complete set of alveolar and palatal obstruents / t^h, $t^ʔ$, s, $s^ʔ$, č, $č^h$, $č^ʔ$, h / reduce to *t* when they surface in the coda. This can be accounted for by claiming that the |h|, |q|, |i|, and |c| particles delink in the coda and that alveolars have an empty place specification. Examples of these reductions are given in (51). The *i* appearing in the example is the subject particle (postposition). With the subject particle suffixed to the noun, the final consonant is syllabified in the onset and particle delinking does not occur. Notice that the same |i| particle that spreads from palatals to *ɨ* to form the vowel *i*, spreads from underlying vowel *i* back to underlying alveolars in (51 a and d). We thus have a bidirectional palatalization process; the vowel *i* palatalizes onsets unspecified for place (alveolars) and palatal onsets palatalize empty vowels (*ɨ*) by |i| particle spread. The two complete processes of (51a) are illustrated in (52, 53).

(51a)	/nat^h/	⇒	[nat]	'piece'	/nat^h	+ i/	⇒	[na$č^h$i]
b)	/nač/	⇒	[nat]	'daytime'	/nač	+ i/	⇒	[nači]
c)	/na$č^h$/	⇒	[nat]	'face'	/na$č^h$	+ i/	⇒	[na$č^h$i]
d)	/nas/	⇒	[nat]	'sickle'	/nas	+ i/	⇒	[naši]

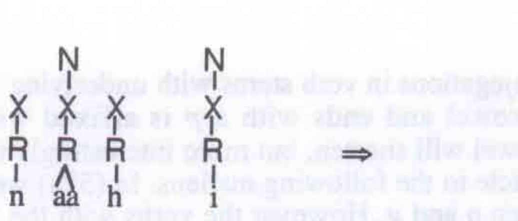
(52)



/nat^h/ ⇒ [nat]

[10] The motivation for these particle representations are described in Dodero (1992).

(53)



/nat^{h}i/ ⇒ [nač^{h}i]

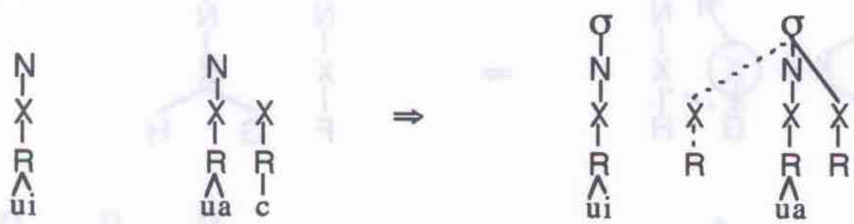
After a coda coronal obstruent reduces to *t*, the place feature of a following onset consonant will spread left into the empty coda. This process also glottalizes underlyingly lenis onset consonants. As one might expect due to the tendency of nasals to assimilate to the place of following consonants in general, this spread also occurs with the featureless nasal (*n*) as the target coda consonant. Examples are given in (54):

(54a) i̯etpota⇒i̯eppˀota 'to peep' pitko⇒pikkˀo 'to comb and...'
b) sinmi⇒simmi 'spicy' i̯ənku⇒i̯əŋku 'research'

There is a rule that inserts an epenthetic consonant between morphemes in certain compounds. In an intervocalic environment these will surface as /t/. In other environments the previous rules concerning consonants will apply. In (55) the consonant is inserted between vowels and surfaces as *t*. In (56) the epenthetic consonant triggers glottalization of the following *k* and the consonant itself is a target of spread of the |k| particle. Note that the resulting sequence is not a geminate but an unreleased lenis *k* followed by a glottalized *k*. Onset lenis obstruents are automatically glotallized after any coda obstruent.

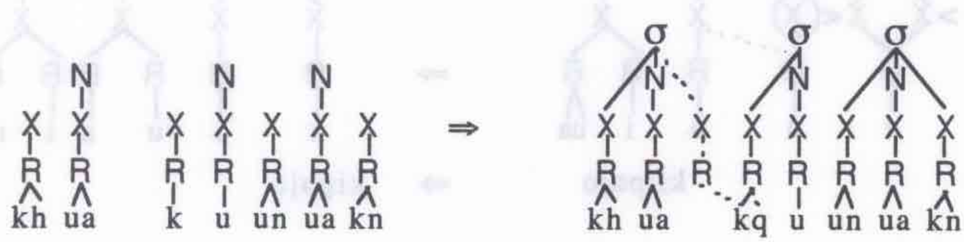
Thus if it can be assumed that consonant epenthesis is a process of inserting an empty non-nuclear X slot and, as we have seen, this slot behaves as a *t*, we can assume that *t* is the empty consonant. I will thus hypothesize that not only does *t* function as the underspecified default consonant in Korean, but it is actually an empty segment. In a following section we will analyze data that suggest that the alternations *p~u* and *t~ɨ* exist in Korean. These come about through the formation of diphthongs.

(55)



/ü + os/ ⇒ [ütot] 'upper + clothes' ('over clothes')

(56)



/k^{h}o + kumoŋ/ ⇒ [k^{h}okkˀumoŋ] 'nose + hole' ('nostril')

3.5 The *t* ~ *ɨ* Alternation

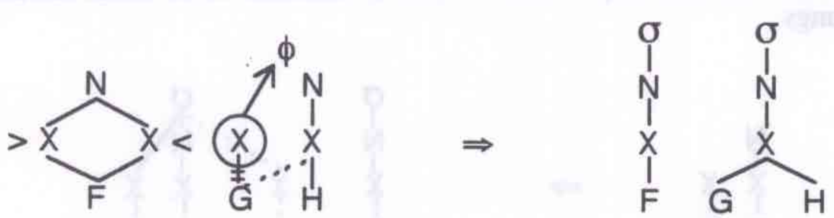
The final piece of evidence comes from verb conjugations in verb stems with underlying long vowels. When a verb stem that includes a long vowel and ends with a *p* is affixed with a conjugational suffix two processes occur. One, the vowel will shorten, but more interestingly the *p* weakens to a *u* through the reassociation of the *u* particle to the following nucleus. In (57a) we see that with a short vowel, there is no alternation between *p* and *u*. However the verbs with the long vowel in the stem in (57b and c) have a *p* that alternates with *u* when the affix starts with a vowel.

(57)	stem	~əi̯o	~ta	
a)	kup	kupəi̯o	kupta	'to be bent'
b)	ku:p	kuu̯əi̯o	ku:pta	'to bake'
c)	ki:p	kiu̯əi̯o	ki:pta	'to mend'
d)	kət	kətəi̯o	kətta	'to fold'
e)	pu:t	puəi̯o (pu̯əi̯o)	pu:tta	'to pour'
f)	i:t	iəi̯o (i̯əi̯o)	i:tta	'to connect'

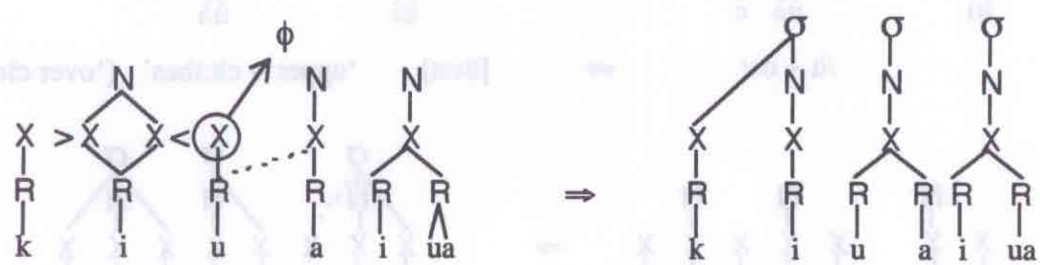
The situation in (57d) is similar to (57a); the short stem vowel precludes consonant to vowel alternations. In (57e and f), the environment is met for the consonant to vowel alternation. In this case, however, *t* is alternating with emptiness.

The schematic process is given in (58). This process can account for both the *p* stems (59) and the *t* stems (60). In (59) the |u| particle spreads from a non-nuclear to a nuclear slot. In (60) the process attempts to spread emptiness. The result of this spread in (60) is an X-slot dominating two root nodes, one of which is empty. This structure is equivalent to the monophthong ə. The X-slot is deleted and no trace of the original *t* remains. In (59) the |u| particle specifying the *p* is realized as *u̯* by the reassociation of its dominating root with the following nuclear X-slot. In (60, next page) the reassociation of the empty root node to the following nuclear X-slot results in an effective monophthong.

(58)

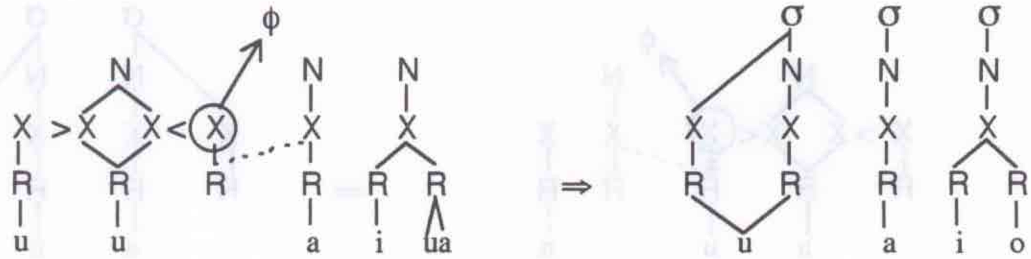


(59)



ki:pəi̯o ⇒ kiu̯əi̯o

(60)



pu:təjo ⇒ puəjo [11]

3.6 A Universally Non-Existent Diphthong

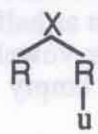
Figure (61) lists the set of rising diphthongs in Korean, in none of which is ɨ an element.

(61) i̯e i̯ɛ i̯ə i̯a i̯u i̯o
u̯i u̯e u̯ɛ u̯ə u̯a

One might argue that this distribution could be attributed instead to coincidental structural gaps or naturalness of rising diphthongs with elements of *i̯* or *u̯*. However Donegan (1978), in her early vowel analysis which utilizes the same three particle features, shows no evidence of the existence in any language of any rising diphthongs with ɨ as an element.

It is predicted from this analysis that rising diphthongs (diphthongs filling a single X-slot) with ɨ as an element do not exist. In a structure in which an X-slot is associated with an empty root node and a filled root node as in (62), the empty root node would not contribute any phonological information to the X-node. This results in a monophthong, in this case [u].

(62)



Because it is posited that ɨ is the empty vowel, the hypothetical diphthong *ɨ̯u* would appear as the structure in (62). Thus it is hypothesized that no rising dipthongs (of single X length) can contain ɨ as element (in both the initial and second position) for the result would be a monophthong. This can be illustrated with the following example.

Adjective stems are also subject to the same process as the verbs above. The suffix that attaches to an adjective when it modifies a noun is *ɨn*. Using the adjective *tə:pta* 'to be hot', the underlying form of 'hot weather' is /tə:pɨn nalsˀi/. The derivation in (63) indicates the surface form [təun]. This is significant because we have what we know is an underlying ɨ. If the hypothesis that rising diphthongs cannot contain ɨ as an element were incorrect, we would expect a surface form of **u̯ɨ* here. But since the hypothesis holds whether we begin with an empty nuclear X-slot (which we hypothesize is equivalent to ɨ) or whether we begin with a ɨ (which is hypothesized to be equivalent to an empty nuclear X-slot) we can be fairly certain that ɨ is truly empty and that it cannot be an element of a rising diphthong.

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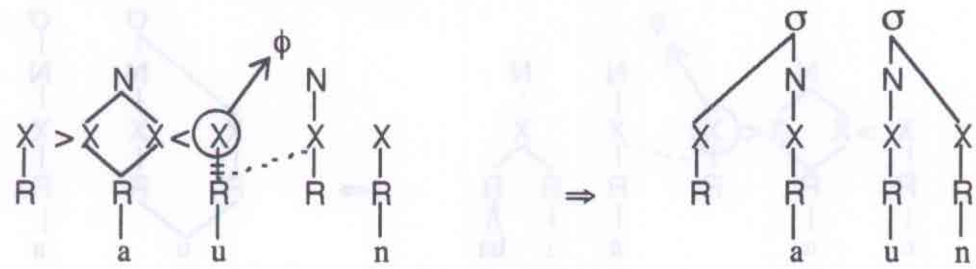
[11] The resulting vowel hiatus gives rise to diphthongization in the alternate form *pu̯əjo*.

(63)



/tə:pɨn/ ⇒ [təun]

These data thus demonstrate the parallelism between the consonants and vowels. Located in the vowel space midway between /u/ represented by the particle |u|, and /i/ represented by the particle |i|, we have the location of the featureless vowel /ɨ/. Similarly, located in the consonant space midway between /p/ represented by the particle |u|, and /č/ represented by the particle |i|, we have the location of the featureless consonant /t/. Thus it appears to be possible to divide the consonant space in a fashion similar to vowels. In Korean, the opposition between the |i| particle and the |u| particle that is apparent in the vowel space is preserved in the consonant space.

4. Conclusion

We have seen the predictions that two different phonology frameworks make concerning the status of empty segments. Emptiness must be measured in terms of universal alternations and not of language specific convenience. The act of assigning emptiness to a feature for the purpose of handling a particular phenomenon such as epenthesis has repercussions for the entire grammar. The underspecification framework does just that, it assigns emptiness for the convenience of epenthesis. Particle phonology, on the other hand, takes advantage of observations of universals; *ɨ* behaves as an empty segment would be expected to behave. In coalescence processes, *ɨ* does not contribute any features to the result, nor can it exist as half of a rising diphthong. It is a vulnerable target of particle spread, more so than any other vowel. While other vowels can be used for epenthesis, those vowels do not behave like an empty vowel in other processes in the same language.

The data presented here concerning the behavior of *ɨ* suggest that particle phonology is a more efficient framework; it assigns emptiness in a manner parallel to the assignment of emptiness in language as a universal. It is constrained; features required for derivations are always available. It does not require redundancy rules; its usage of unary features precludes the existence of redundant features which can block derivations. It parallels the nature vowel sounds; its featureless vowel is in fact the universal empty vowel.

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