
**Keywords:** representation, internal structure, non-linear phonology

1. Introduction

The history of phonology has been a history of a shift of balance between “rules” and “representations” (Anderson (1985)). When linguists are concerned with the study of language itself, the notion of representations is focused upon. On the other hand, when the emphasis in research shifts “from the properties of languages to properties of grammars” (Anderson (1985: 6)), rules are given more attention. The two notions are complementary to each other, and a good theory of phonology must have a good balance of the two notions.

*The Phonological Structure of Words* is an introductory textbook; its main aim is to present the phonological representation of the internal structure of words various sub-theories of non-linear phonology may offer at present. In this sense, the book under review is mainly concerned with a theory of representation. Though rules play an important role in generating the representations presented, they are not the central concern, thus allowing various devices of non-linear sub-theories to play part.

* I am deeply indebted to two anonymous reviewers for valuable and most helpful comments on the earlier versions of this article.
A phonological word has a complex hierarchical structure of various phonological constituents: features, segments, syllables, and feet. The book deals with the representation of each domain in the framework of non-linear phonology which has sprung out of the generative linear approach of SPE (Chomsky and Halle (1968)). The authors have illustrated the insights of various theories, autosegmental phonology, dependency phonology, government phonology and metrical phonology among others, and have successfully shown that the differences among these theories are not as great as they seem at first sight. The discussion is thorough and easy to follow for students with little knowledge of phonology, though a basic knowledge of general phonetics is required. The book gives the flavor of different approaches within non-linear phonology.

The currently influential Optimality Theory (OT: Kager (1999)) is not treated in this book, and is only briefly mentioned in the epilogue. This decision of not taking up OT reflects the theoretical position of the authors, and it will be examined further in the discussion section. According to the authors, the greatest difference between their position and OT is the treatment of cross-linguistic variation. While OT uses constraint ranking, the authors of the book under review use parameter setting in accounting for cross-linguistic variance. However, it seems to me that the major difference between OT and the present book is the different emphasis placed on the rule-representation dichotomy. The central concern of OT is to present a coherent and unified system for generating phonological output; thus, OT is rule-oriented in the sense that it focuses on the system of “rules which specify the properties of the (well-formed) sentences in such a system” (Anderson (1985: 6)), though their system uses constraints rather than rules to generate them. In contrast, the present book is oriented toward representations of phonological structures, and the authors are relatively flexible about the rules that generate them. They state that “as a matter of convenience we formulate most of the processes we consider in terms of derivational rules, but we are not concerned with the status of these rules in the phonology of the language under consideration: they should be viewed primarily as descriptive devices (xii).”

In what follows, I will first present the conceptual framework in which this book is written. Then I will describe the contents of the book in more detail. Finally, in the discussion section, I would like to discuss and evaluate the theory of phonology presented by the book.
and its presentation as an introductory textbook.

2. A Summary

2.1. The Conceptual Framework

According to the authors, a theory of phonology has three different aspects: a theory of levels, a theory of representation (for each level), and a theory of mapping between different levels (cf. Goldsmith (1993); also Hulst and Ritter (2000)). The book under review treats only one aspect of phonological theory: a theory of representation. Within the level of phonology, there are two levels, the input representation and the output representation. The input and the final output representations reflect the way in which lower units are combined to form units in higher layers in the hierarchical structure of a prosodic word. They also reflect the consequences of various parameter settings. The phonological operations observed in this theory of representation may be both language-specific and universal. The authors consider that the extrinsic ordering of rules is not necessary; in other words, there is no need for intermediate representations. A set of unordered rules fill in, spread, and remove feature values. Thus, there are only two representations; further, the final output is no less phonological than the initial input. They are considered to be the same in kind. Thus, the authors prefer to call them the input and the output representations and reserve the term ‘level’ to refer to levels outside the phonological domain such as phonetic level and morphological level. The reason for postulating the two representations comes from a need to postulate a representation which abstracts away from redundancy and which also functions as an input to productive allomorphic alternations.\(^1\) The final output representation contains all the necessary information to derive the phonetic realization of the structure. However, the mapping between the phonological and phonetic levels is not treated in this book.

\(^1\) In Hulst and Ritter (2000), three levels are postulated: the morphophonemic level, the word level (with hierarchically structured well-formed syllables and words with minimally redundant phonological information), and the post-lexical phonetic level (expressed in broad phonetic description that is the interface with the articulatory and acoustic devices). Each level is characterized by only one representation. Thus, an intra-level derivation that creates two representations is not posited.
2.2. The Contents

Chapter 1 is concerned with phonological segments, in particular, their internal structure. Such internal structure is motivated by the fact that there are phonological processes and constraints that are observed in a group of segments that seem to share the same characteristics or features. Such groups of segments sharing the same feature or features tend to pattern similarly as a natural class. The case of nasal place assimilation is illustrated: the nasals /m, n, ñ/ are assimilated in place of articulation to the following stops, for example, 'camber' [kæmə], 'canter' [kæntə], 'canker' [kæŋkə]. Segments sharing the feature [nasality] are the target of the phonological process here; furthermore, the segments that trigger the process of assimilation and the targeted segments share the same place features such as [labial], [alveolar] and [velar]. Features as minimal building blocks of language sound are discussed.

The authors then introduce the major class features [sonorant] and [consonantal] which distinguish major classes of segments such as vowels, liquids/nasals and obstruents.

\[
\begin{array}{ccc}
\text{Obstruent} & \text{Nasal/Liquid} & \text{Vowel} \\
[\text{son}] & - & + & + \\
[\text{cons}] & + & + & - \\
\end{array}
\]

Then the features [continuant] and [voice] are introduced to make further distinctions among the major classes. In the obstruent class, fricatives are [+continuant], while stops are [−continuant]. Nasals are [−continuant], as they have a complete closure in the oral cavity, while liquids are [+continuant]. The concept of sonority hierarchy is discussed in relation to major class features, and a case of historical change of sound (pre-Old English to Modern English 'own': Lass and Anderson (1975: 158)) which reflects progressive lenition in the hierarchy of sonority is illustrated: Pre-OE [aagan] > OE [aavan] > ME [oowen] > lME [oon] > MdE /oon/ (/oɔn/, /oːn/, etc.).

In the next section, the vowel-height features and the related issues of binary vs. multi-valued scalar features are introduced; for example, the front vowels of Scots English are apparently distinguished only by relative height: beat [bit], bit [bɪt], bait [bɛt], bet [bɛt], bat [bæt]. On the other hand, the tense/lax and ATR (advanced tongue root) approaches for finer distinction of vowels are also necessary. Systems incorporating various features such as relative vowel height, tense/lax and ATR are all found in languages of the world, and therefore must
be in the feature system. In other words, some language systems are better explained by the tense/lax features, while other systems are better represented by relative vowel height or the ATR feature.

The major places of articulation for consonants are distinguished by the features [labial] (labial), [coronal] (alveolar, post-alveolar, palatal), [dorsal] (palatal, velar, uvular) and [radical] (uvular and pharyngeal). These features are defined in terms of active articulators as against the SPE type of features which are defined in terms of passive articulators (MacCarthy (1988: 99)). Coronals are further distinguished by the feature [anterior]: dental and alveolar sounds are [+ant], whereas post-alveolar, retroflex, and palatal sounds are [−ant]. Coronals may also be distinguished into tongue-tip (apical) sounds and tongue-blade (laminal) sounds by the feature [distributed]. [−Distributed] sounds are those produced with a "relatively long" consonantal stricture, and they include laminal (tongue-blade) sounds and palatales; on the other hand, [−distributed] sounds are those produced with a "relatively short" stricture, and they include apical (tongue-tip) sounds and retroflexes. The feature [strident] distinguishes various members of the class of fricatives.

After the introduction of the consonantal features, grouping of features is discussed. The discussion leads to the introduction of autosegmental phonology which, with the device of feature geometry, visually presents the grouping of features and the relationship among various groups of features. (2) illustrates the feature geometry of the sound /θ/.

(2)

Lastly, by illustrating some cases of tone association and vowel harmony it is shown that segmental representation may be overlapping, that is, a single segment may be linked to more than one value of the same feature (prenasalised and postnasalised consonants in Apinayé (Anderson (1976))), and a single feature may be associated with more than one segment (vowel harmony).
In Apinaye as illustrated in (3), consonants take on the specification for nasality from the contiguous vowel. Thus, when there is a sequence of two consonants between two vowels as in (3a), the first consonant takes the specification for nasality from the preceding vowel and the second one from the following vowel. When there is only one segment between the two vowels as in (3b), a single segment is split into two in the nasality feature and takes on the features [+nasal] and [−nasal] at the same time, resulting in prenasalised and postnasalised segments.

(3) prenasalised and postnasalised stops in Apinaye
a. \([V \ b \ d \ V]\) b. \([V \ b \ V]\)
   \([V \ m \ d \ V]\) \([V \ m b \ V]\)
   \([V \ b \ n \ V]\) \([V \ b m \ V]\)
   \([V \ m \ n \ V]\) \([V \ m \ V]\)

Autosegmental accounts of Turkish vowel harmony propose that the features [back] and [round] are floating lexically; they are not associated with a particular vowel in a word. Thus, the word ‘borulari’ (pipe, possessive plural) may be specified only in [height] underlyingly as in (5a). By the two association rules and one condition given in (4), the two features [back] and [round] are spread and shared by a number of segments within the word, and the final form [borulari] may be derived.

(4) a. Associate [back] and [round] to the first vowel (initial association)
b. Associate [back] and [round] to the remaining vowels (spreading)
c. [⁺round] may not associate to non-initial non-high vowels (condition on target vowel).

(5) a. \([b \ [-high] r \ [+high] - l \ [-high] r - \ [+high]\)
   \([-\text{plural}]\)
   \([-\text{possessive}]\)
   \([⁺round]\)

b. \([b \ [-high] r \ [+high] - l \ [-high] r - \ [+high]\)
   \([-\text{plural}]\)
   \([-\text{possessive}]\)
   \([⁺back]\)
   \([⁺round]\)

c. \([b \ [-high] r \ [+high] - l \ [-high] r - \ [+high]\)
   \([-\text{plural}]\)
   \([-\text{possessive}]\)
   \([⁺back]\)
In Chapter 1 the authors have looked at how features are combined to form segments. Chapter 2 is concerned with the nature of features themselves. In particular, the question of how many values should be assigned to a feature is considered. For example, Ladefoged (1971: 35) suggests more than two contrastive values for [nasality] in the language Chinantec: non-nasalised, lightly nasalised and heavily nasalised. In other words, nasality seems to be multi-valued in Chinantec. Within the binary system, there are two different types of opposition, privative and equipollent (Trubetskoy (1939)). Features with equipollent opposition are binary; that is, for a feature [F], both [+F] and [−F] segments form natural classes. For example, the lack of sonority seems to be a positive property which might be required in characterising a group of segments; for example, a group of segments that are [−sonorant] undergo final devoicing. Also, there are processes which involve a [+sonorant] group of segments. On the other hand, privative opposition implies the presence or absence of a particular property. Such features do not have [+] or [−] values; they are either present or absent. Such features are single-valued. Nasality is an example of privative opposition. The lack of nasality is not a positive property of a segment, and it does not play a positive role in phonological processes. In other words, a phonological process that involves a group of [−nasal] segments is not found in world languages though there are processes that involve a group of [+nasal] segments. Thus, there is asymmetry in features such as nasality.

In order to illustrate possible representations of feature asymmetry, the concept of underspecification is introduced. In this conceptual framework, the marked value for a feature is underlingly specified, but the unmarked value is absent in phonological representations until it is filled in by later rule applications. Also, redundant features may not be specified in the underlying representation. For example, in English all non-low back vowels are [+round]; thus, if a vowel is [−low, +back], it is also [+round]. Therefore, the value [+round] is redundant.

Two types of underspecification theories, Contrastive Specification Theory (Steriade (1987); Archangeli (1988); Mester and Ito (1989)) and Radical Underspecification Theory (Archangeli (1988); Archangeli and Pulleyblank (1994)) are introduced.

(7) illustrates the underlying feature matrix for the Contrastive Spe-
cification Theory for the five vowel system represented in the fully specified matrix in (6). According to this theory, all the redundant features and feature values are unspecified. Therefore, the feature [round] may be omitted from the matrix. The vowel /a/ is the only vowel which is [+low] in the system; thus, the other specifications for this vowel may be left out. In (7) all non-contrastive values and features are omitted. They may be filled in by redundancy constraints: if [+low] then [−high], if [+low] then [+back], if [+high] then [−low], if [−back] then [−low] (the last two statements derive logically from the first two: if A → B is true, then ¬B → ¬A is also true).

Radical Underspecification Theory claims that all features are asymmetric; in other words, no feature is underlyingly equipollent. This theory allows only one value of a feature in the underlying representation. For example, the underlying value for the feature [nasal] would be [+nasal]. Feature asymmetry is expressed by a set of default rules such as, [−] → [−high], [−] → [−low], [−] → [−back], in order to generate the fully specified matrix in (6). (8) is a feature matrix expressed in terms of Radical Underspecification Theory for the five-vowel system in (6). One redundancy rule, if [+low] then [+back] would be necessary to complete (8).

(6) the fully specified matrix for a system of five contrasting vowels

<table>
<thead>
<tr>
<th></th>
<th>/i/</th>
<th>/u/</th>
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<tr>
<td>[high]</td>
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<tr>
<td>[low]</td>
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<td>+</td>
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<tr>
<td>[back]</td>
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<td>+</td>
<td>−</td>
<td>+</td>
<td>+</td>
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<tr>
<td>[round]</td>
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(7) Contrastive Specification Theory

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<tbody>
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<td>[high]</td>
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(8) Radical Underspecification Theory

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<td>[high]</td>
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<td>[back]</td>
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</table>

As an alternative to the binary feature system proposed by underspecification theories, Single-valued Feature Theory is also discussed in de-
tail. For example, single-valued vowel features are i (high frontness), u (high roundness) and a (lowness). (9) presents the feature specifications for a ten vowel system incorporating the concept of dependency (Harris (1994)). In a dependency-based approach, distinction between any pair of mid vowels, for instance, is achieved by making one feature dominant over the others; for the mid vowel /e/, the feature i is more important than the feature a. Thus, in the case of /e/, i is the head and a is the dependent. The head features are underlined. @ is the neutral or centrality feature representing laxness.

(9) /i/ /e/ /a/ /o/ /u/ /t/ /e/ /a/ /o/ /u/

\[
\begin{array}{cccccccc}
i & i & i & i & i & i & i & i \\
a & a & a & a & a & a & a & a \\
o \, \, \, u \, \, \, u \, \, \, u \, \, \, u \, \, \, u \\
\end{array}
\]

Representations of vowel systems using the two Underspecification approaches and Single-valued Feature theory are compared and analysed. Umlaut and harmony processes are also analysed under the three approaches. What characterises Single-valued Feature Theory is that its representations are more direct; in other words, there is minimal difference between the underlying representation and the surface representation. In the case of (9), the two are identical. Moreover, the vowel features i, u, a correspond to quantal vowels (Stevens (1972)), and they are phonetically grounded as well as phonologically motivated.

The last two chapters are concerned with word-internal prosodic domains larger than phonological segments: syllables and feet. In the first part, phonological motivation for syllables is discussed. Then two different views in representing the internal structure of a syllable are introduced: Onset-rhyme theory and Mora theory. Mora theory directly accounts for the concept of syllable weight. Syllable weight plays an important role in phonological processes such as accentuation and compensatory lengthening. Syllable weight may be light, heavy or super heavy. In the Onset-rhyme theory, the definition of syllable weight may be different from language to language: rhyme-weight languages, nucleus-weight languages and coda languages. In rhyme-weight languages (for example, English), the number of segments in the rhyme is important, whereas in nucleus-weight languages (Selkup, a West Siberian language), the number of segments in the nucleus is important. In coda languages (for example, Dutch), syllables are heavy only when
there is a coda consonant. The syllable weight for the three types of languages is illustrated in the representations of both Onset-rhyme theory and Mora theory in (10) through (12).

(10) Rhyme-weight languages

a. Onset-rhyme theory

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b. Mora theory

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(11) Nucleus-weight languages

a. Onset-rhyme theory

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b. Mora theory

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(12) Coda languages

a. Onset-rhyme theory

<table>
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<td>rhyme</td>
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</table>
b. Mora theory

Onset-rhyme theory circumvents the problem of syllable weight by the introduction of a skeletal tier which represents timing units. The skeletal tier assures the independence of syllabic position and segmental content. (13) illustrates the skeletal tier and the root tier of the word 'beacon' in English. In languages of the world, onsets and rhymes with more than three segments are very much limited, and they tend to occur only at the edges of a word. In order to account for this fact, the concept of prependix and appendix to a syllable structure is introduced. Extrasyllabicity is also discussed in this context. The syllable structure of the Dutch word 'striktst' (strictest) in the Onset-rhyme model is illustrated in (14).

The template for a syllable in each language is determined by a set of binary parameters; that is, language specific varieties are accounted for...
by parameter setting as in (15).

(15) Binary parameters for syllable templates (the unmarked or default setting is shown in bold)
   a. obligatory onset: yes or no
   b. branching syllable: yes or no
   c. branching onset: yes or no
   d. branching rhyme: yes or no
   e. branching nucleus: yes or no

Finally, the Onset-rhyme theory is discussed in the framework of government phonology (Kaye et al. (1985); Charette (1991); Harris (1994); Brockhaus (1995)). This view claims that all syllabic constituents are maximally binary; thus, when the nucleus branches, the rhyme cannot further branch. This means that the word-final consonant in the coda position in words like ‘band’ cannot be parsed into the preceding syllable. It is considered to be an onset consonant followed by an empty nucleus. Government phonology has a rather strict structure restriction. On the other hand, OT allows complex consonant clusters since “richness of the base” is assumed in OT. The “markedness” of complex clusters is expressed by the higher ranking of the “faithfulness” constraint over prosodic constraints which demand simplicity in syllable structure.

The choice of the type of syllable theory discussed in the present book depends on “general views regarding the kinds of cognitive structures that one wishes to recognize in linguistic theories. If one believes that the principles underlying the syntax of linguistic expressions generalize over the morpho-syntactic and phonological modules of grammar, then findings in syntactic theory lead to expectations, and limitations, regarding the kinds of models that one wishes to consider for phonology, and the other way around. Dependency Phonology and government phonology explicitly adopt this position.” (Hulst and Ritter (1999: 27)). Another possible way of treating phonology is to consider that phonology is autonomous; that is, the architecture of different modules must be different.

Lastly, Chapter 4 discusses the largest domain within a phonological word, the foot, in the framework of metrical phonology (Halle and Vergnaud (1987); Hayes (1995)). The assignment of foot structure forms the central core of metrical theory. By doing so, the theory can predict the various patterns of accentuation observed in languages of the world with a small set of parameters:
(16) Parameter setting

*foot structure*

(1) headship: left-headed or right-headed
(2) parsing: left-to-right or right-to-left
(3) weight-sensitivity: heavy syllables can occupy a dependent position in a foot or not

*word structure*

(4) headship: left-headed or right-headed

*constituent extrametricality*

This parameter setting is based on the observation that the strong element of any constituent tends to fall on the edge (Liberman (1975)). Also, some elements at the edge of a constituent seem to be ignored in certain phonological processes; such elements are considered to be extrametrical. Peripheral positions in constituents seem to be unique positions in phonetic and phonological processes. (See discussion below for phonetic evidence.)

3. Discussion

As stated in the introduction, theoretical emphasis has been wavering between rules and representations in the history of phonology. For example, SPE was a phonology of grammar. Non-linear phonology developed as a reaction to the rule-oriented SPE, and it proved to be a great tool to illustrate the internal structures of various phonological entities. Currently, as represented by OT, the phonological movement seems to have undergone a shift back to an emphasis on rules. In this climate of OT, the present book by Ewen and Hulst is yet another shift back to a representational approach. The authors have presented a theory-free non-linear framework for phonological representation. Considering how influential OT is in the current movement of phonology, the choice of not mentioning OT is a strong theoretical choice on the part of the authors. Why not OT? In what ways are the non-linear representations presented in this book better than the OT account? There are two points in which the representational approach of the present book may fare better than OT: (1) the clear separation of phonology and phonetics, (2) the handling of certain opacity problems. In the following sections, I will discuss these two points in detail.
3.1. Phonology-Phonetics Interface
3.1.1. Edge Effects and Their Relationship with Constituent Levels

The framework of non-linear phonology has made the expression of the complex hierarchical structure of the phonological domains possible. The existence of the internal structure of utterance has been supported by phonetic evidence. Current studies on the relationship between prosody and articulatory realization have shown that the strength of articulation varies in different positions in a prosodic domain. Furthermore, the edge effects, the strengthening and weakening at the edges of a phonological domain, vary as a function of the level of the prosodic domain. Segments (or certain features) are stronger (or weaker) when they are at the edge of a higher prosodic domain such as the utterance or intonational phrase than when they are at the edge of a lower prosodic domain such as the intermediate phrase, phonological word, or syllable.

Pierrehumbert and Talkin (1992) showed that the /h/ is more consonant-like in terms of breathiness in a phrase-initial position than in a phrase-medial position. Domain-initial consonants and domain-final vowels in the reiterant speech using the syllable /no/ have more extreme, less reduced articulation (Fougeron and Keating (1997)); moreover, the strengthening of the initial consonant is cumulative, that is, linguopalatal contact increases as the level of prosodic domain (the phonological word, the intermediate phrase, the intonational phrase, and the utterance) gets higher. On the other hand, consonants show lenition at the domain-final position: the devoicing of /z/ in American English is most frequent at the ends of words or phrases (Smith (1997)). This effect is cumulative as well; in other words, devoicing occurs more often at the end of a larger domain (sentence) than at the end of a smaller domain (word). The rate of the glottalization of word-initial vowels is also correlated with the break levels of ToBI (Tone and Break Indices); word-initial vowels show a greater rate of glottalization at the edge of a higher prosodic domain (Dilly et al. (1996)).

Jun (1995) showed the gradation of strength in the laryngeal gesture of the lenis stop in Korean as a function of position in the accentual phrase. The lenis stop at the very left edge of an accentual phrase is strong; on the other hand, the lenis stop associated with a syllable inside a word is weak. When a lenis stop is associated with a syllable at the left edge of a word but within an accentual phrase or when a lenis
stop is in the coda position but is associated with the left edge of an accentual phrase due to resyllabification, the glottal gesture has an intermediate strength between the two extremes.

In conclusion, phonetic detail faithfully reflects the structural makeup of speech. The phonological representations must correctly show the complex internal structures of various phonological domains to be able to map onto the phonetic level, and they must match the actual facts. The non-linear representations illustrated by Ewen and Hulst in the present book provide the basic framework for expressing the internal structure of the prosodic word, which is not as easily and obviously captured in the language of linear phonology or OT. This leads to the position that “if the representations are right, the rules follow,” meaning that “languages will ultimately only differ in their representations” (Hulst and Ritter (1999: 21)).

3.1.2. Paradigm Uniformity

The cases of paradigm uniformity preserved in phonetic detail may also be better represented in the machinery of non-linear phonology. Steriade (2000) claims that phonetic detail, which is not contrastive in any language, such as the “extra-short duration” of American English tapping (the Withgott effect: /[tmIleIstik] vs. /[kaepefeIstik]) or greater amount of lingual contact and “longer occlusion duration” of a word-initial onset consonant (for example, [d] in the French phrase ‘d’rôle’), plays an important role in preserving paradigm uniformity. She explains the phonetic differences of the obstruent /d/ in the sequences of ‘de rôle,’ ‘d’rôle,’ ‘drôle,’ and ‘jade rose’ in French by the OT constraint PU (Paradigm Uniformity). However, Steriade’s account blurs the boundary between phonology and phonetics.

On the other hand, in the nonlinear framework of Ewen and van der Hulst, the levels of phonology and phonetics are clearly separated; it is assumed that all the differences that must surface in the phonetic realization are encoded in the output phonological representation. The phonological level prepares the blueprint of the speech sound structure. Phonetic differences are realized as a consequence of following the plan faithfully. From this perspective, the phonetic differences of [d] discussed above may be better represented by a different licensing relationship in government phonology (16). The position of the schwa (the empty nucleus) which affects the features of the preced-
ing /d/ in ‘d’rôle’ may be represented in the licensing relationship between the onset and the nucleus. The phonological representations of ‘de rôle,’ ‘d’rôle,’ ‘drôle,’ and ‘jade rose’ illustrate the phonetic similarities of the /d/ between the first two sequences as compared to the last two sequences in (16). Similarly, the Withgott effect may be represented more clearly in the framework of metrical phonology.

In the framework of Ewen and Hulst, phonetic implementations naturally follow from the output phonological representations; all the necessary information for phonetic realization is already there. In this way the functions of the phonological and phonetic domains may be clearly separated.

\[
\begin{array}{llllllllllll}
\text{Onset} & \text{Nucleus} & \text{Onset} & \text{Nucleus} & \text{Output} & \text{Output} & \text{Output} & \text{Output} \\
\hline
\text{x x x x x} & \text{x x x x x} & \text{x x x} & \text{x x x x x} & \text{x d r o l} & \text{d o r o l} & \text{d r o l} & \text{a d r o z} \\
\end{array}
\]

de rôle d’rôle drôle jade rose

### 3.3. Opacity Problem

In OT, which rejects a serial derivational approach in favour of parallel evaluation of output candidates, opacity presents a serious problem. Opacity is described as a phenomenon in which “output forms are shaped by generalizations that are not surface-true” (Kager (1999: 372)). Opacity is not a problem in the serial SPE approach, where multiple intermediate levels are permitted between the input and the output surface forms. Opacity abounds in Tiberian Hebrew phonology (Idsardi (1988, 2000)). (17) illustrates a case, obviously a rather uneconomical one. Once /ʔ/ is lost, the motivation for epenthesis is not clear. In OT terms, a candidate such as *[tán]* would be more optimal as it would be more faithful to the input form: only Max-C (input segments must have output correspondents=no deletion) is violated. The actually occurring form has two faithfulness violations, Max-C and Dep-V (output segments must have input correspondents=no epenthesis).

\[
\begin{array}{ll}
\text{Underlying representation} & \text{tan} \quad \text{‘basket’} \\
\text{Stress, etc.} & \text{tán} \quad \text{táne} \\
\text{Epenthesis} & \\
\end{array}
\]

Some cases of opacity which present problems to OT may be solved in the non-linear presentation. In the autosegmental approach, the richness of the representation is counterbalanced by the simple operations of inserting and deleting association lines (Hulst and Ritter (1988: 21)). For example, the opacity of approximant devoicing in Isthmus Nahuat illustrated in (18) (Kager (1999: 374)) may be resolved by the spreading of voice feature from the final unstressed vowel to the preceding approximant. The nucleus position of the final unstressed vowel is delinked, but its features are taken on by the preceding approximant. Experimental phonetic study of the nature of the devoiced approximant might reveal other features of the seemingly deleted vowel.

Phonetic grounding is more obvious in the non-linear representation, and the processes employed in it are natural compared to OT, where naturalness of some constraints such as FINAL-C (Stem ends in C) is not clear: (19) is the tableau for /ʃikakil/ in the “sympathy” approach to opacity (McCarthy (1998)).

(18) a. Apocope optionally deletes a word-final unstressed vowel.
   tâmi ~ tám ‘it ends’
   b. Approximant devoicing at the end of a word
   tájo:l ‘shelled corn’
   c. Interaction
   ŋikakîli ~ ŋikakîl ‘put it in it’

(19)

<table>
<thead>
<tr>
<th>Input: /ʃikakili/</th>
<th>FINAL-C</th>
<th>IDENT-∅O</th>
<th>MAX-IO</th>
<th>*VOICED-CODA</th>
<th>IDENT-IO</th>
</tr>
</thead>
<tbody>
<tr>
<td>♦-Candidate: ŋikakili</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. ♦ ŋikakili</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. ŋikakil</td>
<td></td>
<td>*</td>
<td></td>
<td>i</td>
<td></td>
</tr>
<tr>
<td>c. ŋikakîl</td>
<td></td>
<td>•</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

On the other hand, there may be some opacity cases that present problems to Ewen and Hulst’s approach by postulating no intermediate levels and extrinsic ordering. For example, it is not quite clear how the case of Tiberian Hebrew opacity in (17) may be accounted for in
the framework of Ewen and Hulst. Also, the treatment of vowel epenthesis in Turkish (20) (Kager (1999: 389)) may not be apparent without having an intermediate level. One possible solution to this problem is presented by Kiparsky (2000) in his constraint-based version of Lexical Phonology and Morphology. In this version “stems, words, and sentences are subject to a separate serially related OT constraint system.” (Kiparsky (2000: 351)). In the framework of Ewen and Hulst, the opacity problem may also be resolved in a similar way (see Hulst and Ritter (2000: 281)). Introducing serialism seems to be the most natural solution to the opacity problem as the existence of the serial ordering of real time events cannot be denied, faced with the examples in (17) and (20). On the other hand, vowel epenthesis and velar deletion in (20) both seem to belong to the repair processes during the mapping between the morphological and lexical levels, and serial ordering must be allowed during the mapping between levels to solve opacity.

(20) a. Vowel epenthesis
/baj-m/  ba.jim ‘my head’
/jel-m/   je.lim ‘my wind’

b. Velar deletion
/ajak-I/  a.ja.i ‘his foot’
/inek-I/  i.ne.i ‘his cow’

c. Interaction
/ajak-m/  a.ja.im ‘my foot’
/inek-m/  i.ne.im ‘my cow’

Unnaturalness in phonology as illustrated by Anderson (1981) may also be difficult to resolve under the framework of the present book. In the interaction of rules governing quantity and quality of mid-vowels in Breton, the lengthening rule, which makes the quality rule a phonetically natural one, must follow rather than precede the quality rule in order to generate the right representations. The following rules may be posited in order to account for the quality of the mid vowels in Breton. Both quantity and quality rules are phonetically natural ones.

(21) The quality and quantity rules for mid-vowels in Breton
1. quality rule:
   (a) Mid vowels are lowered before [+back] consonants.
   (b) All mid vowels have “true mid” quality underlingly, and this quality is preserved in unstressed syllables and before fortis C’s.
(c) Mid vowels have "high mid" quality when they are lengthened.

2. quantity rule:
   Vowels are lengthened in stressed syllables; in unstressed syllables and before tense consonants, vowels remain short.

Basically, length determines the quality of the mid vowels in Breton. However, due to some sound change that took place later on, the situation became more complex, and the simple system stated above became inadequate. The greatest factor which disturbed the connection between length and quality was the development of consonants in final position. In modern Breton, all final obstruents surface as voiceless lenis whether they are underlyingly fortis or lenis, causing the preceding vowel to lengthen. However, the quality of the preceding mid vowel is determined by the underlying quality of the final consonant; the vowel will be "true mid" before a fortis consonant and "high mid" before a lenis consonant (for non-mid vowels, a contrast such as /kaz/ [kaːz] 'cat' and /kas/ [kaːz] 'sends' may be neutralized). Thus, the surface vowel quality is determined by the fact that the underlying final consonant is [+tense] or [−tense], while its quantity is determined by the fact that the final segment surfaces as [−tense]. As the final segment is [−tense] only in the output representation, naturally, the quantity rule follows quality rule in the order of application, allowing long "true mid" vowels. Now the system of simple rules in (1) and (2) no longer holds. This illustrates the departure of the phonological rule from the phonetic ground in its application.

Hulst and Ritter (2000: 278) criticize that "pushing lexical relatedness very far leads to formulating a lot of rules that account for segmental changes that are not required from the viewpoint of the surface well-formedness of the language. In many cases, the rules recapitulate the historical developments, ... extrinsic ordering was required to control their 'synchronized' historical order of application." Indeed, some unnatural phonological processes are relics of historical events; however, once phonologized, they must be accounted for in the synchronic grammar of a language, and in order to do this, certain arbitrariness may not be avoided.
4. Concluding Remarks

Current studies of the phonology-phonetics interface have shown that what is represented on the most abstract level of phonological representations may be reflected in the phonetic output (Holst and Nolan (1995); Steriade (2000)). As illustrated in the example of ‘de rôle’ and ‘d’rôle,’ some traces of a segment that has been deleted before the final output representation on the phonology level are observed in the phonetic realization. This observation is most clearly and visually represented in the non-linear phonology. On the other hand, the sound system of language is characterized by arbitrary, sometimes unnatural events (often phonologized historical events). This arbitrariness must also be dealt with by a grammar. Representations are only possible through grammatical processes. Therefore, we have to have a clear vision of the interaction of rules and representations in phonology. This must be the goal of any theory of phonology and an area to be developed in the future.

The book under review has given us a chance to look into the structures of word-internal phonological domains and their representations. Parameter setting is used as one of its grammatical devices. Finally, as an introductory textbook, it would be more helpful if the conceptual framework that motivated the authors to present the contents of the book was more explicitly presented at the beginning of the book rather than in the epilogue. Nonetheless, the book is a clear and extremely useful introduction to extensive issues in word level phonology.

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