Dependency Phonology

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1. Introduction

Whenever two minimal units enter into a relation, they form a construction and, typically, the relation between units in a construction will not be equal; is it asymmetrical. This is, in short, the heart of wisdom that Dependency Phonology (DP), or Dependency Grammar more broadly, has contributed to linguistic theory. In contrast with constituency approach, there are no constituents, no 'consist of' relations in the dependency approach. In language, asymmetrical relations are found everywhere where two units combine: in stress languages, two syllables are joined into a 'foot', where one will be stressed and the other unstressed. In morphology, two nouns can form a compound with one being semantically dominant as well as, typically, determining the word class. In syntax, one word in a phrase will function as the syntactic 'head'. Even in single segments such as affricates there is an asymmetric relation between the phonetic parts of the segment. The status and implementation of this head-dependency relation (HDR) in both segmental and suprasegmental structure is the defining feature of the DP framework, which we will discuss in this contribution.

The organization of this chapter is as follows. Section 2 discusses the basic principles of the DP approach. Section 3 reviews some proposals for revision or further extensions of the DP model that have been made in the literature.[1] While these revisions mostly focus on the structure of segments, section 4 discusses suprasegmental structure, starting with the notion of syllable structure and then moving on to the distinction between word and utterance structure. Section 5 deals with the manner in which DP allows the expression of phonological alternations. Section 6 compares DP to other phonological models and section 7 offers a brief conclusion.[2]

As a preamble, a note on the term' dependency'. This term has been used in a variety of ways, as also noted by Ewen (1995). In Feature Geometry proposals (Clements (1985); Sagey (1986)), the term can refer to the hierarchical relation between a mother node and its daughter(s), i.e. as the inverse of dominance: no headedness in the DP sense is assumed; this is the sense in which McCarthy (1988) (and others) have used the term. Mester (1986); (1988) allows different features, residing on different tiers, to be dependent on each other such that spreading one, 'drags along' the other. A related concept is 'government' (the inverse of dependency), as in Government Phonology (Kaye et al. (1985); (1990)) (see chapters 9-11 in this book, as well as section 6 below).

2 Basic principles

2.1. Dependency and Structural Analogy

Dependency Phonology adopts the basic premise of Dependency Grammar, which is that linguistic units enter into *constructions* that are characterized by a relation of dependency between heads and dependents. The relation of dependency is applied in both the *plane* that combines meaningful (conceptually-based) basic units into larger constructs (i.e. syntax; the *content plane*) and in the phonological plane (whose constructs involve meaningless, perceptually-based basic units: the *expression plane*).[3] Fundamental to Anderson's work is the *Structural Analogy Assumption* (see also Anderson (1971); Anderson (1987), Anderson (2004); Anderson (2011a); (2011b; 2011c), Bauer (1994) and Staun (1996a) for discussion), which holds that structural relations and principles are the same in both planes of grammar. The planes therefore primarily differ in terms of the sets of their basic units, i.e. their alphabets, which are determined by the interface with phonetic substance (for the expression plane) and conceptual meaning (for the content plane).[4] The assumption of structural analogy has roots in Louis Hjelmslev's theory of glossematics (e.g. Hjelmslev (1953)). It might seem that this assumption runs counter to the modularity assumption that is prevalent in Generative Grammar (and Cognitive Science in general), but this is only true if we assume that recognizing different modules (of grammar or of the mind) somehow entails that these modules must have radically

different organizations. Anderson, as do we, adopts the more plausible assumption that different modules follow the *same* principles of organization to the extent that this is possible. Indeed, there is no reason to believe that the notion of dependency, or any of the other basic principles that we will discuss, are limited to grammatical modules.[5] By taking analogies between the two planes as non-accidental and in fact reflecting the relevance of general principles in both domains, Anderson's Dependency Grammar takes a stance that has obvious implications for the debate about an alleged Universal Grammar that merely comprises a syntactic system, relegating phonology to a separate 'expression system' (e.g. Hauser et al. (2002)). We will follow Anderson in claiming that the existence of profound analogies between the expression plane and the content plane strongly argues against separating the cognitive systems that permit humans to construct a mental grammar for their language(s) in this radical fashion. At the same time, we agree with Anderson that there is little reason to believe that these analogies reflect principles that are confined to an alleged innate Universal Grammar, however construed.

Dependency structures form an alternative to constituency-based approaches: there is a principled distinction between the two. In a dependency approach, all nodes are associated to units from the alphabet. This means that there are no phrasal nodes that dominate non-terminal nodes. This fundamental difference may be obscured by several factors, however. Firstly, constituent structure in Generative Grammar has been augmented with the notion of headedness ever since Chomsky (1980). Constituents are said to be headed, with the head being a basic, i.e. lexical, unit that determines the characteristic properties of the phrase it heads. The resulting hybrid approach (constituency-cum-headedness) has also found its way into Generative Phonology (specifically in theories of suprasegmental structure). Secondly, depending on how dependency graphs are conceived, it is often very easy to map a dependency graph onto a more familiar-looking constituent structure, especially when the relationship of subjunction is used (see section 4). While such a mapping may be deemed to serve no purpose, it is nonetheless the case that the resemblance may obscure the principled difference. Despite these factors that might blur the distinction to the casual observer, the rejection of constituent structure is fundamental to Dependency Grammar.

Anderson makes a distinction between two types of dependents: complements (dependents that the head requires) and adjuncts (optional modifiers of the head). We will illustrate this distinction in section 4, where we discuss the DP approach to syllable structure. The dependency approach that is reviewed in this chapter has been developed by John Anderson (and a number of other phonologists) over the last five decades. With reference to the alphabets for each plane, Anderson has advocated a strong substantive, or grounded, position. Phonological units and structures are firmly grounded in perceptual acoustics, while the basic units and structures of morphosyntax are grounded in meaning/conceptual structure. Groundedness also extends to structure, i.e. the formation of constructions, in both planes. Headedness in both planes correlates with a substantive notion of *cognitive salience*. The substance-based approach stands in stark contrast to so-called substance-free theories (see e.g. Hale and Reiss (2000); Blaho (2008)).

We add a word about the 'sociology' of Dependency Grammar here. While an appeal to dependency as the organizational relation that binds words together into sentences has deep roots in ancient approaches to language (Percival 1990), it is due to the work of a few scholars that this approach has developed into a branch of linguistics in modern times. In particular, Tesnière (1959) is a foundational work, but other relevant references are Hays (1964), Gaifman (1965), Heringer (1967) and Marcus (1967). We refer to Anderson and Ewen (1980), Anderson and Durand (1987), van der Hulst (2006) and of course Anderson and Ewen (1987) for general overviews of the dependency approach to phonology. As far as we can tell, Anderson is the only linguist who has applied this approach to phonology. While, as we will show, various ingredients of his proposal (developed in the early 1970s, in collaboration with others) bear strong resemblances to versions of generative phonology that were developed in the 1970s and 1980s, these later developments took place independently, mostly in the United States. Indeed, Anderson, working in Edinburgh (Scotland) did not 'found a school' which could exercise influence in other countries, let alone continents. We are aware of only one dissertation in this framework that was written in the US (Kang 1991). Dependency Phonology's major resource remains *Principles of Dependency Phonology* (Anderson & Ewen 1987). Various other phonologists have also made contributions to DP, mostly with publications in European journals and in some edited volumes.[6]

2.2. Segmental structure: monovalency, grouping, dependency and contrastivity

In this section, we focus on segmental structure. In the segmental domain, DP introduced at least six important innovations, several of which date back to early publications by John Anderson and Charles Jones (Anderson & Jones 1972; 1974):[7]

(1) Segmental structure

- Phonological primes (called 'components') are monovalent
- Phonological primes are organized into intrasegmental classes (called 'gestures')
- Combinations of primes and of classes enter into a head-dependency relationship
- The same phonological primes figure in the representation of vowels and consonants
- Representations are minimally specified
- Some primes may occur in more than one class

We must note that these aspects are largely independent and, as such, may be shared (in part) with other approaches (see section 6). The following sections deal with specific, characteristic topics in DP: monovalency (2.2.1), the idea that vowel structure is organized in a triangular way (2.2.2), segment-internal grouping (2.2.3) and minimal specification (2.2.4).

2.2.1. Monovalency

With little if any precedent in phonology, Anderson and Jones (1972; 1974) proposed, in response to the tradition of binary features (Jakobson et al. (1952), Chomsky and Halle (1968)) that the basic building blocks of phonology are monovalent (i.e. have only one value) or unary instead of binary.[8] While DP uses the term component, we will here, following Government Phonology (Kaye et al. 1985), refer to these unary features as *elements*.[9]

An important distinction between the binary and unary approach is the fact that the binary approach allows reference to both values of a distinctive feature. For example, in the case of the feature [±voice], binary theories recognize both a class of voiced and a class of voiceless segments, whereas unary approaches only allow reference to the class that is positively specified with an element. (That is, if we disallow reference to the absence of a property in a unary model.) Given this fact, a unary approach should count as the null hypothesis because it is more restrictive, placing the burden of proof on proponents of binary features; see Kaye (1988). Historically, features entered the phonological arena as binary units (see again Jakobson et al. (1952) and Chomsky and Halle (1968)) and for this reason it is often assumed that unarists have to defend their position against the binary approach. However, from a methodological point of view, once a contrast has been established, the initial hypothesis must be that opposition is encoded in monovalent terms, thus claiming that 'the other value' is a phonological non-entity. This hypothesis can be falsified either by facts that require reference to the other pole (still privative), or by facts that require reference to both poles. Facts of the latter type necessitate an equipollent characterization of the opposition, either in terms of a binary feature or in terms of two unary features.

Apart from the fact that a unary feature theory is more restrictive, Anderson and Jones also motivate their proposal on the argument that binary features present a problem for the notion of markedness. This had in fact also been noticed by Chomsky and Halle (1968), who devoted a 'late chapter' (chapter 9) in their *Sound Pattern of English* (SPE) to the fact that a theory using binary features cannot cope with certain recurrent asymmetries between the two values of some, or perhaps all, features. Comparing the vowels /ü/ and /i/, they note, as others did before them, that the roundness of /ü/ and the non-roundness of /i/ should be weighted differently, in that front vowels, in the absence of a rounding contrast, are always [–round]. Another indication of the asymmetry comes from cases of neutralization. For example, in the domain of obstruents, where voicing is typically distinctive, voiced obstruents seem more restricted in that, if the opposition is neutralized word-finally, the voiceless obstruents emerge. Unary features allow for a direct and, in fact, literal expression of markedness. The vowel /ü/ is more marked than /i/ because it must bear the mark of roundness, both vowels being specified as front.

Likewise, voiced obstruents are more marked than voiceless obstruents (at least in most contexts; see below), since they bear an element corresponding to [+voice] and voiceless obstruents do not.

In binary feature theories, the most straightforward expression of the asymmetry between the two values is to leave the 'expected' values literally unmarked. (Hence these values themselves became known as 'unmarked values'). Thus, the unmarked value of [round] (for front vowels) is minus and the unmarked value for voice (in obstruents) is also minus[10]. This approach is referred to as Underspecification Theory (Halle 1959: et seq.). However, for technical reasons Chomsky and Halle (1968) could not appeal to underspecification (see Stanley (1967)), but instead adopted special *m/u* values for features (alongside the plusses and minuses) and a set of markedness (and linking) conventions (see Kean (1975), van Lessen Kloeke (1982)). This theory of markedness, however, was soon abandoned and eventually underspecification made a comeback (Ringen (1978); Kiparsky (1982), Archangeli (1984)). Kiparsky and Archangeli proposed that unmarked values should not only be unspecified if they are redundant (i.e. in the absence of a contrast) but also when contrast is in place. This approach, which encodes unmarkedness in terms of non-specification, came to be known as Radical Underspecification Theory.[11]

On one view, a monovalent approach represents an extreme form of radical underspecification. The claim is simply that unmarked or default values play no role in the phonology whatsoever. However, we must note that the issue of using under- or non-specification is not confined to binary feature systems: it is also relevant in monovalent theories (see e.g. Durand (1988) and section 2.2.4 below).

Clearly, while a single-valued system reflects the spirit of (radical) underspecification by establishing a direct correlation between markedness and complexity, it does so in a more rigorous way. Despite the fact that radical underspecification theories ban one value, the 'unmarked' default one, from phonological representations, the option is left open that these values are filled in at some point in the derivation, after which they may start playing a role in the phonology by figuring in rules as targets, changes or environments. More dramatically, it has been argued that the markedness of a value may not be universal in that some languages may show a

'markedness reversal' (see e.g. Battistella (1990), de Lacy (2006)). This, then, allows for a situation in which [+voice] is the default value for (e.g. final) obstruents in some language. Monovalent theories do not allow for markedness reversals, nor do they allow the 'unmarked value' to become active in the phonology. The 'unmarked value' is a phonological non-entity.

The reader might ask how, if this is the case, markedness can ever be contextual. Thus, how can we account for the fact that [-round] is unmarked for front vowels, requiring the specification of [+round] for front rounded vowels, among back non-low vowels, [+round] is the unmarked value, which would suggest that [–round] must be specified for back non-round vowels in case of a contrast? A unary system that uses the unary features [front] and [round] would seem to be committed to representing the 'less marked' /u/ as more complex than the more marked /ɯ/:

(2)	/i/	/ü/	/ɯ/	/u/
	Front	Front Round	–	– Round

We will return to this conundrum below, which has haunted unary systems for a long time.

All things being equal, a unary approach is more restrictive than a binary approach. However, in practice, when comparing different feature theories, all things are never equal. Theories can differ in terms of which specific features they have, what kinds of intrasegmental relations (such as head-dependency) are used, and what kinds of formal manipulations ('rules') they permit. The issue of fair comparison becomes even more complicated when monovalent approaches include primes that seem to be polar opposites. We see this in some non-DP models that use unary features, for example when two monovalent feature [ATR] and [RTR] are proposed (see Steriade (1995) and others). Van de Weijer (1992; 1993; 1996) proposed the opposite manner features [stop] and [cont], with the idea that both define recurrent natural classes. Van der Hulst ((2005), (in prep.)) argues for a particular approach that makes systematic use of primes that form pairs of

polar opposites (see section 3.4). Adopting apparently polar opposites is not equivalent to adopting a binary feature, however. Under usual assumptions, two values of a binary feature cannot be combined with a segment, or if they can, this must lead to phonetic sequencing (as in [–cont][+cont] proposals for affricates). Unary features, on the other hand, even when apparently opposites, may be combined to represent an intermediate category. This will be illustrated in section 2.2.2, where we will discuss the specific DP proposals for unary feature sets that have been proposed within DP. This will also introduce the notion of intrasegmental dependency.

2.2.2. The triangular set

Moving beyond the issue of the 'arity' of features, we will now discuss the specific set of elements that have been proposed in DP. Anderson and Jones (1972; 1974) focused on the representation of vowels. Given this limitation, this early publication did not propose a 'complete' set of phonological elements and therefore did not develop the notion of grouping elements into subsegmental units (classes, gestures). They introduced the characteristic and basic |a|, |i|, |u|[12] set, showing how these units can be used to represent vowels, allowing them to occur by themselves or in combinations. Let us take a closer look at the DP proposal for vowel representation.[13] Clearly, the DP system differs from the SPE system not only by using unary rather than binary features, but also by choosing different phonetic parameters for characterizing the vowel space. Whereas the SPE system is bidirectional (just like, for instance, the unary feature system proposed by Sanders (1972)), since it only uses the high-low and the front-back dimensions in the description of vowels, lip rounding being superimposed on these two dimensions, the feature system of DP is tridirectional. [14]

Characteristic of tridirectional feature systems is the fact that they at least employ three basic primes in their element set, corresponding to the three extremes of the vowel triangle. In DP, these elements are first and foremost grounded in acoustic percepts. The three basic primes are commonly represented by the symbols |i|, |u| and |a|, after the vowels that these elements represent if they occur alone:

(3) The basic primes of tridirectional unary feature systems for vowels:

	Acoustic	Articulatory
|i|	acuteness/sharpness	frontness
|u|	gravity/flatness	roundness
|a|	sonority	lowness

From a phonetic point of view, these elements, are clearly basic. They constitute the so-called quantal vowels (Stevens 1972), that is, they are the acoustically most stable vowels, in that their acoustic effects can be produced with a fairly wide range of articulatory configurations. In addition, these three vowels are maximally distinctive, both from an acoustic and an articulatory point of view (see Liljencrants and Lindblom (1972) and related work). Moreover, /i/, /u/, and /a/ are also basic as far as phonology is concerned. They constitute the canonical three-vowel system, and they typically are also the first vowels that children acquire. The choice of |i|, |u| and |a| as basic vocalic elements is therefore well-motivated, both phonetically and phonologically.

With the aid of these three vowel elements at most seven vowels can be characterized, if we bear in mind that they can not only be used in isolation, but also in combination with each other:

(4)

{|i|}[15]	{u,i}	{|u|}
{i,a}	{u,i,a}	{u,a}
	{|a|}	

It will be obvious that these seven representations do not exhaust the maximal number of different vowels that are found in the language systems of the world, nor, more crucially, possibly richer (or simply different) sets of vowels that occur in specific languages. To express vowel systems containing nine or even more vowels, additional ways are needed to represent the total number of vowels in terms of (combinations) of the three basic vocalic elements. In principle, there are two ways in which this increase of the combinatorial potential of the three features could be achieved. Features might either occur more than once in a particular representation, or one of the features in a feature

combination might be prominent relative to another feature (or features). Of these two conceivable positions, the former is defended by Schane (1984) (in Particle Phonology (PP); see section 6), while DP (as well as Government Phonology; see section 6) invokes the concept of dependency to arrive at a larger number of possible representations.

Compare, for instance, the DP and PP representations of the vowel /ɛ/ in the partial vowel system in (5).

(5)

/i/	DP: {i}	PP: {I}
/e/	DP: {i;a}	PP: {IA}
/ɛ/	DP: {a;i}	PP: {IAA}
/a/	DP: {a}	PP: {A}

Here dependency is expressed using the symbol ';', {A;B} being read as 'B is dependent on A', or 'A governs B'; see (6) for another notation.[16]

As shown, in DP, elements are not just joined in a simple, symmetrical combination, but they can also enter into a relationship in which one element is relatively prominent, i.e. the 'head' and the other element is the dependent. If a language has just one mid-series the dependency relation can remain unspecified. We note at this point that it is commonly assumed in phonology that contrastive use of phonetic properties involves a binary opposition, which can be expressed with a binary feature or a unary feature (vs. its absence). Apparently gradual differences along a phonetic dimension can be represented with more than one feature. This can be seen in binary systems where two or more features that refer to height or aperture, jointly capture a three- or four-level height distinction. In DP, such gradual effects are captured by invoking combination of elements and their various dependencies. With reference to sonority we will discuss this in section 3.4.

In addition, two elements can even entertain a relation in which neither feature is dominant, a relationship which DP calls 'mutual/bilateral dependency'. Thus we arrive at the set of dependency relationships in (6), in two alternative notations that Anderson and Ewen (1987) use to express dependency; the braces stand for 'a class of segments characterized by the element structure in question':

(6) a. {|X;Y|} or {|X==>Y|} -- Y is dependent on X

b. {|Y;X|} or {|Y==>X|} -- X is dependent on Y

c. {|X:Y|} or {|X<=>Y|} -- X and Y are mutually dependent

By allowing the features to enter into a relationship of 'mutual dependency' with |a|, a relationship in which neither element counts as the head, DP maximally generates the following set of representations on the basis of the features |i|, |u| and |a|:

(7) The maximum number of combinations of |i|, |u| and |a| in DP:

{|i|}	{|u,i|}	{|u|}
{|i;a|}	{|u,i;a|}	{|u;a|}
{|i:a|}	{|u,i:a|}	{|u:a|}
{|a;i|}	{|a;u,i|}	{|a;u|}
	{|a|}	

Implicitly, it is assumed that {|i,a;u|}, {|u;a,i|}, {|i;a,u|}, {|a,u;i|} do not result in phonetically distinct vowels, i.e. that they result in phonetically equivalent events. This means that the combination |u,i| seems to behave like a unit, such that |u| and |i| cannot occur on opposite ends of the dependency relation. In other words, this combination of elements does not seem to show a dependency asymmetry.

Although the system of DP would in principle allow for the gradual oppositions {|i|} vs. {|i;u|} vs. {|i:u|} vs. {|u;i|} vs. {|u|}, it turns out, as Anderson and Ewen (1987: 275) observe, that "in virtually all languages, we find at each height maximally one segment containing both |i| and |u|; in other words, dependency relationships holding between |i| and |u| are not required".[17] Yet, although they may not be required in practice, the fact remains that nothing in the theoretical framework of DP renders dependency relations between the features |i| and |u| impossible on a principled basis. Van der Hulst ((2005), (in prep.)) proposes to use these two possible ways of combining the color elements to represent the two kinds of rounded vowels in Swedish (e.g. Riad (2014)).

Staying with the DP proposal to not allow |i| and |u| to combine in two ways, at most eight front vowels and four back vowels can be represented, plus the low vowel. This is still, however, not enough to characterize all possible vowels and vowel systems in the world's languages. In particular, the central vowels and/or the back unrounded vowels cannot be represented on the basis of (6) alone. Here the 'and/or' refers to the fact that it is not certain that central and back unrounded are distinct phonological categories, although the former class, according the IPA-system, allows both rounded and unrounded vowels. The mid rounded vowels perhaps require a separate class in any event. This brings us back to the issue raised in (2) of the representation of /u/ vs. /ɯ/, which raised the question how this contrast can be represented without running into a 'markedness paradox' To solve this problem, there have been various proposals to separate backness from roundness, thus 'splitting up' the U-element.

Van der Hulst (1988) addresses this issue in the context of a specific proposal that builds on the fact that elements in head position contribute more strongly to the resulting vowel than the same element in dependent position; indeed such elements have greater perceptual and thus cognitive salience. This means that phonetic interpretation is sensitive to the head or dependent status of an element. Van der Hulst (1988) pushes this one step further by proposing that a specific phonetic interpretation of elements correlates with their head and dependent occurrence, as summed up in (8), using articulatory rather than acoustic labels:[18]

(8)

Interpretation of |u|	Head:	Velar constriction
	|	
	Dependent:	Rounding
Interpretation of |i|	Head:	Palatal constriction
	|	
	Dependent:	Advanced Tongue Root

Interpretation of |a|	Head:	Pharyngeal constriction
	|	
	Dependent:	Openness (RTR)

This proposal allows an element to occur twice, which is not a standard assumption in DP. By itself, however, this system does not solve the markedness issue, since /u/ is more complex than /ɯ/ in (9).

(9)	/i/	/ü/	/ɯ/	/u/
	i	i	u	u
		u		u

We will return to van der Hulst's proposal (which was developed in van der Hulst (1989) and also in work by Norval Smith and students; e.g. Botma (2004); (2009); Botma and Smith (2006); (2007); Smith (1988)) in section 3, where we will discuss the idea of using an element more than once in a representation.[19] Here we will focus on the overt recognition of the dual character of |u| which has also been acknowledged in other proposals. A number of phonologists, notably Lass (1984) and Rennison (1986), have argued that these two aspects of |u| should in fact be given independent status, thus splitting up |u| into two features, |ω| ('labiality' or 'roundness') and |ɯ| ('velarity' or 'high backness'), which still entails the same problem as in (9): /u/ comes out as more marked:

(10)	/i/	/ü/	/ɯ/	/u/
	i	i	ɯ	ɯ
		ω		ω

Again, these various proposals do not solve the problem of how to represent central vowels in a manner that reflects their markedness. To deal with the problem of central vowels, Anderson and Ewen (1987) propose a different solution. To the vowel /ɯ/ they assign not only the two color elements, but also a new element: |ə|, the centrality element:

(11) The representation of /u/: standard DP: {|u|}

The representation of /ɯ/: standard DP: {|u,i,ə|}

While this proposal solves the markedness asymmetry by representing central vowels as more complex, another solution that could be considered is to represent /ɯ/ as devoid of any elements; this is in fact what Anderson (2011c) suggests. The idea that one vowel can be represented as the null set has other precedents, especially with regard to one of the central vowels, in particular the schwa (see e.g. S. Anderson (1982)).[20] At first sight, this makes this vowel the least complex, but if we limit the markedness-complexity correlation to segments that are positively specified, we can add the special clause that a segments that is devoid of any property is the most 'marked' vowel, due to the fact that it misses any perceptual salience, which is worse than mixing two perceptual images as in vowels that combine two or more elements.[21] The proposal to acknowledge the 'null option' (lacking elements) may obviate the need for the centrality element, although it is not clear how central vowels of different heights will be represented, if the null 'element' is not allowed to combine. Van der Hulst (in prep.) solves this problem by introducing a fourth element |∀|, similar to the centrality element, which can enter in a dependency relationship with the element |a| to represent four colorless vowels of different heights:

(12)

	I	IU	Placeless	UI	U
∀	i ~ ɪ	y / ʏ	ɨ ~ ɯ	ʉ̶	u / ʊ
∀A	e	ø	ɘ ~ ɤ	ɵ	o
A∀	ɛ	œ	ɜ ~ ʌ	ɘ̶	ɔ
A	æ	ɶ	a	ɑ	ɒ

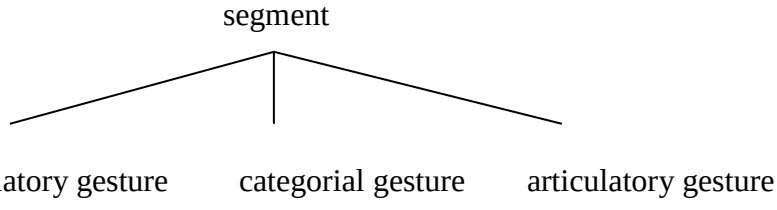
This chart also contains two series of non-back round vowels, based on the headedness of combinations of the two color elements. It does not distinguish between advanced and non-advanced vowels (as indicated for the high series, which requires an element for the expression of tongue root position), which we will discuss in the next section, after first introducing the notion of grouping.

2.2.3. Grouping

The relevance of feature grouping has long been recognized in DP. While it was not part of the original proposal by Anderson and Jones (1974), Lass and Anderson (1975) and Lass (1976) offer a number of specific arguments that support the view that the matrix characterizing the segment should be split up into at least two submatrices, or **gestures**. This subdivision into element sets reflects the fact that phonological processes can refer precisely (e.g. delete or spread) to either of these gestures, the other gesture being unaffected (cf. the so-called 'stability effects' of Autosegmental Phonology, Goldsmith (1976)). Lass (1976) discusses cases of reduction of full consonants to the glottal consonants [h] and glottal stop, [ʔ], which occur, for instance, in many varieties of Scots (cf. also Lass (1984: 113-15), which show the independence of the laryngeal features vis-à-vis the oral features, a proposal also made in Thráinsson (1978) on the basis of Icelandic preaspiration data and subsequently in various versions of Feature Geometry. The DP arguments for grouping are essentially analogous to the arguments that have been presented for feature classes in Feature Geometry (see Clements (1985); Sagey (1986)).

In early DP work, the bipartite division that was suggested by Lass and Anderson (1975) into a laryngeal gesture and an oral gesture, was replaced by the following proposal for a tripartite gestural division of segments (Anderson and Ewen (1980), Ewen (1980), Lass (1984)), by splitting the oral gesture into a gesture for major class and manner-like distinctions (the categorial gesture), and a strictly articulatory (place) gesture. The term 'gesture' here is used completely equivalently to the way in which 'class node' is used in Feature Geometry, where one segment (the unity of which is expressed by the root node, which consists of various class nodes).

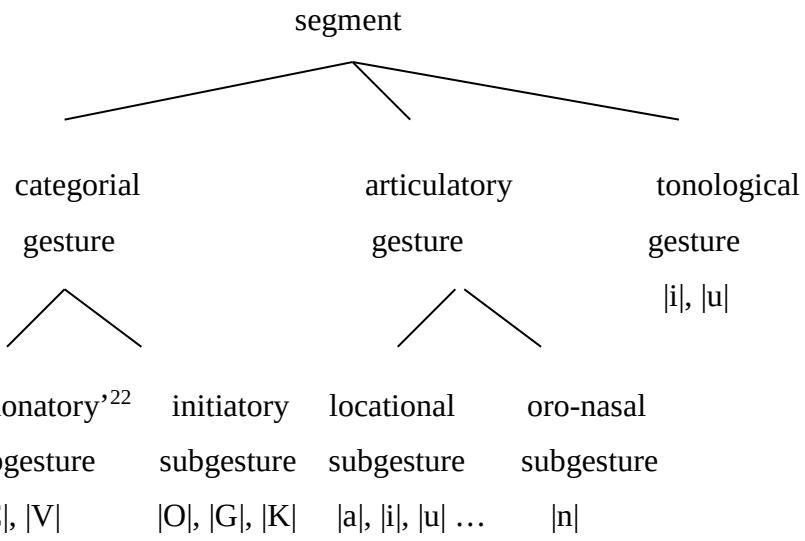
(13)



The initiatory gesture contains elements expressing airstream properties and glottal states.

Ewen (1986: 205) extends this model by recognizing two major 'super' gestures, the categorial and the articulatory gesture, both of which contain two subgestures. The categorial gesture contains a 'phonatory' subgesture (for elements expressing manner or stricture properties and major class distinctions) and the initiatory subgesture (as before, for airstream properties and glottal states). The articulatory gesture contains the locational subgesture (with elements for place properties) and an oro-nasal subgesture containing just one element (viz. nasal). In addition, a tonological gesture is added:

(14)



The locational elements listed in (14) are not an exhaustive set; see below.

We will discuss the structure displayed in (14) in more detail, following Anderson and Ewen (1987) (henceforth AE). The proposals which AE make for the tonological gesture are sketchy (see also below). Most work focuses on the development of the 'phonatory' subgesture (for manner and major class distinctions) and the locational gesture (for place). We will discuss these two subgestures in turn.

The 'phonatory' subgesture contains two elements, |V| and |C| which AE define as follows:

> "|V|, a component which can be defined as 'relatively periodic', and
> |C|, a component of 'periodic energy reduction'." (p. 151)

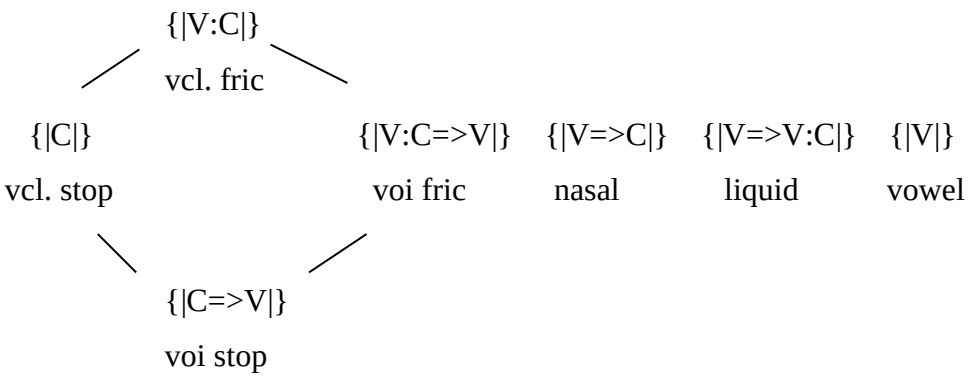
As mentioned above, from the start DP adopted the view that the primary interpretation of element is acoustic, a position that Government Phonology has adopted as well. They then continue:

> "..,|V| and |C| differ from the [Jakobsonian] vocalic and consonantal distinctive features in that the presence of, say, |V| in a segment does not necessarily imply that the segment is in a simple binary opposition to an otherwise identical segment not containing |V|. Rather [...] the more prominent a particular [...] component [...] the greater the preponderance of the property characterized by that component. Notice too that |V| and |C| can characterise segments either alone or in combination." (p. 151)

'Prominence' of elements is expressed in terms of a head-dependent relation.

These dependency relations provide the tools to express a number of major segment classes in terms of combinations of |V| and |C|, as shown in (15):

(15)



Below the actual representations, we have indicated which classes of segments they represent. AE argue that the representations reflect a sonority ranking, going from left to right, in which the classes of voiceless fricatives and voiced stops are claimed to have equal sonority. Further distinctions (leading to separate representations for laterals, strident fricatives, etc.) will be discussed below. Note the use of complex structures that involve 'primary (or head) structure' like |V:C| entering into a dependency with other,

'secondary' structure, another instance of using the same element multiple times (within a gesture); see section 3.4.

In order to characterize the segment classes in (15) in a feature system of the SPE type (Chomsky & Halle 1968) we would need the features [voice], [consonantal], [continuant] and [sonorant], where DP uses just two single-valued features: the elements |C| and |V| and their interdependencies. However, pure reductionism was not AE's primary motivation for replacing major class and manner features by CV-complexes. They claim that their approach is more adequate than traditional binary theories in a number of respects. First, as saw above, by replacing binary features with structures of varying complexity, representations more adequately reflect the relative markedness of phonological major class and manner categories. In (15), the categories vowel and voiceless stop are the least complex, which reflects their relatively unmarked status. Fricatives are more complex than stops and voiced obstruents are more complex than voiceless ones. This again reflects well-known and widely accepted claims regarding the relative markedness of these categories. Secondly, as also stated earlier, AE also claim that the array of structures provides an adequate characterization of the notion of relative sonority. Degrees of sonority correspond to the amount of 'V-ness' that a representation contains. (We could likewise define strength in terms of the amount of 'C-ness'.) This is useful in the characterization of lenition processes (see section 5). Thirdly, AE claim that the structures composed of |C| and |V| provide a more adequate basis for the expression of phonological processes than traditional binary systems do. With reference to (15), AE note that these structures reflect an asymmetry in the behavior of 'voicedness', as opposed to 'unvoicedness'. If we assume (as most phonologists do) that phonological rules can only cause phonetic events by manipulating phonological units, the structures in (15) express that languages can spread 'voicing' but not the absence thereof. If this is empirically correct, representations as in (15) are superior to binary feature systems in which [+voice] and [–voice] have the same status.[23] Finally, the CV-constellations are constructed in such a way that affinities between the phonological categories that they represent are formally expressed. For example, in the structures in (15), an ungoverned |V| can be glossed as [(+)sonorant], whereas a governed |V| forms the equivalent of [(+)voice]. This particular example reveals that DP manages to express distinct but

clearly related phonological categories in terms of a single primitive appearing in different structural positions, where traditional feature systems must stipulate a relation in the form of redundancy rules like [+sonorant] → [+voice]. In DP, [+sonorant] and [+voice] are manifestations of one and the same element, viz. |V|. The relation between these two categories is therefore inherent to the basic vocabulary.

Before we turn to a further discussion of the syntax of the categorical elements |C| and |V|, we will briefly discuss the other 'gestures' (element classes) in (13). First, we turn to the second subgesture of the categorial gesture, viz. the initiatory subgesture. DP advocates the idea that the traditional concept of phonation (involving glottal states and vocal fold vibration) is relevant to two different gestures. Vocal fold vibration (voicing) is, as we have seen, expressed within the 'phonatory' subgesture of the categorial gesture, whereas glottal state distinctions are incorporated in the initiatory gesture. This latter subgesture contains the 'glottal opening' element |O| ('aspiration') and two elements used for the description of different types of airstream mechanisms, |G| (for 'glottalicness', i.e. 'constricted glottis') and |K| (for 'velaric suction').

AE argue that the use of |O| is called for in three types of languages (AE: p. 188):

- Languages that have a voice distinction that involves more than two categories (e.g. Indonesian, which has voiceless, 'lax voice' and 'tense voice')
- Languages that do not seem to use voice but rather aspiration (e.g. Icelandic)
- Languages that have an opposition between voiced and voiceless sonorants (e.g. Burmese, which has this contrast for nasal and laterals)[24]

Proceeding with this sketch of DP, let us turn to the daughters of the locational subgesture. AE introduce the place elements in (16):

(16) *DP place elements*

|i| 'palatality, acuteness/sharpness'	|l| 'linguality'
|u| 'roundness, gravity/flatness'	|t| 'apicality'
|a| 'lowness, sonority'	|d| 'dentality'
|@| 'centrality'	|r| 'retracted tongue root'
|α| 'Advanced Tongue Root (ATR)'	|L| 'laterality'

Not all these elements play an equally important role in the theory. The heart of the set of place elements is formed by the familiar 'aiu' subset, which plays a key role in the representations of vowels and consonants. Two further elements are added for vowels, centrality (already discussed above and perhaps redundant) and ATR (an element that we will return to below). Here we will focus on the elements which are mainly or exclusively used for consonants (the right-hand column).

|l|, lingual, was motivated by Lass (1976) to capture the natural class of high front vowels and tongue blade and tongue body consonants, which he claims recurs in sixteen processes in the history of English.

|t| is meant to capture the contrast between apical and laminal coronals, while |d| distinguishes dentals from alveolars. Systems that have dentals and alveolars frequently distinguish these places also in terms of apical and laminal, although no system seems to have an apical/laminal distinction at either the dental or alveolar place of articulation. However AE argue that in certain cases both |d| and |t| seem necessary.

|r| is introduced to represent pharyngeal consonants. AE also consider using this element in vowels to capture the ATR/RTR distinction (AE: 243-245). However, given the evidence that in many harmony systems the [ATR] value is dominant, AE suggest that another element, |α|, is needed for such systems.

|L| is introduced without too much motivation, simply to capture laterality, despite the fact that laterals are also captured in the phonatory gesture. One might say, however, that |L| is needed for lateralized segments such as lateral fricatives.

Here are some representative consonantal place representations:

(17)	{|u|}	{|l|}	{|l,i|}	{|l,u|}	{|l,u,a|}
	labials	dentals, alveolars	palatals	velars	uvulars

Note that the variety of elements that is used here in the representations for consonants somewhat weakens the idea that elements are used across the board, i.e. for both consonants and vowels (see the fourth assumption in (1) above). Both in DP and DP-

inspired approaches (Smith (1988), van de Weijer (1996), Staun (1996b), among others) various proposals have been made to cut back the set of locational elements to the basic aiu-set. Also in Radical cv Phonology (van der Hulst in prep.) all the extra elements in (16) have been eliminated, with the resulting set being fully employed for both consonants and vowels.

The oro-nasal subgesture contains precisely one element, |n|, for 'nasality'. Recall that there also is a phonatory characterization of nasals {|V=>C|}. This is comparable to the case of laterality for which DP also proposes a phonatory representation (for laterals proper) as well as an element (for lateralization).

One might wonder whether DP really needs a nasality element, or, if it turns out that such a element is necessary, whether this element should occupy an entire subgesture by itself, which seems to have been proposed on the basis of general phonetic considerations. With respect to the first question, AE argue that nasal consonants not only form a natural class with other sonorant consonants by sharing certain characteristics in their categorial (particularly phonatory) representations, but they also form a natural class with nasalized segments, which may have different specifications in the categorial gesture. In order for this latter natural class to be reflected by the DP representations of the segments in question, AE argue that we need a separate component, |n|.

Before we return to the 'phonatory' (i.e. Major class/Manner) subgesture, let us briefly look at AE's proposals for the tonological gesture. In their excursus on representations for tonal distinctions, AE make the intriguing suggestion that the elements |i| and |u| (as part of the tonological gesture) could be employed for high and low tone, respectively.

> "..we propose that the appropriate representations for the two tonal components are [...] |i| and |u|. In other words, we are suggesting that |i| and |u| in the tonological gesture bear the same relation to |i| and |u| in the articulatory gesture as |V| in the categorial gesture does to |a| in the articulatory gesture [...] That is, |i| involves (relatively) 'high frequency' and |u| (relatively) 'low frequency'; whether this is interpreted as high (of low) F_0 or as concentration of energy in the higher

(or lower) regions of the spectrum depends on the context – i.e. gesture – in which it occurs." (p. 273)

What is most noticeable in this proposal is the idea to use the same elements, viz. |i| and |u| in two different gestures. To emphasize that this strategy is present in the AE proposals, we will here also quote AE on their suggestion concerning the identity of |a| and |V|.

> "...there is clearly a relationship between |a|, as a component within the articulatory gesture, and |V|, as a component of the categorial gesture. Consider the acoustic glosses which we have given the two components: |V| corresponds with maximal periodicity, and |a| with maximal sonority. Vowels, by virtue of their periodicity are the most sonorous of the categorial segment-types, while open vowels are the most sonorous within the class of vowels. [...] The open unrounded vowel, then, might have {|V|} both as the representation of the categorial gesture and of the articulatory gesture." (p.215)

The importance of these quotes is to show that AE suggest the strategy to employ the same elements *in different (sub)gestures* (which needs to be distinguished from using the same element more than once within a gesture), thus deriving similarities in phonetic interpretation, while attributing the differences to the fact that the '(sub)gestural location' of an element has a bearing on the phonetic interpretation as well.

This shows that DP offers two possibilities for reducing the number of primes. Firstly, fewer primes are needed due to the dependency relation. Two traditional features can be replaced by the dependent and head occurrence of a single prime, e.g. |V| for [voice] and [sonorant]. Secondly, fewer primes are needed given grouping. One particular element may occur in various groups, each time with a different phonetic interpretation and thus replace two or more features.

In section 3.4 we will elaborate on this reduction strategy, which forms the foundation of Radical cv Phonology.

2.2.4. Minimal specification and polysystematicity

Even though the adoption of unary features pre-empts the notion of underspecification in many ways, it does not become inapplicable. Anderson advocates a strong minimalist view with respect to the specification of phonological information, which must be strictly contrastive. All redundant, predictable properties should be eliminated from the representation. Underspecification becomes relevant when we consider positional phonotactic restrictions, as for example in the well-known case of English initial clusters. In a trisegmental cluster like /spr/ the initial segment, if consonantal, can only be /s/, which means that all properties of this segment, except its consonantality, are predictable. Likewise, the second segment (a voiceless stop) and third segment (an approximant) also have many predictable properties. Without spelling out what the minimal representation in terms of components would be, it seems clear that very few elements are required.

It is important to note that (in general, not just in DP) the use of underspecification undermines the traditional notion of the phoneme as a unit that generalizes over allophones that occur in different positions, being in complementary distribution. Such a rejection is masked by the use of terms like ‘archiphoneme’. Rather, it leads to a type of analysis in which each position in the string of segments has its own contrastive set of oppositions (its own segment system, so to speak). This means that phonology is **polysystematic** (as recognized in the Firthian approach (Firth 1948)). For example, if a language limits syllable-final consonants to plain voiceless stops, the relevant position only allows a contrast between whatever the plain voiceless stops are that the language allows in terms of place. If this is labial, coronal or dorsal, then a final ‘k’ can simply be represented as {consonantal, dorsal}. However, an initial ‘k’ might contrast with all other consonants and might therefore have a richer representation, e.g. {consonantal, voiceless, stop, dorsal}. The polysystematic view holds that these two sets of features are independent and not unified under a joined concept of ‘the phoneme /k/’. Nevertheless, these two sets are mapped onto phonetic events, which happen to be very similar. The classical notion of the phoneme formally expresses this phonetic similarity which, as argued by Pike (1947), provides a natural basis for an economical alphabetic

writing system. However, Anderson sees this traditional notion of phoneme as not being a genuine phonological entity.

In conclusion, segments in all positions of the syllable have their own sets of oppositions. Segments in a given position are specified minimally to distinguish them from other segments that can occur in the same paradigmatic slot. Furthermore, in any such system one member can always be specified as the null option (i.e. without any elements).

Anderson extends the use of underspecification to linear order. We return to this point in section 4 where we discuss the DP approach to syllable structure.

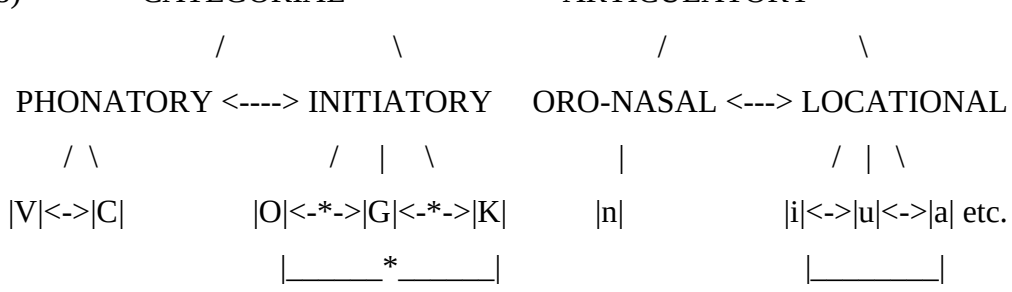
3. Developments in DP

In this section and the next we discuss several developments that have taken place in DP, especially in the characterization of segmental structure. We will organize these developments according to the (sub)gestures they apply to.

3.1 Developments with respect to inter- and intrasubgestural dependency

Standard DP used the possibility of allowing subgestures to enter into dependency relations, but this was not fully exploited. Thus is schematically summarized in (18), where an asterisk indicates that no dependency relations are proposed between the units connected by the bidirectional arrow:

(18)



In (18) we also encode that there are no dependency relationships between the two main higher gestures: there are no circumstances under which segment types are distinguished

by means of a difference in the dependency relation between the components of the categorial and articulatory gestures.

It is unclear why AE use precisely the dependencies illustrated in (18) and no others. In an attempt to restrict the DP model, Davenport and Staun (1986) argued to dispense with inter-subgesture dependency. They show that once the glottal opening component |O| is assigned to the major class/manner ('phonatory') subgesture and a new component |i| ('initiator velocity', expressing the direction of airflow) is assigned to the initiatory subgesture, there no longer is a need for dependency relations between the phonatory and the initiatory subgestures. We refer to Davenport and Staun's (1986) work for further discussion of this point, and the ramifications of their proposal for the DP framework.[25]

3.2 Developments with respect to the oro-nasal subgesture

Noting that DP expresses nasality in two ways (see above), Davenport (1995) proposes to dispense with the component |n| altogether. This implies that the categorial characterization of nasality 'survives', although Davenport's proposal is that nasality is not expressed in the Major class/Manner ('phonatory') subgesture (i.e. not in terms of specific |C|/|V| combination), but as a separate component |N| in the initiatory subgesture. So, in a sense, Davenport's proposal is a compromise between the two 'old' ways of expressing nasality in DP. We refer to Davenport's article, which shows that the dual representation of nasality leads to unsatisfactory results in DP.

3.3 Developments with respect to the initiatory subgesture

Davenport and Staun (1986) maintain an initiatory subgesture, which contains components for airstream distinctions: |I| 'egressive airflow' (nor present in AE 1987), |G| 'glottalicness' and |K| 'velaric suction'; |O| which forms part of this subgesture in AE has been moved to the phonatory subgesture in their model. Furthermore, we just saw that Davenport (1995) proposes to add a component |N| 'nasal' to the initiatory subgesture. However, their proposal has not been worked out in further detail, as far as we know, and

so it remains ‘food’ for further thought on the issue of intrasegmental structure within DP.

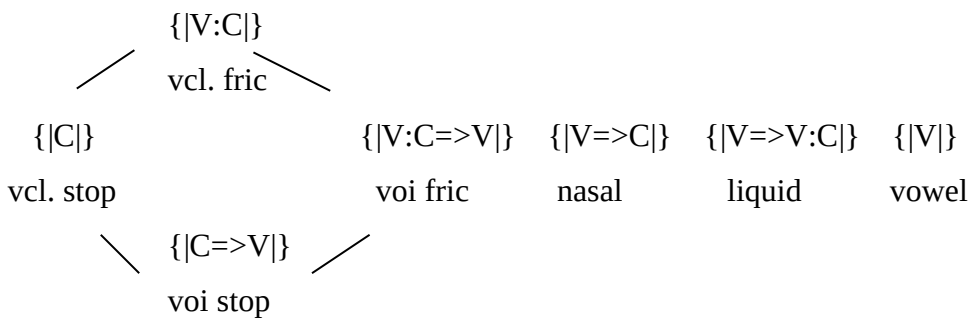
It is noteworthy that research in DP has not developed a separate ‘laryngeal’ gesture that would capture voicing, aspiration and glottalic constriction (as in most Feature Geometry models). It is also noteworthy that Feature Geometry proposals have generally not proposed a class node with features for initiation, i.e. for ingressive sounds like implosives, and clicks or egressive sounds like ejectives. Segments of the latter type are usually expressed with laryngeal features or as complex segments with a double articulation (see Sagey (1986)).

3.4 Developments with respect to the Major class/Manner ‘phonatory’ subgesture

We will now turn to a more extensive evaluation of the organization of the phonatory subgesture and argue that the ‘syntax’ of CV combinations is not clearly defined in AE’s version of DP, a point also emphasized in den Dikken and van der Hulst (1988), who offer an alternative which can be seen as an important step in the development of Radical cv Phonology (van der Hulst (1994); (1995); (2005); in prep.).

For convenience, in (19) we repeat the set of distinctions built from |C| and |V| which AE propose as a kind of core set:

(19)



The core of this set is formed by the five different basic structures that are composed of two elements:

(20)	{|C|}	{|C=>V|}	{|V:C|}	{|V=>C|}	{|V|}
	stop	voi stop	fricative	nasal	vowel

As we see in (19), this set can be expanded by adding a secondary instance of a basic structure in dependent position.

From the viewpoint of generative power, one would like to know exactly what the set of possible C/V combinations is that includes primary and secondary structures. AE do not address this issue explicitly. Rather, as seems motivated by the attestation of potential manner contrasts, they continue to add new structures, more or less in an ad hoc way (even though they provide cogent arguments for each individual structure that they propose). For example, AE add the following more complex representations to capture further distinctions:[26]

(21)	{|V:C<=>V|}	{|V=>V:C=>C|}	{|V:C<=>V=>C|}	{|V:C=>C|}
	fricative trill	lateral	voiced lateral fricative	non-sibilant fricative

Here we even see the use of three levels of structure for the two categories in the middle. The argumentation that AE provide in favor of these representations is based on attested natural classes. Fricative trills may pattern with voiced fricatives in conditioning phonological processes (AE give ‘Aitken’s Law’ as an example). Given the representations in (21), the relevant natural class can be represented as in (22):

(22) {V:C=>V}

Lateral liquids, of course, must be distinguished from r-sounds, which motivates the second structure in (21). AE write:

> “...laterals are phonetically unique, as far as the phonatory sub-gesture is concerned, in having effectively two manners of articulation. While there is a stricture of open approximation at one or both sides of the mouth (at least for

> sonorant laterals), there is also closure in the centre of the oral tract. [...] Essentially, then, the |C| node characterizes a secondary [..] stricture type within the phonatory sub-gesture." (p. 163)

The dependent |C| in laterals expresses the fact that laterals may pattern with stops. In traditional feature systems, there is no direct way to express such a class without introducing the feature [continuant] in laterals, which is redundant since laterals are already uniquely characterized as [+lateral].

The extra dependent |C| in the third representation in (21), then, also adds laterality to the fricatives (p.164).

The fourth structure reflects the distinction between sibilant and non-sibilant fricatives.

> ".../s/ may be interpreted as the optimal fricative phonetically; acoustically it shows the 'simplest' combination of consonantal and vocalic properties, while the other fricatives involve energy reduction in various frequency bands. In comparison with the sibilants, then, the other fricatives display extra /C/-ness." (p. 166)

Even though AE carefully motivate the structures in (20) and (21), formally capturing many relations between different sound classes that must be stipulated in traditional feature theories, questions can be raised concerning the restrictiveness of their approach. The 'syntax' underlying combinations of components (|C| and |V| in this case) is not explicitly defined, i.e. we do not know what the total set of possible dependency structures is. Clearly, AE assume that the syntax is, in a sense, recursive, so that structures that have been formed can be input to further combinatorial structures. However, given that this recursive syntax allows, in principle, many other structures, we must conclude that AE make no serious attempt to come to grips with the notion 'possible phonological segment'. Arguably, the notion of possible segment does not play a decisive role for AE. Their approach allows one to conceive of structures of various degrees of complexity and the only relevant concern would then be to predict that more

complex structures imply structures of lower degrees of complexity within a given language (within a given position).

While this is a valid position, den Dikken and van der Hulst (1988) nonetheless make a proposal with respect to the use of the components |C| and |V| that imposes a general limitation on the complexity of CV-structures. The initial idea in this proposal (based on van der Hulst 1988, discussed in section 2.2.2) is that each component can occur *at most* twice. In several articles and in work in progress, van der Hulst has developed this initial proposal, trying to maintain a systematic and 'controlled' set of structures in which each structure is actually used to express attested contrasts; this is the theory of Radical cv Phonology (RcvP), cf. van der Hulst (1995); (1996; 2000; 2005; 2015a; 2015b; in prep.). Recall that Anderson and Ewen (1987) explored the use of the same elements in different subgesture (see above). In RcvP, this idea is pushed to its logical extreme. In addition, the proposal is that there are only *two* elements. Somewhat arbitrarily, RcvP adopts the labels |C| and |V| for these two elements. In each gesture, these two components allow a four-way distinction in phonological classes: C, C;V, V;C, V.[27] [28]

These structures will receive different interpretations depending on the syllabic positions that they occur in:

(23)	Onset head	C	C;V	V;C	V
		stop	stop strident	fric.	strident fric.[29]
	Onset dep.	nasal	liquid	rhotic	glide
	Rhyme head	high	high-mid	low-mid	low
	Rhyme dep.	nasal	liquid	rhotic	glide

The syllabic structure also has a four-way distinction (C, C;V, V;C, V), which is encoded in its basic template which maximally allows a branching onset and a branching rhyme.

While this proposal allows a reduction to four basic structures, there does seem to be a need for some further finer distinctions which thus call for secondary occurrences of the C and V components. We have seen that the use of secondary structures was already present in (21). Although Anderson (2011c) does not present a complete outline of the DP elements and their structures in phonological segments, he *explicitly* recognizes a distinction between primary and secondary occurrences of elements, which represents a major innovation compared to Anderson and Ewen (1987). Revising the combinatorial system in (18) and (19), he proposes to represent nasality and voicing in terms of secondary occurrence of the C and V elements:

(24)

{V;C {c}}	{V;C}	{V;C{v}}
nasal	lateral	rhotic

Anderson (2011c: 114)

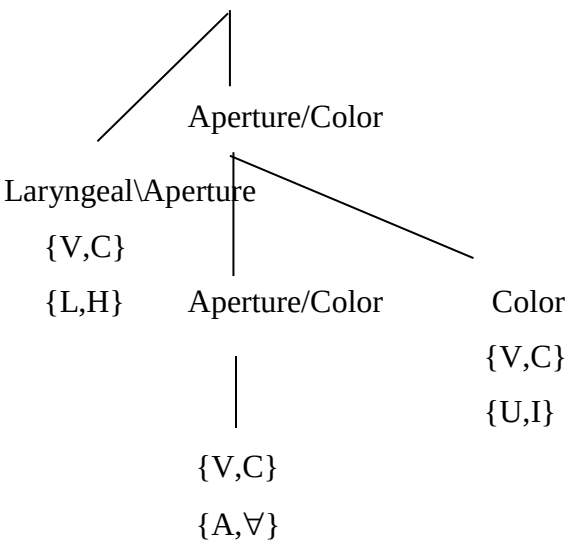
(25)

{C;V{v}}	voiced fricative
{C{v}}	voiced stop

Anderson (2011c: 362)

The idea to use elements in a secondary role (which is also a trait of RcvP) deserve further exploration. We conclude this section with one example from van der Hulst (in prep.). The RcvP model, as we have discussed, postulates two antagonistic elements in each class. This raises the question how the triangular approach to location in the AIU approach is incorporated in this model. Van der Hulst suggests that the traditional view, which regards |u| and |i| as 'colors' and |a| as 'sonority' suggests that |u| and |i| belong to one class (which we may call 'color' for convenience), whereas |a| belong to another class (which we can call 'sonority' or 'aperture'). However, this implies that |a| must have an antagonistic counterpart, which van der Hulst represents as |∀|. The element labels used here are for convenience only, because the real elements are |C| and |V| in both classes:

(26)

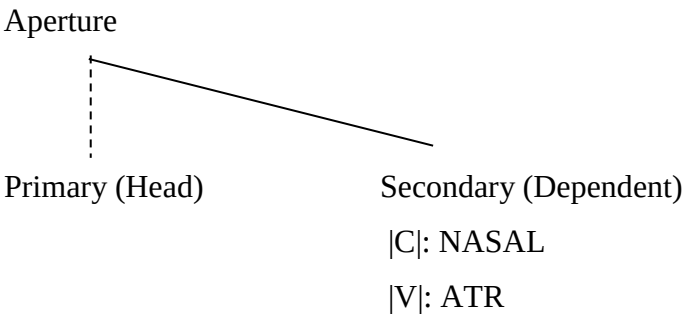


The labels ‘Aperture’ and ‘Color’ as well as ‘Laryngeal’ are merely mnemonic short hands for structural representations that indicate that the ‘Aperture’ node is the head, taking ‘color’ as a dependent complement (indicated by the ‘/’) and ‘laryngeal’ as an dependent adjunct (indicated by ‘\’) (see Anderson (2011c: 355), and below for the use of this ‘slash’ notation). Likewise, the use of the traditional element labels (A, I, U, L, H) simply serves the purpose of reminding the reader how the C and V elements in the different class are phonetically interpreted.

By recognizing a fourth basic element, namely |C| in aperture, the RcvP model converges on six elements, just like certain recent versions of Government Phonology (see Scheer & Kula, this volume: chapter 9, section 5), where the so-called |ʔ| element correlates with the |C| element in RcvP’s aperture.[30]

Van der Hulst then proposes that both elements can occur as a secondary (dependent) element, which is a dependent to the aperture unit in (26):[31]

(27)



For vowels (or nuclei), the secondary |V| is interpreted as pharyngeal (ATR), whereas one proposed interpretation of secondary |C| is NASAL, which would imply that the secondary elements denote the two non-oral cavities, pharyngeal and nasal, respectively.[32] [33]

The RcvP model explores the use of secondary elements for all three elements classes.

4. Suprasegmental structure

In DP it is assumed that the syllable is the basic unit for expressing phonotactic restrictions, and that, in addition, several phonological processes also motivate the syllable as a domain. Syllables are headed constructions, because they are "characterized by the presence of an atomic element, the syllable peak, in whose absence there is no syllable" (Anderson & Durand 1988: 9).

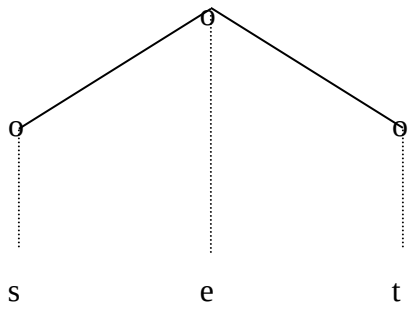
A simple syllable such as /set/ can be characterized by the following two statements:

(28) a. Government relations: s ← e → t (e governs s and t)

b. Precedence relations: s < e < t

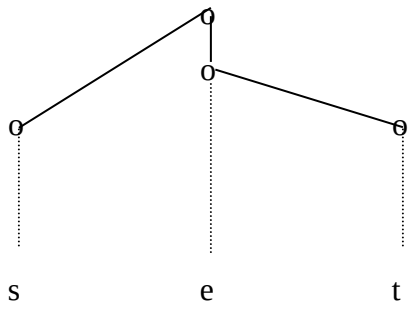
In a dependency graph, all segments are represented as nodes, which are connected by lines. Head nodes are represented higher on the vertical axis:

(29)



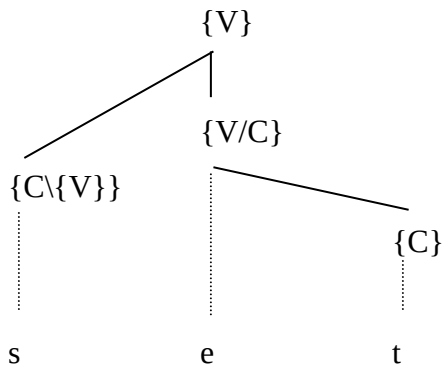
In this structure the onset and coda consonants are equal dependents of the nuclear head vowel. Anderson suggests that the following structure, which introduces subjunction is also consistent with the basic principles of dependency grammar:

(30)



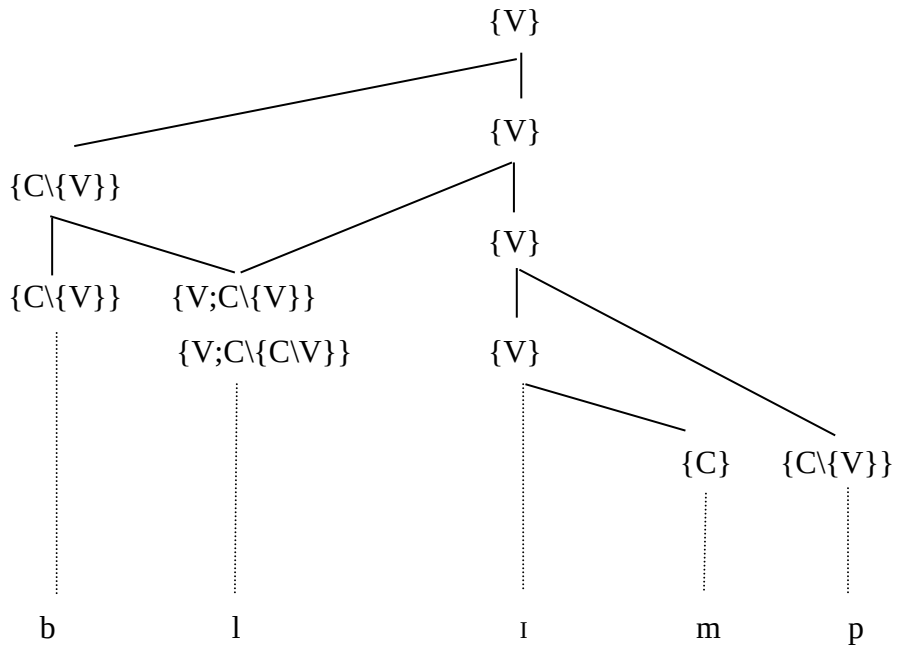
Here /e/ is dominated by two nodes, one subjoined to the other. The /t/ is taken to be a complement that is selected by the lax vowel which requires a following consonant. The /s/, on the other hand, is an adjunct. Anderson (2011c: 83 ff) introduces the following notation to represent the various nodes:

(31)



The ‘/’ indicates ‘looking for a complement’, while the ‘\’ notation stands for being an adjunct to what is to the right of ‘\’. Anderson’s approach only uses binary structures, so for more complex syllable types additional structure is needed. This is illustrated in (32):

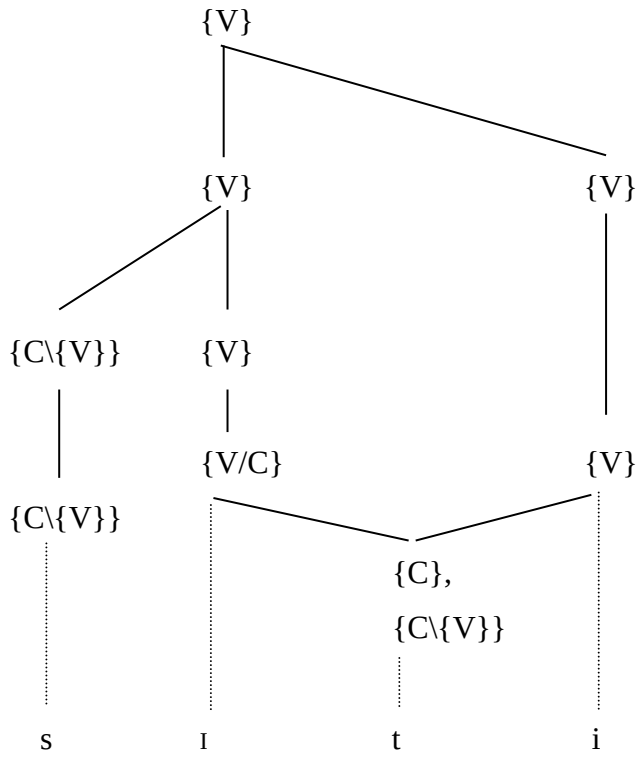
(32)



The second consonant /l/ ({V;C}) is, at the same time, an adjunct to the /b/ ({V;C\{V}}) and to the following vowel /ɪ/ {V;C\{C\V}}). Likewise, the final consonant /p/ is an adjunct to the ‘rhyme’ that is formed by the vowel and following consonant.

Dependency graphs also permit one daughter to be dependent on two heads, which creates a structure that appears to correspond to the notion of ambisyllabicity (cf. Kahn (1980), among others):

(33)



Here we have also included the dependency relation that represents 'foot structure'. Indeed, early work in DP anticipated the essence of metrical theory by representing 'stress' as an exponent of a dependency relation between two syllables.

Anderson (1986b) proposes an interesting constraint on syllable representations:

(34) **The Dependency Preservation Condition**

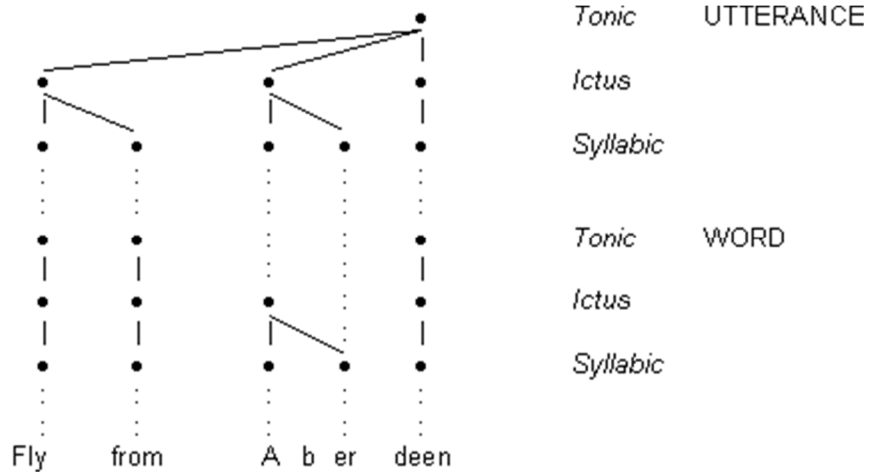
Dependency relations are preserved, where possible, throughout a derivation (and in diachronic changes)

Anderson introduces this condition as part of his syllabification algorithm, to ensure that dependencies introduced by earlier rules are not undone or reversed by later rules. We note that this principle anticipates the Projection Principle proposed in Government Phonology (see Kaye et al. (1990)).

Within the expression plane, Anderson makes an intraplanar distinction between word structure and utterance structure, which is more or less equivalent to the distinction between lexical and post-lexical structure. Here we reproduce a diagram from Anderson

(1986b) which illustrates this distinction (and which abstracts away from many details of node labeling):

(5)



Each word has its own dependency structure, capturing syllabic structure and stress. Then words are gathered into an utterance structure which in particular cases imposes a post-lexical foot like structure that is reminiscent of the so-called Abercrombian foot in grouping syllables that belong to different words.[34]

5. Rules in DP

This section discusses how phonological alternations are represented in DP. Proponents of DP do not always agree on which rules should be accounted for in the phonology, and which are merely lexical idiosyncrasies. Recently, Anderson (2014) addressed this topic, making the claim that there are no phonological rules, except structure-building redundancies. There are alternations manifested in pairs of morphologically related lexical items, and there are adjustments when morphological units are put together, expressed in the interface between morphology and (lexical) phonology – i.e. the morphophonology. Similarly, there are adjustments at the lexical-utterance interface. There are no phonological mutations or shifts, except diachronically. Nor do they always agree on the role of abstractness, i.e. the specific question to what extent underlying

representations should be allowed to diverge from the phonetic surface. However, the fact that phonology is substance-based militates against 'ghost segments' that never reach the surface as well as empty syllabic positions.

Rules in DP are generally quite comparable to normal autosegmental spreading operations, with the obvious proviso that only elements (corresponding to the 'marked' binary feature values) can be spread (or be referred to in constraints). Where effects arise that do seem to require such rules, additional machinery (e.g. in the form of constraints) is necessary. Similarly, the elements posited in DP can be used in constraint-based frameworks (Prince & Smolensky 1993 [2004]) without difficulties. Here the question arises of what the set of elementary features is, but this is fundamentally a different question of whether the head-dependency relation can be used among such features.

DP assumptions about segmental as well as suprasegmental structure are helpful in an understanding of processes of vowel harmony. With respect to segmental features DP makes strong predictions about what types of harmony are found (viz., ones that are based on existing elements) and what types are not found (viz., ones that are based on the 'negative values' of unary elements). It also helps to characterize the targets of harmony as syllable heads , while consonants play a secondary role (see e.g. van der Hulst and van de Weijer (1991), (1995) and van der Hulst (to appear)).

Another process that is particularly elegantly captured in DP is neutralization (see above, and e.g. Anderson and Ewen (1981); Staun (1985)). For vowel neutralization, we can think of different sets of vowels appearing in different positions: stressed vs. unstressed, oral vs. nasal, in roots vs. in affixes, where typically the vowels in the latter conditions form a subset of the vowels in the former condition. Although languages differ in their patterns, in all cases that we know of, the reduced set can be described as lacking an element and/or the head-dependency relation that is present in the fuller set. It is also important to note that the analyses can be conceived of as rules or as the result of constraint interaction. For consonant neutralization, final devoicing was mentioned above, which favors an unmarked consonant type over a marked one.

Thus, in many cases, the relatively constrained tool set of DP results in more elegant accounts of segmental processes. Such is also the case with processes like diphthongization (e.g. /e:/ → /ei/ → /ai/), merger of vowels (/ai/ → [e]), vowel lowering

and raising rules, and breaking (see e.g. Anderson and Ewen (1987), Anderson (1986a); Colman (1987); (2005); Lass (1987), Rennison (1986); (1987; 2014).

DP offers the extra mechanism of rules (and constraints) based on the dependency relation alone, i.e. affecting the headship of one of the elements that enters into a dependency relation with another element. Rules of this type elegantly account for processes that are more difficult to describe using traditional distinctive features, e.g. vowel raising and lowering (chain shifts), neutralization of vowel contrasts in particular positions.

Finally, lenition (either as historical process or in synchronic phonology, see e.g. Gurevich (2011)) is hard to capture in frameworks based on binary features, since a number of different features ([voice], [consonantal], [continuant], [sonorant], etc.) are involved in what appears to be a unified phenomenon. Representations like those in (19) above are eminently suited to capture lenition as a shift in the preponderance of the element |V| (see e.g. Ó Dochartaigh (1979); (1980) for an analysis of Celtic lenition in the DP framework).

To express certain types of chain processes, DP allows a mechanism called resolution, which was already proposed in Anderson (1973):

(35) a. Add B to A = AB = <u>A</u>B
Add B to <u>A</u>B = <u>A</u>BB = A<u>B</u>
Add B to A<u>B</u> = A<u>B</u>B (or ABB) = B

b. A > <u>A</u>B > A<u>B</u> > B
Add B Add B Add B

This schema applies as follows:

(36) Add V to C => C;V (high vowel becomes high mid)
Add V to C,V => V;C (high mid vowel becomes low mid)
Add V to V;C => V (low mid vowel becomes low)

This schema allows the representation of processes that involve the apparent deletion of elements. It can be applied both to the vowel-related shifts (e.g. the Great Vowel Shift in the history of English), or to consonant-related phenomena such as lenition.

6. Related approaches

In van der Hulst and Smith (1982), the ideas of DP were presented in the context of an overview of recent non-linear developments in generative phonology. Although these ideas have remained largely unnoticed, three major hallmarks of DP (monovalency, grouping and intrasegmental dependency) have all, in various degrees, been incorporated in various other approaches, including 'mainstream' Generative Phonology, especially in the development of Feature Geometry, a movement that started around the early to mid-eighties. Here we mention the crucial parallels.

Feature theories in mainstream generative phonology have also appealed to unary features, but in a weaker form by proposing that only *some* features are single-valued. For example, various scholars have suggested that [round] is single-valued (e.g. Steriade 1987). Ito and Mester (1986) argued that [voice] is a single-valued feature. Goldsmith (1985; 1987) went even further and proposed a system in which both [round] and [low] are single-valued, with the proviso that the scope of [low] is extended to low and mid vowels. In his system, [back] is still binary. The strong version of this claim says that *all* features are single-valued. This strong position was precisely what Anderson and Jones proposed. The use of unary elements, more specifically the use of the triangular IAU set was adopted in the approach of Schane (1984a et seq.) who applied these elements to vowel processes, in particular monophthongization and diphthongization. Schane did not employ dependency, but instead used an additive mechanism. Van Nice (1991) proposes an extension of Particle Phonology in which the elements |i| and |u| are grouped under a single node. Similar proposals were made in Ewen and van der Hulst (1985); (1988) and van der Hulst (1989) within the context of DP. Further applications of Particle Phonology can be found in Hayes (1989) and Broadbent (1999). The latter adds a dependency relation and thus removes the idea of stacking particles, turning this essentially into a

variant of DP.[35] The use of so-called empty nuclei, a hallmark of Government Phonology (GP; Kaye et al. (1985); (1990)), is not acknowledged in DP, which, given its substance-based attitude, cannot make reference to units that have no substantive correlate.

The pivotal aiu-set of elements was also adopted in Government Phonology, which in addition also introduced the use of dependency relations between elements. Both DP and GP emphasized the perceptual nature of the elements, as well as the idea that the elements generalize over vowels and consonants. That said, both models went through a similar development of proposing additional elements, sometimes elements that would only apply to consonants. GP has reverted to a simpler set of six elements, while one variant of DP, namely RcvP, makes a very similar proposal (see above). A point of potential difference between GP and PP could be that the former insists that each element can be independently phonetically realized. In spirit, this demand would seem to square with the substance-based approach of DP, but the independent realization has simply not been taken to be a condition on elementhood in DP; nor is it clear to us why such a condition would have to be imposed. GP claims to be a theory about the computational system that underlies phonology and as such it is stressed that phonetic factors can play no role in establishing a phonological model. DP does not make such a claim and, in fact, by making grounding a cornerstone of the entire enterprise, it could never be impervious to phonetics. But in fact, GP's basic elements are firmly rooted in acoustics, just as in DP. In practice, GP and DP come to very similar conclusion about what phonology is about, with the exception of DP's denial of empty nuclei which drives a wedge between both models that is caused by GP's non-commitment to phonetic substance in all respects.

For a close comparison of DP and GP versions of element theory, we refer to den Dikken and van der Hulst (1988) and van der Hulst (2016a). In recent years GP has developed a use of headedness which is perhaps different in that elements are used as either headed or non-headed, irrespective of whether or not they occur in combination with other elements. This introduces a kind of diacritic headedness which we do not find in DP (see Scheer & Kula, this volume: chapter 9). DP and GP also converge on the rejection of constituent structure in favor of a strictly relational approach in terms of head-dependency relations.

Certain proposals in GP have also developed the idea of an intrasegmental grouping. We refer to chapter 9 in this hand book for a discussion of various proposals. One such proposal, developed in Kula (2002), while placed within the context of GP, incorporates an element 'geometry' that incorporated various aspect of standard DP proposals as well as of RcvP.

There is furthermore a striking parallel between DP and GP regarding the rejection of constituency. For example, with respect to syllable structure DP does not appeal to constituents such as onsets and rhyme, or even a constituent syllable. Dependency graphs do not represent constituency. We here draw attention to the fact that a similar stance is taken in current versions of Government Phonology (see Scheer & Cyran, this volume: chapter 10) which claim to abandon constituency in favor or so-called lateral relations. It seems to us that the representation of 'syllable structure' and other relations in terms of these lateral relations between segments as basic units comes close to being a variant of the dependency approach.

We conclude that, viewed from a certain distance, DP and GP have come very close, although there are still differences that may be difficult to bridge, such as the rejection by DP of empty elements or the matter of whether or not elements should be independently pronounceable.

With reference to feature geometry proposals, we observe three parallels.

The idea that one set of elements can generalize over consonants and vowels (while not fully adhered to in the original proposals in Anderson and Ewen 1978, but restored in later DP work by others) also occurs in feature geometry models; see Hume (1994), Clements and Hume (1995), Padgett (2011), among others. This idea was also present in the earliest work on binary features (Jakobson, Fant and Halle 1952), but had been abandoned in Chomsky and Halle (1968). A return to using the same features for consonant and vowel distinctions can also be seen in proposals to combine one set of features for tone and phonatory categories (cf. Yip (1980), Duanmu (1990), and Bao (1990), following the spirit of Halle and Stevens (1971)).

As discussed in section 3.2, DP proposed a dual representation for nasality, i.e. in terms of a C/V combination and in terms of a separate element for nasality. Proposals within Feature Geometry have sometimes also adopted a separate node for the feature

nasal (cf. Sagey (1986); (1988)). Piggott (1990); (1992) proposes a 'velic class node' dominating only [nasal]. In addition, he adopts a node 'spontaneous voicing', which may also dominate a feature nasal. The duplication of nasality in Piggott's model bears a clear resemblance to the way DP treats nasality, but its precise status remains a topic of controversy.

Finally, with reference to Feature Geometry, it is obvious that the DP notion of gesture is completely parallel to the class nodes that were introduced in the work of Clements (1985) and Sagey (1986).[36]

7. Conclusion

In this chapter we have reviewed the initial proposals and later developments of Dependency Phonology. We have highlighted the following properties of this approach:

- The use of unary primes (DP, shared with GP, PP)
- The use of dependency relations between primes (DP, shared with GP)
- The use of grouping (DP, shared with Feature Geometry and some versions of GP)
- The occurrence of elements in more than one group
- The replacement of constituency by head-dependency relations (shared with GP)
- Polysystematicity, i.e. a rejection of the phonemes as an abstract unit that generalizes over phones that are in complementary distribution
- Strict minimality: representations are stripped of all redundant properties, including linear order (within syllables) where this order can be derived from dependency relations and general principles of linearization (mainly based on sonority)

The use of the same elements in different gestures, for which the seeds were planted in Anderson and Ewen (1987) was pushed to the extreme in Radical cv Phonology (which otherwise embraces all the traits of DP),[37] which uses its recognition of grouping to

reduce the set of elements to just two,[38] Since these two elements occur in three gestures, a six-way division results, which parallels recent proposals in Government Phonology.

Anderson and Ewen (1987), based on nearly two decades of previous work, present a complete research program for phonology which anticipated some of the major developments that took place in the field of phonology at large. The approach puts emphasis on the explanatory strength of a restricted representational system and on grounding phonology in phonetics. The least developed aspect of DP is its rule component, because a derivational account of alternations is not taken to be part of the synchronic phonology; synchronically there is simply a morphological alternation. In spirit, DP favors a surface-oriented approach, avoiding abstract (non-substance-based underlying or lexical representation) and (extrinsic) rule ordering.

Endnotes

[1] Both these sections recapitulate, with modifications, parts of den Dikken and van der Hulst (1988).
[2] Full disclosure: the authors of this chapter, which focuses on the work of John Anderson, as the originator of Dependency Phonology (in the context of his adoption of Dependency Grammar for all modules of the grammar), subscribe to the basic tenets of the Dependency approach.
[3] Anderson places morphology in the lexicon. In this component the units are combinations of basic phonological and basic syntactic units; see Anderson (2011a-c).
[4] Differences between the planes can also be due to how the primitive elements combine, as well as to how these planes interface. With respect to the former point, we observe that while recursion is possible in both syntax and phonology (see van der Hulst 2010), it is much more widespread in syntax.
[5] We may speculate about the question whether the head-dependency relation is a purely linguistic characteristic, or that it belongs to a more general cognitive domain. Humans surely possess strong systems of perception and association, which helps them to make sense of the world, which typically involves many parts and in which relations between parts are important. From birth onwards, infants will learn that in any environment some parts are vital, and some merely 'background noise'. They quickly learn (or perhaps know innately) that some parts are worth focusing attention on, and some parts may be discarded.
[6] Progress in segmental phonological theory in general has been halting, we believe, as a result of the rise of Optimality Theory. We hope that renewed interest in this field, e.g. based on advances in cognitive science, will pay special attention to the dependency relation.
[7] A prepublication appeared in 1972 in *Edinburgh Working Papers in Linguistics*. This paper did not propose the second principle in (1), which was introduced later, following Lass & Anderson (1975).

[8] See van der Hulst (2016a) for an overview of the unary/binary 'debate', and van der Hulst (2016b) for references to some earlier proposals for unary features.
[9] See Sanders' (1972) simplex feature hypothesis; and see van der Hulst (2013) for some earlier precedents.
[10] Whether voiceless for obstruents is unmarked in all positions could be a matter for debate, given the tendency for intervocalic voicing.
[11] Steriade's contrastive specification theory would only leave non-contrastive values unspecified (Steriade 1987).
[12] Various notations have been used for unary features, such as bold lower case. We will use lowercase. Elements are enclosed in vertical lines.
[13] The following is partly based on den Dikken & van der Hulst (1988).
[14] Their choice of three units resemblance the adoption of two 'colors' and 'sonority' in Natural Phonology (see Donegan 1978), which in terms echoes Jakobson' color and sonority axes (Jakobson 1968). The triangular idea also resembles Stevens' quantal distinction as well as the proposals in Wood (1975, 1979). See van der Hulst (2015b).
[15] Different notational systems have been employed by different authors, both for single elements and for combinations of elements. Here we use curly brackets.
[16] Of course, many other notations can be used. In GP, for example, the head element is underlined.
[17] Government Phonology makes the same claim (see Kaye et al. (1985)), but they derive it from the internal logic of their theory.
[18] Van der Hulst also proposed that for each element we expect that its head occurrence automatically entails the dependent occurrence, unless the presence or absence of the dependent is contrastive in a system.
[19] We will return to the idea that ATR is a manifestation of the |I| element in dependent position later on.
[20] In treatments of vowel harmony in Turkish the back unrounded vowel, which harmonizes for both roundness and frontness, would for that reason alone be specified as 'empty'; see van der Hulst & van de Weijer (1991).
[21] This point is also acknowledged in Anderson (2011a-c, 2014).
[22] We put this term between quote marks because the use of the term 'phonatory' here is unfortunate; it essentially is about major class and manner.
[23] In this particular case, voicing, there is a significant literature claiming that the phonology needs reference to both values of voicing. See, for example, Wetzels & Mascaró (2001) and chapter 15 of this book.
[24] This has also been suggested in other work, such as Lombardi (1991) and it is supported by the fact that languages that have a voicing contrast for sonorants invariably also have an aspiration contrast for stops, as well as by the fact that in English approximants are partially devoiced in clusters of voiceless stops followed by an approximant: aspiration in vowels (*key*, *tin*) is phonetically similar to devoicing in approximants (*clean*, *twin*).
[25] AE also exploit the possibility of allowing variable dependency between the two subgestures of the articulatory gesture. Arguably, one could be skeptical about the two distinctive degrees of nasalization, however.
[26] In the second and third case AE do not indicate whether the (mutual) dependency relations are hierarchically ordered.
[27] Van der Hulst (2005) rejects mutual dependency.
[28] As noted in Anderson (2011c) replacing all elements by |C| and |V| in all classes is an instance of plane-internal structural analogy. Anderson resists the idea that all classes need to make the exact same set of structural distinctions, as van der Hulst seems to imply. This is comparable to his rejection of arguing that all phrase types in syntax must have the same structure, as originally proposed in X-bar syntax,
[29] The representation of the strident/non-strident distinction for fricatives remains a problem. Also, contra Anderson, van der Hulst does not represent voicing in the manner class: he expresses this with a secondary v-element, but still in the categorical gesture (see below).
[30] This convergence is discussed in more detail in van der Hulst (2016). In a sense this fourth element, with reference to vowels, also restores the cold vowel that was proposed in Kaye, Lowenstamm & Vergnaud (1985).

[31] Van der Hulst (in prep.) also discusses secondary occurrences of the elements in the other two gestures. All gestures generalize over consonants and vowels. The laryngeal gesture represents phonation distinctions for consonants and tonal distinctions for vowels. He proposes that, in its representation of tonal distinctions, this gesture can adjoin separately to the whole segmental structure in order to encode the 'autosegmental' nature of tonal properties.
[32] Another phonetic interpretation of 'pharyngeal' can be considered is RTR. The interpretation of pharyngeal as either ATR or RTR is taken to be 'areal'. By subsuming both phonetic interpretation under one element, it is explained why no language uses both contrastively; see van der Hulst (to appear).
[33] For consonants, in line with Anderson's proposal, secondary |V| would denote voicing (and, we add, perhaps also nasality).
[34] We refer to Lahiri & Plank (2007) for a review of different views on the relationship between lexical structure and utterance level prosodic structure. Anderson's view squares with what they refer to as the traditional view that is reflected in the work of Abercrombie (1964).
[35] Rennison (1987) also uses the AIU set and a tier-based representational system (without dependency). Goldsmith (1985) adopts some of these elements, while Hyman (2002) uses the unary features low, high, front and round.
[36] We note that the notion of gesture was brought to the attention of a general audience in van der Hulst & Smith (1982), in a volume that contained work by many of the later proponents of Feature Geometry.
[37] However, early presentations of RcvP unintentionally retain the appearance of constituency and of labels like onset and rhyme as primitives; see the criticism in Anderson (2011c).
[38] This extreme position, namely the occurrence of the same element in all groups was suggested by Petra Kottman, who proposed to use |I| and |U| in all groups, which entailed, of course, a broad set of (phonetically related) interpretations of these two elements.

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