The fundamentals of particle phonology

Sanford A. Schane
University of California, San Diego

Particle phonology has evolved from a dissatisfaction that I experienced working within the current theoretical and notational framework of generative phonology. I had been looking at historical processes affecting vowels and diphthongs. In trying to describe the kinds of changes undergone by these entities, I was particularly frustrated by the inability of the standard notation to characterise in any enlightening way the internal structure of vowels, as well as relationships evident between particular vowels and diphthongs. The first difficulty – the nature of the internal structure of vowels – was not simply due to an inadequate set of distinctive features. Rather, the problem resided in the very notion of features as autonomous building blocks out of which segments are composed. This view contributed partially to the other difficulty – the expression of relationships between vowels and diphthongs. An additional factor to this problem came from restrictions of the notation in regard to what could appear to the left and to the right of an arrow. The notation forced me to formulate rules whose statements often did not accord with my conception of the nature of the processes. It seems to me that a highly-valued notational system should have the property that I have come to call 'mirroring'. If one believes that a process or change happens in a certain way, then the notation should not just describe that event but should reflect as closely as possible its manner of occurrence.

Let me illustrate what I mean by 'mirroring'. The palatalisation of a consonant in the vicinity of a high front vowel is generally viewed as the assimilation onto the consonant of certain properties of the vowel. It is this relationship between the 'palatalised' aspect of the consonant and the 'palatalising' environment of the vowel that we wish to record. Chomsky & Halle (1968: 305–308), in discussing their vowel features, note how these features describe secondary articulations in consonants. They compare their treatment of palatalisation, which utilises the features [+high, −back], with the older feature [+sharp]. The rules of (1) state that a consonant is palatalised before a high front vowel. Rule (1a) requires independent, unrelated features; (1b) does not.

(1) a. $C \rightarrow [+\text{sharp}] / \text{—} \begin{bmatrix} \text{V} \\ +\text{high} \\ -\text{back} \end{bmatrix}$ b. $C \rightarrow \begin{bmatrix} +\text{high} \\ -\text{back} \end{bmatrix} / \text{—} \begin{bmatrix} \text{V} \\ +\text{high} \\ -\text{back} \end{bmatrix}$

Although both rules are sufficient for describing palatalisation, the second is more revealing of the assimilation process to the extent that there is a direct mirroring between the 'palatalised' features and the 'palatalising' environment.

For this particular example, the notation of generative phonology mirrors the nature of the process, and I believe it is fair to say that generative phonology has considered mirroring to be one of the goals of its notation. However, there are many phenomena affecting vowels and diphthongs where the notational conventions and the associated set of distinctive features fail to reveal how the entities participate in those events.

Particle phonology is a radically different way of describing vowels and diphthongs – their internal structures, their interrelationships, and their evolution and change. The presentation is organised as follows. In §1, I discuss the purpose and the components of a phonological notation. In §2, I introduce the elements and descriptive devices of particle phonology and I present the particle representations of vowels and diphthongs. In §3, I look at different types of phonological processes and I show how they are accommodated within particle notation. In §4, I take up the important issue of 'mirroring', where I examine various inadequacies of the standard notation and demonstrate how particle phonology overcomes these. In §5, I consider special aspects of particle phonology that have no correlates in the standard notation, and I show how particle analysis provides new interpretations of phonological change. In §6, I contrast particle phonology with the standard framework.

1 Components of a formal notation

Phonology deals with entities and events. The entities may correspond to sounds, phonemes, or even more abstract segments.[1] The events are changes – either diachronic sound correspondences, or else synchronic surface realisations of underlying representations. In all cases, something becomes something else.

A formal notation is a means for specifying entities and describing events. Although it is convenient to represent each phonological entity by a special symbol (i.e. the alphabet cum diacritic notation of traditional phonetic transcription), when looking at phonological events one finds that segments frequently participate in them in groups and, furthermore, that the same segment may belong to one group for a particular event and to another group for some other event. Therefore, in order to capture the various generalisations and cross-classifications, segments must be categorised according to sets of properties attributed to them. The distinctive features of generative phonology constitute such a set of PRIMITIVE PHONOLOGICAL ELEMENTS. Other symbols (e.g. the arrow, the null symbol, parentheses) provide further DESCRIPTIVE DEVICES for talking about what happens to segments. Finally, a small number of FORMAL OPERATIONS restricts the types of permitted changes: entire segments may be inserted,

deleted, or metathesised,
undergo a change in va
characterised through thr
descriptive devices, and f

2 The primitives of

The primitive phonolog
types: ELEMENTARY PARTI
tary particles – *a*, *i*, and *u*
[i], and [u]; in combinati
or openness for *a*, palata
for *u*. Vowels other than
composed of combination
illustrates the segment-l
particles. Here, the par
TONALITY, are opposed tc

(palatality) i ·

In addition to the elem
'plus' sign between parti
of the 'plus' represent vo
between particles specifies
symbol beneath particles i

2.1 Short vowels

Table 1 presents the partic
phonetic symbols appear
tations are unbracketed.)

[i]	i
[e]	ai
[ɛ], [æ]	aai

deleted, or metathesised, or else one or more features of a segment may undergo a change in value. A formal notational system, then, can be characterised through three components: primitive phonological elements, descriptive devices, and formal operations.

2 The primitives of particle phonology

The primitive phonological elements of particle phonology are of two types: ELEMENTARY PARTICLES and PUNCTUATORS. There are three elementary particles – *a*, *i*, and *u*. In isolation, they correspond to the vowels [a], [i], and [u]; in combination, they represent phonological traits – aperture or openness for *a*, palatality or frontness for *i*, and labiality or rounding for *u*. Vowels other than [a], [i], and [u], as well as all diphthongs, are composed of combinations of particles. Fig. 1, in typical triangular fashion, illustrates the segment-like and feature-like aspects of the elementary particles. Here, the particles *i* and *u*, as different manifestations of TONALITY, are opposed to the APERTURE particle *a*.

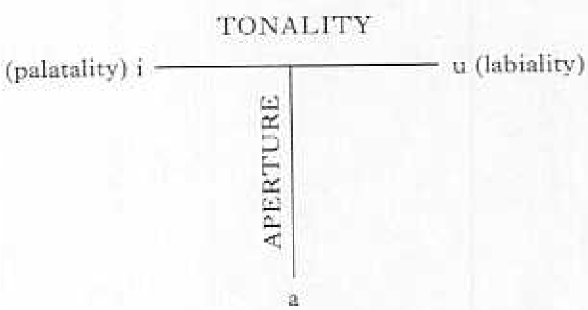


Figure 1.
Elementary particles

In addition to the elementary particles, there are three punctuators. A 'plus' sign between particles signifies that the particle sets on each side of the 'plus' represent vowels belonging to separate syllables. A 'space' between particles specifies length in vowels and diphthongs. A 'half-moon' symbol beneath particles indicates nonsyllabicity.[2]

2.1 Short vowels

Table 1 presents the particle structures of some short vowels. (Traditional phonetic symbols appear in square brackets, whereas particle representations are unbracketed.)

[i]	i	[u]	u	[ü]	iu			[ɨ]	—
[e]	ai	[o]	au	[ö]	aiu			[ʌ]	a
[ɛ], [æ]	aai	[ɔ]	aau	[œ]	aaiu	[a]	a	[a]	aa

[Table 1. *Short vowels*]

One can see how complexes of particles define the different vowels: front vowels contain the particle *i*, rounded vowels have *u*, and nonhigh vowels exhibit *a*. Furthermore, vowel height is directly linked to the number of aperture particles; additional occurrences of that particle produce a 'more open' vowel. The central series of vowels requires special comment. A single occurrence of the aperture particle stands for [a] in those languages with only one central vowel. For languages with both [ʌ] and [a], it is the former that is represented by one occurrence of the aperture particle, whereas the latter would have two. Hence, the interpretation of particles (e.g. whether *a* represents [ʌ] or [a]) is system-dependent. The vowel [ɨ], lacking both tonality and aperture, is without elementary particles.[3]

2.2 Long vowels

Long vowels contain extra particles and the 'space' punctuator. There are two modes of representation. First, for vowels with tonality, length may be shown by repetition of the tonality particles. Hence, front vowels will have *i* as their marker of length, and rounded vowels will have *u*. A parallelism then emerges for all vowels of a given series: thus, [e:] is distinguished from [e] in the same way that [i:] is differentiated from [i], etc. However, for nonhigh central vowels, it is an extra occurrence of the aperture particle that marks length. An alternative mode of representation of long vowels is as a geminate sequence of two shorts. That is, there is duplication of the entire particle configuration.[4] Table 2 depicts some long vowels.

[i:]	i i	i i	[u:]	u u	u u	[ɨ:]	— —	— —
[e:]	ai i	ai ai	[o:]	au u	au au	[ʌ:]	a a	a a
[æ:]	aai i	aai aai	[ö:]	aiu iu	aiu aiu	[a:]	aa a	aa aa

[Table 2. *Long (tense) vowels*]

2.3 Diphthongs

Complexes of particles, in their role as short monophthongal vowels, constitute unordered sets. (For the sake of convenience, I list particles in alphabetical order.) For long vowels, though, a space separates the particles representing each mora. Partial ordering obtains also in the representation of diphthongs. The particle sets of the halves of a diphthong occur in their proper sequence. The 'half-moon' punctuator denotes that the sets are ordered as listed, and it also specifies the nonsyllabic component. Furthermore, diphthongs counting as more than one mora will contain the 'space' as part of their representations.[5] Some selected diphthongs are presented in Table 3.

[ii̯]	i i̯	[uu̯]	u u̯	[ia̯]	i a̯	[i̯e]	i̯ ai
[ei̯]	ai i̯	[ou̯]	au u̯	[ea̯]	ai a̯	[i̯u]	i̯ u
[ai̯]	a i̯	[au̯]	a u̯	[ua̯]	u a̯	[i̯a]	i̯ a
[ui̯]	u i̯	[iu̯]	i u̯	[oa̯]	au a̯	[u̯e]	u̯ ai
[oi̯]	au i̯	[eu̯]	ai u̯	[aa̯]	a a̯	[u̯a]	u̯ a

[Table 3. *Diphthongs*]

2.4 Tense and lax vowe

For those languages that
short vowels are lax (in
specification is needed to
Hence, such vowels must
whatever other particles a
Some short lax vowels are

[ɪ]
[ɛ]

[Ta

The particle structures
will account for the doubl
of these vowels. In a repres
twice; once, as the space
occurrence of tonality. Bu
much as a redundant marl
of tenseness. Where long,
then, a dual opposition: pr
vs. 'short'), and tonality
'tense' *vs.* 'lax'). This ass
is particularly appropriat
considered to have 'more
1978: 63).

3 The operations of

Particle phonology recogn
MUTATION, CLONING, DRON
affect the sequencing of
particles, whereas the rema
Examples of these operati

3.1 Fusion and fission

Fusion accommodates tho
phthongs. The separately
combine into a single con
of the prime virtues of pa
particular diphthong/mon
that provide a certain intui
of the monophthongal vo
diphthongs or sequences
particle representations ag

2.4 Tense and lax vowels

For those languages that contrast long and short vowels, and where the short vowels are lax (in opposition to long tense ones), an additional specification is needed to show the more open quality of the short vowel. Hence, such vowels must contain the aperture particle in addition to whatever other particles are necessary for indicating tonality and height. Some short lax vowels are illustrated in Table 4.[6]

[ɪ]	ai	[ᴜ]	au	[Ü]	aiu
[ᴇ]	aai	[ᴏ]	aau	[Ö]	aaiu

[Table 4. *Short lax vowels*]

The particle structures of Tables 2 and 4 suggest an interpretation that will account for the doubly-marked long/tense and short/lax opposition of these vowels. In a representation such as **ai i** [e:], length seems to appear twice; once, as the space between particles, and again, as the second occurrence of tonality. But one can view the extra tonality particle, not so much as a redundant marker of length, but rather as an explicit indicator of tenseness. Where long/tense is opposed to short/lax, there emerges, then, a dual opposition: presence *vs.* absence of space (interpreted as 'long' *vs.* 'short'), and tonality particle *vs.* aperture particle (interpreted as 'tense' *vs.* 'lax'). This association of the tonality particle with tenseness is particularly appropriate in view of the fact that a tense vowel is considered to have 'more' tonality than its lax counterpart (Donegan 1978: 63).

3 The operations of particle phonology

Particle phonology recognises seven basic operations: FUSION, FISSION, MUTATION, CLONING, DRONING, ACCRETION, and DECAY. Fusion and fission affect the sequencing of particles, mutation involves an exchange of particles, whereas the remaining operations change the number of particles. Examples of these operations are presented in Table 5.

3.1 Fusion and fission

Fusion accommodates those processes where diphthongs become monophthongs. The separately occurring particles of a diphthong fuse or combine into a single complex configuration for the monophthong. One of the prime virtues of particle notation is the ease with which it relates particular diphthong/monophthong pairs. In fact, it is just such relations that provide a certain intuitive confirmation of the particle representations of the monophthongal vowels. It is not difficult to find instances where diphthongs or sequences of vowels have fused into single vowels whose particle representations agree with the sequential entities. For example, in

	Fusion	
[ai̯] > [e]	ai̯ > ai	Gothic, Romance, Sanskrit
[au̯] > [o]	au̯ > au	
[ae] > [ɛ]	a+ai > aai	Ewe
[ea̯] > [æ]	aia̯ > aai	Kwakiutl
[o̯a] > [ɔ]	ạua > aau	Rumanian
[u̯i] > [ü]	u̯i > iu	Korean
[u̯e] > [ö]	u̯ai > aiu	Korean, Old French
[eu̯] > [ö]	aiu̯ > aiu	Old French
[oi] > [ö]	aui̯ > aiu	Greek
	Fission	
[ü] > [ju]	iu > ju	Middle English
[e:] > [ei̯]	ai i > ai i̯	Old French
[o:] > [ou̯]	au u > au u̯	Old French, Icelandic
[e:] > [je]	ai i > jai	Icelandic
[ö:] > [öü̯]	aiu iu > aiu i̯u̯	Germanic
[ɪ] > [ia̯]	ai > ia̯	Soeste (Germanic)
[ɔ] > [oa̯]	aau > aua̯	
	Mutation	
[ei̯] > [oi̯]	aii̯ > aui̯	Old French
[ou̯] > [eu̯]	auu̯ > aiu̯	
[ii̯] > [ui̯]	i i̯ > u i̯	Soeste, Old West Scandinavian
[uu̯] > [iu̯]	u u̯ > i u̯	Soeste
	Cloning	
[u] > [ü]/ — [i]	u > i̯u/ — i	Germanic
[o] > [ö]/ — [i]	au > ai̯u/ — i	
[i] > [ü]/ — [u]	i > iu̯/ — u	
[i] > [e]/ — [a]	i > ại/ — a	Early Germanic
[u] > [o]/ — [a]	u > ạu/ — a	
[e] > [e̯a]/ — [a]	ai > ạia̯/ — a	Rumanian
[o] > [o̯a]/ — [a]	au > ạua̯/ — a	
[ai̯] > [ei̯]	a i̯ > ai i	Old High German
[au̯] > [ou̯]	a u̯ > au̯ u̯	
	Droning	
[æ] > [e]/ — [i]	ạai > ai/ — i	Old English
[e:] > [i:]	ai i > i i	Early Modern English
[o:] > [u:]	ạu u > u u	
[ɛ:] > [e:]	ạai i > ai i	
[ɔ:] > [o:]	ạau u > au u	
	Accretion	
[u] > [ü]	u > i̯u	Old French
[i] > [ɪ]	i > ại	Vulgar Latin
[u] > [ʊ]	u > ạu	
[ii̯] > [ei̯]	i i̯ > ai i	Early Modern English
[uu̯] > [ou̯]	u u̯ > ạu u̯	
[ii] > [ei]	i i > ai i	Scanian (Swedish)
[ee] > [ɛe]	ai ai > ạai ai	
[ɛɛ] > [æɛ]	aai aai > ạaai aai	
	Decay	
[ü] > [i]	iu̯ > i	Old West Scandinavian, Greek, English
[ü] > [u]	i̯u > u	
[e] > [a]	ai̯ > a	Sanskrit
[o] > [a]	au̯ > a	
[e] > [i]	ại > i	Liuseño
[o] > [u]	ạu > u	
[e] > [i]	ai̯ > i	Russian
[o] > [a]	au̯ > a	

[Table 5. *Particle operations*]

a multitude of language
This change has occur
provides another well-
continue to alternate w
provides motivation for
vowels. In Ewe, an Afr
of [a] and [e] – for exa
(SPA 1979: 730), one c
Rumanian dialects (Na
These examples repres
monophthongisations o
[ü] occur in free variat
[eu̯] of Old French have
in some of the dialects
particle notation, diph
than the temporal seque
tion, and diphthongs th
tions of particles must
particular, the last thre
Fission is the oppos
monophthongs. The co
split up to become a sec
is evident in the Midd
monophthong is render
the diphthongisation of
diphthongisation to [ei̯
but [e:] became instead
changed. In Germanic,
glide. In these example
that vowel and a glide.
the length representati
homorganic glides of th
particle. In the Soeste
vowels diphthongised i
glide: [ɪ] > [ia̯], [ᴇ] > [e
for laxness in the mon
the diphthongs.

3.2 Mutation

Mutation interchanges
conversely, *u* is replace
dissimilation. Romance
noted, Old French had a
[ei̯] changed to [oi̯], an
1975: 55), the long high
switched tonality: [i:]

a multitude of languages, [ai̯] and [au̯] have become [e] and [o], respectively. This change has occurred in Gothic and throughout Romance. Sanskrit provides another well-known case, for in that language the diphthongs continue to alternate with the corresponding monophthongs. Fusion also provides motivation for the multiple-aperture representation of the lower vowels. In Ewe, an African language, [ɛ] occurs as a frequent contraction of [a] and [e] – for example, [ɲa e] 'to him' becomes [ɲɛ]. In Kwakiutl (SPA 1979: 730), one of the sources of [æ] is the dipthong [ea̯]. In some Rumanian dialects (Nandris 1963: 86), the diphthong [o̯a] has fused to [ɔ]. These examples represent fusions of aperture and tonality. There are also monophthongisations of just tonality. In Korean (SPA 1979: 380), [u̯i] and [ü] occur in free variation; so do [u̯e] and [ö]. The diphthongs [u̯e] and [eu̯] of Old French have both become [ö] in the modern language, whereas in some of the dialects of ancient Greek it was [oi̯] that evolved to [ö]. In particle notation, diphthong/monophthong pairings are nothing other than the temporal sequencing of particles – linear *vs.* simultaneous realisation, and diphthongs that exhibit different sequences of the same combinations of particles must be linked to the same monophthong. (Note, in particular, the last three examples.)

Fission is the opposite of fusion. It handles the diphthongisation of monophthongs. The complex particle configuration of a monophthong is split up to become a sequence of particles for the diphthong. This process is evident in the Middle English borrowing of French [ü]. The French monophthong is rendered as [i̯u] in English. As another example, consider the diphthongisation of long vowels. In Old French, [e:] and [o:] underwent diphthongisation to [ei̯] and [ou̯]. In Icelandic, [o:] too changed to [ou̯], but [e:] became instead the rising diphthong [i̯e]; only the sequencing has changed. In Germanic, [ö:] becomes a diphthong with a front rounded glide. In these examples of fission, one sees how a long vowel splits up into that vowel and a glide. The tonality particles that originally were part of the length representations of the long vowels become the sources of the homorganic glides of the diphthongs. Fission may also affect the aperture particle. In the Soeste dialect of Low German (Grundt 1975: 55), lax vowels diphthongised into vowels of higher quality and following downglide: [ɪ] > [ia̯], [ᴇ] > [ea̯], [ʊ] > [ua̯], and [o] > [oa̯]. The aperture particle for laxness in the monophthongs has been serialised as the downglide of the diphthongs.

3.2 Mutation

Mutation interchanges the two tonality particles: *i* is replaced by *u* and, conversely, *u* is replaced by *i*. Mutation is the particle analogue of tonal dissimilation. Romance and Germanic provide some examples. As already noted, Old French had acquired the diphthongs [ei̯] and [ou̯]. Subsequently, [ei̯] changed to [oi̯], and [ou̯] became [eu̯]. In the Soeste dialect (Grundt 1975: 55), the long high vowels diphthongised and their first elements also switched tonality: [i:] > [ii̯] > [ui̯] and [u:] > [uu̯] > [iu̯]. Old West

Scandinavian [iː] and [üː] merged to [iː], which then became the diphthong [ui̯] in Modern Faroese (Andersen 1972: 22).[7] As a consequence of mutation, there is greater tonal separation between the syllabic and nonsyllabic halves of a diphthong.

3.3 Cloning and droning

Cloning and droning affect the number of particles of a configuration. Both are the particle analogues of assimilation. In one common type of cloning, a particle from one syllable is copied into the vowel of another syllable. Germanic umlaut is an obvious example. The rounded vowels [u] and [o], when followed in the next syllable by [i], were fronted to [ü] and [ö], respectively. The particle *i* from the umlauting environment has been copied into the preceding vowel. In the less common, but nonetheless similar, labial umlaut, a labial particle is copied into the vowel of the previous syllable. There is also cloning of the aperture particle. In early Germanic, the high vowels [i] and [u] were lowered to [e] and [o], respectively, when followed by [e], [o], or [a], all of which contain the particle *a*. In Rumanian, [e] and [o] have been 'broken' into the diphthongs [e̯a] and [o̯a]. The breaking took place when these vowels were followed by [e], [ʌ], or [a]. An aperture particle from the second vowel has been cloned and has become the nucleus of the 'broken' diphthong. Cloning can take place also between the two parts of a diphthong. In the development of Old High German, [ai̯] became [ei̯], and [au̯] became [ou̯]. The tonality particle of the glide has been cloned into the nucleus of the diphthong.

Whereas the vowels [u], [o], and [a] of Old English were umlauted to [ü], [ö], and [æ], respectively, original [æ] in an umlaut environment was raised to [e].[8] The fronting of back vowels has been described as the cloning of the particle *i* from the second vowel into the target, so that the palatal particle is added to vowels originally not possessing it. However [æ] already contains the palatal particle. Hence, the only way that this vowel can become more like a following [i] is through an increase in height, or, equivalently, through a loss of aperture, and this is precisely what occurs. For the palatalisation (umlaut) process, then, vowels that lack the palatal particle will acquire one, whereas those already possessing one will lose an opposing particle. The latter phenomenon constitutes DRONING.[9] Part of the Great Vowel Shift (GVS) of English also exemplifies droning (see §5.1.3). Long mid vowels became highs, and lower mid vowels were raised to mids. In particle notation, an upward shift of this type is easy to characterise: it is loss of an aperture particle.

3.4 Accretion and decay

Accretion and decay change the number of particles in nonassimilatory environments. Accretion is the spontaneous addition of a particle. Vulgar Latin [u] became [ü] everywhere in French. The particle *i* has been added.

At an early stage in the history of Latin, there were contrasting pairs of long and short vowels of the same quality. Subsequently, short [i], [e], [u], and [o] became lax – that is, they acquired the particle *a*. We noted that in the first stage of the GVS, the mid vowels and lower mids were raised one degree. The high vowels instead diphthongised and were lowered one step: [ii] became [ei̯], and [uu̯] became [ou̯]. Here too there is addition of an aperture particle. A more dramatic example of lowering is seen in the Scanian dialect of Swedish (Bruce 1970). Long vowels, which behave as two shorts, diphthongise: the first half of the long vowel moves down one step. This development for the front unrounded vowels is as follows: [ii] > [ei], [ee] > [εe], and [εε] > [æε]. In particle notation, downward vowel shifts represent the acquisition of aperture particles.

Decay is simplification of a complex particle configuration: one or more of the component particles are lost. Most neutralisations provide examples of decay. In the merger of Old West Scandinavian [i:] and [ü:], the latter lost its labial particles. In Greek [ü] also merged with [i], and the same change occurred in the history of English with the loss of umlauted vowels. Although unrounding, or loss of the particle *u*, seems to be the favoured way for front rounded vowels to be simplified, it is also possible for them to give up palatality, or the particle *i*. This version of decay causes [ü] to merge with [u]. The dual tonality structure of front rounded vowels accounts for both avenues of decay. Indo-European had the vowel qualities [i], [e], [a], [o], and [u], which occurred both long and short. In Sanskrit, [e] and [o], both long and short, merged with [a]: the mid vowels lost their tonality particles. Luiseño, an Amerindian language of Arizona (Bright 1965: 343), has also five vowels. In unstressed syllables, [e] and [o] merge with [i] and [u], respectively: the mid vowels lose their aperture particles. Russian exemplifies a mixed system, where, in unstressed positions, [e] has merged with [i], a loss of aperture, but [o] has merged with [a], a loss of tonality.

3.5 An example of a chain reaction

I provide now an example of the interaction of several particle operations. Consider the sequence of developments from Vulgar Latin [o:] and [e:] (lengthened in stressed syllables) to Modern French [ö] and [u̯a], respectively – e.g. Lat. *flōr*, *mē*; Fr. *fleur*, *moi*.

(2)

		Fiss	Mut	Fus	Fiss	Decay
[o:] > [ou̯] > [eu̯] > [ö]	au u	> auu̯	> aiu̯	> aiu		
[e:] > [ei̯] > [oi̯] > [u̯e] > [u̯a]	ai i	> aii̯	> aui̯ >		u̯ai	> u̯a

We have already noted the first two stages: [o:] and [e:] diphthongised to [ou̯] and [ei̯], and the nuclei of the diphthongs then underwent dissimilation, becoming [eu̯] and [oi̯], respectively. The former then monophthongised to [ö]. The other diphthong, [oi̯], had a very different development: it changed to [u̯e]. (French eliminated its falling diphthongs either through monophthongisation or through conversion to rising diphthongs.) Finally, [u̯e] became [u̯a].

Observe the particle analysis of these changes. The original Vulgar Latin long vowels undergo fission. Next, the nuclei of the diphthongs are subject to mutation. For [eu̯], there is then fusion to [ö]. The progression from [o:] to [ö] can be characterised as an exchange of tonality particles (mutation), sandwiched between changes in the sequencing of particles (fission and fusion), but the number of particles remains constant. Consider now the development of the diphthong **aui̯** [oi̯]. Nonsyllabicity moves into the first half of the diphthong and becomes attached to the labial particle; the aperture particle then gravitates into the nucleus, yielding **u̯ai** [u̯e]. Once again, there is nothing more than a resequencing of the existing particles. Finally, simplification or decay takes place in the nucleus, the first instance of loss of a particle. I suggest, as an exercise, that the reader recast these changes in the standard notation of generative phonology and compare that restatement to the particle notation.

3.6 Three laws of particle phonology

There are situations where particle representations require adjustments. These modifications are due to some general properties governing the structure of vowel systems.

3.6.1 *The law of mora conservation.* In languages with both long and short vowels, diphthongs generally behave like long vowels. Mora conservation requires that mora count be preserved during fusion and fission (Vennemann 1972: 869). In Sanskrit, the diphthongs [ai̯] and [au̯] constituted two morae. The resulting fusion in that language yielded [e:] and [o:], respectively, and not short vowels (Allen 1962: 31). With just two particles there is no way that **a**+**i** or **a**+**u** can directly fuse into long mid tonality vowels. In order to respect mora conservation, there occurs CROSS-CLONING: each particle is copied into the other mora. In this way, **a**+**i** and **a**+**u**, upon fusion, will yield **ai ai** and **au au**, respectively. Notice, though, that in a language, such as Spanish, that does not contrast long and short vowels, a fusion of **a**+**i** or **a**+**u** will produce **ai** or **au** directly.

3.6.2 *The law of diphthongal differentiation.* Diphthongal differentiation requires that the syllabic and nonsyllabic parts of a diphthong differ from each other either in height or in tonality (i.e. the two halves of a diphthong may not be identical), if that diphthong is to contrast with the corresponding long vowel. What this means is that [ii̯] and [i:], for example, would never be contrastive in the same language, but [ei̯] and [e:] very well could be. Now the diphthongs [ii̯], [uu̯], and [aa̯] do arise in the course of change. Because they are structurally equivalent to the corresponding long vowels, either they will merge with those vowels, or else, if they are to remain diphthongs, the language must modify them in some way. Later, I shall examine cases where diphthongal differentiation comes into play.

3.6.3 *The law of maximum aperture.* In the discussion of central vowels, it was noted that [a] must be represented as **aa** if [ʌ] is present in the vowel pattern. The representation of [a] will depend also on the number of tonality vowels. Maximum aperture requires that [a] not have fewer aperture particles than the lowest tonality vowels. This adjustment accommodates the interaction of [a] with these vowels. In Sanskrit, with a three-vowel system, the fusion of [a] and [i] produced [eː]. A similar change happened in the history of Spanish, with its five-vowel system. However, in Vulgar Latin, which had developed a seven-vowel pattern of the type [i], [e], [ɛ], [a], [ɔ], [o], and [u], the fusion of [a] and [i] yielded [ɛ]. In Old English, there were also three front unrounded vowels. In the umlaut process, [aː] was fronted to [æː]. In Vulgar Latin and in Old English, because the lowest front vowel has two occurrences of the aperture particle, so must [a].

As another example of the law of maximum aperture, let us see how it interacts with vowel harmony in Turkish. Turkish has eight vowels, as represented in Table 6.

[i]	[u]	[ü]	[ɨ]	i	u	iu	–
[e]	[o]	[ö]	[a]	ai	au	aiu	a

[Table 6. *Turkish vowels*]

Because the lowest tonality vowels are mid (i.e. have one aperture particle), [a] too is represented by a single occurrence of the aperture particle. Furthermore, it is the aperture particle that minimally distinguishes [a] from the particleless [ɨ]. In the particle representations of the Turkish vowels, all high vowels lack the aperture particle, whereas all nonhigh vowels contain exactly one occurrence of it. This structure is crucial for the operation of vowel harmony. Table 7 shows which variants of suffix vowels occur after preceding vowels. Note that there are four variants where the suffix contains a high vowel, but only two where there is a nonhigh vowel.

Preceding vowel	Suffix vowel	Preceding vowel	Suffix vowel
[i], [e]	[i]	[i], [e]	[e]
[u], [o]	[u]	[u], [o]	[a]
[ü], [ö]	[ü]	[ü], [ö]	[e]
[ɨ], [a]	[ɨ]	[ɨ], [a]	[a]

[Table 7. *Turkish vowel harmony*]

In Turkish, vowels harmonise for tonality. Let us assume that the underlying forms of suffixal vowels are without tonality, and that the purpose of vowel harmony is to add tonality to these vowels. In underlying representations, then, a high suffixal vowel will be represented by the particleless [ɨ], whereas a nonhigh one will be represented as [a]. The vowel harmony process functions as follows: (1) the tonality particle(s) from a preceding vowel will be cloned (copied) into a high suffixal vowel; (2) only the palatal particle from a preceding vowel will be cloned into a nonhigh suffixal vowel. In the case of underlying particleless [ɨ], it will acquire palatality (becoming [i]), labiality (becoming [u]), or both palatality and labiality (becoming [ü]) after front unrounded, back rounded, and front rounded vowels, respectively; where the preceding vowel is central, there is no tonality to be cloned and, consequently, underlying [ɨ] will surface as such. In the case of underlying [a], it will acquire palatality (becoming [e]) after any front vowel; because it never acquires labiality, [a] will surface as such after any nonfront vowel. Notice that in particle notation, the addition of the palatal particle to [a] is sufficient to convert it to [e]. We do not need to state as part of the vowel harmony rule that with the addition of tonality a low vowel is raised to mid height.

4 Mirroring

Having presented the particle representations of the different vowels and the formal apparatus and operations of particle phonology, I turn now to the question of 'mirroring' – that is, how accurately the notational system is able to track the nature of the events it describes. I claim that particle notation comes much closer to this goal than the standard notation, for there are processes that the latter handles only with difficulty. Moreover, particle phonology places severer constraints on descriptions of sound change.

4.1 Monophthong and diphthong pairings

We have established that there are pairings between certain sequences of vowels (diphthongs) and particular single vowels (monophthongs). I shall compare now the expression of these relationships in particle notation and in the standard framework. Consider again the change of [ai] to [e]. This process is commonly described as the coalescence of two segments into one, where the quality of the derived segment is an amalgam of the qualities of the two input segments. In (3a) we have the particle notation of this change, whereas (3b) is a representation in the standard notation.

(3) a. a+i > ai b. $\begin{bmatrix} \text{V} \\ +\text{low} \\ +\text{back} \\ -\text{round} \\ 1 \end{bmatrix} \begin{bmatrix} \text{V} \\ +\text{high} \\ -\text{back} \\ -\text{round} \\ 2 \end{bmatrix} \rightarrow \begin{bmatrix} 1 \\ -\text{low} \\ -\text{back} \end{bmatrix} \quad \emptyset$

The expression of the change in (3a) is fairly transparent.[10] Let us look at (3b) then. On the left side of the arrow one finds the sequence [ai], shown as two segments, and on the right is the resulting [e]. But the change is not depicted as a direct fusion. The (original plus) specifications of the features [low] and [back] for the segment [a] have been changed (to minus values), as indicated on the right, while the values for [high] and [round],

because these features are nc
What this notation claims
converted to [e], whereas or
the null symbol on the righ
a fusion of two segments in
in *one* of the original comp
other.[11] Notice, furthermor
segment and to delete the se
first and modified the secon
is arbitrariness in the choice
But there is yet an additi
diphthong to be converted
only to change values for the
unlikely, though, that [ai] c
Among the various possibil
actualised. In particle phor
vowel not possessing exclus
except [e], [ɛ], and [æ] – wc
fusion of [a] and [i].[12] The c
representation limits severel
notion of fusion implies tha
all and only, the particles of
demonstrates how a suitabl
constraining qualities: (1) p
as a fusion; and (2) it constrai
make-up of the vowels that

4.2 Diphthong and long v

Just as the standard notati
diphthongs and the qualit
inadequately relations betw
uncommon for a long vowel
syllabic and a homorganic
notation? In discussing the
a rule of diphthongisation, s

(4) a. $\emptyset \rightarrow \begin{bmatrix} -\text{syllabic} \\ +\text{high} \\ \alpha\ \text{back} \\ \alpha\ \text{round} \end{bmatrix}$ /

This rule inserts, from outsic
to the vowel. The rule dis
variables) between the sequ
simultaneous ones of the (lo
particle notation for this
complex configuration of the

because these features are not mentioned on the right, remain unchanged. What this notation claims is that the original segment [a] has been converted to [e], whereas original [i] has been deleted (as designated by the null symbol on the right). The standard notation, unable to portray a fusion of two segments into one, must treat all coalescence as a change in *one* of the original components, with concomitant suppression of the other.[11] Notice, furthermore, that in (3b) I chose to modify the first segment and to delete the second one. I could just as well have deleted the first and modified the second (that is, by lowering [i] to [e]). Hence, there is arbitrariness in the choice of segments to be retained or eliminated.

But there is yet an additional concern. This notation would allow the diphthong to be converted into any vowel whatsoever. One would need only to change values for the appropriate features on the right. It is highly unlikely, though, that [ai] could become [u], [o], [ɔ], [ü], [ö], [i], or [ʌ]. Among the various possibilities, probably only [e], [ɛ], and [æ] are ever actualised. In particle phonology, this problem does not arise, for any vowel not possessing exclusively the particles *a* and *i* – that is, all vowels except [e], [ɛ], and [æ] – would be ruled out as possible products of the fusion of [a] and [i].[12] The crucial point here is that the nature of particle representation limits severely what the output of fusion may be. The very notion of fusion implies that the resulting complex of particles contains, all and only, the particles of the input.[13] The particle treatment of fusion demonstrates how a suitable notation may display both mirroring and constraining qualities: (1) particle phonology portrays the fusion process as a fusion; and (2) it constrains in the tightest way possible the phonological make-up of the vowels that evolve therefrom.

4.2 Diphthong and long vowel pairings

Just as the standard notation fails to mirror the relationship between diphthongs and the quality of particular monophthongs, it portrays inadequately relations between diphthongs and long vowels. It is not uncommon for a long vowel, after diphthongising, to exhibit a shortened syllabic and a homorganic upglide. How is this handled in the standard notation? In discussing the GVS, Chomsky & Halle (1968: 264) propose a rule of diphthongisation, shown in (4a):

(4) a.

$$\phi \rightarrow \begin{bmatrix} -\text{syllabic} \\ +\text{high} \\ \alpha\,\text{back} \\ \alpha\,\text{round} \end{bmatrix} \Big/ \begin{bmatrix} \text{V} \\ +\text{tense} \\ \alpha\,\text{back} \\ \alpha\,\text{round} \end{bmatrix} \text{—}$$

b. ai i > ai i̯
au u > au u̯

This rule inserts, from outside, a glide that must be specified as homorganic to the vowel. The rule displays no correlation (other than the alpha variables) between the sequential properties of the diphthong and the simultaneous ones of the (long) tense vowel from which it originates. The particle notation for this diphthongisation is presented in (4b). The complex configuration of the long vowel splits up into a shortened version of that vowel and an upglide. The tonality particle that originally represented length becomes the source of the glide and its homorganic quality. The vowel is automatically shortened once its length component is extracted. There is absolutely no change in the set of particles nor in the mora count. The only notational change is the appearance of the 'half-moon' symbol, the explicit indicator of the diphthongisation process.[14]

4.3 Vowel height

Another problem confronting the standard notation is its treatment of vowel height. By strait-jacketing height into the two binary features [high] and [low], it handles awkwardly processes (such as the GVS or the Swedish diphthongisations) where vowels of differing height move up or down the height scale. This type of progression always requires reference to a complex set of variables. One need only consult the extant literature to get an idea of some of the contortions gone through in handling vowel shifts. In their synchronic analysis of the reflexes of the GVS, Chomsky & Halle (1968: 187) propose two rules: one that interchanges high and mid vowels, followed by one that interchanges the derived mids with low vowels. Wang (1968) tries to remedy this situation by positing a single rule with multiple variables. Some of his outputs come out incorrect, and he needs an additional rule of emendation. Yip (1980) proposes a binary analysis of the Swedish data. The expression of this process in the standard notation, once again, turns out to be a rather tortuous affair. Furthermore, to get her analysis to work, she is compelled to distort the data as presented by Bruce. The particle treatment of vowel shift, on the other hand, is relatively straightforward. An aperture particle is lost by those vowels involved in upward movement, whereas one is gained in downward movement. Vowel shifts in height provide strong confirmation for treating height as multiple occurrences of the aperture particle.

4.4 Markedness

Let us consider a very different type of notational problem – that associated with 'markedness'. Within generative phonology notions of markedness have played a somewhat minor role, but, nonetheless, have generated some interesting discussion in attempts at explaining and constraining phonological change. A fundamental tenet of markedness theory is the idea that language sounds are not equal-valued. The theory attributes varying degrees of complexity to different segments, and it further maintains that these differences are reflected in phonological behaviour. Supposedly, less marked sounds are 'easier' to articulate or perceive, are learned first by the child embarking on his linguistic career, enjoy a high frequency of occurrence in the world's languages, and often are the culmination of a sound change. More marked sounds have the opposite characteristics. My purpose here is neither to justify nor refute these claims, but rather to demonstrate that the notation of generative phonology fails to mirror phonological complexity in any interesting way.

In the standard framewo
vowels, then, have the sam
on the other hand, vowels ar
numbers of particles. Bec
contains within itself a buil
determines degree of compl
each, are the least marked
unrounded and back round
marked, but front rounded
marked.[15] For vowels of t
greater markedness. Long
short ones that are lax ar
distribution of complexity a
of Chomsky & Halle in thi

In the standard framewo
inherent way for judging co
by Chomsky & Halle (196
by *m*'s and *u*'s (for mar
conventions provides the t
conventions are, in them
example the convention giv
for the feature [high] is [+

(5) a. [*u* high] → [+high

This convention reflects th
mid ones. However, if one v
one need merely change th
unmarked value for [high]
has no internal motivatio
established on the basis o
statistical frequencies, the
earlier, the very phenome
particle phonology, the me
to the notational system.
metric, short of defining a
is interesting for this discu
a direct mirroring of deg
visually has more compon

5 Aspects of particle

An appropriate notation n
it describes, but due to its
lend new perspectives on
primitive elements in parti
each of them must perfor
particle corresponds to d

In the standard framework, vowels are specified for every feature; all vowels, then, have the same number of markings. In particle phonology, on the other hand, vowels are specified through different combinations and numbers of particles. Because of this, particle notation automatically contains within itself a built-in 'markedness' metric: number of particles determines degree of complexity. Thus, [a], [i], and [u], with one particle each, are the least marked vowels. For vowels of the same height, front unrounded and back rounded, with one tonality particle each, are equally marked, but front rounded vowels, with both tonality particles, are more marked.[15] For vowels of the same series, lower height corresponds to greater markedness. Long vowels are more complex than short ones, and short ones that are lax are more complex than plain short ones. This distribution of complexity agrees, for the most part, with the observations of Chomsky & Halle in this regard.

In the standard framework, the equal-valued +'s and −'s provide no inherent way for judging complexity. In the markedness system proposed by Chomsky & Halle (1968: 405), these binary values must be replaced by *m*'s and *u*'s (for marked and unmarked), and a set of marking conventions provides the translation between the two systems. Yet these conventions are, in themselves, completely arbitrary. Consider as an example the convention given in (5a), which states that the unmarked value for the feature [high] is [+high].

(5) a. [*u* high] → [+high] b. [*u* high] → [−high]

This convention reflects the claim that high vowels are unmarked *vis-à-vis* mid ones. However, if one were to decide to make mid vowels simpler, then one need merely change the marking convention, as in (5b), such that the unmarked value for [high] would be [−high]. The 'correctness' of (5a) has no internal motivation whatsoever, but, by and large, has been established on the basis of extraphonological factors – in particular, the statistical frequencies, the acquisitional data, etc. that were mentioned earlier, the very phenomena that markedness is supposed to explain. In particle phonology, the measure of complexity is a matter purely internal to the notational system. There is no way to change the effects of this metric, short of defining a totally different set of vowel parameters. What is interesting for this discussion, though, is that particle notation provides a direct mirroring of degree of markedness. A more marked segment visually has more components than a less marked one.

5 Aspects of particle phonology

An appropriate notation not only should mirror the nature of the events it describes, but due to its choice of primitive elements, it ought also to lend new perspectives on the data it confronts. Because there are fewer primitive elements in particle phonology than in the standard framework, each of them must perforce bear a higher functional burden. The same particle corresponds to different features of the standard framework.

Therefore, one might expect these features to be much more intimately connected than the standard notation suggests. I present several examples of this type.

5.1 Tension

Particle phonology reduces vowel properties to manifestations of aperture, palatality, and labiality. Many phonological processes can be interpreted as oppositions of these global qualities.

5.1.1 *Long/short and tense/lax.* The evolution of short lax vowels provides a cogent example of tension. The long and short vowels of Classical Latin, when nonlow, exhibited a dual opposition of long/tense versus short/lax, shown as stage 2 of (6):

(6)

Stage 1	[iː]	[i]	[eː]	[e]	[uː]	[u]	[oː]	[o]	[aː]	[a]
Stage 2	[iː]	[ɪ]	[eː]	[ᴇ]	[uː]	[ʊ]	[oː]	[ɔ]	[aː]	[a]
Stage 3	[i]	[e]		[ɛ]	[u]	[o]		[ɔ]	[a]	

Such a system is generally assumed to have evolved from one where only length was decisive and where pairs of long and short vowels were of the same quality (stage 1). However, a stage 1 system can be unstable (Chen & Wang 1975), and the superposition of qualitative differences onto the quantitative will lead to more salient distinctions.

The particle analysis of these changes is shown in (7):

(7)

Stage 1	i i	i	ai i	ai	u u	u	au u	au	a a	a
Stage 2	i i	ai	ai i	aai	u u	au	au u	aau	a a	a
Stage 3	i	ai		aai	u	au		aau	a	

At stage 1, the second tonality particle of the long vowels [iː], [eː], [oː], and [uː] represents *only* length. Here, the particle contrasts with its absence. At stage 2, the long vowels maintain their original quality, whereas the short tonality vowels become more open. In the particle treatment, it is precisely the short vowels that undergo change and acquire aperture particles. The notion of 'tension' explains why short vowels must initiate this process. They acquire aperture particles that will be opposed to the already existing tonality particles of the long vowels. It is this tension that is the basis of the tense/lax dichotomy. Notice that tension cannot exist for the pair [aː]/[a], simply because [aː] is without tonality. The opposition of tonality and aperture, as the core of the tense/lax contrast, explains the exemption of [aː] and [a] from the tense/lax correlation.[16]

There is an additional benefit of this analysis. The standard notation has

no way of accounting for tl
whereas short ones are lax.
correlation but goes no fur
tonality particles represent
at stage 2 as both length an
traits inevitable. This interp
of aperture particles (laxne

Let us turn to the next p
of (6)). In Vulgar Latin, dis
one might expect merger c
a coalescence happened onl
were lowered one degree,
vowels one step down (that
into a new vowel height (th
accounts assume two differ
short nonlow vowels open
further lowered to become
original laxing of short vo
vowels with mids is an auto
merger, the tense/lax oppos
The former exists only in
contrast disappears, then s
open' lax vowels can then

We would like the notat
particle phonology describ
particles of the long tense
the short lax ones. When
opposition between the tor
particles (for laxness). Ten
can denote only lowered h

Compare the particle an
the corresponding rule in t

(8) [V, −tense, α high] → [−lon, +ten, −hig, −αlo

In addition to length, char
the particle analysis, the on
all, it is the length oppositi
automatically.[19]

5.1.2 *The palatalisation hi*
enables one to place it al
tonality. Consider, for exa
The vowel [e] is more ope
two. This scaling for ape

no way of accounting for the fact that long vowels are frequently tense, whereas short ones are lax. A rule, such as [αlong] → [αtense], states the correlation but goes no further. In the particle analysis, at stage 1, the tonality particles represent length only. Their subsequent interpretation at stage 2 as both length and tenseness makes the correlation of these two traits inevitable. This interpretation is made possible only by the acquisition of aperture particles (laxness) on the part of the short vowels.[17]

Let us turn to the next phase in the evolution of these vowels (stage 3 of (6)). In Vulgar Latin, distinctions in length are lost. In such a situation, one might expect merger of the members of each long/short pair. Such a coalescence happened only for the low vowel [a]. The other short vowels were lowered one degree, and either they merged with the former long vowels one step down (that is, [ɪ] > [e] and [ʊ] > [o]), or else they evolved into a new vowel height (that is, [ᴇ] > [ɛ] and [o] > [ɔ]).[18] Most traditional accounts assume two different lowering operations for *high* vowels: first, short nonlow vowels opened to become lax; then, lax high vowels were further lowered to become mids. I maintain that the only lowering was the original laxing of short vowels. The subsequent association of the high vowels with mids is an automatic consequence of the loss of length. Before merger, the tense/lax opposition is intimately entwined with the long/short. The former exists only in company with the latter. When the long/short contrast disappears, then so must the tense/lax one. The original 'more open' lax vowels can then function only as vowels of lower height.

We would like the notation to mirror this scenario. Notice in (7) how particle phonology describes these developments. At stage 2, the tonality particles of the long tense vowels are opposed to the aperture particles of the short lax ones. When length is lost at stage 3, there is no longer an opposition between the tonality particles (for tenseness) and the aperture particles (for laxness). Tension is eliminated, and, consequently, aperture can denote only lowered height.

Compare the particle analysis of the change from stage 2 to stage 3 with the corresponding rule in the standard notation, given in (8):

$$(8)\quad \begin{bmatrix} \text{V} \\ -\text{tense} \\ \alpha\ \text{high} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{long} \\ +\text{tense} \\ -\text{high} \\ -\alpha\text{low} \end{bmatrix}$$

In addition to length, changes are required in tenseness and in height. In the particle analysis, the only necessary modification is one of length. After all, it is the length opposition that is neutralised. The other changes follow automatically.[19]

5.1.2 *The palatalisation hierarchy.* The particle composition of a vowel enables one to place it along scales reflecting degrees of aperture and tonality. Consider, for example, the front vowels [i] **i**, [e] **ai**, and [æ] **aai**. The vowel [e] is more open than [i], and [æ] is more open than the other two. This scaling for aperture is directly correlated to the number of aperture particles contained in the vowel. One can also place these three vowels along a scale of palatality, in which case the vowels would occur in the converse order of the aperture scale. The vowel [i] has the highest degree of palatality, whereas [e] and [æ], because of their aperture particles, have attenuated palatality. Furthermore, the attenuation for [æ] would be greater than that for [e].

Individual properties can be intensified or reduced in one of two ways.

INTENSIFICATION: a property X can be increased either by the addition of X or (in particular, where X is already present) by the removal of an opposing property Y.

REDUCTION: a property X can be diluted either by the removal of X or by the addition of an opposing property Y.

Let us see how this scaling elucidates some aspects of vowel behaviour. Earlier, we alluded to the palatalisation of consonants. Now, certain vowels are more prone to induce palatalisation than others. Some examples of a palatalisation hierarchy are shown in Table 8:

(1) Tonality: [i], [e] > [ü], [ö] > [u], [o], [a]
(2) Height: [i] > [e] > [ɛ] > [æ]
(3) Tenseness: [i:], [e:] > [ɪ], [ᴇ]

[Table 8. *Palatalisation hierarchy*]

When we examine the particle representations of (1), we find that front unrounded vowels with only *i* as tonality have maximum palatality, front rounded vowels with both *i* and *u* have 'diluted' palatality, whereas back rounded vowels with only *u* and central vowels without tonality particles both lack palatality entirely. We have already discussed the height hierarchy exemplified in (2), so let us turn to the tenseness hierarchy of (3). Front unrounded tense vowels, with an extra occurrence of *i*, have maximal palatality, whereas lax vowels, with *a*, have attenuated palatality. Notice, incidentally, that the long tense high front unrounded vowel [i:] (whose particle representation is **i i**) is the most palatalising of the vowels.[20]

Once again, these relationships are poorly captured in the standard notation. In particular, there is absolutely no connection between the feature [tense] and the other features that characterise palatality. Particle phonology, by treating tenseness as an augmentation of tonality, is able to show how tense palatal vowels fit into the schema. We noted that the internal particle composition of a vowel enables one to determine its degree of markedness. In the same way, just by examining its inner composition, one can establish the position of a vowel within the palatalisation hierarchy.[21]

5.1.3 *Heightened tonality*. In early Germanic, [e] became [i] when followed by [i] in the next syllable (see first half of Table 9). The vowel [e] already contains the palatal particle. Hence, the only way, according to the palatalisation hierarchy, that it can further increase its palatality is through loss of aperture, the operation called droning. Also, in early Germanic (and later in Middle English), the diphthong [ei̯] was monophthongised to [iː]. This too is the same change, except here the segment responsible for the raising is the nonsyllabic immediately after the syllabic (rather than the vowel of the next syllable). The diphthong [ei̯] first changes to [ii̯]. The latter, not being sufficiently differentiated from the corresponding long vowel (see §3.6.2), merges with it and becomes [iː].

[e] > [i]/ — [i]	ai > i/ — i	Early Germanic
[ei̯] > [ii̯] > [iː]	ai i̯ > i i̯ > i i	Early Germanic
[eː] > [iː]	ai i > i i	GVS
[ɛː] > [eː]	aai i > ai i	GVS
[iː] > [ii̯] > [ei̯]	i i > i i̯ > ai i̯	GVS
[uː] > [uu̯] > [ou̯]	u u > u u̯ > au u̯	GVS

[Table 9. *Heightened tonality*]

This way of looking at raising sheds light on the mechanism of what, at first, might appear to be a totally different process – the tendency for tense vowels to be raised (Labov 1972), as exemplified by that part of the GVS that takes [eː] to [iː], and also [ɛː] to [eː]. In particle notation, the only difference between monophthongal [eː] **ai i** and diphthongal [ei̯] **ai i̯** lies in the syllabicity/nonsyllabicity of the second tonality particle. In view of this near identity, the GVS raising of [eː] to [iː] (and, of course, [ɛː] to [eː]) becomes analogous, once again, to the raisings of [ei̯] to [iː] and of [e] to [i] when followed by [i] in the next syllable. In all cases, the configuration **ai** is affected by the particle **i** of the next mora, even though that particle represents different things: a high front vowel of a following syllable, a palatal upglide of a diphthong, or length/tenseness. Yet, high tonality vowels, upglides, and tenseness are just different embodiments of heightened tonality. It is this unifying property that is made visible in particle notation.[22]

A second crucial development took place during the first stage of the GVS. The long high vowels [iː] and [uː] diphthongised to [ei̯] and [ou̯], respectively (see second half of Table 9). There is evidence suggesting that the GVS began with the raising of the mid vowels and that it was an avoidance of merger that caused the high vowels to diphthongise (Carter 1975; Lass 1976). Wolfe (1972) cites changes similar to the first part of the GVS in Old Prussian and in Czech. In those languages, too, long mid vowels become high, and the high vowels [iː] and [uː] are realised as [ei̯] and [ou̯]. She concludes that the lowered nucleus of the diphthong is an automatic consequence of the diphthongisation process.

We have here a further example of tension. We noted that in the particle analysis, the raising of [eː] and [oː] represents loss of an aperture particle, a heightening of tonality. I maintain that it is precisely a heightening of tonality that underlies all vowel changes in the first phase of the GVS. However, the high vowels, lacking aperture particles, cannot be raised further. Diphthongisation (or fission) becomes their response to a heightening of tonality. Fission splits apart the long vowels, serialises their extra tonality particles, and highlights them as separate components of heightened tonality. But the new diphthongs [ii̯] and [uu̯] have identical first and second components, and, according to the law of diphthongal differentiation, they are not sufficiently distinguished in internal structure from the monophthongs [i:] and [u:] that are derived from the raised mid vowels. Thus, the diphthongs are still threatened with merger, and so their nuclei must change. They acquire aperture particles, and, in this way, the diminished tonality of the nuclei becomes opposed to the new heightened tonality of the invading long vowels. In the meantime, original [ɛ:] and [ɔ:] have been raised to [e:] and [o:], respectively. But the diphthongs [ei̯] and [ou̯] will not be in conflict with these new mid vowels, because the two halves of the diphthongs are no longer identical.[23]

Contrast the tension of the English diphthongisations with the similar Icelandic process. There, the high vowel [i:], via [ii̯], underwent mutation of the nucleus and changed to [ui̯], its way of obeying diphthongal differentiation.

5.2 Particle exchange

I have suggested that the changes in the first stage of the GVS (i.e. raising and diphthongisation) comprise a unified process of heightening of tonality and that the subsequent lowering of the diphthongs, brought about by diphthongal differentiation, represents tension in aperture. Furthermore, when one looks at the entire GVS there is an impressive symmetry in the arrangement of shifting vowels. From the viewpoint of particle phonology, the symmetry is reflected as PARTICLE EXCHANGE: the loss of particles by one set of vowels is offset by a gain elsewhere in the system. I shall illustrate this phenomenon with the GVS and with changes from Indo-European to early Germanic.

The GVS comprises three major phases, as shown in (9):

(9) Stage 1	[e:] > [i:]	[ii̯] > [ei̯]	ai i > i i	i i̯ > ai i̯
	[ɛ:] > [e:]		aai i > ai i	
	[o:] > [u:]	[uu̯] > [ou̯]	au u > u u	u u̯ > au u̯
	[ɔ:] > [o:]		aau u > au u	
Stage 2	[a:] > [ɛ:]	[ei̯] > [ʌi̯]	aa aa > aai aai	ai i̯ > a i̯
		[ou̯] > [ʌu̯]		au u̯ > a u̯
Stage 3	[e:] > [i:]	[ʌi̯] > [ai̯]	ai i > i i	a i̯ > aa i̯
	[ɛ:] > [e:]		aai i > ai i	
		[ʌu̯] > [au̯]		a u̯ > aa u̯

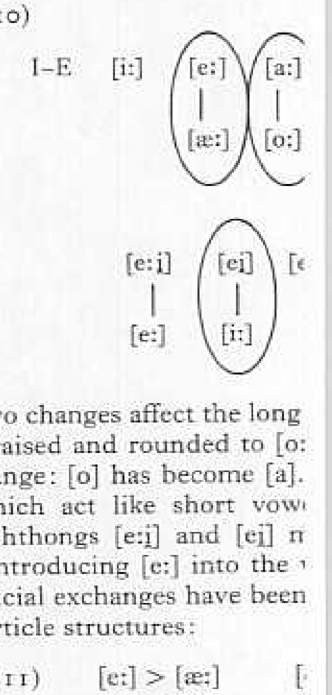
We have extensively considered stage 1: the raising of mid and of lower mid vowels, and the diphthongisation and lowering of high vowels. At stage 2, the nuclei of the diphthongs [ei̯] and [ou̯] are centralised, becoming [ʌi̯]

and [ʌu̯], respectively, and th
stage 3, the diphthongs are f
vowels [e:] and [ɛ:] (the latter
respectively. Observe the sy
stage 2 in the front/central d

Notice how the symmetri
nonhigh tonality vowels eac
(diphthongised) high vowels
diphthongs lose their tonal
particles for tonality (i.e. pal
both nonhigh front vowels
diphthongs each acquire one

As another example of reci
of vowels from Indo-Europe

(10)



Two changes affect the long
is raised and rounded to [o:
change: [o] has become [a].
(which act like short vow
diphthongs [e:i̯] and [ei̯] n
reintroducing [e:] into the
crucial exchanges have been
particle structures:

(11) [e:] > [æ:]
[a:] > [o:]

There are two reciprocal
The long vowel, when low
diphthong, when raised to
affects [a:] and [o]. The long
particles; the short vowel, v

How might reciprocal ch
sound change? It is uncon
complex segment types, wh

s their response to a height-
vowels, serialises their extra
te components of heightened
ıu̯] have identical first and
ıw of diphthongal differen-
l in internal structure from
from the raised mid vowels.
ı merger, and so their nuclei
:les, and, in this way, the
ɔosed to the new heightened
:antime, original [ɛ:] and [ɔ:]
But the diphthongs [ei̯] and
ıid vowels, because the two
cal.[23]
ongisations with the similar
via [ii̯], underwent mutation
ay of obeying diphthongal

tage of the GVS (i.e. raising
ess of heightening of tonality
ıhthongs, brought about by
n in aperture. Furthermore,
impressive symmetry in the
ʋpoint of particle phonology,
NGE: the loss of particles by
ı the system. I shall illustrate
ıanges from Indo-European

s shown in (9):

ı i > i i   i i̯ > ai i̯
ı i > ai i
u > u u   u u̯ > au u̯
u > au u
ıa > aai aai   ai i̯ > a i̯
au u̯ > a u̯
ı i > i i   a i̯ > aa i̯
ı i > ai i
a u̯ > aa u̯

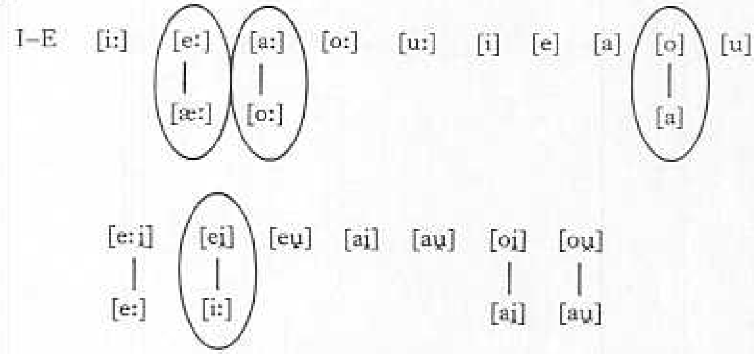
raising of mid and of lower
ering of high vowels. At stage
re centralised, becoming [ʌi̯]

and [ʌu̯], respectively, and the low central vowel [a:] is fronted to [ɛ:]. At stage 3, the diphthongs are further lowered to [ai̯] and [au̯], and the front vowels [e:] and [ɛ:] (the latter derived from [a:]) are raised to [i:] and [e:], respectively. Observe the symmetries: stage 1 involves shifts in height, stage 2 in the front/central dimension, and stage 3 in height, once again.

Notice how the symmetries exemplify particle exchange. At stage 1, nonhigh tonality vowels each lose an aperture particle, while the two (diphthongised) high vowels acquire one. At stage 2, the nuclei of the diphthongs lose their tonality particles, and the vowel [a:] acquires particles for tonality (i.e. palatality).[24] Stage 3 repeats aspects of stage 1: both nonhigh front vowels each lose an aperture particle, while the diphthongs each acquire one.

As another example of reciprocal change, consider in (10) the evolution of vowels from Indo-European to early Germanic:

(10)



Two changes affect the long vowel system: [e:] is lowered to [æ:], and [a:] is raised and rounded to [o:]. Among the short vowels, there is a single change: [o] has become [a]. This same change affects the vocalic nuclei (which act like short vowels) of the diphthongs [oi̯] and [ou̯]. The diphthongs [e:i̯] and [ei̯] monophthongise: [e:i̯] becomes [e:] (thereby reintroducing [e:] into the vowel system), and [ei̯] is raised to [i:]. The crucial exchanges have been circled in (10) and are reproduced in (11) as particle structures:

(11)	[e:] > [æ:]	[ei̯] > [i:]	ai i > aai i	ai i̯ > i i
	[a:] > [o:]	[o] > [a]	a a > au au	au > a

There are two reciprocal changes. The first one involves [e:] and [ei̯]. The long vowel, when lowered to [æ:], gains an aperture particle; the diphthong, when raised to [i:], loses one. The second particle exchange affects [a:] and [o]. The long vowel, when converted to [o:], acquires labial particles; the short vowel, when changed to [a], loses its labial particle.

How might reciprocal change fit into the overall picture of historical sound change? It is uncontroversial that some changes lead to more complex segment types, while others lead to simpler ones. The simplifications of markedness theory account for only half of the flux. Other factors must be at work if overall complexity is to be preserved. Some complications can be attributed to suprasegmental influence and others to assimilation, but there are still many context-free changes that do not fit into these categories. I suggest that a simplifying change and a complicating one can pair up in some fashion and reciprocally affect each other. This is not to say that the changes must happen simultaneously. They could, of course, but I suspect that most such changes are sequential: one change takes place, and then a complementary one occurs.[25] The balancing is highly structured, and particle notation reveals the symmetry as particle exchange. Often, a segment or group of segments loses a particular kind of particle, while the same type of particle is acquired elsewhere.[26] It is as though there is a constant flow of energy moving among the vowels. Reciprocal change is a manifestation of a tendency observed again and again in phonology: phonological systems strive toward symmetry.

6 Summary

The most salient difference between the standard framework and particle phonology is in the choice of primitive phonological elements. Let us contrast some of the properties of distinctive features and of elementary particles.

Distinctive features are atomistic, inclusive, unitary, and autonomous. Segments are composed of features; segments are specified for all relevant features; each feature occurs exactly once; and the phonological interpretation of features is (by and large) language-independent.

Elementary particles are compositional, additive, multiple, and dependent. Complex vowels are composed of simpler ones; vowels are specified only for those components present; particles may occur multiply; and because of their different functions, the interpretation of particles is language-dependent.

Let us look at each of these characteristics.

6.1 Atomistic *vs.* compositional

The standard framework sharply differentiates between segments and features. The former are composed of the latter. In particle phonology, the entity and the property are entwined. Particles represent individual vowels as well as traits of vowels. Colour provides a useful analogy. Red, blue, and yellow are the primary colours of the artist's palette. These three exist as independent colours, and combinations of them produce all other colours. It is the dual physiognomy of particles that allows a simple account of alternations between diphthongs and monophthongs. In the fusion of [ai̯] to [e], for example, the sequential particles of the diphthong are functioning as independent segments, whereas in the resulting monophthong the same two particles function as properties of the vowel. With features, on the other hand, there is no way that the two sets of features composing the halves of a diphthong can fuse into a monophthong, simply because one or more features of the sets will have contradictory values (i.e. will be specified as + in one of the segments and as − in the other).

6.2 Inclusive *vs.* additive

In the feature framework, segments require a specification (i.e. a + or a − value) for each of the features. In particle phonology, vowels are specified only for those components that are present. The additive nature of particles provides a built-in 'markedness' system. This characteristic also accounts for a fundamental property of diphthong/monophthong pairs: each half of the diphthong is phonologically simpler than the corresponding monophthong.

6.3 Unitary *vs.* multiple

Each distinctive feature occurs at most once in the specification of a segment. Elementary particles may occur multiply. First of all, because there are fewer particles than features, particles must occur more than once if only to cover all of the types of vowel contrasts. This property is evident in the treatment of both vowel height and vowel length. Multiple occurrences of aperture accommodate very elegantly those vowel shifts where vowels of differing height move stepwise up or down the height scale. Multiple occurrences of tonality make it possible to characterise relationships between long vowels and diphthongs.

6.4 Autonomous *vs.* dependent

The distinctive features are autonomous. Because features have fairly exact phonetic correlates, each feature plays a precise role in defining a segment. The most important property of particles is their capacity to perform different functions.[27] The tonality particles *i* and *u* correspond to high vowels, when uncombined; they function as upglides, when nonsyllabic; they indicate frontness and rounding, respectively, when part of a complex configuration; and they denote length and/or tenseness, when in combination with tonality vowels. The particle *a* corresponds to a central vowel, when uncombined; it functions as a downglide, when nonsyllabic; it indicates lowered height, when part of a complex configuration; it marks length for central vowels; and it denotes laxness for those vowels opposed to tense ones. But in neither case is it a question of arbitrary associations. In one instance, the various properties are manifestations of a generalised tonality, and in the other, of aperture.[28] However, the particular interpretation of a particle – for example, whether the aperture particle denotes lowered height or laxness – will depend on the language system and other elements that are present. The nonautonomous character of particle representation is by no means a liability. It accounts for such phenomena as the association of lax vowels with vowels of the next lower height, and relations between tenseness and palatality/labiality. These various relationships cannot be expressed with the distinctive features. The inadequacies stem from a too-close correlation with phonetic substance. Particles, by reducing vowel properties to expressions of tonality and aperture, classify vowels in a highly abstract manner.[29] It is this greater degree of abstraction that lends a new perspective to the study of vowels and of their evolution.[30]

* * *

'Ar,' he moaned. He had lost the *P*.
Once a Garp, then an Arp, now only an Ar; she knew he was dying.
He had just one vowel and one consonant left...
'Aaa,' said Garp. Even the *r* was gone.
He was reduced to a vowel sound...

John Irving, *The world according to Garp*.

NOTES

[1] Phonology deals, of course, with entities other than segments (e.g. prosodic phenomena). Particle phonology is a theory about segmental entities and, in particular, vowels.

[2] The 'plus' corresponds to the SPE feature [+syllabic], the 'space' to [+long], and the 'half-moon' to [−syllabic]. The three elementary particles, on the other hand, accommodate various values of the features [high], [low], [back], [round], and [tense].

[3] To say that [i] is particleless is not to suggest that it is an empty vowel. It still maintains vocalicness, a trait it shares with all other vowels. What is unique about [i] is its lack of elementary particles.

[4] Traditionally, there are two ways to represent long vowels: either as a single segment specified as long, or else as a sequence of two identical short segments. Both representations are needed for phonological description (Kenstowicz 1970; Pyle 1970). One approach treats length as a feature, the other as an independent segment. The notational variance of [e:] and [ee], for example, is reflected as **ai i** and **ai ai** in particle phonology. Now in the standard notation, there is no inherent relationship between an independent feature [+long] and an entire duplicated segment. In particle phonology, one can view the abbreviated representation of length as a 'factored' version of the full representation, where, for example, **a(i i)** is equivalent to **ai ai**, except that the parentheses can be omitted.

[5] Particle phonology can differentiate the following: an 'overshort' diphthong such as [ei̯] **aii̯**, that counts as one mora; a 'normal' diphthong of the type [ei̯] **ai i̯**, that counts as two morae; and an 'overlong' diphthong such as [e:i̯] **ai i i̯**, that counts as three morae.

[6] The particle configurations of lax vowels overlap with some of the vowels of Table 1. Thus, [ɪ] coincides with [e], [ʊ] with [o], etc. Recall, from the discussion of [a], that the interpretation of particles depends on the network of contrasts in a particular vowel system.

[7] Old West Scandinavian [u:] has become [uu̯] in Faroese (where [u] represents a front rounded vowel). I would maintain that [u:] first became [uu̯], then [iu̯] via mutation (exactly analogous to [i:] > [ii̯] > [ui̯]); subsequently, the [i] of [iu̯] was labialised by the following glide. My interpretation of the OWS data differs dramatically from that of Andersen (1972), who, in the context of his theory of

diphthongisation, claims that [i:] first became *[ɨ:], which then diphthongised to [ui̯], whereas [u:] became *[ʉ:], then [uu̯]. Both Andersen's and my scenarios are examples of the way that theories lead to interpretations of data.

[8] In the umlaut and raising of Old English, [a] was fronted to [æ], then subsequently raised to [e]. Its long partner [a:] was only fronted to [æ:]. Umlauted [ö] and [ö:], derived from [o] and [o:], were soon unrounded to [e] and [e:].

[9] Droning is the elimination of a superfluous particle. The term has an apiarian origin. The male bee, when no longer needed, is ejected from the hive.

[10] A two-dimensional array would provide an even more iconic representation of the fusion of (3a):

$$\mathbf{ai} > \begin{matrix}\mathbf{a}\\ \mathbf{i}\end{matrix}$$

Here the horizontal sequence to the left correlates directly to a temporal ordering of separately occurring particles, whereas the vertical array on the right portrays a simultaneous occurrence. For typographical reasons, I have not adopted this mode of notation. Because in (3a) the sequential and simultaneous realisations of particles occupy the same dimension, one requires some kind of punctuator, such as the plus sign or the half-moon symbol, for showing the difference.

[11] The inability of the standard notation to depict monophthongisations as fusions has been noted by Pagliuca & Mowrey (1980: 512–513), but they propose no resolution to the problem.

[12] For a given language, the particular result of a fusion of [a] and [i] will depend on which front vowels are in its system and on constraints, such as the law of maximum aperture (see §3.6.3).

[13] The particle notation for fusion (e.g. **a+i > ai**) is reminiscent of the notation of chemistry, where the input of elements determines the composition of a compound (e.g. Na + Cl = NaCl). The phonological notation [a] + [i] > [e] would be analogous to the chemical statement: Sodium + Chlorine = Salt.

[14] Natural classes (for purposes of rule writing) are expressed in particle notation by means of the elementary particles and the three logical operators for negation, conjunction, and disjunction. For example, **(i)** represents front vowels, **(−i)** central and back vowels, **(i&u)** front rounded vowels, **(i&−u)** front unrounded vowels, **(iv−u)** front and central vowels, **(ivu)** tonality vowels (to be abbreviated as **T**), etc. The diphthongisation rule of (4) could then be given as: **aT T > aT T̯**. If falling diphthongs are the expected outcome of the diphthongisation of long vowels, then the rule could be written simply as: **aT T** > fission. However, I shall not develop this notation further, as it is not particularly germane to the considerations of this paper.

[15] The proposed metric assumes the presence of elementary particles. The vowel [i] is not particularly favoured and is considered more marked than many other vowels. I must attribute this special status of [i] to its lack of elementary particles.

[16] I agree with Donegan's (1978: 64) observation that the tense/lax opposition only applies to vowels with tonality, and that an opposition such as [a:]/[ʌ] is one of length linked to height and not to tenseness. This restriction between tense/lax and tonality is built into particle notation.

[17] Particle phonology makes the claim that the tense/lax opposition does not exist independently, but it is always found in the company of long/short. (The latter, of course, need not be accompanied by the former.) Mona Lindau (personal communication) has found this correlation to hold in the numerous languages she has investigated.

[18] The lowering of lax vowels and their merger with long vowels of the next height down took place also in Middle English. This change, known as Open Syllable Lengthening, affected initially stressed short vowels of bisyllabic words. Particle analyses of this development and of the GVS are discussed in Schane (1984).

[19] Once Vulgar Latin acquires three vowel heights among its tonality vowels, the representation of [a] will become **aa** in accordance with the law of maximum aperture (§3.6.3).

[20] The glide [i̯] is probably even more palatalising than the high front vowel. This means that the 'half-moon' symbol, which normally denotes nonsyllabicity, functions also as an intensifier – that is, it augments further the property of the particle it accompanies.

[21] A labialisation hierarchy, analogous to the palatalisation one, can be established along the same principles.

[22] In the GVS, raising takes place also among the rounded vowels – [oː] becomes [uː], and [ɔː] is raised to [oː]. Here, the labial particle of the long vowel is responsible for the raising. The same principle – a heightening of tonality – is at work.

[23] In Schane (1984), I offer an alternative account of the mechanisms underlying the lowering of diphthongs in the GVS.

[24] Because Middle English has three vowel heights among its long tonality vowels, according to the law of maximum aperture, the representation of [aː] as a geminate will be **aa aa**. In the change from [aː] to [ɛː], the palatal particle is copied into each mora. The resulting **aai aai** has been represented by the abbreviated **aai i** at stage 3. Recall (note 4) that **aai aai** and **aai i** are interchangeable notations.

[25] Although reciprocal change may be sequential, nonetheless, the pair of changes occurs at roughly the same period in the history of a language. Without some type of temporal cohesion, reciprocal change is a vacuous notion.

[26] Not all reciprocal change involves the same particle(s). There is a type of change where one of the sounds is modified in some way, and then the other sound becomes identical to what the first one was. In French and Greek, [u] spontaneously became [ü], and then [o] was raised to [u]. In this case, [u] has acquired a palatal particle – a complication, and [o] loses an aperture particle – a simplification. The 'push chains' and 'drag chains' of Martinet (1955) are of this type.

[27] The distinctive features correspond to aspects of the speech event 'under partially independent control' (Chomsky & Halle 1968: 297). The Jakobsonian feature [+flat], on the other hand, is nonautonomous. Its interpretation – as retroflexion, labialisation, or pharyngealisation – depends on a particular language system; nonetheless, these different realisations of [+flat] share a generalised acoustic characteristic – i.e. a downward shift of formants (Jakobson *et al.* 1965: 31).

[28] In Schane (1973), operating with the standard distinctive features, I proposed that palatality is primary for characterising front unrounded vowels, labiality for back rounded, and aperture for [a]. Donegan (1978) proposes palatality, labiality, and sonority (her term) as vowel traits. Her parameters are binary features, except for sonority (height), which is n-ary; in addition, she has features of length and tenseness. Anderson and Jones (1977) treat vowel qualities as complexes of *a*, *i*, and *u*. Their proposal is quite different from mine. They allow hierarchical structure; thus, [e] and [ɛ] are differentiated as *i* dominating *a*, and as *a* dominating *i*, respectively. They do not treat length or tenseness/laxness as complexes of vowels.

[29] Ladefoged (1981) and Lindau & Ladefoged (1984) have argued extensively that the features required for phonological classification must function as 'cover' categories that may encompass diverse phonetic realisations. In other words, phonological features are abstract entities whose global properties are circuitously linked to phonetic substance. This view accords with my conception of the relationship between particles and the phonetic attributes of individual vowels. This position, however, is not so extreme as that of Foley (1977), who claims no correspondence whatsoever between phonological categories and phonetic parameters.

[30] I have not investigated whether the principles of particle phonology are applicable to the study of consonants. Are the various places and manners of articulation of consonants reducible to a small number of particles? If not, is it the case then that vowels are structured entirely differently from consonants?

REFERENCES

Allen, W. Sidney (1972). *Sandhi*
Andersen, Henning (1972). Dipl
Anderson, John M. & Charles J.
English. Amsterdam: North H
Bright, William (1965). Luiseño
Bruce, Gösta (1970). Diphthon
Linguistics, Lund University 3.
Carter, Richard (1975). Some th
Didier L. Goyvaerts & Geoffr
English. Ghent: E. Storia-Scie
Chen, Matthew Y. & William
implementation. *Lg* **51**. 255–28
Chomsky, Noam & Morris Hall
Harper & Row.
Donegan, Patricia J. (1978). *On*
Linguistics, Ohio State Universi
Foley, James (1977). *Foundation*
University Press.
Grundt, Alice W. (1975). *Compen*
University Linguistics Club.
Jakobson, Roman, C. Gunnar M.
analysis. Cambridge: MIT Pre
Kenstowicz, Michael J. (1970). O
in Linguistics 3. 73–110.
Labov, William (1972). The intern
& Ronald K. S. Macaulay (eds.)
Indiana University Press. 101–
Ladefoged, Peter (1981). What ar
Lass, Roger (1976). *English phonol*
University Press.
Lindau, Mona & Peter Ladefoged
Martinet, André (1955). *Economie*
Nandris, Octave (1963). *Phonétiqu*
Pagliuca, William & Richard Mo
[grave]. *Lg* **56**. 503–514.
Pyle, Charles (1970). West Greenla
Papers in Linguistics 3. 115–146.
Schane, Sanford A. (1973). [bacl
Kiparsky (eds.) *A Festschrift for*
174–184.
Schane, Sanford A. (1984). Two En
Aronoff & Richard Oehrle (eds.)
SPA [Stanford Phonology Archiv
Donald Sherman & Marilyn M.
a sample of the world's languages.
Vennemann, Theo (1972). Phone
phonology. *Lg* **48**. 863–892.
Wang, William (1968). Vowel featu
Lg **44**. 695–708.
Wolfe, Patricia M. (1972). *Linguis*
Berkeley: University of Californi
Yip, Moira (1980). Why Scanian is

han the high front vowel. This
rmally denotes nonsyllabicity,
ɪnts further the property of the

lisation one, can be established

rounded vowels – [o:] becomes
l particle of the long vowel is
a heightening of tonality – is at

of the mechanisms underlying

among its long tonality vowels,
presentation of [a:] as a geminate
ıe palatal particle is copied into
esented by the abbreviated **aai i**
are interchangeable notations.
nonetheless, the pair of changes
of a language. Without some type
uous notion.
icle(s). There is a type of change
way, and then the other sound
nch and Greek, [u] spontaneously
is case, [u] has acquired a palatal
re particle – a simplification. The
)55) are of this type.
the speech event 'under partially
: 297). The Jakobsonian feature
rs interpretation – as retroflexion,
n a particular language system;
flat] share a generalised acoustic
ts (Jakobson *et al.* 1965: 31).
stinctive features, I proposed that
rounded vowels, labiality for back
proposes palatality, labiality, and
ers are binary features, except for
, she has features of length and
wel qualities as complexes of *a*, *i*,
n mine. They allow hierarchical
dominating *a*, and as *a* dominating
enseness/laxness as complexes of

984) have argued extensively that
ication must function as 'cover'
etic realisations. In other words,
e global properties are circuitously
ords with my conception of the
ic attributes of individual vowels.
ıat of Foley (1977), who claims no
ılogical categories and phonetic

f particle phonology are applicable
ıces and manners of articulation of
articles? If not, is it the case then
from consonants?

REFERENCES

Allen, W. Sidney (1972). *Sandhi*. The Hague: Mouton.

Andersen, Henning (1972). Diphthongization. *Lg* **48**. 11–50.

Anderson, John M. & Charles Jones (1977). *Phonological structure and the history of English*. Amsterdam: North Holland.

Bright, William (1965). Luiseño phonemics. *IJAL* **31**. 342–345.

Bruce, Gösta (1970). Diphthongization in the Malmö dialect. *Working Papers in Linguistics, Lund University* **3**. 1–20.

Carter, Richard (1975). Some theoretical implications of the Great Vowel Shift. In Didier L. Goyvaerts & Geoffrey K. Pullum (eds.) *Essays on the Sound Pattern of English*. Ghent: E. Storia-Scientia. 369–376.

Chen, Matthew Y. & William S.-Y. Wang (1975). Sound change: actuation and implementation. *Lg* **51**. 255–281.

Chomsky, Noam & Morris Halle (1968). *The sound pattern of English*. New York: Harper & Row.

Donegan, Patricia J. (1978). *On the natural phonology of vowels. Working Papers in Linguistics, Ohio State University* **23**.

Foley, James (1977). *Foundations of theoretical phonology*. Cambridge: Cambridge University Press.

Grundt, Alice W. (1975). *Compensation in phonology: open syllable lengthening*. Indiana University Linguistics Club.

Jakobson, Roman, C. Gunnar M. Fant & Morris Halle (1965). *Preliminaries to speech analysis*. Cambridge: MIT Press.

Kenstowicz, Michael J. (1970). On the notation of vowel length in Lithuanian. *Papers in Linguistics* **3**. 73–110.

Labov, William (1972). The internal evolution of linguistic rules. In Robert P. Stockwell & Ronald K. S. Macaulay (eds.) *Linguistic change and generative theory*. Bloomington: Indiana University Press. 101–171.

Ladefoged, Peter (1981). What are linguistic sounds made of? *Lg* **56**. 485–502.

Lass, Roger (1976). *English phonology and phonological theory*. Cambridge: Cambridge University Press.

Lindau, Mona & Peter Ladefoged (1984). Variability of feature specifications.

Martinet, André (1955). *Economie des changements phonétiques*. Berne: A. Francke.

Nandris, Octave (1963). *Phonétique historique du roumain*. Paris: C. Klincksieck.

Pagliuca, William & Richard Mowrey (1980). On certain evidence for the feature [grave]. *Lg* **56**. 503–514.

Pyle, Charles (1970). West Greenlandic Eskimo and the representation of vowel length. *Papers in Linguistics* **3**. 115–146.

Schane, Sanford A. (1973). [back] and [round]. In Stephen R. Anderson & Paul Kiparsky (eds.) *A Festschrift for Morris Halle*. New York: Holt, Rinehart & Winston. 174–184.

Schane, Sanford A. (1984). Two English vowel movements: a particle analysis. In Mark Aronoff & Richard Oehrle (eds.) *Language sound structure*. Cambridge: MIT Press.

SPA [Stanford Phonology Archives] (1979). Crothers, John H., James P. Lorentz, Donald Sherman & Marilyn M. Vihman (eds.) *Handbook of phonological data from a sample of the world's languages*. Department of Linguistics, Stanford University.

Vennemann, Theo (1972). Phonetic detail in assimilation: problems in Germanic phonology. *Lg* **48**. 863–892.

Wang, William (1968). Vowel features, paired variables, and the English Vowel Shift. *Lg* **44**. 695–708.

Wolfe, Patricia M. (1972). *Linguistic change and the Great Vowel Shift in English*. Berkeley: University of California Press.

Yip, Moira (1980). Why Scanian is not a case of multivalued features. *LI* **11**. 432–436.