Phonological aspects of nasality: An element-based dependency approach
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1 Theoretical preliminaries

In this chapter, I provide an introduction to the main ingredients of Element-based Dependency from a general theoretical perspective. On the one hand, this concerns an outline of the basic assumptions regarding the structure of Element-based Dependency representations, which is based in part on Dependency Phonology. On the other hand, this concerns an outline of the basic assumptions regarding the content of Element-based Dependency representations, which is based, again in part, on that of Element Theory.

This chapter is organized as follows. First, in §1.1, I consider some of the challenges confronting theories of segmental structure. These challenges suggest that such theories require relatively abstract features in order to adequately express the relations between different segment types, as well as the relations holding between the manner, phonation, and place properties of which segments are composed. Next, in §1.2, I focus in some detail on the notion of dependency, and consider how this notion can be used to express the relation between manner, phonation, and place. Finally, in §1.3, I outline the main tenets of Element Theory and discuss some problematic aspects of this framework, thereby setting the stage for the Element-based Dependency approach.

1.1 Introduction

A theory of segment specification must account for a number of aspects. First, given a particular language, it must represent the distinctive properties of those segments that are contrastive. Second, it must be capable of expressing the various operations and processes affecting these segments. Third, it must provide an account of how segments are organized in prosodic structure. This last aspect is relevant not only with respect to the prosodic interpretation of segments, but also because many regularities that hold at the level of segmental organization are most appropriately expressed in terms of prosodic structure, in particular that of the syllable. These regularities include the linear order of segments and the distribution of contrastive material in the segmental string.

The above aspects are to some extent related, for instance with respect to the notion of markedness. Consider a language with an underlying contrast between
plain and aspirated stops. In the terminology of Trubetzkoy (1939) this type of contrast involves a privative opposition, in that the aspirated series has a property—aspiration—which the plain series lacks. Since this property is distinctive, it must be represented in the segmental organization. The representation must also convey the fact that the aspirated series is marked with respect to the plain series. This is important, since if the contrast is neutralized, we expect this to occur in the direction of the plain series. In addition, the representation should allow for a natural expression of the neutralization process itself. Consider as an illustration the distribution of aspirated stops in English:

<table>
<thead>
<tr>
<th>(1)</th>
<th>a. pit</th>
<th>b. spit</th>
<th>c. hit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>/pʰt/</td>
<td>/spt/</td>
<td>/h[t]</td>
</tr>
<tr>
<td>repeat</td>
<td>/r[pʰt]/</td>
<td>/r[spt]/</td>
<td>/v[ɪhikjola]</td>
</tr>
<tr>
<td>mutter</td>
<td>/mʌtə/</td>
<td>/mʌstə/</td>
<td>/v[ɪtikɬ]/</td>
</tr>
</tbody>
</table>

The forms in (1a) show that the distribution of aspiration is prosodically conditioned, in that aspirated stops are found in foot-initial position only. The forms in (1b) show that no aspiration is found in case the stop is preceded by /s/. Here at least two explanations are possible. One would be to say that in this context the stop is not in absolute foot-initial position, so that the lack of aspiration in *spit* and *respite* is due to the same reason as the lack of aspiration in *mutter*. This implies that /s/-plosive clusters are part of the same foot. An alternative explanation would be to say that /s/ is responsible for neutralization of the aspiration contrast. This receives some support when we take into account that the distribution of /h/ parallels that of aspirated stops, as is shown by the forms in (1c). Note, too, that there is cross-linguistic support for a phonological relation between /s/ and /h/; consider for instance the fact that in some dialects of Spanish /s/ is realized as [h] in the coda position of a syllable (cf. Harris 1983). This suggests that the representation of aspirated stops, /s/ and /h/ shares a common structural basis. I will not attempt an analysis of aspiration in English here; however, the facts indicate that such an analysis must include both prosodic and segmental aspects of phonological structure.

1. Throughout this dissertation, the term “stop” refers to consonantal articulations that involve complete closure of the oral cavity. Unless otherwise noted, I assume that stops function as obstruents (i.e. as plosives) phonologically. The basic manner structure of a nasal, on the other hand, is that of a sonorant stop.

2. Following among others Harris (1994), I assume that the underlying contrast in the English stop system is in terms of aspiration; that is, the fortis stops are aspirated and therefore marked, whereas the lenis stops are neutral and therefore unmarked.

3. It has been proposed for instance that /s/, /h/, and aspirated stops are specified for the feature [spread glottis]. Neutralization of the aspiration contrast after /s/ can then be analyzed in terms of a cooccurrence restriction involving this feature; see Iverson & Salmons (1995) for an account along these lines.
It has proved a challenge to adequately combine the various aspects of segmental structure into a coherent framework of segment specification. A problem faced by all theories is that of overgeneration, in terms of the number of segments and the number of operations. Two strategies can be employed to counteract this problem: reduction of the number of feature values, and reduction of the number of features themselves.

Taking the reduction of the number of feature values first, since *The Sound Pattern of English* (Chomsky & Halle 1968; henceforth SPE) the main development has been the position that features are unary-valued (or “monovalent”). This position has been defended most extensively by proponents of Dependency Phonology as well as related frameworks such as Government Phonology (see e.g. Kaye et al. 1985, 1990), Particle Phonology (Schane 1984), and Element Theory (Harris & Lindsey 1995).

Consider the issue of feature values in relation to the SPE feature [±nasal]. The fact that nasals typically act as a natural class is an argument for taking [+nasal] or [nasal] to be relevant. However, given that there appear to be no instances where non-nasals act as a natural class, the evidence tips the balance in favour of a unary-valued feature [nasal]. The point is that a binary-valued feature results in overgeneration, since [–nasal] predicts a segment class that is phonologically irrelevant; hence, a binary-valued feature [±nasal] is empirically inadequate.

A further problem of binary feature theories is that in such theories it is impossible to take relative segmental complexity as a diagnostic for phonological markedness. As was noted above, in languages with contrastively aspirated stops we expect neutralization to be in the direction of the plain series of stops, making the aspirated series marked. This type of markedness difference is straightforwardly expressed in a unary feature theory. In such a theory aspirated stops are literally marked, in the sense that they have an extra feature, for instance [spread glottis], as compared to plain stops. Thus, as far as relative markedness is concerned, unary feature theories have an inherent evaluation metric. In binary feature theories, on the other hand, relative markedness must be accounted for by additional theoretical machinery such as underspecification and redundancy rules. Clearly, having unary features is the more restrictive option.

Another strategy to prevent overgeneration is to minimize the number of features themselves. The extent to which this is possible depends on the theory of segment specification. Feature minimization is inherently problematic for frameworks in which features are explicitly defined in terms of articulatory phonetic categories, such as in the Articulator Model of Feature Geometry (see for instance Sagey 1986, Halle 1992, Halle et al. 2000). In this approach, feature

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4 See Den Dikken & Van der Hulst (1988) for an overview; for a more recent discussion see Ewen & Van der Hulst (2001).

5 See e.g. Rice & Avery (1991a) and Steriade (1993) for arguments against [–nasal].
minimization goes against the fundamental hypothesis that phonologically relevant categories are shaped by the configuration of the vocal tract.

There are other reasons why strictly articulatory feature theories are problematic. One, as observed by Smith (1988), is that an articulatory interpretation of phonological phenomena often conceals rather than reveals the nature of the process involved. The point here is that segmental phonology is driven not only by articulatory, but also by acoustic factors. Consider in this respect the frequently observed interaction between rounded segments and labials (and sometimes velars). An example of such interaction can be found in the Dravidian language Tulu. As is noted by Clements (1990), in Tulu the high unrounded central vowel /i/ surfaces as rounded when preceded by a labial consonant, or by a rounded vowel in the preceding syllable. Thus, in the forms in (2a) /i/ is retained, while in the forms in (2b) /i/ is realized as [u].

(2)  a. kaṭṭi ‘bond’ b. kappu ‘blackness’
    kaṇṭi ‘eye’ poṛṇu ‘girl’
    ari-n-i ‘rice-ACC’ ṛuṇ-u-u ‘country village-ACC’

This interaction between labials and rounded vowels is difficult to express in terms of articulatory features, since the relation between the relevant features, say [labial] and [round], remains essentially stipulative. No such problems are encountered in a theory where features express both acoustic and articulatory properties of sounds, since here the link between labiality and roundness can be characterized in acoustic terms, i.e. by the fact that both involve a “diffuse-falling” spectral pattern.6

Features that refer to both articulatory and acoustic properties of segments do not have a single phonetic correlate. In this sense, such features are less concrete than strictly articulatory or acoustic features.7 A shift away from phonetic concreteness has three general advantages. First, as noted, it permits feature reduction. Second, it allows an interpretation of phonological interaction between segments that is not motivated by superficial phonetic similarities. For instance, I will argue in §5.2 that the type of nasal which is analyzed as voiceless in SPE is more properly regarded as aspirated. As such, this type of nasal is characterized by the same feature that characterizes sibilants, fricatives, and aspirated stops. Support for this view comes from the observation that these segment types show natural class behaviour. Furthermore, sibilants, in particular

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6 See e.g. Blumstein & Stevens (1981) for the acoustic similarity between labiality and roundness.

7 This point is underscored by the observation that vowels traditionally classified as [+round] (or [+labial] for that matter), are in some languages produced with little or no lip rounding. Consider for instance the high back vowel of Japanese, which is phonetically realized as [u] even though its phonological behaviour is that of an unmarked peripheral vowel.
are frequently involved in the creation of distinctively aspirated nasals. The relation between aspirated nasals and sibilants does not follow straightforwardly from their shared phonetic characteristics, however. A third advantage of a model that employs relatively abstract features is that such a model circumvents a problem that is faced by SPE-type feature theories, i.e. the fact that some features lack a clear phonetic correlate. A case in point concerns the feature \((+\text{sonorant})\). According to Chomsky & Halle (1968:302), segments specified for \([+\text{sonorant}]\) are “produced with a vocal tract cavity configuration in which spontaneous voicing is possible”. This definition is both unspecific and imprecise, however, since it classifies \(/s/\) as sonorants.\(^8\) Subsequent work has attempted to provide an acoustic definition of sonorancy (see e.g. Ladefoged 1971), but no clear phonetic correlate has been found to date (see Malsch & Fulcher 1989 and Nathan 1989 for discussion of this issue).

It has also proved difficult to find a clear phonetic correlate of the feature \((+\text{nasal})\), which in SPE-type feature theories characterizes both nasal and nasalized segments. Ladefoged & Maddieson (1996) observe that a prime characteristic of nasals is their formant structure, an acoustic property that is generally associated with sonorants. The identification of nasals as being sonorant is essential with respect to their phonological behaviour, as we will see in §2.3. Ladefoged & Maddieson further observe that the unifying characteristic of nasalized segments is the articulatory property of a lowered velum, the point being that there is little acoustic similarity between, say, a nasalized vowel and a nasalized fricative. Ladefoged & Maddieson (1996:136) thus conclude that the feature specifying nasality must have both an acoustic and an articulatory correlate:

\begin{quote}
Nasals, nasalized vowels and approximants are all \([+\text{sonorant}]\), but fricatives are obstruents and the acoustic signature of their obstruency is poorly compatible with nasality. The similarities between nasals and nasalized consonants arise from articulatory considerations, whereas the differences arise from acoustic considerations.
\end{quote}

This interpretation presupposes that nasalized fricatives are phonologically relevant, i.e. that such sounds must be given a specific segmental representation. Nevertheless, the fact that nasalized fricatives are articulatorily possible does not imply that they qualify as a phonological class. In fact, I will argue in §2.4.3 that segments such as \(/\text{ɔ}/\) and \(/\text{ɔ}/\), which may be described as voiced nasalized fricatives phonetically, function as sonorants phonologically. This suggests that

\(^8\) Chomsky & Halle do not consider the glottis to form part of the vocal tract. The problem with this view is that whereas the vocal tract configuration of \(/\text{h}\text{ɔ}/\) is typically that of a neighbouring vowel, the glottal configuration of \(/\text{h}\text{ɔ}/\) rules out spontaneous voicing.
an articulatory characterization of nasality in terms of a lowered velum is inadequate from the viewpoint of phonology.

The lack of an adequate articulatory characterization of nasality is underscored by the fact that velopharyngeal opening is also found in the context of oral vowels (see e.g. Moll 1962, Van Reenen 1981, Clumeck 1976, and Huffman 1989). This leads Huffman to posit an orality threshold, i.e. a limit above which nasal flow rates reflect nasalization that is phonologically relevant. However, given that Huffman’s findings show that nasal airflow rates are speaker-dependent and, in addition, are dependent on vowel quality and vowel place, it is questionable whether this account sheds any light on a universal articulatory correlate of nasality (see also Ploch 1999).

An acoustic definition of nasality is equally problematic. As Entenman (1977) and Ploch (1999) point out, nasality does not appear to have a unique acoustic correlate, neither in terms of an upward shift in F1 (see e.g. Dickson 1962, Delattre 1966, House & Stevens 1971), nor in terms of lowering of F1 intensity (see e.g. Hattori et al. 1958, Dickson 1962). A further complicating factor is that it has been shown that many of the acoustic cues associated with nasalization can also be achieved by other means (see Schwartz 1971, Beddor 1993). For instance, we will see in §6.2 that the lack of a clear acoustic correlate of nasality may give rise to spontaneous nasalization, a phenomenon whereby vowels are nasalized by a neighbouring glottal, sibilant or aspirated consonant.

The lack of clear phonetic correlates suggests that an account in which sonorancy and nasality are characterized in terms of single, phonetically motivated features such as [sonorant] and [nasal] must be rejected, and that a more abstract characterization of these concepts is required. To this end it has been proposed that sonority, i.e. relative sonorancy, is derivable from the relative complexity of segments. This is the position in Dogil (1988), Rice (1992), and in Element Theory (Harris & Lindsey 1995). Dogil and Rice assume that the more sonorous a segment is, the more structure it has. Element Theory takes the reverse view, assuming that the most sonorous segments, i.e. vowels, consist of the smallest number of “elements”.

The relation between segmental complexity and inherent sonority is less straightforward in Dependency Phonology, since here the representation of segments at the two ends of the sonority scale, i.e. voiceless stops and vowels, is maximally simple. In Dependency Phonology it is assumed that the degree of sonority depends on the presence of the component |V| in the representation of a segment, and, more specifically, on the position of |V| within that representation (see e.g. Anderson & Ewen 1987).

Element Theory and Dependency Phonology also offer a more abstract approach to nasality. For instance, in the “Revised” version of Element Theory

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9 For more discussion bearing on this issue see, among others, Entenman (1977), Van Reenen (1981), Huffman & Krakow (1993), and Ploch (1999).
in Ploch (1999) nasality is characterized by the same element which characterizes voicing in obstruents, i.e. |L|, with the difference in interpretation depending on the context in which |L| appears. In Dependency Phonology, on the other hand, nasality is a “derived” concept, in the sense that it consists of a combination of more basic building blocks. For instance, Anderson & Ewen represent nasal manner in terms of a combination of the components |C| and |V|, in such a way that |C| is dependent on |V|. Here |C| and |V| are defined in extremely general phonetic terms, and it is only in this relation that they represent nasal manner.\(^\text{10}\)

The interpretation of nasality in Element-based Dependency is in many respects a combination of that in Dependency Phonology and Element Theory. Like Dependency Phonology, nasal manner involves a combination of more basic building blocks. Like Element Theory, one of these building blocks is the element |L|, which, depending on its context, is interpreted as sonorancy, voicing, or nasalization. In the remainder of this chapter, I focus in more detail on a number of aspects of Dependency Phonology and Element Theory which are also relevant in Element-based Dependency.

1.2 Dependency

Recent work in Dependency Phonology (e.g. Humbert 1995, Smith 2000) assumes that phonological structure is maximally binary branching and consists of head-dependency relations (see also Van der Hulst 1989, 1995, Dresher & Van der Hulst 1995, Van de Weijer 1996). The distinction between heads and dependents makes it possible to reduce the number of features, since the same feature can be assigned a different (but related) interpretation depending on whether it occurs as a head or as a dependent. This type of approach reduces the number of features, and thus restricts the range of possible segments. In addition, it allows for a straightforward interpretation of a number of featural relationships, both positive and negative, in that these can be expressed by instantiations of the same feature in different structural positions. In this section, I consider the notion of dependency in Dependency Phonology in more detail; I then proceed to make explicit how this notion figures in Element-based Dependency.

In linguistic theory the notion of dependency refers to a binary asymmetric relation in which one element in a construction is the head and the other the dependent. Within segmental phonology the notion of dependency figures in a number of frameworks, although these differ as to the specific interpretation of

\(^{10}\) Note that I am concerned here with the Dependency Phonology representation of nasal manner, not nasalization. Anderson & Ewen represent the latter in terms of the component |n|, which they assume is located in the “articulatory gesture”. See Davenport (1995) for an alternative account.
the dependency relation (see Ewen 1995 for an overview). Consider for instance the kind of dependency used in Feature Geometry (see e.g. Clements 1985, Sagey 1986, McCarthy 1988), which Ewen terms “structural dependency”:

\[
\begin{align*}
\text{(3a)} & & \text{a. } X & & \text{b. } [\text{coronal}] \\
& & \text{Y} & & [\text{distributed}]
\end{align*}
\]

In Feature Geometry, (3a) is interpreted as a representation in which Y is structurally dependent on X, in the sense that the presence of Y implies the presence of X. A concrete example of this type of dependency is given in (3b). (3b) expresses the fact that segments specified for [distributed], the traditional feature which distinguishes between apical and laminal articulations, are a subset of segments specified for [coronal]; that is, any segment that is [distributed] is also [coronal]. Hence, in this scenario dependency is equated with immediate dominance.

How does this relate to the conception of dependency in Dependency Phonology? In Dependency Phonology the notion of dependency must be viewed in relation to the reduced number of features which this theory employs. Anderson & Ewen (1987:151) assume that the representation of segmental manner involves two components: “[\text{V}], a component which can be defined as ‘relatively periodic’, and [\text{C}], a component of ‘periodic energy reduction’”\(^\text{11}\). These components are retained in more recent work in Dependency Phonology (see e.g. Humbert 1995, Bolognesi 1998, and Smith 2000). In each of these models the interpretation of [\text{C}] and [\text{V}] depends on the structural position in which they occur. It is in this respect that dependency becomes relevant. In Anderson & Ewen we find representations of the type in (4):\(^\text{12}\)

\[
\begin{align*}
\text{(4a,d)} & & \text{a. } \text{C} & & \text{b. } \text{C} & & \text{c. } \text{V} & & \text{d. } \text{V} \\
& & \text{V} & & \text{C}
\end{align*}
\]

(4a,d) show that voiceless stops and vowels, the segment types that occupy the two extremes of the sonority scale, are represented in terms of a single [\text{C}] and a single [\text{V}]. The assumption that the representation of voiceless stops and vowels

\(^{11}\) The notions of “component” and “element” are equivalent to the notion of “feature” to the extent that each refers to the smallest unit in the phonological organization. I adopt the convention of representing components and elements between vertical lines.

\(^{12}\) The arborescent notation used here is formally equivalent to the notation in terms of arrows used by Anderson & Ewen. I ignore the structural relation which Anderson & Ewen refer to as mutual dependency, which plays a role in their representation of fricatives and liquids.
is maximally simple entails that the representation of intermediate manner types is more complex, as is shown by the representation of voiced stops and nasals in (4b,c). In voiced stops |C| dominates |V|. Anderson & Ewen refer to this relation as one in which |C| “governs” |V| or, alternatively, as one in which |V| is “dependent on” |C|. Thus, in voiced stops |C| is the head and |V| is the dependent. The reverse relation, i.e. one in which |V| dominates |C|, represents nasal manner.

This scenario shows that the interpretation of |C| and |V| is context-sensitive. Head |C| involves maximum energy reduction; a segment with a manner structure consisting of |C| only is therefore maximally consonantal, i.e. a voiceless stop. Head |V| involves maximum periodicity; a segment with a manner structure consisting of |V| only is therefore maximally vocalic, i.e. a vowel. When dominated by |C|, as in (4b), |V| is interpreted as voicing. Dependent |V| thus increases the periodicity of a stop, but leaves its obstruent status intact. When governed by |V|, as in (4c), |C| implies a reduction of energy. This dependent |C| does not affect the sonorancy of the segment concerned, however; the resulting structure is interpreted as nasal manner.13 In terms of traditional features, |C| in (4c) is therefore roughly equivalent to [–continuant]. Note that all the distinctions in (4) are expressed in terms of two unary features, combined with the notion of dependency.

The preceding discussion indicates that the interpretation of the dependency relation in Dependency Phonology differs from that in Feature Geometry. In both frameworks there is a relation of implication between the head and the dependent, in the sense that the presence of a dependent implies the presence of a head. Observe, however, that in Dependency Phonology, unlike in Feature Geometry, there is no implication as regards the content of the components. In the representation of nasal manner for instance, |C| is present by virtue of |V| because a dependent requires a head, but not because the content of |C| requires it to be a dependent of |V|; rather, it is the configuration as a whole which identifies a segment as nasal. Note that the lack of implication in terms of content is due to the lack of phonetic concreteness of the manner components that are assumed in Dependency Phonology.

By way of contrast, most of the dependency relations assumed in Feature Geometry follow from the articulatory definition of the features involved; recall [distributed] and [coronal], for instance. Ewen (1995:581) notes in this respect that in Feature Geometry “the interpretation of the dependency relations represents an attempt to formalize the constraints on human articulators”. The problem with this interpretation concerns the characterization of features in terms of concrete articulatory phonetic categories. This becomes apparent when

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13 Anderson & Ewen cite Jakobson & Halle (1956:56), who observe that “nasality, by superimposing a clear-cut formant structure upon the consonantal pattern, brings consonants closer to vowels".
we consider the various Feature Geometry proposals regarding the location of the feature [nasal]. Within Feature Geometry it has been proposed that [nasal] is located under the Manner node (Clements 1985), the Peripheral (or Laryngeal) node (Hayes 1986), the Root node (McCarthy 1988, Piggott 1988), the Supralaryngeal node (Trigo 1993), the Soft Palate node (Sagey 1986), the Spontaneous Voice node (Rice & Avery 1989, Rice 1993), under either the Spontaneous Voice node or the Soft Palate node (Piggott 1992), or under both (Tourville 1991). Each of these proposals has its merits, but, as Humbert (1995:13) points out, they cannot all be correct.

The variety of proposals regarding the location of the feature [nasal] indicates that the structural principles underlying Feature Geometry are not sufficiently constrained. In Feature Geometry, motivation for a particular feature organization comes both from articulatory phonetic considerations and from the behaviour of features in processes. There are, however, no independent principles that help restrict the range of possible structures. This problem demonstrates that a restrictive model of segment specification benefits from having relatively abstract features, since the structural principles of such a model can be motivated independently from the content of the features involved. In this respect Dependency Phonology is, in principle at least, more adequate than Feature Geometry.

In §1.2.1 I consider the role of dependency in Element-based Dependency, paying particular attention to the interpretation of the dependency relations that hold between the manner, phonation, and place properties of segments.

1.2.1 Dependency relations between manner, phonation, and place

In this section I will take as my starting point recent work in Dependency Phonology, in particular Humbert (1995). This model assumes the following general organization of segmental structure (cf. Humbert 1995:31; see also Smith 2000:240-1):

(5) \[\text{manner} \quad \text{phonation} \]
\[\text{place}\]

14 The Spontaneous Voice node, abbreviated SV, has also been referred to as Spontaneous Voicing node (Piggott 1992) and as Sonorant Voice node (Piggott 1993); this variation appears to be terminological only.

15 With regard to the location of [nasal] articulatory phonetic evidence is difficult to find, since in articulatory terms [nasal] is not dependent on any other feature. Note, incidentally, that this presupposes—incorrectly, in my opinion—that there is an adequate articulatory definition of phonologically relevant nasality.
The organization in (5) expresses the fact that manner functions as the segmental head. Place is dominated by manner and, in Anderson & Ewen’s terms, is therefore dependent on it. The interpretation of phonation, which subsumes the various laryngeal distinctions, is less straightforward. I return to this issue shortly; first, I consider some arguments for the headedness of manner.

A first and general argument for according manner head status is that manner is the most characteristic aspect of a segment. This is reflected in the standard description of speech sounds: a sound like [p], for instance, is a labial stop, not a “stopped labial”.

A more specific argument for the primacy of manner is that the manner properties of a segment determine to a large extent its position in prosodic structure. As such one expects manner properties to be visible for the purposes of syllabification. Consider for instance the distribution of vowels and consonants in syllable structure, the fact that many languages only permit sonorants in the syllable coda (see e.g. Fudge 1969, Selkirk 1982, Goldsmith 1990), or the fact that in some languages the set of weight-bearing codas is restricted to sonorants (see Zec 1991). According manner properties the status of segmental head provides a way to formalize their prosodic visibility.

A third argument for the head status of manner concerns the observation that place assimilation processes typically operate in the context of a particular manner type.16 A case in point is English in-prefixation; here the prefix nasal surfaces as homorganic with a following stop, as in (6a), and as [n] before fricatives and vowels, as in (6b,c). Before nasals and liquids, the prefix nasal undergoes complete assimilation with concomitant degemination, as in (6d,e):17

(6)  a. impartial [ɪmˈpɜːrəlt] inglorious [ɪnˈɡlɔːriəs]  
    b. infertile [ɪnˈfɜːrtəl] invalid [ɪnˈvæld]  
    c. inactive [ɪnˈæktɪv] inelegant [ɪnˈɛləɡənt]  
    d. immoral [ɪˈmɔːrəl] innumerate [ɪnˈnʌmərət]  
    e. illegal [ɪˈlɪɡəl] irregular [ɪrˈɡɜːlə]

Hence, place specification of the nasal takes account of the manner properties of the stem-initial segment. By way of contrast, processes affecting manner usually, although not exclusively, apply without regard to place.18 Consider for

16 This point is also made by Smith (2000:238).
17 This is the scenario of Borowsky (1986). Note that in-prefixation applies to a restricted number of forms of predominantly Latin origin; for present purposes it is immaterial whether the process has synchronic status. Note also that nasal place assimilation is optional before fricatives, e.g. invalid [ɪnˈvæld] ~ [ɪnˈvæld].
18 In chapter 7 I consider a number of processes in which only a subset of nasals is targeted. While this suggests that such asymmetries result from differences in place, I will argue that at least some of them may in fact be the result of a difference in manner.
instance a typical process of intervocalic lenition in which voiced stops are
turned into fricatives, as in Spanish.

It could be argued that a further argument for the primacy of manner
concerns the observation that the manner properties of a segment determine the
range of possible place distinctions. Consider for instance the observation that
sibilants, affricates, and laterals are limited to coronals. Taking sibilants as an
example, this can be expressed in informal terms by making coronal place
dependent on sibilant manner, as in (7):

\[(7) \quad \text{sibilant} \quad \mid \quad \text{coronal}\]

We can interpret (7) to mean that sibilant manner, in the capacity of segmental
head, “selects” the dependent coronal place specification. The selectional
properties of heads are of course familiar from other linguistic domains;
consider for instance the selection of complements by verbs.

Similarly, there appear to be good grounds to regard manner as selecting
phonation, given the observation that the distribution of the various laryngeal
distinctions—voice, aspiration, glottalization, breathy voice, and implosion—
depends on the manner type of the segment involved. That is, whereas stops and
affricates are compatible with any laryngeal contrast, fricatives permit only a
contrast in terms of voice, aspiration, and glottalization, and sonorants only in
terms of aspiration and glottalization.

In Dependency Phonology the fact that obstruents, but not sonorants, are
compatible with distinctive voice has been interpreted to mean that a structure
with head \( |C| \) and dependent \( |V| \) is well-formed, whereas a structure with head
\( |V| \) and dependent \( |V| \) is ill-formed. This is the position of Humbert (1995), who
assumes that (8a) denotes a voiced obstruent, and that the structure in (8b)—a
“voiced sonorant”—is illicit:

\[(8) \quad \text{a. } \quad \text{b. } \quad \star |V| \]

\[
\begin{array}{c}
\quad |C| \\
\quad ...
\end{array} \quad \begin{array}{c}
\quad |V| \\
\quad ...
\end{array}
\]

The cooccurrence restriction between head and dependent \( |V| \) is motivated by
the observation that voicing is redundant in sonorants, and hence should not
form part of their phonological specification. Nevertheless, this does not take
away the fact that the impossibility of head and dependent \( |V| \) as a phonological
structure must be stipulated in Humbert’s approach.

A further argument against a cooccurrence restriction between head and
dependent \( |V| \) is that such a restriction is at odds with the Dependency
Phonology assumption that components lack phonetic concreteness. This can be
illustrated by considering the interpretation of place components. In recent
versions of Dependency Phonology, as well as in related approaches, it is assumed that the components $|U|$, $|I|$, and $|A|$ specify place in both consonants and vowels.\footnote{See for instance Van der Hulst (1988a,b), Van der Hulst & Smith (1990), Smith (1988, 2000), Smith et al. (1989), Humbert (1995), and Van de Weijer (1996); I make a similar assumption in §2.5.} As such, one and the same component, say $|A|$, can be dominated by a consonantal or by a vocalic manner structure, as is represented in informal terms in (9a,b):

\begin{center}
\begin{tabular}{cc}
(9) & a. consonant & b. vowel \\
& \hspace{1cm} & \hspace{1cm} \\
& A & A
\end{tabular}
\end{center}

The advantage of this approach is that it restricts the number of components, but at the same time it means that the interpretation of components is variable: $|A|$ is interpreted as velar when it is dominated by a consonantal manner structure, and as low when it is dominated by a vocalic manner structure. More generally, this scenario shows that place components have a context-sensitive interpretation, depending on the manner type by which they are dominated. In Humbert (1995), however, this context-sensitivity is not extended to include phonation, where dependent $|V|$ is restricted to distinctive voice.

Two points emerge from the preceding discussion. First, cooccurrence restrictions between manner and phonation are required only in case a dependent component lacks a context-sensitive interpretation. Given that cooccurrence restrictions are by their nature stipulative, the challenge for a dependency-based approach is to exploit context-sensitivity to its fullest potential. This challenge is met in Element-based Dependency, where the element $|L|$, which specifies voicing in obstruents, has the complementary interpretation of nasalization in sonorants. This dual interpretation of $|L|$ obviates the need for any cooccurrence restrictions between manner and phonation.

The second point concerns the relation between manner, phonation, and place. In an approach in which the interpretation of dependent structures is completely derivable from their structural context, there is no sense in which the head, i.e. manner, can be said to select the range of phonation. This suggests that phonation does not necessarily have to be viewed as being structurally dependent on manner. Indeed, there is reason to assume that the organization in (10) offers a more adequate representation of the relation between manner, phonation, and place:\footnote{I assume, in (10) as well as below, that manner and phonation are dominated by a subsyllabic constituent, i.e. an onset (O), a nucleus (N), or a coda (C). This organization will be motivated in §1.2.2.}
(10) O, N, C

manner phonation

place

(10) conveys that manner and place form what may be termed the segmental “core”.21 This is in line with the observation that it is unmarked for a segment to be specified for manner and place, but marked for a segment to be specified for phonation.

One argument in favour of (10) is to some extent theory-internal, and concerns the Element-based Dependency interpretation of dependent [L] as voice and nasalization. This interpretation is motivated by the observation that sonorants permit a nasalization contrast but not a voicing contrast, whereas obstruents permit a voicing contrast but not a nasalization contrast. Consider as an illustration the Element-based Dependency representations of a nasalized vowel, a voiced obstruent stop, and a voiced sibilant:

(11) a. N L L place

b. O ? L H L place

c. O L L place

Nasalized vowel Voiced stop Voiced sibilant

In (11a) vocalic manner is represented in terms of the head element [L], which is more or less equivalent to head [V] in Anderson & Ewen (1987). The fact that the manner structure is [L]-headed implies that dependent [L] is interpreted as nasalization. The manner structure of the (obstruent) stop in (11b) is represented in terms of the element [ʔ]. The fact that the structure is [ʔ]-headed implies that dependent [L] is interpreted as voice. The manner structure of an (obstruent) sibilant is represented in terms of the head element [H], as in (11c). The fact that this structure is [H]-headed implies that here, too, dependent [L] is interpreted as voice.

While the complementary interpretation of [L] can be maintained for supralaryngeal articulations, matters are complicated when we consider the status of dependent [L] in relation to laryngeal segments, in particular /h/. To the best of my knowledge, there are no languages which have an underlying contrast between voiced and voiceless /h/. There are, however, languages with an underlying contrast between plain and nasalized /h/, such as Seimat (Blust 1998)

21 In this respect, (10) is similar to the segmental structure assumed in Smith (2000). Smith (2000:241) views phonation as “a dependent of the entire segment”, but does not provide any arguments for this claim.
and Kwangali (Ladefoged & Maddieson 1996). In addition, there are languages
that have a single /h/ which is underlyingly nasalized, such as Sui (Haudricourt
1967), Sedang (Smith 1973a), Gourmantché (Dell 1993), and some southern
dialects of Thai (Brown 1965, Matisoff 1975). In Element-based Dependency,
nasalized /h/ can be represented as in (12):

\[
\begin{align*}
&\text{O} \\
&\text{H} \\
&\text{L} \\
\end{align*}
\]

The representation in (12) shows that laryngeals consist of a placeless (or
“degenerate”) manner component (see also Humbert 1995, Smith 2000). More
specifically, I assume that the manner structure of /h/ consists of the same
element which specifies sibilant manner, i.e. [H]. Given this, the important
observation is that dependent [L] is interpreted as voice in case [H] dominates a
place element, as in sibilants, but as nasalization in case the segmental core
consists of [H] only, as in /h/. This shows that the interpretation of dependent [L]
takes account not only of the manner type of the segment involved, but also of
the presence of place. The fact that both manner and place are relevant suggests
that phonation forms a dependent of the entire segmental core, rather than of
manner alone. More generally, the preceding discussion shows that Element-
based Dependency representations involve two distinct types of dependency.
The first type, i.e. dominance, is observed in the relation between manner and
place. The second type, i.e. branching, is observed between manner and place on
the one hand, and phonation on the other. I consider branching dependency in
more detail in §2.6.

An additional advantage of the structure in (10) is that phonation can now be
viewed as being dominated by a subsyllabic constituent, as can be seen in the
representations in (11) and (12) above. In the following section, I will argue that
this organization permits a restrictive approach to the distribution of contrastive
laryngeal specifications.

1.2.2 The prosodic interpretation of laryngeal contrasts

Aside from context-sensitive features and formally restrictive structures, another
way to prevent overgeneration is to limit the scope of features to those domains
in which they are contrastive. To this end I assume, following Kehrein (2002),
that the distribution of laryngeal distinctions is regulated by subsyllabic rather
than by segmental positions (see also Golston & Kehrein 1998, 1999). This is

\[\text{This makes it possible to express phonological interaction between /s/ and /h/ of the kind discussed in §1.1.}\]
expressed in (13), where the phonation component is dominated by an onset (O), a nucleus (N), or a coda (C):

\[(13)\quad O, N, C\]

\[\text{manner} \quad \text{phonation} \quad \text{place}\]

An important consequence of the direct link between syllable structure and contrastive feature specifications is that there is no longer a level which corresponds to that of the segment. Another important consequence is that syllables form part of the underlying representation, instead of being projected in the course of the phonological derivation. Hence, this approach constitutes a move towards a non-segmental phonology.\(^{23}\)

The structure in (13) makes a number of predictions. First, onsets, nuclei, and codas have at their disposal a maximum of one laryngeal contrast. This predicts for instance that we never find an onset constituent such as */p^h^z^/\(^{*}\), where both aspiration and voice are contrastive. Second, within onsets, nuclei, and codas the order of supralaryngeal and laryngeal articulations is never contrastive. This predicts for instance that languages do not contrast preaspiration and postaspiration within the same onset, e.g. */^h^p^/~/p^v^/, or creaky voice and postglottalization within the same nucleus, e.g. */^h^/~/^a^/. Third, within onsets, nuclei, and codas languages never have a contrast between a laryngeal segment and the corresponding laryngeal modification. This predicts for instance that contrasts such as */^p^/~/^p^/\(^{*}\) and */^m^/~/^m^/\(^{*}\) are unattested. Kehrein surveys a wide range of languages and concludes that these predictions are borne out.

Adopting a version of Feature Geometry, Kehrein formalizes his approach by making the Laryngeal node, which he assumes dominates the features [voice], [spread glottis], and [constricted glottis], a dependent of a subsyllabic constituent. Some examples of this organization are given in (14), where LAR is short for the Laryngeal node and [cg] is short for the feature [constricted glottis]; in (14) I ignore supralaryngeal specifications.

\(^{23}\) See e.g. Jensen (1994), Van der Hulst (1995, 2000), and Golston & Van der Hulst (1999) for a discussion of some of the advantages of this type of approach.
The assumption that [constricted glottis] is dominated by the onset introduces a degree of indeterminacy in the phonetic realization of the phonological material contained in that onset. For instance, the realization of the combination of /m/ and [constricted glottis] may include, among other things, preglottalization, postglottalization, and creaky voice. According to Kehrein, this variability is irrelevant to the extent that it is never phonologically contrastive. I return to this issue in chapter 5, where I focus in some detail on the phonological status of laryngeally modified nasals.

Although restrictive, one problem of Kehrein’s approach to laryngeal contrasts is that it is based on phonetically concrete features. As a consequence, Kehrein is forced to stipulate that manner types differ as regards their compatibility with laryngeal contrasts. For instance, in order to account for the irrelevance of voicing in sonorants, Kehrein must assume that [voice] is incompatible with [sonorant]. Similarly, Kehrein accounts for the absence of distinctive breathy voice in fricatives in terms of a cooccurrence restriction between fricative manner (i.e. [–sonorant, +continuant]) and breathy voice (i.e. [voice, spread glottis]). Note that these restrictions do not follow from the structure and the content of the representations. In addition, Kehrein must stipulate that some manner types permit a greater number of laryngeal features than others; that is, while stops and affricates may contrast in terms of breathy voice (i.e. [voice, constricted glottis]), fricatives and sonorants are limited to a maximum of one laryngeal feature. Again, these asymmetries do not follow from the structure and the content of the representations assumed by Kehrein.

Element-based Dependency provides a more restrictive approach to the compatibility of manner and phonation types. This is due first and foremost to the context-sensitive interpretation of dependent |L| as voice and nasalization. Treating nasalization on a par with laryngeal modifications not only extends the prosodic scope of elements to nasalization, but also obviates the need for a cooccurrence restriction between [voice] and [sonorant]. Furthermore, I will argue in §2.4 that the asymmetric distribution of breathy voice and voiced creak can be attributed to the structural position that voicing (i.e. [L]) may have in stops, but not in fricatives and sonorants. As we will see, an important consequence of this view is that the number of laryngeal dependents can be limited to a maximum of one, regardless of the manner type to which they are attached.

\[
\frac{1}{14}
\begin{align*}
\text{a.} & \quad \begin{array}{c}
\text{O} \\
\text{LAR} \\
\text{[cg]} \\
\text{\textipa{/\textipa{m}}/} = [\text{\textipa{m}}, \text{m}^{\prime}, \text{m}^{\prime\prime}, \ldots]
\end{array} \\
\text{b.} & \quad \begin{array}{c}
\text{O} \\
\text{LAR} \\
\text{[cg]} \\
\text{\textipa{pr}^{\prime}}/ = [\text{\textipa{p}^\prime}, \text{\textipa{p}^\prime\prime}, \text{\textipa{p}^\prime\prime\prime}, \ldots]
\end{array}
\end{align*}
\]
I consider the Element-based Dependency approach to phonation in more detail in §2.4. In the remainder of this chapter I outline the main tenets of Element Theory.

### 1.3 Element Theory

Following Dependency Phonology, I assume that phonological representations are maximally binary-branching and consist of head-dependency relations. However, I depart from Dependency Phonology as regards the content of these representations. Rather than by \(|C|\) and \(|V|\), I assume that the manner and phonation properties of segments are expressed by the elements \(|\beta|\), \(|H|\), and \(|L|\), a subset of the elements used in Element Theory. We will see that the recognition of three rather than two elements, although less restrictive, leads to a more insightful interpretation of segmental structure. I introduce the Element-based Dependency interpretation of \(|\beta|\), \(|H|\), and \(|L|\) in §2.1. To set this proposal on a concrete footing, I first introduce the relevant Element Theory background here, based on Harris & Lindsey (1995).\(^{24}\)

Element Theory elements are like SPE-type features to the extent that they constitute the smallest building blocks of phonological organization. An important assumption of Element Theory is that elements are monovalent. As was noted in §1.1, monovalency has two advantages: it reduces the risk of overgeneration, and it offers an evaluation metric to measure the inherent complexity of segments, in the sense that the more elements a segment requires in its specification, the more complex that segment is.

In Element Theory relative segmental complexity corresponds by and large to relative sonority, in such a way that the least complex segment type is the most sonorous.\(^{25}\) Hence, vowels are maximally simple and voiceless stops are maximally complex. This relation between segmental complexity and sonority is motivated primarily by lenition processes, which in Element Theory are uniformly characterized as involving reduction in complexity. Some representative lenition trajectories are given in (15):

\(^{24}\) Since Harris & Lindsey (1995) is, in their own words, the first “full-blooded version of element theory” (cf. Harris & Lindsey 1995:36), I take this article as the basis for the following discussion. It should be noted, however, that Element Theory is in many respects a continuation of the theory of “charm and government” of Kaye et al. (1985). An earlier Element Theoretical proposal can be found in Harris & Lindsey (1992).

\(^{25}\) I use the qualification “by and large” since, as noted in §1.1, sonority is not a primitive of Element Theory.
THEORETICAL PRELIMINARIES

(15) **Context**     **Lenition process**
      a. *initial*     f, s, x > h > ə
      b. *final*      p, t, k > ? > ə
      c. *intervocalic* p, t, k > b, d, g > β, δ, ɣ > w, j > ə

In terms of Element Theory, each step in the lenition trajectories involves the removal of an element. Thus, in Element Theory vocalization is equated with loss of complexity.

The Element Theory interpretation of segmental complexity is not without problems. Its main weakness lies in the relation between complexity and markedness. That is, whereas the interpretation of peripheral vowels as maximally simple is in line with markedness observations, the interpretation of voiceless stops as maximally complex is not. A more appropriate relation between complexity and markedness would be to have minimally complex representations at both the vocalic and the consonantal end of the segmental spectrum, as in Dependency Phonology. This implies that in Dependency Phonology lenition cannot be expressed as involving across-the-board reduction.

Ewen & Van der Hulst (2001:107) observe that this is not necessarily problematic, since not all types of lenition are equally amenable to an analysis in terms of feature reduction:

> [I]ntervocalic changes seem to be triggered by assimilation to some property of the surrounding vowels; there seems to be no *a priori* reason to expect that spreading should lead to reduction in complexity. Indeed, in a single-valued approach, we would expect the reverse, if anything.

Nevertheless, it should be noted that a spreading account of intervocalic lenition is not without problems either. Consider as an illustration the following facts from Ibibio, a Benue-Congo language of Nigeria (cf. Harris 1997:320):

(16) a. [dip] 'hide'     b. [diβe] 'hide oneself'
   [wet] 'write'      [were] 'be written'
   [fak] 'cover'      [fγaγ] 'cover oneself'

   c. [utan] 'plaiting’ (*[uran])
   [uknap] ‘covering’ (*[uγaŋ])

In the morphologically related forms in (16a,b), final [p t k] correspond to intervocalic [β r ɣ], which suggests that [β r ɣ] are the lenited counterparts of [p t k]. However, the forms in (16c) indicate that lenition does not apply in any intervocalic context. This leads Harris to analyze the lenition context as foot-

---

26 This approach to complexity is also assumed in Radical CV Phonology (see e.g. Van der Hulst 1995).
internal, noting that foot structure in Ibibio is independently motivated by verbal morphology and by certain phonological processes. This analysis implies that the intervocalic consonants in (16c) are not foot-internal; as such, Harris considers the nominalizing prefix /\(u\)-/ to lie outside the verbal foot template.

Consider next how an analysis in terms of spreading accounts for the Ibibio facts. The assumption underlying a spreading analysis is that the property which spreads is realized as continuancy in the targeted stop. In traditional feature theory, the relevant feature would then be [+continuant]. The problem with this interpretation is that the continuancy of vowels is usually considered redundant, so that their [+continuant] specification is not expected to play a role in the phonology. In Dependency Phonology this problem can be circumvented by assuming that the [V] component of the vowel spreads to a dependent position in the stop, in such a way that the resulting structure is phonetically interpreted as a fricative. This aside, the major problem that is faced by any spreading account of the Ibibio facts concerns the identification of the trigger of the lenition process. The spreading operation must refer to both the vowel preceding and following the affected stop, because both are relevant with respect to the segmental environment in which lenition occurs. Even so, it remains unclear which of the vowels does the spreading: the first, the second, or both. Given this, and given the fact that Ibibio lenition is crucially prosodically conditioned, it seems more feasible to relate the lenition of consonants to their occurrence as foot-internal onsets, as Harris does, than to their segmental environment. Note that such an interpretation does not necessarily commit us to the view that foot-internal lenition involves feature loss, as is assumed by Harris. Indeed, in §1.3.2 I will analyze a similar lenition process in Fore as involving the addition of the “vocalic” manner element [L].

### 1.3.1 Autonomous interpretation

Another basic assumption of Element Theory is referred to by Harris & Lindsey (1995) as the “autonomous interpretation hypothesis”. This involves the idea that elements are phonetically interpretable in isolation. Element Theory differs in this respect from traditional SPE-type feature theories (but not from Dependency Phonology), where a particular feature is interpretable only in combination with other features.

The autonomous interpretation hypothesis predicts that each element is capable of independently defining a segment. This is an attractive result, establishing as it does a relation between segmental complexity and markedness. Nevertheless, the notion of autonomous interpretation as used in Element Theory has some problematic aspects. First, Harris & Lindsey (1995:35) assert that autonomous interpretation figures “with varying degrees of explicitness” in related approaches such as Dependency Phonology, Government Phonology and Particle Phonology. However, it should be observed that in Element Theory, too, only a limited number of elements have stand-alone phonetic interpretation. This
concerns first of all the peripheral vowels /u i a/, which consist of the place elements /\U, /I, and /A/ respectively. The second class of segments which consists of a single element are the laryngeals /h/ and /r/, which are represented by the “noise element” /h/ and the “amplitude drop element” /r/. Harris & Lindsey maintain that the single-element status of laryngeals is supported by lenition processes in which /h/ and /r/ form the pre-final stage of the lenition trajectory. Recall, however, that lenition does not necessarily provide a good diagnostic for segmental complexity.

Importantly, the lack of complexity of /h/ has a different motivation than the lack of complexity of /i a/. On the one hand, complexity in Element Theory is related to sonority, in such a way that the more vocalic a segment is, the fewer elements it contains. On the other hand, autonomous interpretation dictates that each element is interpretable in isolation, regardless of its sonority. This suggests, then, that the Element Theory approach to complexity is incompatible with the autonomous interpretation hypothesis.27

Below, I will suggest two modifications to avoid this problem. First, I take the head status of manner to imply that segments must be minimally specified for manner at the level of underlying structure. This automatically reduces the number of autonomously interpretable elements to the set of manner elements. As regards these, I assume that segmental manner is characterized in terms of a subset of Element Theory elements, i.e. /h, /H, and /L/, to which I assign a more general interpretation. Second, I propose a more refined interpretation of the relation between complexity and markedness, in the sense that /h, /H, and /L/ each correspond to a particular unmarked segment type. To appreciate these modifications, it is useful to first consider the role of /h/ in Element Theory.

Harris & Lindsey (1995:69) assume that the element /h/ characterizes those segments which involve “an abrupt and sustained drop in overall amplitude”. This corresponds to the class of segments that is traditionally specified as [-continuant], i.e. stops, nasals, and, in some languages at least, laterals.28 In isolation /h/ is interpreted as /h/, while combined with a place element /h/ is interpreted as a complete closure of the oral cavity. The combination of /h/ and a place element thus produces a stop, either oral or nasal, depending on the presence of an additional element specifying nasality.

This scenario shows that the phonetic interpretation of elements is context-sensitive; in this respect, Element Theory elements are like Dependency Phonology components. A further similarity between both frameworks is that elements, like components, lack a specific articulatory phonetic correlate. As Harris & Lindsey (1995:70) observe:

27 It should be noted that the incompatibility between segmental complexity and autonomous interpretation is to some extent masked by the limited number of elements which enjoy autonomous interpretation—but this, surely, is not a desirable state of affairs.

28 I will argue in §2.2.3 that the continuant status of laterals is a language-specific matter.
To say that each element is independently interpretable is not to say that it can be targeted by executing a unique articulatory gesture. The performance of a particular elemental pattern typically involves the arrangement of one or more of an ensemble of gestures.

Like Harris & Lindsey, I assume that [ʔ] is a property of non-continuants. For reasons outlined in chapter 2, I further assume that head [ʔ] is present in the manner structure of non-sibilant fricatives, and that dependent [ʔ] is interpreted as glottalization.

The role of [H] and [L] in Element Theory is discussed in Harris (1994). As regards their interpretation Harris follows Kaye et al. (1985), where [H] and [L] are referred to as the “high-tone” and the “low-tone” element. This terminology is motivated by the relation between high tone and aspiration, and between low tone and voice.29 Harris is primarily concerned with the interpretation of [H] and [L] as laryngeal articulations. He assumes that the articulatory phonetic interpretation of [H] and [L] corresponds to that of the features [stiff vocal cords] and [slack vocal cords], respectively.30

As far as the role of [H] and [L] in laryngeal contrasts is concerned, Harris observes that in English the lenis stops /b d g/ are in fact rarely voiced, but usually phonetically voiceless. The fortis stops /p t k/, on the other hand, are always realized as voiceless, and in foot-initial position are aspirated. Furthermore, there is evidence to suggest that in English it is aspiration rather than voicing that is phonologically active, since initial fortis stops transfer aspiration to a following sonorant, as in clue [ˈkluː] and cry [ˈkriː]. English differs in this respect from a language like French, where lenis stops always surface as voiced and fortis stops are never aspirated.

According to Harris, the difference between English and French corresponds to a difference in the kind of laryngeal contrast that these languages employ. In English the element [H] is active, so that the fortis series is phonologically marked for [H] and the lenis series is neutral. In French the element [L] is active, so that the lenis series is phonologically marked for [L] and the fortis series is neutral. The relevant contrast is illustrated in (17) (cf. Harris 1994:135):

<table>
<thead>
<tr>
<th>Element</th>
<th>English</th>
<th>French</th>
</tr>
</thead>
<tbody>
<tr>
<td>voiced</td>
<td>L</td>
<td>&lt;beau&gt; ‘beautiful’</td>
</tr>
<tr>
<td>neutral</td>
<td>-</td>
<td>&lt;bye&gt;  ‘skin’</td>
</tr>
<tr>
<td>voiceless aspirated</td>
<td>H</td>
<td>&lt;pie&gt;  -</td>
</tr>
</tbody>
</table>

29 The relation between laryngeal features and tone is for instance observed in the development of distinctive tone contrasts (see e.g. Matisoff 1973a, Kingston & Solnit 1988, and Yip 2002). I offer a brief discussion of this issue in §5.2.4.

30 See Halle & Stevens (1971) for a discussion of these features.
In languages with more than a two-way laryngeal contrast |H| and |L| are both active, and both may appear in the representation of a single segment. This is illustrated in (18) for Thai and Gujarati (cf. Harris 1994:135):

<table>
<thead>
<tr>
<th>Element</th>
<th>Thai</th>
<th>Gujarati</th>
</tr>
</thead>
<tbody>
<tr>
<td>voiced</td>
<td>/bāa/</td>
<td>‘shoulder’</td>
</tr>
<tr>
<td>neutral</td>
<td>/pāa/</td>
<td>‘forest’</td>
</tr>
<tr>
<td>voiceless aspirated</td>
<td>/pʰāa/</td>
<td>‘split’</td>
</tr>
<tr>
<td>breathy voiced</td>
<td>L, H</td>
<td>-</td>
</tr>
</tbody>
</table>

This approach offers a straightforward account of how languages may differ in the way that they employ laryngeal contrasts, although some aspects of it are problematic. One, as noted by Ewen & Van der Hulst (2001), is that |H| and |L| do not refer to distinct articulatory and acoustic parameters. That is, Harris’ characterization of |H| and |L| appears to imply that the contrast between the two is equipollent, contrary to the Element Theory position that elements are monovalent. As a consequence, it must be stipulated that |H| and |L| are in some languages mutually exclusive within a segment; compare Brockhaus (1995) with respect to German, for instance. For this reason, Ewen & Van der Hulst propose to replace |H| by the Dependency Phonology component |O|, denoting glottal opening (see also Anderson & Ewen 1987).

A more general problem is that the function of |H| and |L| is limited to laryngeal articulations, which means that they are exceptions to the autonomous interpretation hypothesis. Subsequent work has attempted to provide a more general interpretation of these elements. In the “Revised” Element Theory of Ploch (1999) for instance, |H| has taken over the function of the noise element |h|, in that it has been assigned the variable interpretation of stiff vocal cords, frication, and, in voiceless stops at least, oral release. As far as the interpretation of |L| is concerned, Ploch assumes that this depends on whether |L| is a head or an operator, and on whether |L| is linked to an onset or to a nucleus. This leads to the following context-sensitive interpretation of |L| (cf. Ploch 1999:169):31

<table>
<thead>
<tr>
<th>Onset</th>
<th>Nucleus</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-operator</td>
<td>nasality</td>
</tr>
<tr>
<td>L-head</td>
<td>voicing, prenasalization</td>
</tr>
<tr>
<td></td>
<td>low tone/pitch</td>
</tr>
<tr>
<td></td>
<td>nasality</td>
</tr>
</tbody>
</table>

I will discuss this interpretation of |L| in more detail in §2.4.3. The point to note here is that in Ploch’s approach, too, |L| requires the presence of other elements in order to be phonetically interpretable.

---

31 Ploch attributes this interpretation of |L| to Kaye (1993); this reference concerns a series of lectures held at SOAS. Ploch’s distinction between head and operator is more or less equivalent to the distinction between head and dependent made here.
Similar to “Revised” Element Theory, Element-based Dependency assigns a more general function to |L| (as well as to |H| and |R|), relying on the assumption that the interpretation of elements is derivable from their position in the phonological structure. I return to this issue in §2.1.

1.3.2 Phonetic interpretation

As regards phonetic interpretation, I share with Harris & Lindsey the assumption that different elemental compositions may map onto identical patterns in the acoustic signal (see also Harris & Lindsey 1992). This essentially means that the internal structure of a particular segment is determined by its phonological behaviour, and not by its phonetic realization. This implies, then, that a particular phonetic entity does not have a unique phonological representation. Rather, this representation depends on the phonological system of the language concerned.

Consider in this light the relation between sonorancy and voice, and more specifically the observation that sonorants pattern with voiced obstruents in some languages, but not in others. In traditional feature theory, the absence of class behaviour of voiced obstruents and sonorants is generally accounted for by making [voice] redundant in sonorants, while in those languages where voiced obstruents and sonorants do pattern together, it is assumed that the process concerned applies after the specification of redundant [voice] (see e.g. Kiparsky 1985, Itô & Mester 1986).

This interpretation has been challenged on a number of occasions, most notably by proponents of the SV-hypothesis (see e.g. Rice & Avery 1989, 1991b, and Rice 1993). Rice (1993) points out certain cases in which sonorant voicing plays a role in the lexical component of the phonology. Consider as an illustration the following data from the Puyo-Pongo dialect of Quechua. As the forms in (20) show, Puyo-Pongo Quechua contrasts voiceless and voiced stops following nasals (cf. Rice 1993:315):

(20)  a. pampalina ‘skirt’ b. hambi ‘poison’
      /ˈtanki/ ‘soot’ /ˈtʃunga/ ‘ten’
      ṭuntina ‘to stir the fire’ indi ‘sun’

The forms in (21) indicate that this contrast is limited to stem-internal context; in case of an intervening morpheme boundary, a stop following a nasal surfaces predictably as voiced:

(21)  a. wasi-ta ‘the others-OBJ’ b. wakin-da ‘the house-OBJ’
       sink-pa ‘porcupine-GEN’ kam-ba ‘you-GEN’
       satʃa-pi ‘jungle-LOC’ hatum-bi ‘big one-LOC’
Hence, the process which voices suffix-initial stops after nasals applies in derived environments only.

In an account in which nasals, as sonorants, are redundantly specified for [voice], the redundancy rule that fills in [voice] must be viewed as being lexical, given that it must distinguish between derived and non-derived contexts. According to Rice, this leads to a scenario where the point at which redundant feature specification applies must be stipulated for each language.32 This, Rice observes, is problematic, since it is contrary to the basic motivation of the redundancy rule approach, i.e. to provide a universal constraint which limits the power of a theory of underspecification.

Rice proposes an alternative analysis of the Puyo-Pongo Quechua facts in which nasals are specified for an SV-node, which identifies nasals as sonorants. Postnasal voicing can then be formalized in terms of spreading of this node to a following stop, given the appropriate morphological context. This is represented in (22), where N denotes a nasal and C a stop:

\[(22) \quad \text{N)STEM} \quad \text{SFX(C)} \quad \text{SV}\]

For present purposes, the important observation is that in this analysis the derived voiced stops are interpreted as sonorants, even though there is no indication that these stops are phonetically any different from the voiced stops of, say, Dutch, which are never the result of postnasal voicing.33

There is evidence to suggest that the notion of sonorant obstruents can be extended to underlying forms. Rice observes that Bear Lake Slavey, in common with many other Athapaskan languages, displays a number of morphologically conditioned alternations between voiced stops and nasals. Some examples are given in (23):

(23)  a.  sedá ‘my eye’ (se ‘1-SG-POSS’ + da ‘eye’ + high tone ‘POSS’)
      natú ‘my tear’ (na ‘eye’ + tu ‘water’ + high tone ‘POSS’)
   b. -de ‘win-IMPERF’
      -nô ‘win-PERF’
      -be ‘swim-IMPERF’
      -mî ‘swim-PERF’

32 Rice cites additional evidence from Japanese and Kikuyu which suggests that the redundancy rule that fills in [voice] is a late lexical rule (as in Japanese) or an early postlexical rule (as in Kikuyu).

33 In Dutch, voicing in stops is either underlingly present or the result of spreading from an adjacent voiced obstruent; sonorants never trigger voicing. I return to this issue in §2.2.5.
In the forms in (23a), the alternation between voiced stops and nasals depends on whether the morpheme in question functions as the morphological head of the word. If it does, as in [sɛdã] ‘my eye’, we find a voiced stop; if it does not, as in [nʌtʊ] ‘tear’, we find a nasal. In the forms in (23b), the alternation signals the distinction between the perfective and the imperfective.34

Rice argues that these alternating consonants are sonorants underlyingly. Evidence for this view comes from the existence of a second, non-alternating class of consonants. As is shown in (24), these surface as voiced stops regardless of morphological context:

(24)  a. sɛ-da ‘my chin’ (sɛ ‘1-SG-POSS’ + da ‘chin’)  
      da-yã ‘my beard’ (da ‘chin’ + yã ‘hair’ + high tone ‘POSS’)  
   b. -da ‘move-IMPERF’  
      -dô ‘move-PERF’  
   c. dô ‘animal food storage place’  
      df ‘four’

In (24a), unlike (23a), we find [d] irrespective of whether the morpheme in which it is contained functions as the morphological head. In (24b), the perfective is signalled by nasalization of the vowel, but, unlike (23b), vowel nasalization does not condition the presence of a preceding nasal. Finally, the forms in (24c) show that some instances of [d] can cooccur with a following nasalized vowel in monomorphemic forms.

The differences between (23) and (24) lead Rice to conclude that the stops in (23) are sonorants, and as such specified for SV, while the stops in (24) are obstruents, and as such specified for [voice]. This contrast is illustrated in (25) for the initial consonants of the imperfective forms of ‘win’ and ‘move’:

(25)  a. d       b. d  
       |       |  
       SV    LAR  
       |       [voice]

The sonorant stop in (25a) is realized as a nasal through spreading of [nasal] from a following vowel or, given the appropriate morphological context, through application of a default rule which fills in [nasal]. Thus, the fact that only some instances of voiced stops alternate with nasals is formalized by making [nasal] structurally dependent on the SV-node.

I return to the SV approach in §4.3.1, where I focus on the phonological interaction between sonorants, nasals, and voiced stops. However, one general

34 The change in vowel quality is due to ablaut, and not germane to the discussion here; vowel nasalization signals the perfective morpheme.
problem is worth noting here: in order to account for the interaction between these segment types, no fewer than three features—SV, [nasal], and [voice]—are required. This makes the SV approach considerably less restrictive than the Element-based Dependency approach, where the interaction between sonorants, nasals, and voiced stops can be expressed in terms of one and the same element, i.e. [L].

So far I have examined some evidence which suggests that the internal structure of a segment depends on its phonological behaviour, and not on its phonetic realization. By the same token, I further assume that an elemental configuration does not necessarily have a unique phonetic interpretation. The observation that languages differ with respect to the phonetic realization of segments is of course trivial, and not all of this variation is phonologically relevant. However, one type of variation that I do take to be relevant to phonology concerns prosodically conditioned lenition. Consider as an illustration the following facts from Fore, a Papuan language of New Guinea. Fore has the consonant inventory in (26) (cf. Scott 1978:6):

\[(26)\]
\[
\begin{array}{cccc}
\text{p} & \text{t} & \text{k} & \text{?} \\
\text{\#p} & \text{\#t} & \text{\#k} & \\
\text{s} & \\
\text{m} & \text{n} & \\
\text{w} & \text{j} & \\
\end{array}
\]

Scott (1978:11) notes that /p t k/ have the following positional variants:

\[(27)\]
\[
\begin{array}{cccc}
\text{Word-initial} & \text{Postglottalic} & \text{Intervocalic} \\
\text{/p/} & \text{[p-φ]} & \text{[p]} & \text{[b-β]} \\
\text{/t/} & \text{[5-t]} & \text{[5-t]} & \text{[l-r]} \\
\text{/k/} & \text{[k-x]} & \text{[k-k^x]} & \text{[g-γ~g^w~γ^w]} \\
\end{array}
\]

In (27), two lenition processes can be observed: in word-initial position /p/ and /k/ undergo optional spirantization, while in intervocalic position /p t k/ surface as voiced, with optional variation in terms of continuancy. I focus here on the type of lenition found in intervocalic context.

Intervocalic lenition in Fore is allophonic, and hence it is legitimate to ask whether it should be accounted for by the phonology. The answer to this depends to some extent on one’s theoretical assumptions, although according to the criteria laid out in Keating (1988) Fore lenition qualifies as phonological: the changes involved are categorial, they produce static effects, and they affect discrete segments.\(^{35}\)

\(^{35}\) Phonetic processes, on the other hand, are typically gradient and non-static, and may affect only part of a segment (cf. Keating 1988); see Cohn (1990) for a discussion of these issues in relation to nasalization.
Consider next how the various changes affecting intervocalic stops can be accounted for in terms of an element-based approach. The problem here is that the phonetic variants of /p t k/ are quite distinct from their underlying counterparts, differing from these in terms of voicing, and optionally in terms of continuancy, sonorancy, and laterality. I assume that these realizations represent different phonetic choices rather than phonologically distinct entities. Given that the constant factor concerns a change in voicing, the following representation of the process is, for phonological purposes at least, sufficient:

(28)  Underlying  Lenited
     ?  →  ?
          \  |  
             L

(28) is the Element-based Dependency representation of Fore lenition. Note that the process is interpreted as involving the insertion of [L] to the manner structure of the lenited stop, where it is dominated by [ʔ]. Making [L] part of the head, rather than a branching dependent, signals that the lenition process is prosodically conditioned. That is, on the assumption that manner is visible to prosodic structure, the lenition of the stop can be related directly to its prosodic position. (28) further conveys that the phonetic result of the lenited output involves a combination of amplitude drop (as expressed by [ʔ]) and periodicity (as expressed by [L]), which in Fore is phonetically interpreted as a voiced consonant with variable continuancy. My claim is that this variability, while potentially linguistically significant, is not something that should be accounted for by the phonology.36

1.4 Summary

In this chapter, I have advanced a number of general arguments in favour of Element-based Dependency, a theory that combines insights from Dependency Phonology and Element Theory. Element-based Dependency assumes a restricted set of single-valued elements. These elements are a subset of those proposed in Harris & Lindsey (1995). The use of a reduced number of elements implies a loss of phonetic concreteness of phonological representations. This loss is in a sense counterbalanced by the assumption that elements have a different, but phonetically related, interpretation, depending on their structural position. A context-sensitivity interpretation of elements requires formally

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36 It could be the case that the outcome of lenition is conditioned by factors such as age, sex, speech rate, or stylistic register; however, I have been unable to find any information bearing on this issue.
rigorous representations. To this end, it is assumed that phonological structures in Element-based Dependency are maximally binary-branching, and consist of head-dependency relations.