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Monovalent 'Features' in Phonology

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In this article, I discuss and review the proposal to replace traditional binary features (such as [+round]) by *unary*, *single-valued*, or *monovalent* units (such as |round|). I will focus on proposals within the context of *dependency phonology*, *government phonology*, and *radical CV phonology*. In all three approaches, in addition to unary primes, use is made of *head–dependency relations*. The central motivation for switching from a binary to a unary understanding of phonological primitives comes from the empirical finding that binary approaches wrongly predict that both values of each feature define natural classes of segments or can be involved in a process. The central idea behind monovalency is that in all cases, only one pole of a phonetic opposition can play these roles. A monovalent approach is thus inherently more restrictive and therefore should form the null hypothesis.

1. *Introduction*

Phonology is that part of linguistics that studies and tries to understand, in terms of formal models, the perceptible side of human languages. The sound side of language comprises, firstly, the way that mental representations of speech sounds (called phonemes) are organized into syllables, syllables into words, and so on. We call this *the syntagmatic dimension*. For each language, there is a set of constraints that determine what is and what is not a possible sound structure for words and sentences, and although languages do differ in this respect, there are general universal laws that set limits on the variation among languages. A further aspect of phonology, which is of particular interest to this article, is that phonemes are not the smallest units of sound organization but instead can be analyzed into smaller, true atoms. This we call *the paradigmatic dimension*. Both the syntagmatic and paradigmatic dimensions define the space of phonological representations or *the representational aspect of phonology*.

A second area of phonological research concerns the fact that the sound form of words or of smaller parts (morphemes and phonemes) is not invariant. This results, firstly, from the fact that phonemes have different realizations (called *allophones*) depending on the surrounding context. For example, if the phoneme /p/ (in English) is initial and followed by a stressed vowel (as in the word *pin*), it is 'aspirated' (produced with a small puff of air). Elsewhere (in final position, as in *cup*), such aspiration does not occur. The variability of phonemes is subject to regularities which may differ from language to language, although it would seem that, again, there are universal tendencies. The contextual variability of phoneme realizations is called *allophony*. While allophony has the side effect of causing variation in the form of morphemes (since these are made up of phonemes), there is a second kind of variability which directly targets the phonemic makeup of morphemes. Here, we find rules that substitute phonemes by other phonemes, again with reference to the surrounding phonemic context as created by the combination of morphemes due to morphological rules. In most phonological theories, allophonic and allomorphic variations end up with different formal treatments, in different parts of the phonology, with allomorphic rules being intertwined with morphology and as such preceding allophonic rules. Together, these types of rules and the derivations that they create make up *the derivational aspect of phonology*.[1]

Phonology is a particularly lively field of inquiry within linguistics, less popular perhaps than other areas such as syntax, yet insiders and attentive bystanders would presumably agree that this subfield of linguistics has not only been the historical source of influential trends in linguistics as a whole during the first half of the 20th century, and during the last quarter of this same century, but also evolved in spectacular ways, developing entirely new perspectives and reconnecting with some of the earlier insights in this field. During the late 1970s, 80s, and early 90s, several complementary and rivaling theories of phonological structure (representation) and variability (derivation) were developed within what is called *generative grammar*. Without denying the great present-day relevance of the earlier history of phonology, this article's focus is on certain developments within generative phonology, with special attention to varieties of phonological approaches that have received less attention than what might be called 'mainstream generative phonology'. The non-mainstream theories that I will focus on are *dependency phonology* (DP), *government phonology* (GP), and *radical CV phonology* (RCVP).

The theory of DP was developed by John Anderson in the early 1970s, and the major sources today are Anderson and Ewen (1987) (AE) and Anderson (2011); see Anderson and Durand (1986) and van der Hulst (2006) for shorter introductions. The central idea of adopting the notion of dependency is that in complex entities (linguistic entities in this case), units that make up the complex unit enter into a *dependency relation*. Thus, for example, in a combination A + B, A could be dependent on B, which would make B the element that is dependent on nothing. This unit is then called the *head*. The head can be identified as the obligatory part of a complex unit. A typical manifestation of head–dependency relations is that the dependent unit cannot be more complex (in terms of its own internal structure) or 'more of something else that matters in the domain at issue' (like 'sonority') than the head (see Dresher and van der Hulst, 1998). Dependency approaches (differing in formal details) have existed for quite some time in the study of sentence structure (Hays 1964). Anderson showed how the same ideas could fruitfully be applied to phonology. With dependency relations in place, many phonological phenomena in both the syntagmatic and paradigmatic dimensions can be explained as manifestations of the dependency organization. For example, vowels, being the obligatory part of syllables, are natural candidates for being the syllable head. As such, vowels are 'more sonorous' than non-head phonemes that belong to the same syllable. Another example, one level up, concerns the status of syllables that are accented. The accented syllable is the obligatory part of the word, and as such, it is the most salient syllable, often allowing greater phonemic complexity internally than non-accented syllables. Almost all linguists subscribe to the view that head–dependency relations of some sort play a role in (theories of) linguistic structure, but the dependency approach has made dependency a foundational notion.[2]

During the early 80s, another theory called *government phonology* (originally formulated in two seminal articles by Jonathan Kaye, Jean Lowenstamm and Jean-Roger Vergnaud, 1985 and 1990) embraced concepts that are very similar to the ideas of DP, while adding important additional proposals. Both DP and GP arose from the desire to abandon or replace aspects of the SPE (Sound Pattern of English) model of phonology (developed by Noam Chomsky and Morris Halle in the late 60s; Chomsky and Halle 1968) by alternatives that were claimed to be more restricted and more explanatory in a variety of ways. There are now a considerable and steadily growing number of articles and books coming from various GP centers, mostly in Europe, and a number of varieties of this approach have emerged. Meanwhile, DP has been less diverse with a smaller number of active proponents and thus fewer developments (again mostly in Europe). The most far reaching revision of DP proposals for intrasegmental structure is embodied in my own variant, which is called *radical CV phonology*. This model shares the characteristics of both DP and GP. Another detailed development is proposed in Staun (2005). All these

approaches share two leading proposals. Firstly, they all appeal to head–dependency relations, and secondly, they all maintain that phonological primitives (features) are monovalent. This article focuses on the monovalency claim.[3]

2. *Why Monovalency?*

Let us agree that many phonological distinctions are inherently binary, for example, segments can be voiced or voiceless, but not 'half-voiced', or '31% voiced'. This being so, and pending what can be done for oppositions that appear to be gradual (such as vowel height), binary oppositions can be expressed in two major ways, which I will call *equipollent* and *privative*.[4] The former way assigns a 'label' to each member in the opposition, while the privative approach assigns a 'label' to only one member, leaving the other literally *unmarked*:

(1) a. Equipollent: [+voice] - [−voice]
    b. Privative: |voice| —

Of course, nothing hinges on the choice of the mark labels. Thus, the following are also possible:

(2) a. Equipollent: [−voiceless] — [+voiceless]
    b. Privative: — |voiceless|

While the difference between (1a) and (2a) is negligible, the different between (1b) and (2b) has immediate empirical consequences. (1b) predicts that the prime that correlates with voicing can be phonologically active in terms of defining natural classes and processes, whereas voicelessness is predicted to be universally inactive. (2b) makes the opposite claim.

An important distinction between the binary and unary approaches in (1) and (2) lies in the fact that the binary approach allows reference to *both* the class of voiced and the class of voiceless segments, whereas a unary approach only allows reference to the class that is positively specified with an element (this is the case if we disallow reference to the absence of a property in a unary model[5]). Given this fact, a unary approach should count as the null hypothesis, placing the burden of proof on proponents of binary features. Unary theory proponents have thus generally claimed that unary theories are more restrictive because they allow the characterization of a smaller set of segments and processes when compared with binary theories. How well unary theories fare in regard to properly characterizing classes of segments has been a matter of debate; see Coleman (1990ab) and Kaye (1990). Formal assessment of unary features/elements can be found in Kornai (1995) and, with specific reference to GP, Breit (2013). Reiss (2011), meanwhile, wonders whether striving for a restrictive system is a necessary requirement for phonological theories.

However, historically, features entered the phonological arena as binary units, as witnessed by the influential first publications that proposed a full set of features (especially, Jakobson, Fant and Halle 1952). For this reason, it is often assumed that proponents of unary primes have to make their case in defense against the binary approach. This is an unreasonable demand since it is logically impossible to prove that, for example, [-round] is never active. From a methodological point of view, once the contrastive use of a phonetic parameter has been established, the initial hypothesis *must* be that one of its values is encoded in monovalent terms, implying that 'the other value' is a phonological nonentity (Kaye 1988). The monovalent hypothesis *can* be falsified by facts that require reference to the other pole. Such facts may lead to adopting 'the other pole' as the monovalent element or, if both poles need reference, to adopting two equipollent monovalent elements.

Indeed, to express an opposition in terms of an equipollent notation by using binary-valued features seems obvious, but the following alternative, which uses two unary primes, should also be regarded as equipollent:

(3) voiced – voiceless

The crucial formal difference between (3) and (1/2a) is that a binary approach would logically rule out that one segment has both values of a feature at the same time, whereas a unary approach would allow, in principle, any combination of primes (even in cases that would seem to mimic the two values of a binary feature as in (3) since the two poles of the opposition are independent phonological entities. A combination of unary primes that seem to form an antagonistic pair would presumably specify some halfway option which might come in handy in cases where phonological oppositions appear to be gradual rather than binary. It should be obvious that the use of equipollent pairs of monovalent features must be treated with care in order to avoid that the monovalency hypothesis becomes itself unfalsifiable. In section 6, it will become clear that RCVP makes systematic use of primes that forms pairs of polar opposites within the context of a restrictive hypothesis that aims at avoiding 'monovalency abuse'.

Meanwhile, early on, proponents of binary features experienced problems with their binary hypothesis. It bothered Chomsky and Halle (1968) 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 weigh differently in that front vowels are 'expected' to be [−round]. One way in which this asymmetry is manifested is in the implicational universal that languages that have /ü/ will always have /i/ (in fact, all languages have /i/), whereas the reverse is not true. Likewise, in the domain of obstruents, where voicing is typically distinctive, voiced obstruents seem more restricted in that, if the opposition is neutralized word-finally (as in German, Dutch, and many other languages), the voiceless obstruent emerges.[6]

Observations of this type lead Chomsky and Halle (1968) to embrace a 'theory of markedness', i.e., a theory that formally expresses the fact that [+round] and [+voice] (both in certain contexts; see below) are 'marked', such that segments with these values are somehow 'more complex' than segments with the opposite values. I cannot discuss here the specifics of Chomsky and Halle's markedness theory.[7] The most straightforward formal expression of the asymmetry between feature values is to leave the 'expected' or more 'freely occurring' values literally unmarked (to be filled in at some point in the derivation):

(4) [+voiced] – [0voiced]

The non-specified values came to be known as 'unmarked values'. Thus, the unmarked value of [round] (for front vowels) is '−', and the unmarked value for voice (in obstruents) is '−'. Whereas the markedness of values may be contextual for some features (such as [round] and [voice]) ([+round] is marked for front vowels but unmarked for back vowels), for others, it may be context-free.[8] For example, it might be argued that as for the value of the vowel feature [nasal], '−' is unmarked no matter what.

The approach in (4) is known as *underspecification theory* (UT). UT seems to blur the differences between binary and unary approaches since, given UT, only one value of binary features is taken to be 'active' (most of the time). Nevertheless, as will be made clear below, both approaches make very different empirical predictions.

Let us first note that there is a relationship between the unmarked nature of a specification and its *predictability* in the phonological inventory of a given language, but the two notions are not the same. In general, we say that a value is predictable if a language is lacking a certain

contrast. Thus, for example, if a language has no /ü/, we say that among high, front vowels, there is no rounding contrast and that the value [−round] is predictable in this class of vowels; i.e., there is only /i/. The rule that encodes the predictability is usually called a *redundancy rule*. However, given markedness theory, we can say that even if the language has a /ü–i/ contrast, this same rule is valid in specifying the roundness value for /i/, which we can then leave unmarked. In this capacity, the relevant rule is often called a *default rule*. Thus, assuming default rules, /i/ has no value for [round] whether the language has /ü/ or not. The use of underspecification in the presence of a contrast has been termed *radical underspecification* (Archangeli 1984; Kiparsky 1982). The view that leaves only non-contrastive value unspecified is called contrastive specification theory (Steriade 1995; Dresher 2009).

On one view, a monovalent approach represents an extreme (indeed 'radical') form of radical underspecification. The claim is simply that the unmarked value can play no role in the phonology whatsoever. Thus, a single-valued system reflects the spirit of (radical) underspecification in expressing markedness considerations directly, but it does so in a more rigorous way, a way that can be empirically falsified. Despite the fact that underspecification theories ban one value, the unmarked one, from phonological representations, the option is kept open that these unmarked values are filled in at some point in the derivation, after which they may start playing a role in the phonology by figuring in the rules as targets, changes, or environments. Proponents of underspecification theories have argued that sometimes, unmarked values must indeed be filled in for that reason (see Steriade 1995).[9] 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'. This, then, allows for a situation in which, for example, [+voice] is unmarked for obstruents in some language (Steriade 1995). Monovalent theories do not allow for markedness reversal nor do they allow the 'unmarked value' to become active in the phonology. The unmarked value is a phonological nonentity.

The claim that phonological primes are single valued has a weak and a strong variant. In the weak form, the claim is that *some* features are single valued. For example, various scholars have suggested that [round] is single valued (Steriade 1987). Mester & Itô (1989) have argued that [voice] is a single-valued feature. Goldsmith (1985) goes further and uses a system in which both [round] and [low] are single valued. In feature geometry theories (Clements 1985; Clements and Hume 1995), it has also been claimed that both unary and binary features are needed, the former as labels for articulators and the latter in all other cases. The strong form of the claim implies that *all* primes are single-valued.[10] Also, as mentioned, the issue of fair comparison gets more complicated when monovalent approaches introduce primes that seem to be polar opposites, like [stop] and [continuant] (cf. 3 for voicing).

When comparing theories of phonological primes, there are three additional important issues that need to be mentioned, which are all orthogonal to the unary/binary debate. Firstly, when Jakobson, Fant, and Halle (1952) introduced their set of binary features, they provided both articulatory and acoustic definitions. In Chomsky and Halle (1968), we find only articulatory definitions, and the primacy of articulation has pervaded the remainder of developments in feature theory in mainstream generative phonology (see Halle 1983). The primacy of articulation is also a hallmark of the so-called *motor theory of speech perception* (Liberman and Mattingly 1985) and articulatory phonology, an approach based on this theory (see Browman and Goldstein 1986). Jakobson himself expressed that he considers acoustic correlates to be primary, among others, because they are shared by both speaker and hearer. In sharp contrast with mainstream generative phonology, acoustic primacy is also promoted in both DP and GP. Especially, proponents of GP will emphatically state that articulation has no place in phonology. They argue that children must store representations long before they themselves come to articulate them (see Harris and Lindsay 1995; Backley 2011, 2012 for additional arguments).

A second important point regards the status of unary primes as building blocks of phonological segments. As we will see, it is quite typical for unary primes to define a segment type all by themselves. For example, if we acknowledge a prime |A| (see below), this prime by itself characterizes a low vowel [a]. This raises the question whether all unary primes are independently pronounceable. If this is so, this shifts the balance of seeing primes as attributes of phonemes to seeing them simply as phonemes themselves. Phonological segments that contain more than one such prime are then 'complex phonemes'. We will see below how this idea is developed in both DP and GP and address its potentially far-reaching consequences in section 7.

The third important property of element systems is that one set of elements is deemed relevant to both consonants and vowels (which was also a leading idea in Jakobson, Fant and Halle 1952). This stands in contrast to SPE where many features are specific to either consonants or vowels, although more recently, the idea of a unitary set of primes has also been proposed in feature geometry; see Clements and Hume (1995) for place features and, following Halle and Stevens (1971), also Bao, (1991) for laryngeal features.

We can now summarize some crucial properties of unary primes, for which henceforth, I will adopt the term *element*:

(5) Properties of phonological elements
- Elements are different from features in that they constitute the building blocks of phonological segments rather than being attributes of segments.
- Elements directly encode markedness. That is, the presence of an element makes a segment more marked and more complex.
- Elements function to designate natural classes.
- Elements indicate which phonetic events (processes) can be active in the phonology.
- Elements are cognitive entities and as such are to be distinguished from the phonetic events that correlate with them.
- Elements have stand-alone pronounceability. That is, each element on its own characterizes a possible phonological segment.
- The correlates of elements are acoustic events, i.e., acoustic images that form the target for articulation for the speaker and the perceptual focus for the listener.
- According to some unarists, the articulatory means to achieve the acoustic target lie 'outside the grammar'.
- The same set of elements is valid for both consonants and vowels.

In the next four sections (3–6), I will briefly review the proposals of DP, GP, and RCVP. Needless to say that all three theories are 'under development', which implies variants that I will gloss over. Section 7 ends this article with conclusions and prospects for future work.

3. Dependency Phonology

3.1. ORIGINAL PROPOSALS

In the segmental domain, DP introduced three important innovations, dating back to Anderson and Jones (1972/1974):

(6) Innovations of DP
a. Phonological primes are monovalent.[11]
b. Phonological primes are organized into intrasegmental classes.[12]
c. Combinations of primes and of classes enter into a head–dependency relationship.

As mentioned in section 1, the most fundamental principle of DP is the idea that units (elements, element classes, segments, syllabic constituents, and so on) which are combined to form higher-level units enter into a *head–dependency relation*.

Here, I will not discuss the specifics of the class organization proposed in various versions of DP nor the arguments for such a grouping,[13] so that we can concentrate on the matter of elements. AE propose elements for various classes[14]:

(7) a. Major class and manner distinctions: |C|, |V|
b. Phonation distinctions: |O|, |G|, |K|
c. Location distinctions: |A|, |I|, |U|, …
d. Nasality: |N|

The first set of elements (7a) contains two elements, |V| and |C|, which AE define as follows:

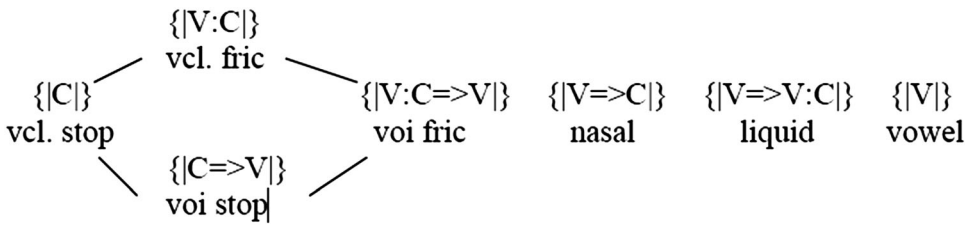
> |V|, [an element] which can be defined as 'relatively periodic', and |C|, [an element] of 'periodic energy reduction'. (p. 151)

Note the use of *acoustic* definitions. 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 […] [element] […] the greater the preponderance of the property characterized by that [element]. 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 hand DP the tools to express a number of major segment classes in terms of combinations of |V| and |C|, as in (8)[15]:

(8)



Underneath the DP representations, I have indicated what classes of segments they represent. AE argue that the representations reflect a *sonority ranking* in which the classes of voiceless fricatives and voiced stops are claimed to have equal sonority. They propose to make further, finer distinctions by allowing more complex C/V structures (leading to separate representations for laterals, strident fricatives, etc.). van der Hulst (1995) offers a critical discussion of the array of C/V structures, proposing an alternative that is claimed to be more restrictive.

We see here that, as stated in the above quote, the precise phonetic interpretation of the elements |C| and |V| is determined by their status in a structure. Roughly, the phonetic impact of the dependent occurrence of an element is less than the impact of that same element as a

head. Note also that we can, if we wish, associate traditional feature names to these interpretations. For example, in the above array of structures, an ungoverned |V| can be glossed as [(+)sonorant],[16] 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|. Thus, the relation between these two phonetic events is 'built in' into the basic vocabulary. This constitutes a very significant advantage that DP has over traditional binary feature systems.

I will only briefly touch upon the second group of DP elements. DP advocates the idea that the traditional concept of phonation (involving glottal states and vocal fold vibration) is relevant to two different element groups. Vocal fold vibration (voicing) is, as we have seen, expressed within the first mentioned group. Other glottal state distinctions are incorporated in the second group, containing the 'glottal opening' element |O| and two elements used for the description of different types of airstream mechanisms, |G| (for 'glottalicness') and |K| (for 'velaric suction'). As for voiceless sonorants, AE propose that voicelessness is a result of these segments being aspirated, the element |O| being present in their segmental representation.

Proceeding with this sketch of DP, let us turn to the locational group. AE introduce the rather rich set of elements in (9):

(9) *DP locational elements*[17]

|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. In this article, I will not comment on the elements in the right-hand set which were proposed for specific consonantal location types.[18] The heart of the set of place elements is formed by the 'IUA' subset, which plays a key role in the representations of vowels and consonants.[19] Three further elements are added for vowels, centrality, ATR, and RTR (Retracted Tongue Root).

A crucial aspect of DP is that two elements can be combined in two ways, using the dependency relation (ignoring the notion of 'mutual dependency'; see fn. 15). This can be illustrated by considering how two series of mid vowels can be represented. Both front and back mid vowels combine the element |A| with either |I| or |U|. Depending on which element is the head, this allows for two series of mid vowels:

(10)

/i/	{I}	/u/	{U}
/e/	{I=>A}	/o/	{U=>A}
/ɛ/	{A=>I}	/ɔ/	{A=>I}
	/a/ {A}		

It will be obvious that these seven representations do not exhaust the maximal number of different vowels that are found in the world's languages nor, more crucially, possible sets of vowels that occur in specific languages. Additional vowel structures arise from allowing combinations

of all three elements.[20] Note, at this point, that the use of dependency relations allows a reconstruction of apparent gradual oppositions such as are involved in vowel height.

Then, we turn to the oro-nasal class, which contains precisely one element, |N|, for 'nasality'. Recall that there also is a C/V characterization of nasals {|V=>C|}. The double encoding of nasals (i.e., both as {|V=>C|} and in terms of the element |N|) is deemed necessary to account for the fact that nasals can pattern with stop consonants (due to their having a |C| element), while they can also induce spreading of nasality in terms of the |N| element.[21]

Let us finally briefly look at AE's proposals for the tonological gesture. In their brief 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 [elements] are […] |i| and |u|. That is, |i| involves (relatively) 'high frequency' and |u| (relatively) 'low frequency'; whether this is interpreted as high (or low) F0 or as concentration of energy in the higher (or lower) regions of the spectrum depends on the context […] in which it occurs. (p. 273)

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

> …there is clearly a relationship between |a|, […] and |V|, [..]. Consider the acoustic glosses which we have given the two [elements]: |V| corresponds with maximal periodicity, and |a| with maximal sonority. Vowels, by virtue of their periodicity are the most sonorous […] 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 [i.e., major class, HH] gesture and of the articulatory gesture [locational class, HH]. (p.215)

The importance of these quotes is to show that AE suggest the strategy of employing certain elements in different classes, thus deriving similarities in phonetic interpretation. This specific idea lies at the root of RCVP where this form of reductionism is pushed to its logical consequence (see section 6).

3.2. DEVELOPMENTS

While a few proposals within DP have been made to revise aspects of the model (see Davenport and Staun 1986, Davenport 1995, Staun 2005), I refer to Anderson (2011) who presents an extensive discussion and illustration of the dependency approach in all areas of grammar. Anderson (2011, part III) deals with phonology. He does not present a complete outline of the basic phonological elements or their grouping into classes. The major innovation compared to AE is the recognition of a distinction between primary and secondary occurrences of elements. For example, the categorical gesture, the basic elements |C| and |V|, makes up major categories such as in (11) (cf. 8):[22]

(11)	C	C;V	V:C	V;C	V
	plosive	fricative	nasal	liquid	vowel

Anderson then proposes the use of secondary elements to make finer distinctions, indicated with lowercase 'c' and 'v' (p. 114):

(12) {V;C {c}} {V;C} {V;C{v}}
nasal lateral rhotic

Some further illustrations are given in p. 363:

(13) {C;V{v}} voiced fricative
{C{v}} voiced stop

Note that, apparently, a separate nasal element has been replaced by secondary {c}, while secondary {v} express voicing, among others. The distinction between primary and secondary specifications of elements is also part of the RCVP model; see section 6.

4. *Government Phonology*

4.1. ORIGINAL PROPOSALS

The first full statement of this theory is offered in Kaye, Lowenstamm and Vergnaud (1985), henceforth KLV85. A proposal was made for a set of elements that would be shared by and be sufficient for both consonants and vowels, although KLV85 only discuss vowel structures in detail.[23] The most complete discussion of the full set of elements can be found in Harris (1994) and Harris and Lindsey (1995). I refer to these sources for extensive discussion of the acoustic properties of elements:[24]

(14) *GP element set*

|I| 'palatality, acuteness/sharpness'
|U| 'roundness, gravity/flatness'
|A| 'lowness, sonority'
|v| 'centrality'
|Î| 'ATR'
|N| 'nasal'
|H| 'high tone or voicelessness'
|L| 'low fundamental frequency'
|h| '*Acoustic*: aperiodic energy'
|?| 'abrupt decrease in amplitude'
|R| 'coronal'

Kaye, Lowenstamm and Vergnaud (1990) adopt the above 11 elements, but not much information is given on their full use. The bulk of the 1985 paper is devoted to vowel issues, while the 1990 paper mostly deals with syllabic organization.

4.2. DEVELOPMENTS

During the 90s, several of the elements came under attack. Striving for maximal empirical coverage, explanation, and economy, GP sought to either eliminate elements or conflate elements. Backley (2011, 2012) provides a comprehensive review of how the original element set ended up being reduced to a set of six elements in the so-called revised theory of elements (Kaye 2000). The following characterization of this set comes from Backley (2011: 66–67):

(15) *Revised GP element set*

|I| high F2 (F2–F3 converge) palatals, coronals, front vowels
|U| lowering of all formants labials, velars, uvulars, rounded vowels
|A| high F1 (F1–F2 converge) pharyngeals, coronals, liquids, non-high vowels
|H| high-frequency energy voiceless obstruents, high tone vowels
|L| low-frequency energy fully voiced obstruents, low tone vowels
|?| sustained drop in amplitude oral/nasal/glottal stops, laryngealized vowels

A specific development in GP has been the use of so-called *non-headed expressions*, proposed in class lectures by Jonathan Kaye and first clearly documented in Harris (1994).[25] While initially suggested as a means to differentiate advanced vowels (headed) from non-advanced vowels

(non-headed), several authors have proposed to extend this difference to characterize additional distinctions.[26] Backley (2011) exploits this idea to the fullest, using what I will call *contrastive headedness* for single elements as well as combinations.[27] The possibility of contrast in terms of headedness for single elements is a major game changer since it essentially doubles the set of elements:[28]

(16)

	Headed	non-headed
|I|	palatals	dental coronals
|U|	labials	velars
|A|	gutturals	alveolar coronals
|?|	constricted glottis	stop
|H|	spread glottis	continuant, (|h| in other varieties)
|L|	voiced	nasal (|N| in other varieties)

For further details, I refer to Backley (2011), who presents the most complete and very detailed application of the six-element theory to date, showing how it can account for segmental inventories and processes. His specific proposals are discussed in van der Hulst (in prep.a) where they are compared with RCVP proposals.

5. The Elements |U| and 'advanced tongue root'

van der Hulst (2015 b) discusses two specific issues in element theory, which relate to whether a fourth element is needed in addition to the 'core' elements |I|, |U|, and |A|. This issue arises in two different ways.

Firstly, there has been the proposal to replace the element |U| by two elements. The |U| element has always had a dual function in element theory: It stands for velarity/backness and roundness at the same time. These two articulatory gestures are united in their acoustic effect, both lowering the second formant. A number of phonologists, notably Lass (1984), Rennison (1987), and Scheer (2004), have argued that these two aspects of |U| should in fact be given independent status, thus splitting up this element into two elements |ɷ| ('labiality' or 'roundness') and |ɯ| ('velarity' or 'backness'). One could argue that such a move, in spite of making a representation of back unrounded vowels possible without the use of a centrality element, is undesirable since it forces one to give up the direct relationship between markedness and formal complexity reflected by the standard DP system. That this is so follows straightforwardly from a comparison of the standard DP representations of a high back rounded vowel with a high back unrounded vowel with those of Lass (1984), given in (17).

(17)

The representation of /u/:	The representation of /ɯ/:
standard-DP: {|u|}	standard-DP: {|u,i,ə|}
Lass (1984): |ɯ,ɷ|	Lass (1984): {|ɯ|}

Thus, whereas in the standard DP system /ɯ/ is formally more complex than /u/, this situation is reversed in Lass's (1984) feature system. Since it is clear that a high back vowel that is rounded is less marked than an unrounded one, Lass's (1984) system clearly does not mirror markedness (as Lass himself also explicitly acknowledges). Scheer (2004) proposes a similar split of |U| based on phonological alternations.

The second issue involves the idea of having a fourth element to encode ATR. This is the |Î| ('ATR') element proposed in KLV85 and the |α| element proposed in DP. As shown in the next section, RCVP differs from DP in adopting an ATR element. The trade-off here is that between having a fourth ATR element and using contrastive headedness. van der Hulst (in prep.a, b) argues that having a fourth element is, firstly, the expected choice within the context of RCVP and, secondly, is supported by the characterization of vowel systems and the treatment of vowel harmony processes.

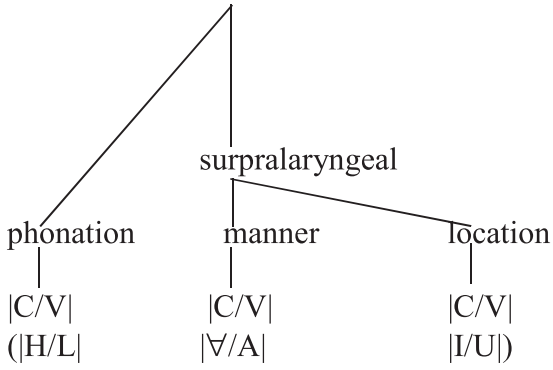
At this point, I return to the question of how monovalent approaches deal with contextual markedness as, for example, in the case of roundness in high vowels. The front vowel /i/ is unmarked in lacking |U|, but how do we express that for back vowels non-rounding is marked? Neither under Lass' proposal nor in the standard version that adopts the element |U| is there a straightforward way to encode that /u/ is less marked than /ɯ/. When |U| is maintained, while |∂| (in DP) or |v| (in GP) are not, central vowels require special attention. These vowels must then be represented as colorless (lacking both |I| and |U|), which suggests that the representation of /ɯ/ is the empty set. Technically, this makes /ɯ/ less complex than /u/, which implies that complexity is not the only measure for markedness. Lacking any characteristic property also makes a segment type marked.

Another case of contextual markedness involves the property ATR, which is usually claimed to be unmarked for high vowels and marked for low vowels (Archangeli and Pulleyblank 1994). However, if ATR is encoded in terms of an element |ATR|, it would seem that high advanced vowels are more complex (and thus marked) than high non-advanced vowels. In this case, as has been argued in Casali (2003, 2008), what seems marked phonetically is not matched by phonological markedness. Casali provides evidence for the claim that in languages with high advanced and non-advanced vowels the latter function as unmarked.

6. Radical CV Phonology

Radical CV phonology is primarily a development of DP proposed in van der Hulst (2005). In this model, only two unary elements are adopted: |C| and |V|.[29] The seeds for this proposal can be found in AE's suggestion, quoted in section 3, to use certain elements in more than one element class. van der Hulst takes this suggestion to its logical end point by adopting only two elements which occur in all element classes. Following AE and Clements (1985), van der Hulst adopts the view that each segment has a 'geometrical' structure consisting of *classes* of elements. Each class contains the elements |C| and |V|:[30]

(18)



The element names in parentheses are given here to allow the reader to identify the correspondence between the different C/V occurrences and the unary elements in other element-based theories. The label '∀' corresponds to the 'ATR' element in both DP and the earlier versions of GP.

van der Hulst assumes that the limitation of the set of elements to two units per class can be seen as resulting from a basic principle of categorization, which in van der Hulst (2015b) is called the *opponent principle*.[31] Briefly, this principle dictates that each phonetic space is parsed into two extreme (polar and antagonistic) categories, which achieves maximal perceptual contrast. This is how we get our phonological primes, which are taken to be unary elements. Assuming, then, that each class in (18) correlates with a 'phonetic space or dimension', |C| and |V| thus denote maximally opposed categories within such a space. While the elements are formal and as such 'substance free', they do correlate with specific phonetic 'events' (phonetic categories). Naturally, since the elements |C| and |V| occur in all classes, these elements correlate with a variety of phonetic interpretations that in traditional binary feature systems are usually associated with distinct features.[32]

While coming from different starting points, RCVP and GP seem to have converged on the idea of there being a small set of elements. The six elements of GP correspond to the two elements of RCVP in each of the three classes:

(19)

Class	C	V
Manner	?	A
Location	I	U
Phonation	H	L

The main difference between GP and RCVP is that it would seem the six elements of GP, rather than forming an arbitrary list (which could have been shorter or longer), are derived from a three-way class distinction and the idea that each class contains the same two elements. Crucially, RCVP makes the claim that elements come in pairs and that within each pair, one element is C biased, while the other is V biased.[34] In essence, the principle that allows a reduction from six to two is that of complementary distribution (at the level of elements). If indeed |?|, |I|, and |H| on the one hand and |A|, |U|, and |L| on the other hand have a distributional and phonetic affinity, these elements, given that they occur in different structural positions in the segmental structure, can be reduced to two elements. The distributional affinity that elements within each set have is being C or V biased, respectively. This means that C elements are unmarked in syllabic onset positions, while V elements are unmarked in syllabic rhyme positions. As for the phonetic affinity, I here refer to Backley (2011), who also discusses the two ways of grouping the six elements in three 'antagonistic pairs'; for each pairing, one element is called 'dark', while they other is 'light':

(20) Antagonistic pairs

'light'	'dark'
|?|	|A|
|I|	|U|
|H|	|L|

By grouping the elements in antagonistic pairs, Backley says we reveal 'three variables that are even more basic than the acoustic patterns associated with the elements themselves' (p. 195).

(21)

variable	relevant values	elements	
		dark	light
resonance	resonant vs. non-resonant	|A|	|?|
frequency	low vs. high frequency	|L|	|H|
color	dark vs. bright	|U|	|I|

In other words, Backley formulates the rationale for the grouping (19). He then writes (p. 195):

> We can think of the perceptual variables in [(21)] as the fundamental properties of spoken language – properties which humans instinctively pay attention to during communication. Now, because contrast is based on acoustic differences, it makes sense for languages to exploit cues that are maximally different, since these are the easiest to distinguish. The cues that are relevant to phonology are therefore the cues that identify the most extreme values of the three variables. In other words, the elements in each pair are opposites.

However, despite acknowledging the classification of elements in (20), which is of course virtually identical to the one in (19), Backley argues that it is not part of the formal system of phonology, although his reasoning in this matter is not entirely clear.[35]

We have seen that RCVP combines the motivation for classes (as developed in DP and in geometrical phonology) with a restricted set of unary elements. In a sense, RCVP provides a meta-theory of the elements that are needed for phonology. Additionally, by replacing the six unary elements by just two, RCVP provides a basis for understanding cross-class relations between the elements that occur in the three different classes.

7. *Concluding Remark: Is Phonology Segmental (or Elemental)?*

In this article, I have reviewed proposals for a set of unary elements in three frameworks (DP, GP, and RCVP). Within the grander scheme of modern phonology, I view these three frameworks as variations of the same theoretical approach toward phonological representations. Crucially, all three employ unary elements and dependency relations. If we regard RCVP as a current development of DP, it would seem that both approaches have converged on proposing a rather small set of elements. Taking the GP elements to be defined in terms of a class node and a C/V specification, both models acknowledge a six-way distinction, although, given its recognition of segment internal structure, RCVP gets away with two elements that form an antagonistic pair.[36] In a sense, RCVP resolves the dispute about unary versus binary features by postulating one binary distinction. As such, RCVP comes very close to encoding equipollence in terms of opposing unary primes as anticipated in (3).

It was argued that unarism eclipses binarism in being the more restrictive theory. All unary approaches share the claim that phonological properties are a matter of presence versus absence of elements, while RCVP adds the notion that elements come in antagonistic (i.e., acoustically maximally dispersed) pairs.

In addition to formal arguments based on generative capacity, it is fair to demand that unary features or elements must also be justified on empirical grounds. However, as pointed out in Kaye (1988), it is logically impossible to prove the non-existence of phonological phenomena that would justify a binary approach over a unary approach. This is, as stated earlier, why a unary approach should be the null hypothesis. That said, it stands to reason that, if decades of phonological work in different models fail to provide convincing evidence for recognizing, for example,

[−nasal] or [−round] as necessary phonological primitives, we have an empirical reason for supporting unarism, which is as good as it gets. Additionally, it could be argued that unary features provide particularly insightful analyses of phonological phenomena. A good example of this kind of support can be found in Schane (1995), where it is shown that processes of diphthongization (and monophthongization) can be well understood in terms of many features. For example, diphthongization of [e:] and [o:] typically produces [ai] and [au], respectively, showing that the two elements (|A| and |I| or |U|) that make up the monophthongs neatly appear when this vowel 'breaks into two parts'. AE provide further arguments of this kind, also based on shift changes in vowel systems.

Given the presumed stand-alone interpretation of all elements, elements are very different from (binary) features. They are not properties of pre-postulated units (phonemes), but rather, they are the true primes of phonological structure. Thus, they are the true phonemes, if this term is taken to refer to 'the primitives of phonology'. We have shown that elements can occur alone or in combinations, and we finally need to raise the question whether segments, understood as linearly ordered units that correspond to speech sounds, are legitimate phonological objects. Both Anderson (2014) and Kaye (2015: 265) clearly state that the notion of segments is inspired by the alphabetic systems used to write West European languages (which also inspired the International Phonetic Alphabet system). The question here is really whether the sequential organization of languages is based on syllabic units (such as 'onsets' and 'rhymes') or smaller units that make up these syllabic units (which would come close to the alphabetic letters). It would seem that even theories that claim to be non-segmental and instead adopt larger (syllabic) units acknowledge structure within these units. While it remains to be determined what this structure is and which aspects of it have provided the (psychological) basis for alphabetic writing systems, it does seem to be the case that alphabetic systems have influenced many theories of syllabic organization in terms of sequential segments as 'bundles' of phonological properties.

Short Biography

Harry van der Hulst (PhD 1984, University of Leiden in the Netherlands) specializes in 'phonology' which is the study of the sounds systems of languages, as well as the visual aspects of sign languages. He has published 25 books and over 150 articles. He has held (guest) positions at the University of Leiden, the University of Salzburg, the University of Girona, Skidmore College, New York University, and Cornell University. He has been Editor-in-Chief of the international linguistic journal. *The Linguistic Review* since 1990. He is currently (since 2000) professor of linguistics at the University of Connecticut. He is married to Nancy Ritter (also a linguist) and has 7 children.

Notes

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[1] See van der Hulst (2015a) for a more complete characterization of phonology. The distinction between two types of phonological rules (allophonic rules and allomorphic rules) was rejected in Chomsky and Halle (1968), only to be restored, in one way or another, in many versions of generative phonology that followed.

[2] In 'orthodox' versions of dependency grammar, dependency relations replace constituent structure relations, whereas in most generative approaches, these relations augment constituency.

[3] Den Dikken and van der Hulst (1988) offer a very extensive review of developments in feature theory since Chomsky and Halle (1968), including proposals for unary features in both dependency phonology (DP) and government phonology (GP),

as well as proposals for feature grouping in feature geometry. Backley's (2012) review is focused on developments of element theory within government phonology.

[4] These terms come from Trubetzkoy (1939), who distinguished three types of oppositions: privative, equipollent, and gradual. In short, binary feature theory reduces all oppositions to equipollence ([+F] vs. [−F]), while unary theory reduces all oppositions to privativity. Here, I will not discuss proposals to generalize the use of multivalued features to all three types of oppositions; see Williamson (1977) and Gnanadesikan (1997).

[5] As all theories of binary features, unary approaches also need statements on co-occurrences of elements that define the segment inventory of languages. It seems inevitable that co-occurrence constraints would use the negation operator (as in 'A implies not B'). However, this does not mean that 'not B' is an entity that can characterize a natural class or be involved in a process; see van der Hulst (in prep.a).

[6] A detailed discussion of the representation of 'voicing' in these different languages is offered in van der Hulst (2015c).

[7] The terms 'markedness' and its various aspects in phonology, both formal and substantive, are discussed in Rice (2007).

[8] One might wonder how a monovalent approach can deal with context dependency of what is considered 'marked'. I will address this issue in section 2015c

[9] In some theories, all values of features are taken to be specified all the time. To account for processes that only seem to see marked values, it is postulated that it is a property of these rules to ignore non-contrastive specification; see Calabrese (2005). Others, i.e., proponents of CST, maintain that only contrastive feature values can be relevant in phonology; see Dresher (2009), including a proposal on how to arrive at strictly contrastive specifications.

[10] Schane (1984ab, 1987, 1995) also proposes a unary system, using 'particles' that are similar to those of DP and GP. His theory does not invoke dependency relations. I refer to his articles for several convincing illustrations (of diphthongization and monophthongization processes) that strongly suggest unary primes for phonology. Nice (1990) proposes a variant of Schane's particle theory that uses a hierarchical grouping of particles. van der Hulst (1989) also suggests a hierarchical grouping.

[11] The idea of monovalent primes has some precedents, which, for reasons of space, will not be discussed here. I refer to van der Hulst (2013) for some historical context. Sanders (1972) is an early plea for monovalent features in phonology.

[12] These classes are called *gestures* (comparable to 'feature classes dominated by a class nodes' in Clements 1985, but not to the 'gestures' in Browman and Goldstein 1986).

[13] See den Dikken and van der Hulst (1988). The DP arguments for grouping are essentially analogous to the arguments that have been presented for feature classes in feature geometry (Clements 1985). However, it is fair to say that DP proponents, generally, have put much less emphasis on arguments based on the treatment of phonological processes (as is usually the case in feature geometry). Rather, Anderson and Ewen (AE) argue in favor of their elements and their classes on the basis of phonetic considerations, taking into account how the phonetic properties of segments and segment classes can be derived from specific combinations of primes. In motivating its primes, DP's point of departure is the need to express contrasts in phonemic inventories.

[14] Many of AE's proposals for the location and phonation group are based on Ewen (1980).

[15] Braces represent the set of segments characterized by the element expression between vertical lines. The double-shafted arrow indicates the dependency relation, while ':' is the symbol for 'mutual dependency', i.e., a relationship in which both elements have equal status.

[16] Despite my insistence on acoustic interpretations, for ease of comparison to binary systems, I will use binary features to indicate the classes of segments that element structure designates.

[17] In AE, elements are symbolized with lowercase letters. In this article, I use capitals, which is also the GP practice. The use of the symbols 'a', 'i', and 'u' stems from the fact that these elements were initially motivated for vowel structures, with the element 'a' by itself representing the 'sound [a]' or 'phoneme /a/'. This should not disguise the fact that these elements are equally relevant to consonants. In the feature geometry framework, we see the reverse: Monovalent features such as [labial], [coronal], and [dorsal], first motivated for consonants, are meant to apply to both consonants and vowels; see Clements and Hume (1995).

[18] Smith (1988) and van der Hulst (1988) make proposals to deal with *all* locational properties of both consonants and vowels with only the IUA set.

[19] The central role of the IUA set is supported by phonetic theories of vowel articulations, as proposed in Stevens (1972) and Wood (1982).

[20] Anderson and Ewen stipulate that different dependencies between |I| and |U| do not yield different vowel phonemes (this is also a claim in government phonology). A specific issue is raised by the representation of non-low central vowels, for which they invoke the element |∂|. The advanced tongue root (ATR) element |α| is required to represent an advanced and non-advanced series among high vowels. AE argue that the element |r| 'retracted tongue root' is also needed in cases where the retracted, rather than the advanced, member in a tongue root opposition appears to be active. As

mentioned, AE allow the combinations of elements in which the relationship is one of 'mutual dependency'; this creates the possibility of a third series of mid vowels, for example. See den Dikken and van der Hulst (1988) for discussion of all these issues.

[21] Davenport (1995) proposes an alternative DP account of nasality.

[22] The ';' represents dependency (like '=>'), while the ':' represents mutual dependency. Anderson also discusses and illustrates the importance of minimal, redundancy-free representations, to which end he makes use of non-specification of elements and relationships as much as possible.

[23] The foundations for this approach were laid in the work by Jean-Roger Vergnaud presented in 1982 at a GLOW conference. The statement by Kaye, Lowenstamm and Vergnaud, (1985: 310) that their 'molecular' approach to segmental structure bears some degree of resemblance to the earlier work by Anderson and Jones, which developed into 'DP' strikes me as somewhat of an understatement. The original proposal contains several aspects that were later abandoned, such as the idea that elements were defined in terms of traditional binary features in terms of which a combination calculus could be formulated, which derived the properties of combinations compositionally from the properties of the elements involved. Another proposal was that elements were grouped in classes in terms of a 'charm property' (roughly corresponding to their degree of sonority). Charm properties guided the likelihood or unlikelihood of element combinations. See Den Dikken and van der Hulst (1988) for detailed discussion of these aspects of the KLV85 theory.

[24] Initially, GP maintained the irrelevance of a gestural organization. Harris (1994) and Harris and Lindsey (1995) make a proposal for an internal organization of segments.

[25] Non-headedness was motivated in terms of element expressions that have a head position which is empty: (A) vs. (A._). In KLV85, this case was covered by expressions that are headed by the centrality element (the former cold vowel): (A) vs. (A.v). We must note that Backley also admits 'double-headed' expressions, which he deems highly marked to the point that he proposes a general ban on them (p. 200), but he still allows languages to have them.

[26] See Ritter (1987), Kim (1996), and Kaye (2000).

[27] Allowing non-headed combinations is somewhat comparable to the notion of mutual dependency in DP.

[28] Ritter (2005) proposes to also eliminate the manner element |?| (and |h|) for consonants, replacing them by a contrastive distinction between headed and non-headed expressions (representing stops and fricatives, respectively). Jensen (1994) also eliminates |?| and |h|, replacing these by additional syllabic organization. This leaves him with five elements (A, I, U, H, and L) because he also does not assume the cold vowel or a centrality element (contrary to Ritter). This makes him the reduction champion, although at the cost of adding more syntagmatic structure for the purpose of encoding stricture distinctions. In recent work, Pöchtrager (2006) and Kaye (2015) follow this path by making all manner distinctions structural. To some extent, this idea is also explored in Golston and van der Hulst (1999).

[29] Hence, the term 'radical'. The use of this term here is not the same, then, as in radical underspecification theory. A full treatment of radical CV phonology (RCVP) is offered in van der Hulst (in prep.a).

[30] For the RCVP treatment of tonal distinctions, I refer to van der Hulst (in prep.).

[31] Avery and Idsardi (2001) propose a theory of features which also introduces the notion of antagonistic pairs, referring to Sherrington (1947) who claims that muscles are organized in antagonistic pairs. In their theory, members of a pair cannot both be active in a single segment, nor can both be distinctive in a single language. For a comparison of this theory, called dimension theory, to RCVP, I refer to van der Hulst (in prep.).

[32] van der Hulst (1969, 2000) makes proposals for the structure of sign phonology which uses dependency and C/V elements.

[33] In RCVP, the informal label for this element is |∀|. It is shown in van der Hulst (in prep.b) that this element represents non-lowness and 'ATR' in vowels. As such, given the opponent organization of RCVP, the ATR element is an expected member of the element family.

[34] This opposition is reminiscent of the charm distinction in KLV85, although not identical to it, with 'V' and 'C' corresponding to positive and negative charm, respectively, in several cases.

[35] Details aside, had Backley decided to integrate this classification into the formal theory, the only remaining difference would have been that the element |?| ('manner: C' in RCVP) in the system is not used for vowel height. The author of this article cannot resist noting that while Backley (2011) refers to RCVP in other places in his very valuable book, he does not make a connection with RCVP at this critical point.

[36] In Pöchtrager (2006) and Kaye (2015), we find a newer version of GP, which also only uses fewer elements, again 'at the expense' of adding more structure to phonological representations.

Works Cited

Anderson, John M. 1985. Structural analogy and dependency phonology. *Acta Linguistica Hafniensia* 19. 5–44.

Anderson, J. 2011. *The substance of language*. Volume I: *The domain of syntax*; volume II: *morphology, paradigms, and periphrases*; volume III: *phonology–syntax analogies*. Oxford: Oxford University Press.

Anderson, John. 2014. Graphophonology and anachronic phonology. Notes on episodes in the history of pseudo-phonology. *Folia Linguistica Historica* 35. 1–53.
Anderson, John M., and Jacques Durand. 1986. Dependency phonology. *Dependency and non-linear phonology*, ed. by Jacques Durand, 1–54. London: Croom Helm.
Anderson, John M., and Colin J. Ewen. 1987. *Principles of dependency phonology*. Cambridge: Cambridge University Press.
Anderson, John M., and Charles Jones. 1972. Three theses concerning phonological representations. *Edinburgh Working Papers in Linguistics* 1. 92–115.
——. 1974. Three theses concerning phonological representations. *Journal of Linguistics* 10. 1–26.
Archangeli, Diana. 1984. *Underspecification in Yawelmani phonology and morphology*. Cambridge, MA: MIT dissertation.
Archangeli, D., and D. Pulleyblank. 1994. *Grounded phonology*. Cambridge, Mass.: MIT Press.
Avery, P., and W. Idsardi. 2001. Phonation dimensions, completion and enhancement. *Distinctive feature theory*, ed. by T. A. Hall, 41–70. Berlin and New York: Mouton de Gruyter.
Backley, Philip. 2011. *An introduction to element theory*. Edinburgh University Press.
——. 2012. Variation in element theory. *Linguistic Variation* 1(1). 57–102.
Bao, Z. 1991. *On the nature of tone*. Cambridge, MA: MIT dissertation.
Breit, Florian. 2013. Formal aspects of element theory. Masters thesis, Department of Linguistics, University College London.
Browman, C., and L. Goldstein. 1986. Towards an articulatory phonology. *Phonology Yearbook* 3. 219-252.
Calabrese, Andrea. 2005. *Markedness and economy in a derivational model of phonology*. Berlin: Mouton de Gruyter.
Casali, Roderic F. 2003. [ATR] value asymmetries and underlying vowel inventory structure in Niger-Congo and Nilo-Saharan. *Linguistic Typology* 7. 307–382.
Casali, Roderic F. 2008. ATR harmony in African languages. *Language and Linguistics Compass* 2(3). 496–549.
Chomsky, Noam, and Morris Halle. 1968. *The sound pattern of English*. New York: Harper and Row.
Clements, G. N. 1985. The geometry of phonological features. *Phonology Yearbook* 2. 225-252.
Clements, G. N., and B. Hume. 1995. The internal organization of speech sounds. *The handbook of phonological theory*, ed. by J. Goldsmith, 245–306. Oxford: Blackwell.
Coleman, J.S. 1990a. Charm theory defines strange vowel sets. *Journal of Linguistics* 26(1). 165–174.
—— 1990b. Vowel sets: a reply to Kaye. *Journal of Linguistics* 26(1). 183–187.
Davenport, Mike. 1995. The characterization of nasality in dependency phonology. *Leiden in last*. HIL phonology papers 1, ed. by Harry van der Hulst and Jeroen van de Weijer, 89–103. The Hague: Holland Academic Graphics.
Davenport, Mike, and Jørgen Staun. 1986. Sequences, segment and configuration: two problems for dependency phonology. *Dependency and non-linear phonology*, ed. by Jacques Durand, 135-159. London: Croom Helm.
Dikken, Marcel den and Harry van der Hulst. 1988. Segmental hierachitecture. *Features, segmental structure and harmony processes*, ed. by Harry van der Hulst and Norval Smith, 1–59. Dordrecht: Foris.
Dresher, B. Elan. 2009. *The contrastive hierarchy in phonology*. Cambridge: Cambridge University Press.
Dresher, B. Elan, and Harry van der Hulst. 1998. Head-dependent asymmetries in prosodic phonology. *Phonology* 15. 317–352.
Ewen, C. 1980. Aspects of phonological structure, with particular reference to English and Dutch. Doctoral dissertation, University of Edinburgh.
Gnanadesikan, Amalia Elisabeth. 1997. Phonology with ternary scales. Ph.D. thesis, University of Massachusetts, Amherst.
Goldsmith, John A. 1985. Vowel harmony in Khalkha Mongolian, Yaka, Finnish and Hungarian. *Phonology Yearbook* 2. 253-277.
Golston, C., and H. van der Hulst. 1999. Stricture is structure. *The derivational residue in phonological optimality theory*, ed. by B. Hermans and M. Oostendorp, 153–174. Amsterdam: John Benjamins.
Halle, Morris. 1983. On distinctive features and their articulatory implementation. *Natural Language and Linguistic Theory* 1. 91–105.
Halle, M., and K. Stevens. 1971. A note on laryngeal features. Quarterly progress report 101. Research Laboratory of Electronics, MIT. 198-213.
Harris, John. 1994. *English sound structure*. Blackwell: Oxford.
Harris, John, and Geoff Lindsey. 1995. The elements of phonological representation. *Frontiers of phonology: atoms, structures, derivations*, ed. by Jacques Durand and Francis Katamba, 34–79. London and New York: Longman.
Hays, D. G. 1964. Dependency theory: a formalism and some observations. *Language* 40. 511–525.
Hulst, Harry van der. 1988. The geometry of vocalic features. *Features, segmental structure and harmony processes*, ed. by Harry van der Hulst and Norval Smith, 77–126. Dordrecht: Foris.
Hulst, Harry van der. 1989. Atoms of segmental structure: components, gestures and dependency. *Phonology* 6. 253–284.
——. 1989. Atoms of segmental structure: components, gestures and dependency. *Phonology* 6. 253–284.
——. 1993. Units in the analysis of signs. *Phonology* 10. 209–241.
Hulst, H.G. van der 1995. Radical CV Phonology: The categorial gesture. *Frontiers of phonology*, edited by J. Durand and F. Katamba. Essex: Longman, 80–116.

Hulst, Harry van der. 2000. Modularity and modality in phonology. *Phonological knowledge: conceptual and empirical issues*, ed. by Noel Burton-Roberts, Philip Carr and Gerard Docherty, 207–243. Oxford: Oxford University Press.
——. 2005. The molecular structure of phonological segments. *Headhood, elements, specification and contrastivity*, ed. by P. Carr, J. Durand and C. Ewen, 193–234. Amsterdam: John Benjamins Publishing Company.
——. 2015a. Phonological systems. *The routledge handbook of linguistics* ed. by Keith Allen. London and New York.
——. 2015b. The opponent principle in RcvP: binarity in a unary system. *The segment in phonetics and phonology*, ed. by Eric Raimy and Charles Cairns. Oxford: Wiley-Blackwell.
——. 2006. Dependency phonology. *The encyclopedia of language and linguistics*. 2nd edition. Volume 3, ed. by Keith Brown, 451–458. Oxford: Elsevier.
——. 2015c. The laryngeal class in RcvP and voice phenomena in Dutch. *Above and beyond the segments*, ed. by Johanneke Caspers, Yija Chen, Willemijn Heeren, Jos Pacilly, Niels Schiller and Ellen van Zanten, 323–349. Amsterdam: John Benjamins Publishing Company.
——. in prep.a. Principles of Radical CV Phonology. Ms., University of Connecticut.
——. in prep.b. Asymmetries in vowel harmony. Ms., University of Connecticut.
Jakobson, R., C.G.M. Fant, and M. Halle. 1952. *Preliminaries to speech analysis - the distinctive features and their correlates*. Second Edition. Cambridge, Mass.: MIT Press.
Jensen, Sean. 1994. Is ? an element?: towards a non-segmental phonology. *SOAS Working Papers in Linguistics and Phonetics* 4. 71–78.
Kaye, Jonathan. 1988. The phonologist's dilemna: a game-theoretic approach to phonological debate. *GLOW Newsletter* 21. 16-19.
Kaye, Jonathan. 1990. The strange vowel sets of charm theory: the question from top to bottom. *Journal of Linguistics* 26(1). 175–181.
Kaye, Jonathan. 1995. Derivations and interfaces. *Frontiers of phonology: atoms, structures, derivations*, ed. by Jacques Durand and Francis Katamba, 289–332. London and New York: Longman.
——. 2000. A user's guide to Government Phonology (GP). Ms., University of Ulster.
——. 2015. In ins and outs of phonology. *The form of structure, the structure of forms: essays on the realization of linguistic structures*, ed. by Sabrina Bendjaballah, Noam Faust, Mohamed Lahrouchi, Nicola Lampitelli, 255–270. Amsterdam: Benjamins Publishing Company.
Kaye, Jonathan, Jean Lowenstamm, and Jean-Roger Vergnaud. 1985. The internal structure of phonological representations: a theory of charm and government. *Phonology Yearbook* 2. 305–328.
——. 1990. Constituent structure and government in phonology. *Phonology Yearbook* 7. 193–231.
Kim, Seon-Jung. 1996. The representations of Korean phonological expressions and their consequences. PhD dissertation, School of Oriental and African Studies, University of London.
Kiparsky, P. 1982. From cyclic phonology to lexical phonology. *The structure of phonological representations* [Part I], ed. by H. van der Hulst and N. Smith, 131–177. Dordrecht: Foris.
Kornai, A. 1995. *Formal phonology. Outstanding dissertations in linguistics*. New York, NY: Garland Publishing.
Lass, Roger. 1984. *Phonology: an introduction to basic concepts*. Cambridge: Cambridge University Press
Liberman, A. M., and I. G. Mattingly. 1985. The motor theory of speech perception revised. *Cognition* 21. 1–26.
Nice, Kathy van. 1990. Hierarchical particle phonology. Ms., University of Texas, Austin.
Mester, R.A., and J. Itô. 1989. Feature predictability and feature specification: palatal prosody in Japanese mimetics. *Language* 65(2). 258-293.
Pöchtrager, Markus Alexander. 2006. The structure of length. PhD dissertation. Universität Wien.
Reiss, Charles. 2011. Towards a bottom-up approach to phonological typology. *Toward a biolinguistic understanding of grammar. Essays on interfaces*. ed. by A.M. di Sciullo, 169–191. Amsterdam & Philadelphia: John Benjamins Publishing Company.
Rennison, John. 1987. Vowel harmony and tridirectional vowel features. *Folia Linguistica* 21. 337–354.
Rice, Keren. 2007, Markedness in phonology. *The Cambridge handbook of phonology*, ed. by Paul de Lacy, 79–98. Cambridge, UK: Cambridge University Press.
Ritter, Nancy A. 2005. How a phonological theory of headedness can account for strong vs. weak phonetic alternants. *Headhood, elements, specification and contrastivity*, ed. by Philip Carr, Jacques Durand and Colin J. Ewen, 277–312. Amsterdam/Philadelphia: John Benjamins publishing company.
Sanders, G. 1972. The simplex-feature hypothesis. Indiana University Linguistic Club.
Schane, Sanford A. 1984a. Fundamentals of particle phonology. *Phonology Yearbook* 1. 129–155.
—— 1984b. Two English vowel movements: a particle analysis. *Language sound structure*, ed. by Mark Aronoff and Richard Oehrle, 32–51. Cambridge, Mass.: MIT Press.
—— 1987. The resolution of hiatus. *papers of the parasession on autosegmental and metrical phonology*. CLS 23, 276–290.
—— 1995. Diphthongisation in particle phonology. *Handbook of phonological theory*, ed. by John A. Goldsmith, 586–605. Oxford: Blackwell.

Schane, Sanford. 2005. The aperture particle |a|: its role and function. *Headhood, elements, specification and contrastivity*, ed. by Philip Carr, Jacques Durand and Colin J. Ewen, 313–338. Amsterdam/Philadelphia: John Benjamins publishing company.

Scheer, Tobias. 2004. *A lateral theory of phonology. What is CVCV, and why should it be?* Berlin/New York: Mouton de Gruyter.

Staun, Jorgen. 2005. Toward a *taw*-based phonological representation of place. *Headhood, elements, specification and contrastivity*, ed. by Philip Carr, Jacques Durand and Colin J. Ewen, 339–368. Amsterdam/Philadelphia: John Benjamins publishing company.

Steriade, D. 1987. Redundant features. In: *Papers from the parasession on autosegmental and metrical phonology*, *CLS* 23, 339–362.

Steriade, Donca. 1995. Underspecification and markedness. *The handbook of phonological theory*, ed. by Goldsmith, J., 114–174Oxford: Blackwell.

Stevens, K.N. 1972. The quantal mature of speech: evidence from articulatory-acoustic data. *Human communication: a unified view*, ed. by E. E. David and P. B. Denes, 51-66. New York: McGraw Hill.

Trubetzkoy, Nikolai S. 1969. *Principles of phonology*, Translated by Christiane A. M. Baltaxe. Berkeley & Los Angeles: University of California Press. Originally published 1939 as *Grundzüge der Phonologie*. Göttingen: van der Hoeck & Ruprecht.

Vergnaud, Jean-Roger. 1982. On the theoretical bases of phonology. Paper presented at the 5th GLOW Colloquium, Paris.

Williamson, Kay. 1977. Multivalued features for consonants. *Language* 53(4). 843–871.

Wood, S. 1982. X-ray and model studies of vowel articulation. *Lund Working Papers* 23. 1–49.