A Unified Approach to Feature Representation

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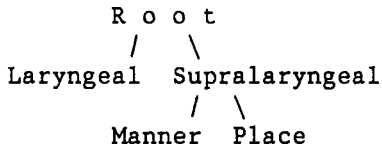
1. Introduction

Since the proposal on hierarchical feature representation by Clements (1985), numerous studies on feature representation have been conducted within the framework of "Feature Geometry" (FG, henceforth). The main reason for arguments pro FG is that phonological processes give evidence for feature grouping. For example, a lot of phonological processes show the independence of the place node separated from the manner node, or the unique status of the laryngeal node independent of the supralaryngeal node, which can be shown in the earlier model of Clements (1985).

(1)



Moreover, various types of assimilation processes can be described as spreading of a single node; e.g. the root node for total assimilation, a class node for partial assimilation, and a terminal feature for single feature assimilation.

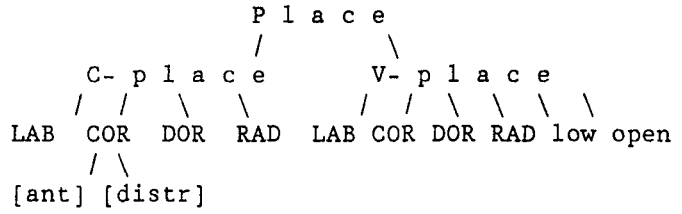
During the various stages of developing this theory, however, there have been numerous changes of the major concepts as well as frameworks. Moreover, as there has been no complete agreement for a unified framework accounting for both vocalic and consonantal processes, most proposals have appealed either to the standard theory of FG by Sagey (1986) or to the unified theory of FG by Clements (1989, 1991). But those theories of FG are still problematic from various theoretical viewpoints. For example, there has been no explanation of the status of the manner node or the internal structure of the place node. Consequently, the uncertainty of the proposals on the articulator nodes leads to the large number of proposals (Steriade 1987, Sagey 1988, McCarthy 1988, Odden 1989, Hayes 1990, Rice & Avery 1991, Lahiri & Evers 1991, Clements 1989, 1991, etc.).

2. Place and manner properties

The various proposals for the theory of FG differ from each other in terms of the hierarchical organization of primes. Or they differ in the description of various processes where consonantal

features and vocalic features interact.[1] Especially, the recent proposal by Clements (1989) has been most influential for numerous studies on featural representation due to its ability of describing both consonantal and vocalic processes by the same set of articulatory features.(e.g. Hume 1990; Kaisse 1991; Lahiri & Evers 1991; Sohn 1991, etc.) Thus, for major articulatory distinctions, Clements (1989) employed the same [labial], [coronal], [dorsal], and [radical] nodes under the separate C- and V- Place tiers. ([open] and [low] were placed under the V-place node for vowel height.)

(2)



This proposal, however, has shown various problems, in the representation of both place and manner. As for the internal structure of the place node, the most noticeable character of this model is in the description of vowels and consonants with the same set of features. But this unified description causes the problem of redundancy since the same articulatory features have to be repeated under the C- and V-place tiers. For example, in the representation of a palatal sound, [coronal] would appear under both the C- and V-place nodes. Moreover, consonant-vowel interaction is characterized by the same features but in an indirect way. For example, a V-place feature may get the C-place status via "**tier promotion**", but it is not clear what triggers this mechanism.[2] Furthermore, [low] and [open] are motivated just for vowel height which might be represented by the DORSAL or the RADICAL node. (For example, in a

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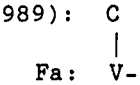
[1] Therefore, in some cases, they result in costly modification of the standard model, e.g. positing a dorsal node for vowels but a velar node for consonants (Steriade 1987). In other cases, they cause a duplication problem by repeating the same phonological primes for the consonantal tier and the vocalic tier (Clements 1989, 1991).

[2] Tier Promotion (Clements 1989):

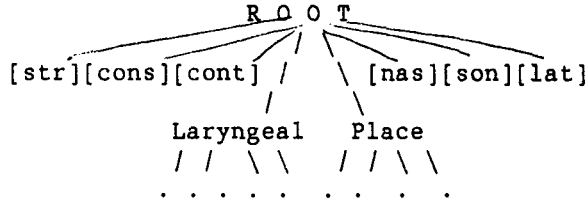


(where Fa = any articulator feature, and V-place is linked to C on the skeletal tier)
1. link a copy of F to the C-place node
2. delink F from the V-place node.

language with a simple vowel height, the RADICAL node can take care of the function of [low].)

Besides these problems with the representation of place, there are also problems with respect to the representation of manner. For example, in Clements (1989, 1991), we can easily observe some redundancies in the distinction between C and V. In other words, before selecting the C- or V- place node, the consonant/vowel distinction may have been represented in the manner node or in the root node, by [consonantal], [sonorant], [continuant], [nasal], etc. Moreover, this sort of indeterminacy problem is not limited to Clements (1989, 1991). In other words, there has not been any explicit description or agreement as for the manner property in FG, simply because there has not been any well-known phonological process solely related to the manner node. Thus most manner features, such as [sonorant], [consonantal], and [continuant], have been represented differently, depending on the type of the model adopted. In Sagey (1988), for instance, [sonorant], [consonantal], and [continuant], as well as [strident], [lateral], and [nasal], are immediate daughters of the root node.[3]

(3)



On the other hand, in McCarthy (1988), [consonantal] and [continuant] together function as the root node, while [continuant] remains as a daughter of the root. Thus, the figure in (4) illustrates the internal organization of the root node and its headship over the other manner properties claimed in McCarthy (1988).

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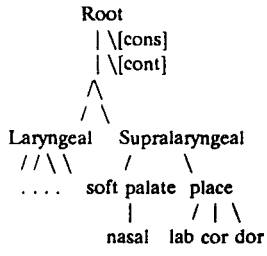
[3] In Sagey (1986), [nasal] was placed under the soft palate node, dominated by the supralaryngeal node, while [consonantal] and [continuant] were considered to be immediate daughters of the root.



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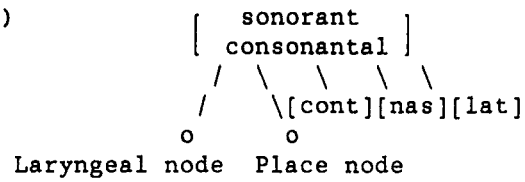
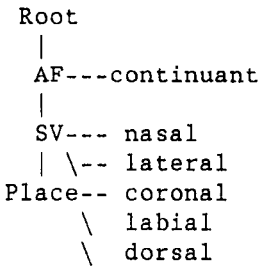


Here we may conjecture that those features characterizing the consonant/vowel distinction or the major class distinctions are related to the universal sonority hierarchy or the head-dependent sonorancy relations between certain groups of features.

In fact, in Rice & Avery (1991), only [continuant] is specified as the daughter of the root node. Then, the "Air Flow (AF)" node dominating [continuant] is described as the head of the sonorancy node, called the "Spontaneous voicing (SV)" node, which in turn is described as the head of the place node.

(5)



Based on this proposal, the following Head-Dependent Constraint (HDC) is derived.[4]

(6) Head-Dependent Constraint (HDC)

For daughters of heads to be linked, dependents must have identical structure.

In a recent paper, Clements (1991) also implies a concept of headship in the representation of place. As shown in the following diagram, the C-place node functions as the head for the vocalic properties.

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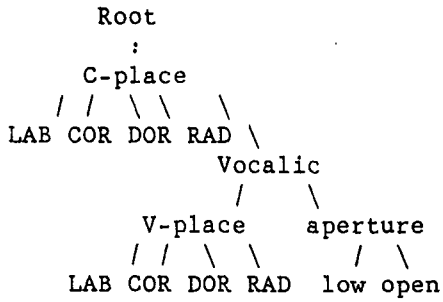
[4] Refer to the introductory chapter in *Phonetics and Phonology 2* for the brief outline showing the arguments for these various hierarchical representations.

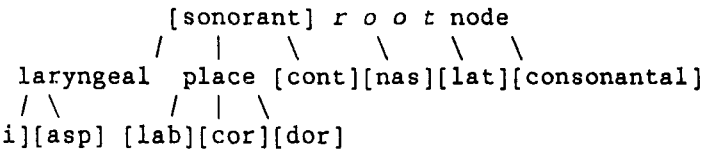
(7)



Nevertheless, except for the head-dependent relationship, those problems discussed already still remain unsolved.

In Kaisse (1992), on the other hand, only [sonorant] is placed on the root node, while [consonantal] becomes the immediate daughter of the root just like other articulator nodes. (In this sense, her proposal is a slightly revised version of McCarthy (1988) in that [sonorant] functions as the root feature.)

(8)



Moreover, in her proposal for independence of the [consonantal] node, Kaisse (1992: 325) shows strong doubt over the "privative" nature of the [consonantal] node. Then, if the [consonantal] cannot be represented in a privative way, this view would substantially weaken the (at least "radical") underspecification theory. (And if we are to maintain the general benefits of underspecification in feature representation, there should be a way to describe the nonprivative nature of consonantality.) Furthermore, although [sonorant] is the sole root feature in this model, Kaisse suggests the possibility for independence of the manner node if it is specified in terms of sonority. Thus she proposes the "sonority redundancy principle" which says that when one major class feature of a segment is changed, its other major class feature is automatically wiped out and replaced by a default specification.[5] Therefore, when [+consonantal] spreads, the result is [-sonorant]. (Kaisse 1992: 323) On the contrary, however, the result would be most likely a [+sonorant] segment when [+consonantal] delinks.

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[5] Sonority Redundancy Principle: Kaisse (1992:324)
The result of spreading [consonantal] to the root node is to delink the sonorancy annotation on that node and replace it with [-sonorant] in case of [+consonantal] and with [+sonorant] in the case of [-consonantal].

Moreover, citing McCarthy (p.c.), Kaisse says that sonorancy does not spread in a binary fashion, but it seems to affect neighboring segment in a gradient way. Then, following this observation, we need to reconsider the current theory of FG which depends on the binarity of feature representation.

As we have reviewed various proposals on FG, therefore, it is revealed that the consonantality or vocalicness of a segment is crucially determined by the sonority hierarchy. In other words, as the manner features such as [consonantal] and [sonorant] are interrelated, they should be combined as one single head feature categorizing segments for their major class distinctions. Thus we need to look for a new framework in which sonorancy functions as the head feature and its phonological behavior can be represented in a gradient way.

In fact, in Dependency Phonology (DP, henceforth) of Anderson & Ewen (1987), the redundancy or the indeterminacy problem of FG have been avoided by representing all segments in terms of sonority hierarchy and the head-dependency relation. DP is similar to FG in that it recognizes the hierarchical organization of phonological primes. But it differs from FG in that phonological primes are unary-valued components which occur alone or in combination. Here components are classified in gestures, corresponding to the class node groupings in FG. When components occur in combination and they are in an asymmetric relation, the asymmetric relation is referred to as "head-dependent". For instance, as shown in the following table, the representations of major segmental types are defined in terms of the head-dependent relationship between V and C properties.

(9)	C	C | V	V:C	V:C | V	V | C	V | V:C	V
	voiceless plosive	voiced plosive	voiceless fricative	voiced fricative	nasal	liquid	vowel

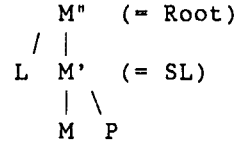
DP has some distinct advantages in explaining vowel-related consonantal processes in a uniform way since it uses the single unified representation for both vowels and consonants. DP, however, suffers from some of the problems that FG has, i.e. the lack of restrictiveness on the internal structure of the formally recognized classes: one gesture could contain 28 components, whereas the other has only one in DP.(Hulst 1991:5) Moreover, detailed segmental representations are excessively complex in many cases. For example, the representations in (9) are manner representations, which are much more complicated than those of FG. Moreover, the representation for place features is also complex, e.g. {|u,d|} for labiodentals, {|1,d|} for dentals. Therefore, the major problem of DP lies not only in its reliance on the use of an excessive number of particles, but also in the excessive complexity of place features.

3. The Model

In order to find a satisfactory solution, I will adopt the basic approach of Hulst (1991) which attempts to incorporate the basic concepts of DP within FG. Then, by modifying this model, I will propose a more satisfactory framework.

In the model we are developing here, there are three gestures proposed by Hulst (1991), Laryngeal, Manner and Place, which are organized in an X-bar like tree structure. Here, "Manner" is the head, "Laryngeal" the specifier, and "Place" the complement. Thus Manner and Place form a unit since Manner and Place are more closely related phonologically than either of these with Laryngeal. This unit can be considered as M' which corresponds to the supralaryngeal node in the early standard theory of FG shown in Clements (1985). (Then the root node can be viewed as the M" node in this formula.)

(10)



In (10), the Laryngeal gesture contains components for tonal distinctions and voicing distinctions. The Manner gesture component represents the manner and major class distinctions, while the Place gesture takes care of place of articulation. Superficially, the general outline for this framework looks similar to the earlier model of Clements (1985). But our current framework is different from Clements (1985) in that it is based on the head-dependent relation allowing dual interpretation for both vowels and consonants. Here the claim that Manner is the head is based on the fact that phonotactics make reference to manner and major class features, rather than place or laryngeal features. There is just as much evidence to regard manner and major class primes as a functional unit as there is to postulate a place and laryngeal gesture. As claimed in Hulst (1991), therefore, there is no reason to consider phonological processes to be more significant than phonotactic constraints.

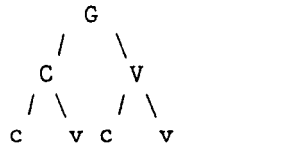
According to Hulst (1991), components are classified as either a C-type component or a V-type component, in addition to the hierarchical grouping. As C and V represent sonority types, a C-type component corresponds to "charmless" and a V-type component corresponds to "charmed" in Government-based phonology of Kaye et al (1985). (Hulst 1991) Therefore, a component is a triplet consisting of a category value, a sonority value and a markedness value.

(11)
Component = {CAT(val), SON(val), MARK(val)}
CAT(val) = {LARYNGEAL, MANNER, PLACE}
SON(val) = {C, V}

Mark(val) = {c, v}

Within each gesture components come in two pairs called "subgestures"; one pair is a C-type pair and the other is a V-type pair. Therefore, subgestures and components are labelled as C/V or c/v. The distinction is made to indicate that the labelling at both levels expresses the marked/unmarked (or optimal) distinction in relation with the sonority value. Since all components have a unique set of attributes, each triplet defines a component. Thus the real primitives of the theory are the attributes-values, which can be considered as the atoms of phonological structure.(Hulst 1991:43) Thus a unified organization of all three gestures can be shown in (12).

(12)



Gesture value (LAR, MAN, PLA)

Subgesture values

Markedness values

In Hulst (1991), one member for each pair is the "unmarked" expansion. For example, within a C-type subgesture, the unmarked expansion is labelled as "c" and the other as "v". Within a V-type gesture, however, the unmarked expansion is labelled as "v" and the marked one as "c". As a consequence, 12 simple gesture structures are derived from this manipulation: 3 x (G-C-c, G-C-v, G-V-c, G-V-v). These define a set of 12 basic phonological unary components.

(13)

Components	Consonant	Vowel
[LAR, C, c]	[c.g]	[H]
[LAR, C, v]	[s.g]	[L]
[LAR, V, c]	[stiff, vc]	[hi register]
[LAR, V, v]	[slack, vc]	[lo register]
[MAN, C, c]	[stop]	[lateral]
[MAN, C, v]	[continuant]	[fricative]
[MAN, V, c]	[closure]	[nasal]
[MAN, V, v]	[strident]	[vowel]
[PLA, C, c]	[coronal]	[front]
[PLA, C, v]	[labial]	[round]
[PLA, V, c]	[laminal]	[ATR]
[PLA, V, v]	[radical]	[low]

The component types shown in (13) indicate the possibility of the dual phonetic interpretation of each component, which is the most

distinctive merit of this framework. The dual phonetic interpretation of components is derived from the postulate that the combination of subgestures involves a head-dependency relation: whether the C-subgesture or the V-subgesture is the head. For example, C-type structures get their consonantal reading when they are the head, otherwise they get the vowel reading (and vice versa for V-type components). Thus labels like "coronal" or "front" are rough indications of the interpretation of [Head, Place, C, c] and [Dependent, Place, C, c], respectively. For proper phonetic interpretation, we must know whether a component is head or dependent as all components have a dual interpretation. Moreover, as subgestures can be expanded as branching, e.g. G-C-c,v, we may get the additional six more subgestural structures, and "cost" is calculated in terms of expansions. Thus the following hierarchy of markedness can be provided.

(14) Markedness hierarchy: Xx < Xy < Xx,y
Xx = unmarked (optimal)
Xy = marked
Xx,y = most marked

There are, however, several crucial problems in Hulst (1991). First of all, according to the markedness hierarchy in (14), any representation with the combined expansion of markedness values is expected to have the most marked status. Therefore, as for the representation of the manner property, all segmental types are represented with a markedness extension. For example, having the most complex manner property, an affricate will have the Cc,v representation, while the unmarked stops will have Cc. Similarly, an approximant appears as Vc,v and a vowel is considered to be Vv.

(15) a. Cc Cc,v Cv b. Vc Vc,v Vv

stop affricate fricative nasal approximant vowel

In representing the laryngeal component, however, an aspirated consonant is represented as the most marked Cv status and a glottalized one as the unmarked Cc, while the most "unmarked" plain consonant will be represented as a single C without any markedness value. In vowels, on the contrary, Vv refers to a low tone and Vc a high tone, but the most unmarked (in a three-tone system) mid tone has the most costly Vc,v representation. (Hulst 1991: 15, 19).

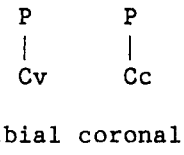
(16) a. Cc C Cv b. Vc Vc,v Vv

glottal plain aspirated high mid low

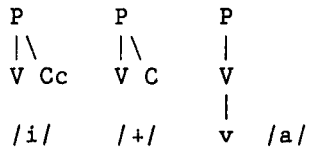
A similar problem also arises in the representation of the place specification; the most marked velar (or dorsal) is described

as a single C without any expansion but the unmarked coronal as Cc. On the other hand, a less marked vowel /i/ or /+/ has a V subgestural representaion without any expansion, while /a/ has the most unmarked opitmal representation Vv.

(17) a. Obstruents



b. Vowels



In other words, a single subgestural representation without any expansion sometimes get the most marked interpretation but, in other cases, an unmarked interpretation.

In order to solve this indeterminacy problem, I will incorporate the basic concepts of underspecification and modify the markededness hierarchy. Therefore, regardless of the types of representation, the most marked one has the expansion of combined markedness values, while the most unmarked one is represented without any expansion.

There is, however, another problem in Hulst's model since the representation of the markedness values (i.e. c, v, and c,v) are arranged in a traditional linear way. Therefore, if we follow his framework, we would have to describe all phonological processes in a linear way. In order to avoid this problem, we have to modify the representation so that the markedness values have a nonlinear formulation. By doing this, we can take advantage of the major benefits of nonlinear phonology as well as underspecification. For example, we can describe assimilation processes by spreading, in which more marked (i.e. more secified) values spread to a less marked (i.e. underspecified) target position.

A third problem lies in the representation of the subgestural values C/V and the markedness values c/v. In other words, in the model we are developing here, there is be no need to differentiate the subgestural values C/V and the markedness values c/v, as both pairs represent phonological distinctions based on sonority. In other words, both the subgestural values and the markedness values are determined based on the sonority scale. What is important in this framework, therefore, is the head-dependent relationship between C and V primes, rather than the types of symbols described by capital and small letters. The empirical consequences of this simplified representation will be shown in the next section on vowel assimilation processes. Based on these observations, therefore, the earlier concept of markedness hierarchy is modified as follows.

(18) Markedness hierarchy (Revised): X < X < X
                                       | |
                                       Y   Y
                                           |
                                           X

(18) indicates that the most unmarked representation is underspecified without any expansion. Thus, the expansion of the combined markedness values are the most marked ones.

Following this new markedness hierarchy, we can now show the various types of representation in a uniform way.

(19) Manner: C C C V V V
             | | | | |
             V V V C C
                | |
                C   V

stop fricative affricate nasal liquid vowel

(20) Laryngeal: a. Consonants b. Vowels
                C C C   V V V
                | | | |
                C   V   C   V

glottal plain aspirated high mid low

(21) Place for consonants: C C C
                           | |
                           V V
                              |
                              C

labial coronal velar

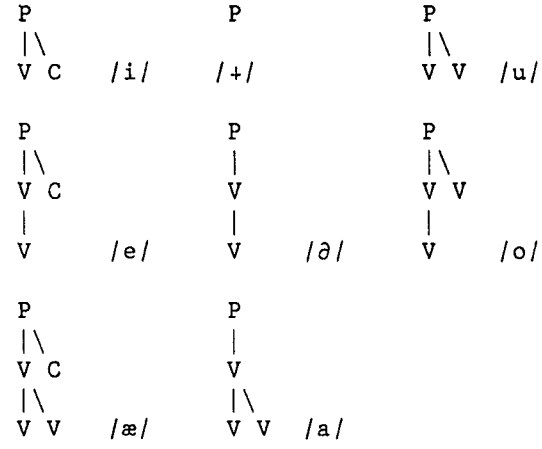
If we compare the representation of the manner properties in (9) with the representation for manner in (19), we see (19) is much simpler since voicing difference can be taken care of in the laryngeal node. In (21), moreover, the most complex segments are affricates for obstruents and liquids for sonorants since they are specified most. Here we also note that, due to this maximal specification, the distribution of place of complex segments is limited to coronals, while nasals or fricatives as well as stops can have various places of articulation. (Rice & Avery 1991)

Another problem of Hulst's model is in the redundant representation of the Laryngeal and the Place nodes. According to the head-dependency relation of this model, the headedness in the Laryngeal and the Place nodes is an automatic consequence of the headedness in the Manner. Therefore, we can simplify the overall description by making the top-most C or V subgestural specification underspecified in the Laryngeal and the Place nodes. In other words, we specify headedness only for the Manner node and this headship is

automatically transferred to the Laryngeal and the Place node by the head-dependent relationship. (Nevertheless, if the manner node has the nasal status, we may have to specify the headship of C or V in the place node since both consonants and vowels can be nasal depending on the language.)

The last problem to be reconsidered in Hulst (1991) arises from the overly complex description of vowels and the lack of underspecification in their representation. The complexity of the representations can be solved in a substantial way by underspecifying "V" as the head in vocalic representation. However, in order to solve the problem of lack of underspecification, we may have to appeal to the basic concepts of "Particle Phonology" proposed by Schane (1984) in which low vowels have more aperture particles than nonlow vowels in a gradient way; the low vowel /a/ would be represented as /AA/, while the mid vowel /∂/ as /A/. Then, like other high vowels, the high vowel /+/ is represented without any aperture particle. Thus, major types of vowels will be specified, following this procedure. For example, the basic vowel inventories in Korean will be represented as follows. The most unmarked vowel /+/ is underspecified as a simple P (meaning the "place" node) without any expansion since the head feature of this vowel will be inherited from the manner node.

(22)



Here the P-V-V show a low vowel which has the most aperture particles. In this sense, the terminal V in the P-V-V string corresponds to the [open] aperture feature in Clements (1991). Thus all the vowels with this terminal V markedness value are [+open] vowels; e.g. /e, ∂, o, æ, a/, and those vowels lacking this value are [-open], i.e. high vowels. On the other hand, the secondary markedness value V in /æ/ and /a/ corresponds to the [low] aperture feature in Clements (1991). Thus only /æ, a/ are low vowels. Finaly, the secondary subgesture C in /i/ and V in /u/ indicate the coronality (frontness) and labiality (roundness), respectively. Thus

those vowels with the secondary subgesture C are all front vowels, e.g. /i, e, æ/, while those with the secondary V are all round vowels, e.g. /u, o/.

Consequently, the the major merit of this representation lies in the ability to represent all gradient vowel heights in terms of aperture. Support for the aperture property comes from many recent studies on vowel height, e.g. Schane (1984), Hayes (1990), Rice & Avery (1991), Clements (1991), etc. Furthermore, an additional automatic consequence of this representation is its compatibility with the underspecification of the vowels. Thus the vowel /+/ with the minimal specification will be considered as the most unmarked "default" vowel.

4. Some consequences of the proposal

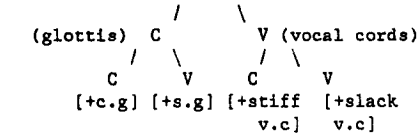
In Ahn (1992), it was shown that the "molecular" theory of feature representation proposed by Hulst (1991) provides a unified and a better description of various consonantal as well as vocalic processes. Moreover, it was shown that it has various theoretical advantages over the standard theories of FG as well as those of DP. In this paper, I will also show how the revised framework developed in the previous section provides a better and more general description of various phonological processes. Moreover, it will be shown that both theoretical and empirical benefits are provided by this approach.

From a theoretical point of view, the following points can be stated. First, as a gradient scalar representation of the manner node is employed in this model, there is no need to separate the [consonantal] or [continuant] node from other mannner features. They can be incorporated into the single manner node together as shown in the previous section.

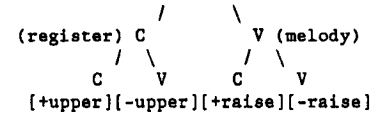
Second, it is now possible to provides a natural explanation for the freer distribution of place for nasals and fricatives, compared to the more limited distribution for laterals and affricates, in terms of markedness hierarchy. In other words, since laterals are more marked than nasals, and affricates are the most marked obsturents, it is quite natural for them to show a very limited distribution universally. This prediction also corresponds to the observations by Rice & Avery (1991).

Third, we can allow dual interpretation of place and laryngeal features, depending on the nature of the manner tier. For example, as shown in the following illustration, each laryngeal property can be interpreted either vocalically or consonantally, depending on the specification of the manner component.

(23) a. Consonantal: Laryngeal



b. Vocalic: Laryngeal



Besides these theoretical consequences, the following phonological processes are well accounted for in this framework.

4.1. (De)consonantalization

As shown in Kaisse (1992:327), various consonants become vocalic in Ahtna, an Athbaskan language of Alaska. For example, before any consonant the pronominal prefixes /b/, /nχ^{w}/, /ɣ/, and /k'/ emerge as [u], [unh], [i], and [i?], respectively. In other words, labials and labio-uvulars emerge as the high back rounded vowel [u], while front velars emerge as the high front unrounded vowel /i/.

(24) a. /b + χaan/ → *uχaan* 'half of it'
b. nχ^{w} + n + χ + ɬ + ʔaen → *unhχɬʔaen* 'he is looking at you (pl.)'
c. ɣ + ɣaan → *iɣaan* 'he is eating it'
d. k' + t + χ + ɣiiɬ → *iʔtaɣiiɬ* 'he will eat something'

Thus, in (24), we have the change of [consonantal] value and a concomitant adjustment in syllabicity.

On the contrary, in many Central Asian Turkic languages, like Uygur, high vowels between voiceless consonants devoice, producing fricatives (or fricative offglides). (Kaisse 1992: 323)

(25) pit → *pɨ̥̆st* 'louse' (or *pi̥st*)

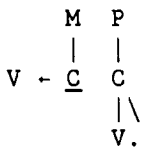
kitap → *kɨ̥̆tap* 'book' (or *kĭ̥tap*)

ʔuka → *ʔɨ̥ϕ^{w}ka* 'younger brother' (or *ʔu̥ϕ^{w}ka*)

Contrary to the previous examples, it is shown that [-consonantal] produces a syllabic consonant or a voiceless vowel. For this reason, Kaisse invoked the "Sonority Redundancy Principle" which ensures that a newly generated [+consonantal] segment will become an obstruent while a newl [-consonantal] segment will become a sonorant. Her analysis of these processes involves linking or delinking the [consonantal] feature located under the root node, causing one to question the status of the manner feature [consonantal].

In this paper, however, these two processes are described as

the C/V alternation within the manner component, as there is no change of place or laryngeal value.

(26)


Note that consonants have the head manner prime C, while vocalics the head prime V in this framework. Thus, if there is any dependent unit under either type of the head node, it will automatically take a default value due to "structure preservation". (Kiparsky 1985) For example, when a fricative or an affricate undergoes deconsonantalization, it appears as a vowel, i.e. C-V, C-V-C → V (as *V-V or *V-V-C is ill-formed.) Thus, obstruents become vowels by deconsonantalization, while vowels would surface as obstruents by consonantalization. (Note, however, that if the target segment is a nasal consonant, the result will be a vowel, rather than a fricative, i.e. V-C → V. The reason for this change is that only the nasals may get specifications for both manner and place nodes if the language has nasal vowels. Thus, in deconsonantalization of nasals, we have to scan not only the manner component but also the place component. In other cases, we observe the independence of each articulatory component.)

4.2. Desonorantization

In the Move dialect of Yagaria, a language of the East New Guinea Highlands, there are alternations between sonorants and obstruents involving *l*/*t*, *v*/*p*, and *m*/*b*. (Rice & Avery 1991: 110) The sonorants occur after a vowel and the obstruents after a glottal stop, the only possible syllable-final consonant in Yagaria. (The glottal stop is subsequently lost.)[6]

(27) a? 'female' + lata 'dual' → atata 'two women'
legi? elidu pa 'we have truely not taken it'
→ wlidu? + va (emphatic)

In Levin (1988), this process is described as strengthening, while Rice & Avery (1991) interprets it as the delinking of the SV (Spontaneous Voicing) node, since there is no change in the place or

[6] The consonantal inventory of Yagaria is as follows.

Obstruents:	p	t	k	?	Sonorants:	m	n		
	b	d	g			v	l	y	
	f	s		h					

the [consonantal] value.

(28) Root]σ σ[Root
        ∔
        SV

Here, however, we note that sonorancy is defined on the basis of degree of aperture within the articulator, i.e. the manner property. In other words, [sonorant] as well as [consonantal] must be defined as manner features as their values are defined by the (scalar) degree of sonorance. Thus, in the current framework, this process is easily acccounted for as a "gradient" change of the manner property, separated from any other component.

(29)
```
        M  P
        |  |
V ← C  C
    :  |\
       V..
```

In both (26) and (29), the head manner prime C alternates with the opposite head prime V, resulting in sonorant/obstruent or vocalic/consonantal alternations.

4.3. Nasal assimilation

In many languages including Korean and Sanskrit, obstruents become nasals by assimilation. (The Sanskrit data are from Rice & Avery (1991).)

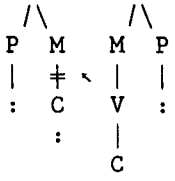
(30) Korean: kuk mul [kuŋmul] 'soup'
t+t ni [t+nni] 'hear?'
pəp man [pəmman] 'law only'
Sanskrit: tat nameas [tannnamas]
vak me [vaŋme]
triṣṭup nunam [triṣṭumnunan]

Now, in the current framework, this process is explained in terms of the universal "markedness tendency" proposed in Ahn (1992) which governs various assimilation processes. The markedness tendency for assimilation given below represents a slight modification of my earlier proposal.

(31) Markedness tendency: assimilation
Scan the relevant component of the markedness value.
Then change the less marked segment to the more marked one by spreading.

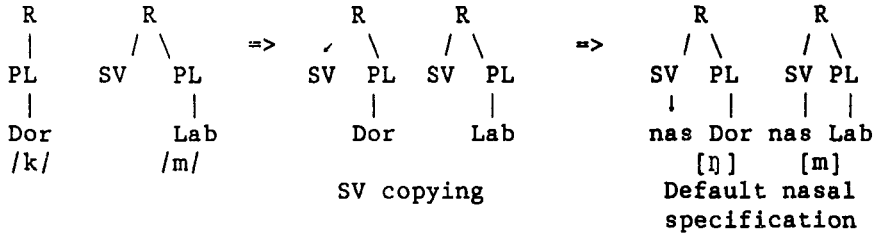
Then how this principle for changing less marked segments to more marked ones lies is illustrated in the following derivation. Here we observe that the less marked (consonantal) manner value C is changed to the more marked V-(C) value.

(32)



Within the framework of FG, Rice & Avery (1991:112) also propose that the SV (spontaneous voicing) node is responsible for nasal assimilation and lateralization. Thus, nasal assimilation is described by the SV node copying.

(33)



Note, however, that SV copying is similar to the costly Node Activation Convention,[7] which has no phonetic motivation since there is no landing site for the spreading feature in the target. Moreover, there is no reason for the SV node copying, rather than spreading since we would get the same result by spreading. Thus an additional device like node copying should be eliminated. Furthermore, as it has no constraint for application, this device can be applied whenever a possble target does not have the SV node.

4.4. N-latralization

In Korean, a syllable-final /n/ is lateralized by being adjacent to an /l/. That is, *n*-lateralization occurs no matter whether an /n/ precedes or follows an /l/.[8]

---

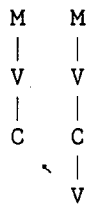
[7] A rule or convention assigning some feature or node α to some node ß creates a path from α to ß. (Archangeli & Pulleyblank 1986)

[8] Thus, in many earlier studies, this rule has been described as a mirror image rule. As Bae (1989) points out, however, this observation is quite misleading. As we examine lateralization more

(34) a. sin + la [silla] 'Sylla dynasty'
pan + lon [pallon] 'counter arguments'
mun + lan [mullan] 'disorder'
b. tal + nala [tallara] 'moon land'
sə̆ul + naki [sə̆ullagi] 'Seoulite'
mul + noli [mullori] 'playing in water'

Here recall that laterals are more marked (i.e. more specified) than nasals. Then, by following the general markedness convention, this process is described as a simple spreading process.

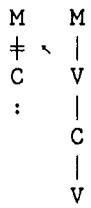
(35)



As the spreading is from the more marked segment to the less marked one, we can easily account for the direction of spreading as well. Thus this process can be interpreted in a mirror image way. (See Note *8* for the mirror image interpretation of Korean *n*-lateralization.)

Moreover, as the data in (30) show, even if other consonants become laterals, the general markedness convention applies here, changing the less marked obstruents to lateral *l*'s. And we can account for this process in an easy way.

(36)



In Rice & Avery (1991), citing Iverson & Kim (1987), it is shown that the Korean /t/ may be realized as a lateral before an /l/. Thus they employ the same type of description used in (33) to account for this alternation.

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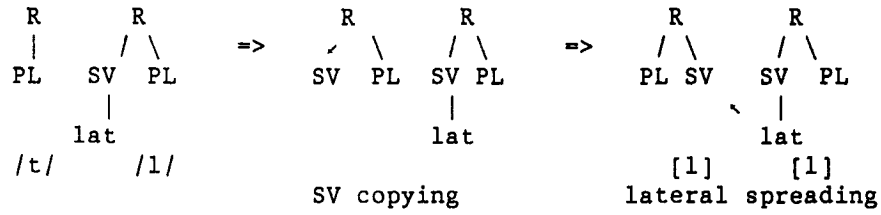
closely, it is revealed that the mirror image application is possible only in Sino-Korean words, while the application in pure Korean words (or other loanwords) is only unidirectional, i.e. progressive: /tal + nala/ [tallara] 'moon land' but /coh-+n + ladio/ [co+nnadio]/*[co+lladio] 'good radio'

(37) tik+t li+l → [tig+lli+l] Names of two Korean alphabets

(38)



Note, however, that it is more likely to get [tig+nni+l] by applying initial avoidance before lateral spreading. This alternative output is compatible with those other 't + l' combinations in which [t] is a derived segment via syllable-final neutralization changing all coronal obstruents to [t]: /t, t', t^h, s, s', c, c', c^h/ → [t]. Thus, in (39), we can get [nn] sequences, rather than [ll]'s.

(39) t^hi+t^h li+l → [t^hi+nni+l] Names of two Korean alphabets (*t^h* & *l*)
siso li+l → [sionni+l] " " (*s* & *l*)
ci+c li+l → [ci+nni+l] " " (*c* & *l*)
pəsəs lyu → [pəsənnyu] 'types of mushroom'

As the *t* → *l* change is a sporadic case of lateralization, rather than a general process, the description in (35) based on the markedness tendency still holds.[9]

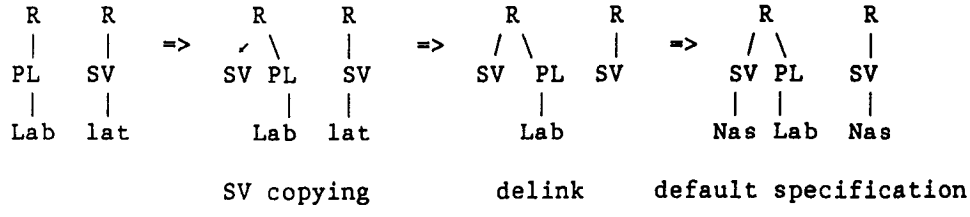
4.5. Consonantal place assimilation

In Korean, there is a process of regressive consonantal assimilation, in which coronal sounds like /t, n, c/ assimilate to

---

[9] Moreover, as shown in the following process of /p + l/ → [mn] change, Rice & Avery assume a wrong ordering. Note that delinking is identical to the initial avoidance process changing an syllable initial /l/ to an [n]. As initial avoidance obligatorily applies before any consonant, it should apply prior to SV copying. But, in their analysis shown below, SV copying precedes delinking, which is counter-intuitive to most native speakers.

/cap + lok/ → [camnok] 'a miscellany'



peripheral consonants, but the reverse direction may not occur in Korean (C.-W. Kim 1973, K.-H. Kim 1987, etc.).[10] Recently, this tendency towards peripheral articulation has been reinterpreted within the frameworks of FG and underspecification.[11] Thus it has been proposed that a specified place node spreads to the underspecified coronal segments which lack the place node (K.-H. Kim 1990, Sohn 1991). Note, moreover, that velars appear to be more peripheral than labials in that labials assimilate to velars, not vice versa: e.g./kamki/ → [kaŋgi]/*[kambi] 'flu.' We can thus summarize the various regressive assimilation possibilities as follows.[12]

(40) a. Coronal -> Labial / _____ Labial
b. Coronal -> Velar / _____ Velar
c. Labial -> Velar / _____ Velar

Based on this observation, we get the following hierarchy for markedness or peripherality.

---

[10] In C.-W. Kim (1973), therefore, it is suggested that directionality toward peripheral regions of the vocal tract is a common tendency shown in various phonological processes in Korean. This tendency is termed "centrifugality". He also claims that centrifugality in Korean is in complementary distribution with the "principle of close articulation". What he means by this principle is that, as one closes one's mouth for a consonantal articulation, labials and alveolars would be the first to be produced. He observed that, as the jaws opening is progressively narrowed by the principle of articulation, the apico-alveolar region is the part which is first obstructed in the mouth, and therefore those areas where there is still enough space for tongue articulation are the peripheral regions in the vocal tract. While the movement for close articulation is vertical toward the upper articulator, centrifugality goes horizontally toward the peripheral regions of the vocal tract.

[11] In Clements (1989, 1991), however, there has been no specific claim as to whether the phonological primes are unary (or privative) components or (underspecified) binary features. Thus there is no way to express the universal unmarkedness of coronality in this model.

[12] It is interesting to observe that, in child language, the place assimilation of consonants always applies regressively regardless of the markedness hierarchy: e.g. /yaŋ mal/ → [yammal] 'socks', /koŋ pu/ → [kombu] 'study', /n+k tæ/ → [n+tt'æ] 'wolf' (But, due to the markedness hierarchy, regressive assimilation is blocked in the speech of an adult.)

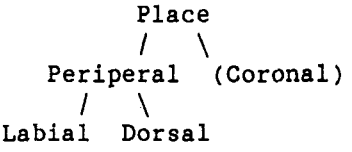
(41) Markedness hierarchy

Coronal < Labial < Velar

Many attempts have been made within the frameworks of FG and underspecification to provide a satisfactory analysis of this consonantal assimilation. Cho (1991) discusses the problems it poses for a universal theory of articulators. For this purpose, she compares two theories of place features, "articulator theory (AT)", which uses unary articulation, and "place of articulation theory (PT)", which uses binary features such as [coronal] and [anterior]. Then she claims that both theories are needed for different languages. In other words, AT and PT are to be selected as different options of a parameter. Recall that, in Korean, dentals assimilate to labials, palatals, and velars, but labials and palatals only assimilate to velars. Due to this gradient complexity in which dentals are least specified, Cho argues that AT cannot capture this complexity gradation because it assigns equal complexity to Labial and Dorsal.

As shown in Rice & Avery (1991), however, this parametric argument is dissolved by introducing the new articulator node "Peripheral".[13]

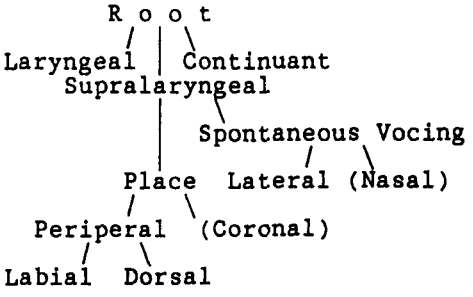
(42)



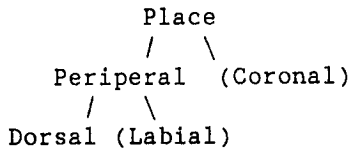
Here note that labials assimilate to dorsals, not vice versa. Thus we need to rearrange the markedness hierarchy for peripheral segments.

---

[13] In addition to the peripheral node, Rice & Avery (1991:103) also propose the separate manner node "Spontaneous Vocing" for lateral and nasal. In the diagram below, the parenthesized articulatory nodes are underspecified default features.



(43)



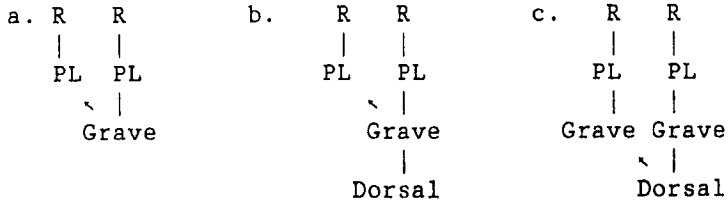
Within our current framework, due to its optimality, a coronal is represented as the unmarked representation, P, without any markedness prime, while the most peripheral velar consonant is specified as the most marked form, P-V-C, as already shown in the previous section. (Here we have to recall that the heads of these consonants are underspecified since they take the head of the manner node by default specification.) Moreover, note that for consonants with the head value C in the manner node, I represent the combination of the markedness values as P-V-C, rather than P-C-V for two reasons. First, the combined representation indicates the most markedness. Second, when fully specified, P-C-V is more marked than P-C-C. Thus, when underspecified, P indicates the most unmarked specification, while P-V-C the most marked one.[14] Consequently, the most marked representation for an articulation node is X-Y-X, rather than X-X-Y. The theoretical consequence of this revision is that we can incorporate the concept of underspecification into our model by underspecifying the C-C as a simple C. Moreover, we can make a unified description of assimilation as a single spreading process, as done in the standard framework of FG. (Avery & Rice 1990, K.-H. Kim 1990, Sohn 1991, etc.)[15]

(44) a. P P b. P P c. P P
V V V V V
C C

---

[14] Consequently, if a V is the head in the manner, the combination of the place values would produce P-V-c-v, rather than P-V-v-c, in full specification.

[15] Within the frameworks of underspecification and feature geometry, this asymmetric place assimilation is described as a uniform process by which a specified place node spreads to the underspecified place node (Avery & Rice 1989, Sohn 1991, K.-H. Kim 1991, etc.).



In (44), we see that more specified (i.e. more marked) value is linked to the less specified representation, converting a less marked segment into a more marked one. By this procedure, less marked (or less peripheral) segments become more marked (or more peripheral) segments, following the markedness hierarchy shown in (41). We also see that as spreading of marked value is done by scanning specification of the markeness value, the tier scansion procedure and the general markedness tendency of (31) still hold.

4.6. Vowel labialization

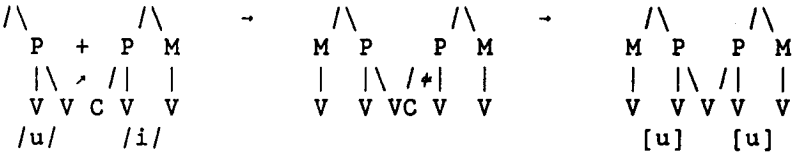
In Tulu, /i/ becomes [u] not only after a round vowel but also after a labial consonant. (Sagey 1986:137)

(45) i → u / { [V, +round] (C (C)) / [C, +labial] } ____

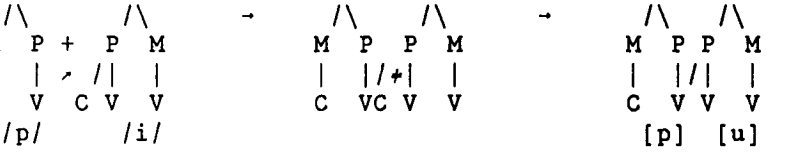
According Sagey's framework, this process is uniformly accounted for by having the labial node dominate [+round]. In Clements (1991), however, her approach is criticized as being odd. For example, the tongue body features [back], [high], and [low] are placed under the dorsal node, while [round] is placed under the labial node. Thus, according to Clements (1991), we would no longer be able to provide a uniform articulatory-based definition of dorsal for both consonants and vowels.

Thus, following the model adopted here, it is accounted for by spreading of the V-value to the right. As shown in (46), as there is already secondary C-value, the V-spreading requires delinking of this secondary value.

(46) a.



b.



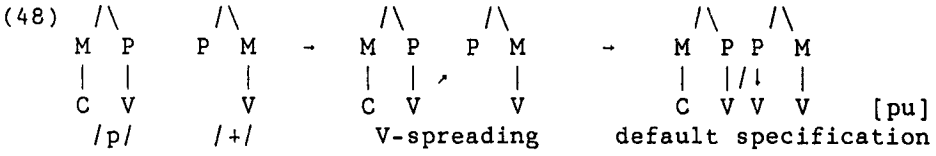
In (46a), it is shown that the front vowel /i/ becomes [u] after /u/ by sharing the labial V prime. On the other hand, in (46b), /i/ also comes after a labial consonant, in which the labiality of the consonanant spreads to the vowel. As a consequence, the preceding segment still remains a labial consonant, while the following vowel would become a round vowel [u] by sharing the labiality prime V.

A similar process can be found in Korean, in which /+/ becomes [u] after a labial consonant as well as a round vowel.[16]

(47) a. /pap'+-ta/ [pap'uda] 'busy'
/kip'+m/ [kip'um] 'pleasure'
/s+lp^h+-ta/ [s+lp^{h}uda] 'sad'
b. /kop-+n/ [koun] 'beautiful'
/tu-+m/ [tuum] 'initial sound'
/ko+l/ [koul] 'district'

Note that labial consonants have a V-value (i.e. P-V) for their place specification and labial vowels have the same V-value for their dependent place specification. Thus we can describe this process in a similar fashion as shown in (48), by saying that vowel labialization is a process of V-value (i.e labiality) adjunction.

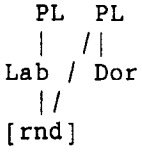
(48)



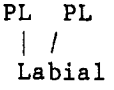
In (48), the back vowel /+/, underspecified for both height and backness underlyingly, will get the roundness by V (i.e. labiality) adjunction. And the height value will be specified by default. The segment preceding /+/ could be either a labial consonant or a round vowel, depending on the representation of the Manner node. Thus, regardless of the Manner status of the preceding segment, the vowel labialization is uniformly triggered by the spreading of the labial node.

In earlier FG approaches, vowel labialization has been treated as a spreading process where the marked (i.e. more specified) place node spreads to the empty place location of the less marked segment.

(49) a. Y.-M. Cho (1988):



b. Sohn (1991):



As for Cho's approach in (49a), however, Kang (1991:74-75) argues that this rule needs a costly device, namely the Node Generation

[16] Kim-Renaud (1974:23) proposed the following rule.
+ → [+lab] / [+lab] _____

Convention (Archangeli & Pulleyblank 1987),[17] since there is no landing site for the spreading feature in the target vowel. He also notes that, following Sagey (1986), labial consonants are represented as having only the labial node, not the terminal feature [round].[18] The second proposal by Sohn (1991) shown in (49b) meets a similar problem since it also needs a special device to generate an absent node for surfacing [round]. Moreover, as both approaches use the same labels like "labial" for both consonants and vowels, they have to face the same duplication problem as confronts Clements (1989, 1991). In the current model we are adopting, however, these issues do not arise.

5. Concluding Summary

Throughout the paper, I attempted to show a possibility of a unified theory of feature representation. For this purpose, I first raised various issues by which the problems of the earlier approaches are revealed. Then I proposed a revised model of feature representation and showed how my proposal works for various phonological processes. In developing my proposal, I adopted the basic concepts of the "molecular" approach by Hulst (1991) with several radical revisions. Moreover, it has been shown how the basic concepts of underspecification and feature geometry can be incorporated in this model. Consequently, the model proposed here provides a unified theory of feature geometry developed in conjunction with the theories of Dependency Phonology and underspecification. Finally, by reanalyzing several well-known phonological processes in several languages, I showed that the model proposed here not only better accounts for these issues, but also does not cause any redundancy problem or unnatural explanation. In sum, this present approach not only shares the major benefits of underspecification and feature geometry but also makes better predictions on both consonant and vowel related issues. As for the characteristics of this framework, I list several points on the merits and theoretical implications of the molecular approach adopted in this paper.

The first advantage lies in the dual interpretation of

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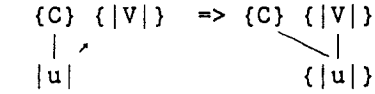
[17] A rule or convention assigning some feature or node α to some node ß creates a path from α to ß. (Archangeli & Pulleyblank 1986:75)

[18] Following the framework of Dependency Phonology, Kang (1991:78) formalizes the rule of vowel labialization as follows.



phonological primes. Based on the notion of "head-dependent" relationship, all primes can be interpreted in two ways, depending on the headship of their governing categories. Therefore, there is no duplication problem which other models such as Clements' have to meet. As a consequence, the various phonological processes can be described in a uniform way.

Second, it becomes possible to predict the Place and Laryngeal gestures by the Manner specification universally. As the Manner specifications partly determine headship in the Laryngeal and Place gesture, the consonantal or vocalic interpretation depends on the head of the Manner gesture. Whether a feature is a head depends on the what kind of feature is the head in the manner gesture.

(47)

Head of Manner	Choice of head in other gestures	
[Manner, C]	[Place, C]	[Laryngeal, C]
[Manner, V]	[Place, V]	[Laryngeal, V]
[Manner, V-C]	[Place, V/C]	[Laryngeal, V/C]
[Manner, V-C-V]	[Place, V/C]	[Laryngeal, V/C]

Third, the consequences of assimilation processes can be predicted by scanning the relevant tier for markedness values, as both consonantal and vocalic processes depend on the general markedness tendency in that more marked segments are preferred to less unmarked ones by the markedness tendency.

Fourth, the current theories of underspecification and feature geometry are compatible in this framework. Moreover, the basic concepts of feature geometry and underspecification can be incorporated in this model. Thus, the changes in both manner and place properties can be handled effectively. For example, both consonantal assimilation and vowel labialization can be handled in a uniform way without causing any duplication problem.

Finally, as we use a head-dependency relation, we get a formal basis for a number of other things. Thus it is possible to display such notions as the primary and secondary articulation involved in vowel labialization in a natural way.

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