Offprint from: Botma Bert & Roland Noske (eds.) (2012): *Phonological Explorations. Empirical, Theoretical and Diachronic Issues*. Berlin/Boston: De Gruyter.

Harry van der Hulst

A minimal framework for vowel harmony

1 Introduction

In this article, I will discuss the bare minimum of theory needed to account for vowel harmony patterns.[1] The proposed model, 'Radical cv Phonology' (RcvP), finds its origin in the framework of Dependency Phonology (Anderson & Ewen 1987; DP) and shares three fundamental aspects with this framework:

(1) a. Phonological primes are unary ('monovalent') elements
    b. Elements, when combined, enter into head–dependency relations
    c. Elements are grouped into units ('gestures')

The details of my theory differ from those in Anderson & Ewen in a number of respects. First, RcvP uses a smaller set of elements, grouped in a slightly different set of gestures. The idea of gestures is similar to that of 'class nodes' as used in Feature Geometry (see Clements 1985; Sagey 1986). Second, I adopt certain ideas that were first presented in the Government Phonology (GP) approach of Kaye et al. (1985), who offer a theory of segmental structure which shares important insights with DP, notably regarding (1a,b). The present approach shares with Kaye et al. a notational system in which elements are represented on 'lines' (which are similar to the 'autosegmental tiers' of Goldsmith 1976), as well as the idea that vowel harmony is the result of a lateral licensing relation between syllable heads, as suggested in Dienes (1997) and Ritter (1999).

Another important aspect of my approach is the adoption of Trubetzkoy's (1939) notion of 'morphophoneme' (or 'morphoneme'), which involves a disjunctive representation of alternants. For example, in Finnish, the vowels /u/ and /y/ alternate as the result of palatal harmony. I will represent the alternating vowels as |U(I)|, and adopt the convention that the element |I| can be phonetically interpreted if and only if it is laterally licensed by a local and

[1] For an extensive discussion of the general model within which the present discussion is couched, see Van der Hulst (2005, 2012a). This paper is a direct continuation of the work on vowel harmony that Norval Smith and I carried out in the 1980s and 1990s — a long and fruitful period of collaboration, which we can hopefully pick up and continue in the coming years.

non-variable (i.e. licensed) instance of another element |I|.[2] Thus, the present approach does *not* view vowel harmony as a feature filling or feature copying procedure.[3] In Trubetzkoy's view, 'archisegmental' representations capture instances of automatic, exceptionless neutralization, i.e. cases where a potential contrast is altogether absent from the phoneme inventory (paradigmatic neutralization), and cases where a potential contrast is absent in a particular position (syntagmatic neutralization). Morphophonemes, on the other hand, capture alternations that are subject to lexical irregularity. Although it is not necessarily the case that instances of vowel harmony display lexical irregularity (i.e. that they are 'lexical' in the sense of Kiparsky 1981, 1985), this seems to be the typical situation. We will see that the model proposed here can predict whether neutral vowels behave as *transparent* or *opaque* to the harmony process, following the original insight of Van der Hulst & Smith (1986). In addition, in a morphophonemic approach there is no need to invoke underspecification (or non-specification) for the purpose of representing vowel harmony, nor do we need recourse to Van der Hulst & Smith's *ad hoc* idea of 'segmental brackets' to deal with disharmonic roots.

The structure of this paper is as follows. In section 2, I will explain the basic ideas of the RcvP approach, with special reference to vowel structures. In sections 3 and 4, I make some remarks about the phonetic interpretation of elements and underspecification of phonological structures. I also illustrate the constraints that govern these structures. Section 5 discusses (and rejects) a proposal to use the presence (vs. the absence) of head-marking contrastively. In section 6, I apply the RcvP model to vowel harmony, using data from Finnish vowel harmony to illustrate the model. Section 7 deals with transparency and opacity, and defends the idea that these two types of behaviour of non-harmonic vowels can be predicted. I further discuss some potential counterexamples and problems for the model proposed here, and some possible ways to resolve these.

2 Gestures, elements and headedness

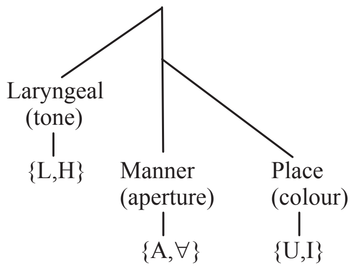
In RcvP, each segment has a tripartite structure consisting of a Laryngeal, Manner and Place gesture, as in (2). Within each gesture, we find precisely two elements.

---

2 As in Dependency Phonology, elements are placed between vertical lines.

3 My approach resembles the 'activation model' of Backley & Takahashi (1996), which is discussed in Van der Hulst (2012b).

(2)



In this paper, I focus on vocalic structures and ignore the ‘tonal’ elements |L| and |H| (for discussion of these, see Van der Hulst 2005, 2012a). The six elements in (2) can in fact be replaced by just two, viz. |C| and |V|, as in (3) (hence the name *Radical* cv Phonology).

(3)

	Elements		RcvP coding	
Manner	A	∀	V	C
Place	U	I	V	C
Laryngeal	L	H	V	C

This reduction is possible because each gesture contains exactly two elements. This allows us to say that the element labels |A|, |U| and |L|, because they occur under different gestures, are paradigmatically speaking in complementary distribution, and so can be reduced to one and the same element, viz. |V|. The same holds for |∀|, |I| and |H|, which can be reduced to |C|. Complementary distribution is a familiar criterion that is used to reduce allophones to phonemes (where allophones are in complementary distribution in a syntagmatic sense). However, the same criterion can be applied to elements, provided that the elements that we reduce to |C| or |V| have something in common. In RcvP, the claim is that in each gesture |A|, |U| and |L| represent vowel- or rhyme-oriented choices (and so reduce to |V|) while |∀|, |I| and |H| represent consonant- or onset-oriented choices (and so reduce to |C|). However, for practical purposes I will here use the element labels |A, U, L, ∀, I, H| in this paper, so as to avoid cumbersome expressions such as ‘|Place: V|’ (instead of ‘|A|’).

It is important to note that |V| and |C| can occur in both onset and rhyme positions. For example, in the manner gesture, |A| is a vowel-oriented element because it is preferred in the syllable nucleus (i.e. the head of the rhyme), and because it denotes maximal openness and sonority. On the other hand, |∀| is a consonant-oriented element because it is preferred in the syllable onset, and because it denotes closure and hence minimal sonority. In vowels, |A| denotes [open] or [low], and |∀| [closed] or [high] (and [ATR]; cf. below). In (obstruent) consonants, |A| and |∀| denote [fricative] and [stop], respectively.[4] For the place and laryngeal gestures we see the same difference, with |U| and |L| representing vowel-oriented choices and |I| and |H| consonant-oriented ones. Reasons of space preclude a more detailed discussion of the interpretation of elements; for this, see Van der Hulst (2012a). However, it should be stressed that two opposing elements cannot be viewed as two *values* of a single feature, e.g. '[+open]' (for |A|) and '[–open]' (for |∀|). The reason for this, as we will see, is that in RcvP two opposing elements can be combined within a single gesture. This is impossible for two values of a binary feature, as this would entail a contradiction.

It seems reasonable to assume that the elements |I| and |U| are relevant in the representation of both vowels and consonants (as in Anderson & Ewen 1987, and, with a different set of feature labels, in Clements 1991), with |I| denoting 'coronal/front' and |U| 'labial/round'. What is perhaps less clear is that the same is true for the laryngeal elements |L| and |H|. In the spirit of Halle & Stevens (1971), I propose that |L| and |H| denote phonation distinctions in consonants (voiced, voiceless, etc.) and (primarily) tonal distinctions in vowels; see Van der Hulst (2012a) for further details. The idea that there is, in addition to this, a set of primes denoting manner in consonants *and* aperture in vowels is, I believe, unique to RcvP. The upshot is that RcvP does not have any elements which are exclusive to either consonants or vowels, in line with the program of Jakobson et al. (1952).

In the remainder of this paper I will limit my attention to vowel structures, ignoring the elements |L| and |H|. Of the remaining four elements, three are the place elements |A, I, U|, familiar from DP and GP. In addition to these, I assume a fourth element, viz. |∀|. Notice that a fourth element is also assumed in both DP (the 'schwa' element) and GP (the 'cold vowel' or ATR element; cf. Kaye et al. 1985, 1990). Both these elements are similar to |∀|.[5]

Gestures may contain a single element or a combination of elements. In the latter case, the elements enter into a head–dependency relation, such that

---

[4] The labels between square brackets represent phonetic properties that correspond to the phonological elements. I have used articulatory properties here, but elements obviously also have corresponding acoustic properties. I will remain neutral as to which of these two types of properties should be regarded as more basic.

[5] Later versions of GP have abandoned a fourth element in the description of vowels (see e.g. Kaye 2001). The removal of the ATR element has come with a price, in that the notion of headedness has been extended in such a way that the presence (vs. the absence) of headedness is a distinctive option. See Van der Hulst (2012a) for detailed discussion and criticism of this idea (see also section 5).

one element is the head and the other the dependent.[6] As was suggested in (1), I assume that variable dependency relations hold *within* gestures. This means for example that within Manner either |A| or |∀| can be the head if both elements are combined. It would seem that dependency relations *between* the gestures themselves are universally fixed, with Manner being the head. In this respect, RcvP departs from standard DP and arguably offers a more restrictive approach to segment-internal structure. For arguments in favour of the general dependency relation in (1), see Van der Hulst (2005, 2012a).[7]

Headedness can be represented in a number of ways. DP uses representations of the kind in (4a), where a head, when combined with a dependent, graphically dominates it. Other notations have also been used, such as a difference in linear order (head first, dependent second) or capitalization. In this paper I will represent heads by means of underlining (which is common in GP), as in (4b):

```
(4) a.  X    X    Y    Y
             |    |
             Y    X
```

b. $\underline{X}$ $\underline{X}Y$ $\underline{Y}X$ $\underline{Y}$ (or $\underline{X}$ $Y\underline{X}$ $X\underline{Y}$ $\underline{Y}$)[8]

c. $\underline{X}[X]$ $\underline{X}Y$ $\underline{Y}X$ $\underline{Y}[Y]$

The structures in (4c) show that a head, when it occurs without a dependent, can be interpreted *as if* it has itself as a dependent. Such predictable dependents will not be indicated. Their virtual presence can be viewed as the result of a 'universal redundancy rule' X ⇒ X, which leads to 'enhancement' (in the sense of Stevens & Keyser 1989) of the head. I will refer to the four structures in (4a-c) as 'basic structures' (regardless of the way headedness is represented), while 'bare' X and Y will be called 'simple structures'.

Following Kaye et al. (1985), I assume that an element in dependent position corresponds to a single phonetic attribute while an element in head position (without an accompanying dependent) denotes a complete segment

---

6 Schane (1984), who also uses unary elements, does not use head–dependency relations. Instead, he assumes the possibility of multiple occurrences of elements, e.g. for representing different degrees of aperture.

7 For related work that is also based on the notion of dependency and unary elements, see Smith (2000) and Botma (2004).

8 Underlining is critical in combinations, since here it must be made explicit which element is the head. Strictly speaking, an element which occurs without a dependent is always a head, so that here underlining could be considered redundant (and will in fact be omitted below); I return to this issue in section 4.

— an idea that is also implicit in DP.[9] For example, in isolation, the head element |U| denotes back rounded /u/, while dependent |U| denotes labiality (i.e. rounding), as in /y/.[10] If the element |U| occurs with a dependent |I|, the result is a ‘fronted /u/’, i.e. a kind of ‘central’ rounded vowel. I will return to the interpretation of such structures shortly.

The idea of having different (but related) phonetic interpretations for elements is referred to as the ‘dual interpretation’ of elements (cf. Van der Hulst 1988a). Consider for example (5):

(5) The dual interpretation of |A| and |∀|

	Head	Dependent
A	/a/	‘low (or retracted)’
∀	/ɨ/	‘high’ (or rather ATR; cf. below)

Combinations of |A| and |∀| denote intermediate aperture degrees and correspond to intermediate central vowels, as in (6):

(6)

A	<u>A</u>∀	<u>∀</u>A	∀	
/a/	/ɜ/	/ɘ/	/ɨ/	(central)
	/ʌ/	/ɤ/	/ɯ/	(back unrounded)

In the case of a three-way distinction in aperture there is a choice of IPA symbols, provided we make the (not uncommon) assumption that languages never employ a phonological contrast between central and back unrounded vowels.

---

9 The (implicit) assumption in DP is that the dependent interpretation differs from the head interpretation. One specific interpretation of this idea is offered in Van der Hulst (1988a), where it was proposed that the dependent interpretation of |I| is ATR. This proposal is not adopted in the present model, which is closer to standard DP and to Kaye et al. (1985). More specifically, the C/V coding of elements used here is reminiscent of the ‘charm values’ used by Kaye et al., an idea which was subsequently abandoned in GP. Kaye et al. derive the dual interpretation of elements by interpreting a head as a full matrix of phonetic properties (corresponding to the traditional binary features), while dependents add ‘hot’ features only. This idea, too, was abandoned. For a more detailed discussion of these issues, see Van der Hulst (2012a).

10 For ease of exposition I refer to phonemic entities (hence the use of slant lines), although it is important to bear in mind that IPA symbols represent approximate phonetic values. A notation such as /u/ is shorthand for the corresponding elemental structure, which represents a cognitive phonological entity that plays a contrastive role in a particular language.

All vowels considered so far are 'manner-only' or 'colourless' vowels. Let us therefore now consider the 'colour' elements, viz. |U| and |I|. These have the dual interpretations in (7):

(7) Interpretation of |U| and |I|

	Head	Dependent
U	/u/	'round'
I	/i/	'front'

Adopting the 'autosegmental line-notation' of Kaye et al. (1985) yields the following representations for the four front unrounded vowels (headedness is indicated by means of underlining):

(8)

/æ/	/ɛ/	/e/	/i/
	∀	$\underline{\forall}$	∀
A	$\underline{A}$	A	
I	I	I	I

A convenient 'flat' notation for e.g. /e/ would be {$\underline{\forall}$AI}.[11]

The next question that must be addressed concerns the interpretation of combinations of |U| and |I|. Consider (9), where |U| and |I| are combined with the aperture element |∀|:

(9)

/u/	/ʉ/	/y/	/i/
∀	∀	∀	∀
U	$\underline{U}$	U	I
	I	$\underline{I}$	

Both Anderson & Ewen (1987) and Kaye et al. (1985) stipulate that there is no difference between |$\underline{U}$I| and |U$\underline{I}$|, which both yield a rounded front vowel.[12] However, I assume that these combinations in fact denote two distinct vowels, which are sometimes referred to as 'outrounded' /y/, i.e. a rounded front vowel', and 'inrounded' /ʉ/, a fronted back-round vowel. These vowels are sometimes contrastive, for example in Swedish.

Cross-classifying aperture and colour, and allowing for both colourless and mannerless vowels, yields 25 different vowels, given in (10):

---

[11] Further bracketing could be added for clarity, i.e. {($\underline{\forall}$A)(I)}. This would be required in the corresponding RcvP notation , where {CVC} would be ambiguous between {(CV)(C)} and {(C)(VC)}.

[12] Kaye et al. attempt to derive this using an elegant 'fusion calculus', but this idea was later abandoned (see Kaye 2000).

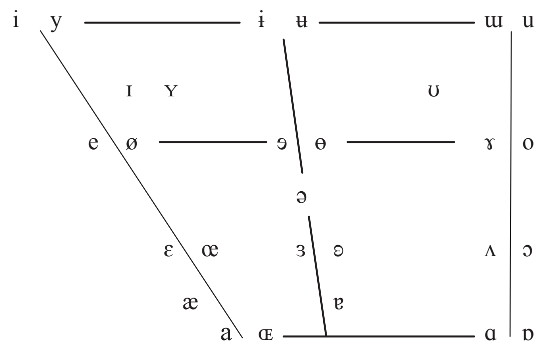
(10)

	I	IU	Colourless	UI	U
∀	i	ʏ	ɨ ~ ɯ	ʉ	u
Mannerless	ɪ	ʏ	ə (~ schwa)		ʊ
∀A	e	ø	ɘ ~ ɤ ~ ɐ	ɵ	o
A∀	ɛ	œ	ɜ ~ ʌ	ɞ	ɔ
A	æ	ɶ	a ~ ɑ		ɒ

Note in (10) that headedness is specified for each gesture separately.

It is interesting to compare the chart in (10) to the IPA chart for vowels, in (11):

(11)



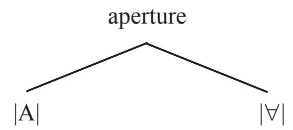
Clearly, the goal of a phonological theory should not be to characterize each and every IPA symbol in terms of a unique element structure. What matters is rather which sound types can occur contrastively in languages. Thus, by lumping different phonetic symbols in one cell, I make the claim that these vowels cannot occur contrastively in any language. Another possible mismatch between the phonology and the IPA is that certain IPA-symbols might correspond to different phonological structures in different languages.

A couple of comments are in order regarding the relation between (10) and (11). First, the IPA chart represents /a/ as front and /æ/ as slightly higher, while in my approach /a/ is analyzed as colourless, with /æ/ being its front counterpart, as in (8). Second, /ə/, i.e. schwa, is represented as a vowel that has neither colour nor aperture. (The symbol /ə/ is sometimes also used to represent the ATR counterpart of the low vowel; I will use the symbol /ɐ/ for this.). As can be seen in (10), schwa is not the only mannerless vowel; in particular, high RTR vowels are also treated as mannerless. This suggests that the presence (vs. the absence) of a head |∀| encodes the ATR distinction among high and low vowels, while among mid vowels this distinction depends on whether ∀ is a head or dependent.

3 The phonetic interpretation of elements

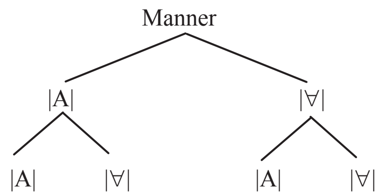
The two elements occupying each gesture are phonological concepts that cover an infinite array of phonetic distinctions within a certain phonetic space. Thus, in the aperture space, |A| groups together an infinite set of aperture degrees, ranging from maximally open to more closed articulations, while |∀| groups articulations ranging from the most close to more open configurations. Somewhere 'in the middle' there is a critical point which divides the two categories, and aperture degrees that straddle this dividing line might be closer to each other than apertures that push the boundaries of a single category. It is well-known from the literature on categorical perception that humans (as well as other animals) have the ability to categorize perceptual spaces into two distinct categories along the lines described here. In this sense we can say that the two elements within each gesture divide a phonetic space into two categories, as in (12):

(12)



If divisions of the perceptual space are recursive, (12) can be further divided as in (13):

(13) a.



b. $\begin{array}{cccc} A & \underline{A} & \underline{\forall} & \underline{\forall} \\ (A) & \forall & A & (\forall) \end{array}$

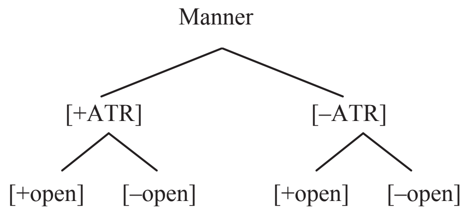
Van der Hulst (2005: 195) shows that (13a) and (13b) can be seen as notational variants of the same idea.[13]

If the phonetic space is construed of as multidimensional, then each split arguably correlates with some fixed phonetic dimension. For example, in the case of vowel manner it could be argued that the manner space results from

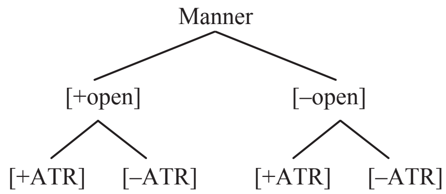
[13] The 'nested subregister model' of Salting (2005) also represents phonological categories in terms of a double split. Salting applies this model to vowel height and place categories, and discusses the parallels between his model and RcvP.

both jaw aperture and from tongue root position. This raises the question whether the phonological representation in (13a) correlates with the phonetic interpretation in (14a) or in (14b):

(14) a.



b.



Work in RcvP has thus far assumed that the aperture division is more 'basic' than the ATR division. Following Dresher (2009), it might be suggested that the choice between these two phonetic interpretations of the double categorical split is language-dependent, however. The potential consequences of this kind of variability are discussed in Van der Hulst (2012a), as are the correlations between RcvP and Dresher's model.

4 Underspecification and intrasegmental phonotactic constraints

4.1 Underspecification

In this section, I consider some of the ways in which vowel structures *could* be represented using a minimal number of elements (or equivalent units) combined with head–dependency relations. In particular, I will argue against the use of underspecification in RcvP representations. This sets the stage for the discussion of vowel harmony in sections 5 and 6, where we will see that underspecified representations are not helpful in accounting for vowel harmony patterns.

Generally speaking, there are two grounds for underspecification. First, predictable specifications can be left out of the structural description of sounds; let us call this 'non-contrastive underspecification'. Second, in any system of opposing units, it is logically possible to replace one member in the opposition by zero, thus replacing a contrast between A and B by A and ∅ (or ∅ and B). Let us call this 'contrastive underspecification' (for this term, see also Steriade 1995). (15) fleshes out both arguments in relation to RcvP.

(15) Grounds for underspecification

a. Non-contrastive underspecification:
   i. Non-distinctive elements need not be specified
   ii. Non-distinctive headedness need not be specified
   iii. Headedness need not be specified if there is only one element in a gesture

b. Contrastive underspecification:
   i. In each gesture, one element can be designated as the default option (and so be left unspecified)
   ii. If headedness among two elements is contrastive, the headedness specification of one of the two combinations can be left unspecified (i.e. the default option)

Note that (15aiii) was assumed in e.g. (6) (cf. also fn. 8). The type of underspecification in (15b) has been called 'radical underspecification' in Archangeli (1984) (see also Kiparsky 1985).[14] The idea of contrastive (or radical) underspecification is perhaps crucial in a traditional binary feature model, where it essentially encodes the monovalency hypothesis of DP and GP. That is, the claim that '–' is the default value of the feature [round], and is thus omitted even when there is a contrast between /i/ and /y/, is a 'weaker' way of saying that roundness is (acting as) monovalent. In a monovalent approach, on the other hand, we could say that contrastive underspecification is directly encoded in the system of phonological primes, rather than a derivational option or a language-specific matter. However, this should not be taken to mean that the 'zero-option' cannot be used in a monovalent system; as was already noted, the zero-option is potentially present in any system of elements (for this issue, see Ewen & Van der Hulst 1986).

Applying contrastive underspecification to RcvP-type representations would mean that the full specification of the contrast between /e/ and /ɛ/ can be reduced (as per (15bii)) to either (16b) or (16c):

(16)

	/e/	/ɛ/	
a.	$\underline{\forall}$A	∀$\underline{\text{A}}$	(full specification)
b.	$\underline{\forall}$A	∀A	
c.	∀A	∀$\underline{\text{A}}$	

[14] There is no connection between this use of the word 'radical' and its use in 'Radical' cv Phonology. Indeed, the issue of non-contrastive or radical underspecification is orthogonal to the basic tenets of RcvP.

As far as the elements themselves are concerned, there is less need for contrastive underspecification in a monovalent approach simply because such approaches use fewer primes. For example, the fact that roundness and backness are encoded by one and the same element obviates the need for redundancy rules which capture the relation between these two properties. However, notice that some elements may be (partially) redundant even in a monovalent system. For example, according to (15ai), the element |∀| can be eliminated in all systems where vowels with either |I| or |U| are non-low; and according to (15aii), systems with a single row of mid vowels would not require a specification of head-dependency relations between |A| and |∀|. Both these situations are illustrated below, in section 4.2.

Despite this, we should not automatically take either type of underspecification as a goal that is worth pursuing. It has been argued that redundant elements (left out based on non-contrastive underspecification) and default elements (left out based on contrastive underspecification) tend to be phonologically inert. This is an interesting hypothesis which needs to be re-examined in the context of a monovalent system like RcvP. However, note that in RcvP there is no need to explain the inertness of '[–back]', '[–round]', '[–low]' and '[–ATR]', since these properties simply do not exist.

Finally, it is worth noting another kind of underspecification, which will play an important role in my discussion of vowel harmony below. This underspecification arises if we specify the common core of alternating vowels only, but leave the alternating part underspecified. Consider for example a suffix vowel that is targeted by root-controlled palatal vowel harmony. In a binary approach, it is common to represent such a vowel as [Øback]. In a unary approach, this kind of underspecification is impossible, as we have seen. Here the vowel in question would simply be represented without the element |I| (the equivalent of [–back]), which amounts to saying that in this type of harmony, it is the back vowel that is basic. Given this, it could be objected that a monovalent approach is unable to represent the contrast between alternating (i.e. [Øback]) and non-alternating (i.e. [–back] or [+back]) vowels. I will return to this issue in section 6, where I argue that this problem is avoided if we make use of the concept of the 'morphophoneme'. Specifically, I will claim that alternating vowels contain the element |I| as a 'variable' element which must be licensed in order to receive a phonetic interpretation. Non-alternating back vowels, on the other hand, simply lack this |I|.

4.2 Intrasegmental constraints

Given the idea of free combination of elements, any actual vowel system represents a subset of the set of possible vowels. This subset can be characterized in terms of a set of constraints (or wellformedness conditions). Constraints are propositions that are true of the system, and they can often be formulated in different but logically equivalent ways (cf. Melis 1976). For example '$\neg$ (A $\wedge$ B)' is logically equivalent to 'A $\rightarrow \neg$ B' or 'B $\rightarrow \neg$ A'. It is important to note here that the use of a negative operator in constraints does not change the system of unary elements into a binary one. This is because the negative operator occurs *in constraints only*, and not in the representation of morphemes. Constraints that are said to be true of the system characterize the set of structures that can be submitted to the phonetic implementation module.

The full specification of a 2-vowel system with just /ɨ/ and /a/ (as has been claimed for Kabardian) is as in (17a); this system is subject to the constraints in (17b):

(17) a. A two-vowel system, fully specified

/ɨ/	/a/
<u>∀</u>	
	<u>A</u>

b. Constraints for a 2-vowel system

Aperture:	i.	¬∅	("cannot be empty")
	ii.	¬(A ∧ ∀)	("no mid vowels")
Colour:	∅		("I and U do not occur")

As per (15aiii) this means that headedness specifications could be omitted:

(18) A two-vowel system, underspecified as per (15aiii)

/ɨ/	/a/
∀	
	A

Headedness information can then be 'restored' if we assume the following principle:

(19) A sole element in a gesture is the head of that gesture.

Also, as per (15bi), one of the two elements can be omitted, with the omitted element being the default option:

(20) A two-vowel system, underspecified as per (15aiii) and (15bi)

/ɨ/ /a/
∀

In RcvP, the element |A| would be the most likely default manner element for vowels, given the fundamental principle in (21):[15]

(21) In a syllabic C-position, the C-element is default; in a syllabic V-position, the V-element is default.

As was already mentioned in section 1, this follows from a universal redundancy rule, given in (22):

(22) The unmarked dependent is identical in terms of C/V labeling.

From this, it follows that for rhymal heads the unmarked aperture element is |A| (i.e. [Manner: V]).[16] To 'restore' the element |A|, we can rely on a default rule which follows automatically from the principle that an element that is filled in must be the opposite of the specified element.[17] In the case at hand:

(23) In the syllabic 'nucleus' (= V) position, the unmarked aperture is |A| (= V).

Let us now turn to more complex vowel systems. Consider first the 3-vowel system in (24):

(24) A 3-vowel system, fully specified

/i/	/u/	/a/
<u>∀</u>	<u>∀</u>	
		<u>A</u>
<u>I</u>		
	<u>U</u>	

This system is subject to the following constraints.

[15] In RcvP, the C/V notation is also applied at the syllable level. Thus the 'onset' is a C unit and the 'rhyme' is a V unit; see Van der Hulst (2005, 2012a).

[16] An idea that could be worth exploring is that in certain specific cases |∀| rather than |A| is left out; this would then trigger a default rule filling in |∀|. Here I leave open the question of whether such 'markedness reversal' (as it is called in radical underspecification theory) is necessary.

[17] In radical underspecification theory this is called a 'complement rule' (Archangeli 1984).

(25) Constraints (for a three-vowel system)[18]

a.	Aperture:	i.	$\neg\varnothing$	("cannot be empty")
		ii.	$\neg(A \wedge \forall)$	("no mid vowels")
b.	Colour:		$\neg(I \wedge U)$	("|I| and |U| do not combine")[19]
c.	Cross-gestural:		$I \vee U \leftrightarrow \forall$	("|∀| and colour must co-occur")

In order to determine the relevant constraints, we must determine which possible vowels (of the full set of options in (10)) are missing, and how these can be ruled out on the basis of predictable or impossible element combinations.

(26) A 3-vowel system, underspecified as per (15aiii)

/i/	/u/	/a/
		A
I		
	U	

We can further leave out either one colour element or the aperture element for /a/:

(27) a. A 3-vowel system, underspecified as per (15aiii, bi), with default |U|

/i/	/u/	/a/
		A
I		

b. A 3-vowel system, underspecified as per (15aiii, bi), with default |I|

/i/	/u/	/a/
		A
	U	

RcvP predicts that (27a), where the default for colour is |U|, is the preferred option, given that |U| is a V-type element (see (3)). In Radical Underspecification Theory (Archangeli 1984), it has been argued that it is /i/ that is more likely to be unspecified, as in (27b). Finally, Van der Hulst (2012a) suggests that (27a) is more likely to occur in prominent (i.e. accented) positions and (27b) in non-prominent ones. This is tantamount to

---

[18] From (25aii) and (25c) it follows that |A| does not occur with colour elements.

[19] Kaye et al. (1985) suggest that certain combinations of elements can be excluded using 'line conflation'. However, given that constraints are needed anyway, there seems to be no need to use a different mechanism for |I| and |U|.

saying that epenthetic vowels are non-optimal vowels: speakers do not use the ‘best’, i.e. the most sonorous, vowels in such non-prominent contexts.[20]

A third possibility in a 3-vowel system is to leave /a/ unspecified, as in (28):

(28) A three vowel system, underspecified as per (15aiii, bi), with default |A|

/i/	/u/	/a/
	U	
I		

Future work should explore the question of whether these options correlate with different phonological behaviours of /i/, /u/ and /a/ in different languages.

In Van der Hulst (2012a) I discuss vowel systems of increasing complexity, the results of which, for reasons of space, cannot be discussed here in full. As was mentioned, it is in fact unclear whether underspecified representations play any other role than saving storage space. Of primary importance are the constraints that characterize a specific vowel system as a subset of the set of all possible vowel structures. These constraints need to be stated. However, it is possible that impoverished representations have an explanatory role to play, for example when it could be shown that redundant information plays no role in the phonology of languages. I refer to both Clements (2002) and Dresher (2009) for discussion of this issue. Meanwhile, I will assume that there seems no harm in representing phonological structure in the most minimal fashion.

It is important to point out that impoverished structures should be mapped onto full representations *monotonically*, i.e. by adding rather than by deleting information. Given this, no separate rules are required to fill in the underspecified structures, since for each impoverished structure there will be only one unique fully specified structure that is compatible with that structure and the constraints. Notice in this respect that the constraints as such do not act as filling-up rules. The fact that some constraints take the form of implicational statements does not make them rules, since a statement like $A \rightarrow B$ is logically equivalent to $\neg(A \wedge \neg B)$.

[20] This suggests that languages may use different vowel inventories in accented and non-accented positions. This option is explored in Van der Hulst (2012a).

5 Contrastive head marking

Some versions of GP, e.g. Walker (1995), suggest that ATR distinctions can be made in terms of what I will call 'contrastive headedness'. The idea is that a combination of elements can be contrastively headed or non-headed, with the former adding a phonetic specification that corresponds to [ATR] (or its acoustic result). In this type of approach, a 10-vowel system can be represented as in (29). (Notice that GP does not distinguish between an aperture and colour gesture.)

(29) A 10-vowel system with ATR

/i/	/u/	/ɪ/	/ʊ/	/e/	/o/	/ɛ/	/ɔ/	/ɐ/	/a/
				A	A	A	A	<u>A</u>	A
<u>I</u>		I		<u>I</u>		I			
	<u>U</u>		U		<u>U</u>		U		

In this view, ATR-harmony involves the requirement that all vowels in the domain are either headed (ATR) or non-headed (non-ATR).

In the model proposed here, a 10-vowel system would be represented as follows:

(30) A 10-vowel system, fully specified[21]

/i/	/u/	/ɪ/	/ʊ/	/e/	/o/	/ɛ/	/ɔ/	/ɐ/	/a/
<u>∀</u>	<u>∀</u>			<u>∀</u>	<u>∀</u>	∀	∀	<u>∀</u>	
				A	A	<u>A</u>	<u>A</u>	A	<u>A</u>
<u>I</u>		<u>I</u>		<u>I</u>		<u>I</u>			
	<u>U</u>		<u>U</u>		<u>U</u>		<u>U</u>		

This system is subject to the constraints in (31):

(31) Constraints

a. Aperture: –

b. Colour: ¬(I ∧ U) ("|I| and |U| do not combine")

c. Cross-gestural: i. (I v U) ∧ A → ∀
ii. ¬(I v U) ∧ A → <u>∀</u>

The minimally specified version of (30) is given in (32):

[21] Recall that in RcvP headedness is specified for each gesture.

(32) A 10-vowel system, minimally specified

/i/	/u/	/ɪ/	/ʊ/	/e/	/o/	/ɛ/	/ɔ/	/ɐ/	/a/
∀	∀			$\underline{\forall}$	$\underline{\forall}$	∀	∀	$\underline{\forall}$	
				A	A	$\underline{\text{A}}$	$\underline{\text{A}}$	A	A
I		I		I		I			
	U		U		U		U		

The difference is that that the headed structures in (29) correspond exactly to the structures in (30) and (32) which have the element |∀| as a head. In order to see this, we must consult the fully specified structures.[22] I prefer my approach over that proposed in GP because the presence of |∀| as the antagonist of |A| better fits the overall architecture of RcvP, where each gesture has two elements. This argument, then, follows the logic of 'structural analogy' (cf. Anderson 1992, 2006). In addition, the use of contrastive head-marking undermines a central principle of DP, namely that all structures are headed.[23] I conclude, therefore, that contrastive headedness is in conflict with the fundamental architecture of RcvP.

6 Vowel harmony

Assuming the four primitives |I, U, A, ∀|, let us now consider the issue of vowel harmony. With four elements, four types of vowel harmony are predicted:

(33) Vowel Harmony types

Palatal harmony involves |I|
Labial harmony involves |U|
ATR harmony involves |∀|
Lowering harmony involves |A|

[22] This brings out the important point that phonological 'processes' need access to information that could be left unspecified in the most minimal representation. I will leave open the question of whether this applies to all information that can be left out. For example, it has been claimed, in e.g. Dresher (2009), that only contrastive elements (features, in other frameworks) can be phonologically active.

[23] I also reject Anderson and Ewen's option of 'mutual dependency' (or 'double-headedness'), which I believe also loosens the system, and is, in a sense, comparable to the use of 'non-headedness' (i.e. absence of head-marking) in GP.

In this paper I will focus briefly on palatal harmony in Finnish as a showcase for how RcvP can account for the behaviour of non-alternating vowels (which usually lack a harmonic counterpart).

6.1 The vowel harmony relation

How should vowel harmony be represented? In a unary system, it is impossible to say that vowel harmony is the result of 'needy', i.e. underspecified, vowels (cf. Nevins 2010), since there is no underspecification to express this 'neediness'. Nevertheless, the idea of 'neediness' is similar in spirit to the GP approach, where 'emptiness' (more specifically, empty nuclei) requires licensing (cf. Kaye et al. 1990). I suggest that a vowel which undergoes harmony possesses the harmonizing element as a *variable element*, i.e. as an element which can be present only if it is licensed by a non-variable, i.e. licensed, occurrence of that same element.[24] Thus, alternating vowels contain the harmonic element as a 'variable'; variable elements will be represented between parentheses.[25] Segmental structures that contain a variable element will be called 'morphophonemes'. For example in Finnish, all vowels that are front (in stems) or *can* be front (in suffixes) are represented as morphophonemes:

(34)	/u/ ~ /y/	{U(I)}
	/o/ ~ /ø /	{AU(I)}
	/a/ ~ /æ/	{A(I)}

While a complete theory of licensing remains to be developed (see Van der Hulst 2012b), for the purpose of this article it suffices to say that variable elements can be licensed in two ways:

(35) a. Positional licensing

A variable element X is licensed in position P (where P is the first/last syllable in domain D, where D is a Word or Stem/Root).

b. Lateral licensing

A variable element X is licensed by a preceding/following occurrence of X.

[24] Scheer (2004) argues on independent grounds that vowel-zero alternations require the specification of the alternating element as 'variable', particularly in cases where zero alternates with two types of vowels, e.g. in Polish yer-alternations.

[25] This notation can in fact be interpreted as a form of underspecification, as in Declarative Phonology, where (x) denotes "either x or nothing" (see e.g. Scobbie et al. 1996).

At this point it is important to make a distinction between the notions of morphophoneme and archiphoneme. Archiphonemes express the idea of underspecification while morphophonemes capture the idea of the lexical listing of alternants, a notion that was revived in Hudson (1974) and Hooper (1976). An archiphoneme can be used in cases where there is neutralization of contrast (which corresponds to non-contrastive underspecification). For Trubetzkoy, a typical example was final devoicing, where the contrast between, say, /d/ and /t/ is contextually neutralized, yielding an archisegment /T/ which has all the properties that /d/ and /t/ have in common. If we extend this concept to those cases in which the neutralization is context-free, we could say that neutral vowels are archisegments. In the neutral vowels of Finnish, for example, the variable element (I) *can* be left unspecified. However, as I will show, neutral vowels are more appropriately viewed as containing the variable element *at all times*, because they actually participate in the harmony process.

6.2. Palatal harmony in Finnish

Finnish has the following vowel inventory:

(36)

[–back]		[+back]		
[–round]	[+round]	[–round]	[+round]	
/i/	/y/	–	/u/	[+high,–low]
/e/	/ø/	–	/o/	[–high,–low]
/æ/	–	/a/	–	[–high,+low]

Each vowel occurs as short and long. The four traditional features constitute the minimal set that is needed to express the relevant contrasts in the Finnish vowel system. In RcvP, the fully specified unary representation of the Finnish vowel system is as follows:

(37) The Finnish vowel system, fully specified

/i/	/y/	/u/	/e/	/ø/	/o/	/æ/	/a/
$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$		
			A	A	A	$\underline{A}$	$\underline{A}$
$\underline{I}$	$\underline{I}$	$\underline{I}$	$\underline{I}$	$\underline{I}$	$\underline{I}$	$\underline{I}$	
	U	U		U	U		

This system is subject to the following constraints:

(31) Constraints on the Finnish vowel system

a. Aperture: $\neg\varnothing$
$A \rightarrow \underline{\forall}$

b. Colour: $I \rightarrow \underline{I}$

c. Cross-gestural: i. $\neg A \rightarrow \forall$
ii. $\forall \rightarrow (I \vee U)$

Since Finnish has palatal harmony, |I| is represented as being variable (barring certain exceptions which are discussed below). This means that we have the following set of morphophonemes:

(39) Finnish morphophonemes (preliminary)

/i/	/y~u/	/e/	/ø~o/	/æ~a/
$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	
		A	A	$\underline{A}$
($\underline{I}$)	($\underline{I}$)	($\underline{I}$)	($\underline{I}$)	($\underline{I}$)
	U		U	

The shorthand notation for morphophonemes is /x~y/. This raises the question to what extent the non-low non-round front vowels are morphophonemes. If 'x' and 'y' represent the two possible structures for each morphophoneme, then (39) should actually be replaced by (40):

(40) Finnish morphophonemes (revised)

/i~ɨ/	/y~u/	/e~ɘ/	/ø~o/	/æ~a/
$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	
		A	A	$\underline{A}$
($\underline{I}$)	($\underline{I}$)	($\underline{I}$)	($\underline{I}$)	($\underline{I}$)
	U		U	

After all, if the variable |I| is not licensed for the first and third morphophoneme, then it will not be there, in which case the first morphophoneme would contain $\underline{\forall}$ only. At the risk of releasing the 'abstractness genie' I will accept that, phonologically speaking, Finnish never lost the back counterparts of /i/ and /e/, viz. /ɨ/ and /ɘ/. This means that the constraint in (38c) is not in fact valid. The surface reality of Finnish is that /i/ and /ɨ/ are mapped onto the same phonetic event, and likewise for /e/ and /ɘ/.

Let us consider some straightforward examples (taken from Kiparsky 1981 and Ringen & Heinämäki 1999), which I will first describe in the way that is customary in the vowel harmony literature:

(41)	a.	Front words		b.	Back words
		vækkæræ	'pinwheel'	makkara	'sausage'
		pöytæ	'table'	pouta	'fine weather'
		kæyræ	'curve'	kaura	'oats'
		tyhmæ	'stupid'	tuhma	'naughty'

Suffixes have front and back alternants depending on the quality of the stem:

(42) a. tyhmæ-stæ 'stupid-ILL' b. tuhma-sta 'naughty-ILL'

One of the most interesting aspects of the Finnish harmony system is the presence of two 'neutral vowels' /i/ and /e/. The data in (43) show that these vowels occur with both front and back harmonic vowels:

(43)	a.	Front words		b.	Back words
		værttinæ	'spinning wheel'	palttina	'linen cloth'
		isæ	'father'	iso	'big'
		kesy	'tame'	verho	'curtain'

Interestingly, if the neutral vowel is preceded by a back vowel, the suffix alternant is back. This suggests that neutral vowels in Finnish are transparent, since they act as though they are invisible to the harmony process:

(44) a. Front words

værttinæ-llæ-ni-hæn	'with spinning wheel, as you know'
lyø-dæ-kse-ni-kø	'for me to hit'

b. Back words

palttina-lla-ni-han	'with linen cloth, as you know'
lyo-da-kse-ni-ko	'for me to create'
tuoli-lla	'on the chair'

As the example *tuoli-lla* shows, neutral vowels do not condition front alternants, even when they are the last vowel of the stem. Notice also that suffix alternants are not always determined by the first vowel of the stem, as is evidenced by disharmonic stems of the type in (45):

(45)	afææri - æ	'business-PART'
	tyranni - ko	'tyran'

Here it is clearly the last non-neutral stem-vowel which determines the suffix alternant.

Consider next the forms in (46), which show that roots containing neutral vowels only take front suffixes.

(46)	velje-llæ	'brother-ADESS'
	tie-llæ	'road-ADESS'

Let us see how we can account for these standard facts in RcvP. Adopting the representations in (40), all vowels in front roots and all suffix vowels contain the variable element (I). In roots, this (I) is licensed in the first syllable (indicated in boldface); this element in turn licenses each subsequent occurrence of (I), including those in suffixes (as is indicated by '>'):[26]

(47) a. tyh mæ - stæ 'stupid-ILL'
(**I**) > (I) > (I)

b. tuhma - sta 'naughty-ILL'
(I)

Note that in roots containing back vowels only, nothing happens. In such roots, agreement between vowels results from the complete absence of the harmonic element. The suffix that is added to a back vowel root will find its variable element unlicensed; as a result, this suffix will also be back.

If a neutral vowel occurs in a back vowel root, it will, like all other vowels in that root, lack the variable element. Effectively, we do not have /i/ or /e/, but /ɨ/ or /ɘ/ in those roots. However, if the neutral vowel occurs in a front vowel root it does contain the variable element. Turning now to suffixes, I will argue that here the variable element is *always* present, even when the suffix contains a so-called neutral vowel. The latter part of this proposal is perhaps the most controversial. (The first part may be empirically wrong if there are suffixes that are invariantly back, which is at least a theoretical possibility.) But why insist that the so-called neutral vowels in suffixes always contain the variable element? The reason for this claim is that only by making this assumption can we maintain that the licensing relation is strictly local (i.e. cannot skip vowels). Consider the two following forms (cf. also (44)):

(48) a. værttinæ - llæ - ni - hæn 'with spinning wheel, as you know'
(**I**)>(I)>(I)>(I)>(I)>(I)

b. palttina - lla-ni-han 'with linen cloth, as you know'
(I)(I) (I)

In (48a) we have a front vowel root. The variable element in the initial vowel is positionally licensed; each of the subsequent vowels is laterally licensed by

[26] It could be suggested that all occurrences of |I| within roots are licensed, instead of attributing the licensing of non-initial syllables to licensed |I|'s in preceding syllables. Nevins (2010) discusses some facts from Turkish which suggest that within roots only the first vowel is specified for the harmonic feature and that subsequent vowels acquire their feature through copying. This suggests that a distinction must be made between positional initial licensing and lateral licensing.

the licensed |I| of the immediately preceding vowel. Clearly, if we were to specify [i] without |I|, as in (49), licensing would not be local:

(49) vært ti næ - llæ-ni-hæn ‘with spinning wheel, as you know’
(I)>>>>(I) > (I)>>>(I)

If licensing is not local we cannot explain the phenomenon of opacity; I will discuss this below.

In (48b), suffix vowels will be back because their variable element cannot be licensed. Of course, in the case of /ɨ/ phonetic interpretation will realize this structure as [i].

It is important to note that the term ‘transparent’ is a complete misnomer in this analysis. A so-called neutral vowel that is preceded by a back vowel is not transparent to anything, since there is no ‘backness’ that ‘spreads’ through it; a neutral vowel that is preceded by a front vowel, on the other hand, passes on the ‘frontness’ itself.

As we have seen, front vowel roots that contain neutral vowels only, as in (46), always take front suffixes. This is shown in (50) for the form [tiellæ]:

(50) ti e - llæ ‘road-ADESS’
(I) > (I) > (I)

How can we account for this? Given what has been proposed thus far it does not follow that roots with phonetic [i] and [e] must be phonologically front. In fact, if we consider Hungarian (whose vowel harmony system is very similar to that of Finnish), we observe that here a subclass of the so-called ‘neutral vowel roots’ take back suffixes (cf. Törkenczy 2011, who refers to these roots as ‘anti-harmonic’):

(51) a. víz-nek ‘water-DAT’ b. híd - nak ‘bridge-DAT’
(I) >(I) (I)

Why does Finnish lack anti-harmonic roots? And why, for that matter, is the class of anti-harmonic roots in Hungarian a fairly small, closed set of roots? To explain these patterns, we must again refer to an old principle, viz. the Naturalness Condition of Postal (1968), which I here interpret as a condition which bears on the relationship between phonological structures and phonetic events, rather than on two *phonological* levels:[27]

(52) Naturalness Condition
Every phonological object has a unique phonetic interpretation.

[27] Indeed, the model proposed here does not recognize more than one phonological level. It attributes phenomena such as phonetic merger to the phonetic interpretation module, rather than to phonological rules that create derived phonological levels.

We can regard this condition as a guideline for the language learner, i.e. “assume that each phonetic event has a unique phonological representation”. Since roots in Finnish and Hungarian do not alternate, the learner will be biased to assume that the phonetically front vowels have a unique and invariable phonological representation in which the frontness corresponds to a phonological element, namely |I|. However, we must assume that the Natural Condition is a guideline only. If we interpret the phonetic merger of two vowels as a historical development, then it is apparently not the case that the phonology must follow suit.

Let us next consider the representation of Hungarian ‘disharmonic’ roots. Here the key insight is that vowels are disharmonic either by virtue of containing a *non*-variable element or by lacking a variable element altogether. Thus, using the examples in (53), the disharmonic sequences /o-y/ and /y-o/ would be represented as follows (note that /y/ is reflected as <ü> in Hungarian orthography).

(53) a. k o szt y m - n ek

A A
U U
I > (I) (A non-variable instance of |I| in /y/)

b. b y r o - n ak

A
U U
(I) (I) (Absence of variable (I) in /o/)

In (53a) we expect a following harmonic suffix vowel to be front, since the invariable |I| will license the variable |I| in the suffix vowel. I will refer to invariable elements as being ‘lexically licensed’. In section 7, I will account for the observation that the invariant /o/ in (53b) behaves as opaque. It should be clear at this point that this is because licensing relations are strictly local; this means that the |I| element in the first vowel of the stem in (53b) cannot license the variable element in the suffix.[28]

[28] An important question is how suffixes that fail to alternate should be represented. If such suffixes invariably contained a back vowel, they would lack the variable element; and if they contain a non-variable (i.e. lexically licensed) element, they would be invariably front. My impression is that the former case is more widely attested, which might mean that lexical licensing is limited to (or is more common for) roots. This issue needs further exploration.

7 Predicting the behaviour of neutral vowels

7.1 The Van der Hulst & Smith (1986) theory

The question arises whether the behaviour of so-called neutral vowels, which can be either transparent or opaque, can be predicted.[29] Van der Hulst & Smith (1986) argue that it can, and I maintain that their proposal is still valid. Van der Hulst & Smith's theory can be summarized as in (54) (see also Van der Hulst 1988):[30]

(54) Opacity and Transparency

a. A vowel that is *incompatible* with the harmonic element is *opaque*

b. A vowel that is *compatible* with the harmonic element is *transparent*

The great advantage of this theory is that it is eminently simple. We have seen that (54b) applies to Finnish, where /i/ and /e/ are clearly compatible with the harmonic element since they contain it. (Van der Hulst & Smith used the term 'compatible' because they assumed that neutral vowels are underspecified for the harmonic element; I have shown in this paper that this is not desirable because it undermines a strictly local conception of licensing.)

Let us next consider a case of opacity, as is illustrated by ATR harmony in Tangale (see Van der Hulst & Van de Weijer 1995). This language has a 9-vowel system of the type in (55):

(55) The Tangale vowel system, fully specified

/i/	/u/	/ɪ/	/ʊ/	/e/	/o/	/ɛ/	/ɔ/	/a/
$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	$\underline{\forall}$	$\forall$	$\forall$	
				A	A	$\underline{A}$	$\underline{A}$	$\underline{A}$
$\underline{I}$		$\underline{I}$		$\underline{I}$		I		
	$\underline{U}$		$\underline{U}$		$\underline{U}$		U	

The Tangale system is subject to the constraints in (56):

[29] For general discussion on neutral (or non-participating) vowels, see Van der Hulst & Van de Weijer (1995), Krämer (2003) and Archangeli & Pulleyblank (1994, 2007).

[30] Krämer (2003) raises a number of valid objections against Van der Hulst & Smith's theory, which the current formalization pre-empts; see Van der Hulst (2012b) for discussion.

(56) Constraints on the Tangale vowel system

a.	Aperture:	–	
b.	Colour:	¬(I ∧ U)	"|I| and |U| do not combine"
c.	Cross-gestural:	i. ∀ → (I v U) ii. (I v U) ∧ A → ∀	"no central vowel except /a/"

To account for the harmony, the following morphophonemes must be postulated:

(57)

/i~ɪ/	/u~ ʊ/	/e~ɛ/	/o~ ɔ/	/a/
(∀)	(∀)	(∀)	(∀)	
		A	A	A
I		I		
	U		U	

Against this background, consider next a sequence consisting of a neutral low vowel that is preceded by an ATR vowel:

(58)

/u/	/a/	/e/
($\underline{\forall}$)		$\underline{\forall}$
	A	A
		I
U		

Here an explanation is required for the observation that the initial |∀|, which is positionally licensed, cannot itself license an |∀| in the suffix vowel. Van der Hulst & Smith accounted for this in terms of a restriction on spreading, arguing that since the low vowel cannot be linked to ATR (on account of the language lacking low ATR vowels), it cannot also be linked to the suffix, as this would result in discontinuous spreading. That is, spreading of the harmonic element must be local, and so cannot skip vowels. This 'spreading metaphor' (cf. Anderson 1980) has not been adopted in the present analysis; rather, the fact that the initial, licensed |∀| cannot license the variable |∀| in the suffix across the /a/ is attributed to the condition that licensing relations must be local, i.e. hold between adjacent syllable heads.

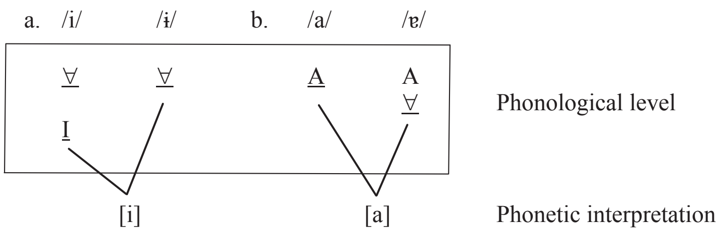
It is now clear why, in the present analysis, neutral vowels of the type found in Finnish *must* contain the variable element when they occur in front vowel roots and in suffixes, rather than be underspecified for it. Recall that if /i/ and /e/ were underspecified for |I|, then we would have to assume that a preceding front vowel can license a following suffix vowel *across* an intervening /i/ or /e/ (see (49)). In such an approach, licensing is not a strictly local phenomenon. But to account for Tangale-type opacity, on the other hand, licensing *must* be regarded as local, as we have just seen.

A further comment is in order regarding the licensing of the element |∀|. In an ATR system, [–ATR] mid vowels contain |∀| as a dependent.

(59) /ɛ/ /ɛ/
∀ (∀̲)

Clearly, the dependent |∀| cannot license a variable occurrence of the same element in a suffix: a dependent element cannot license a head element. This can be interpreted as an instance of a head–dependent asymmetry in the sense of Dresher & Van der Hulst (1998). The question of whether the reverse is possible (i.e. a head element licensing a dependent element) remains to be established.

The astute reader will have detected a potential problem for the claim that the present model predicts that in an ATR system low retracted vowels *must* be opaque. A system in which such low vowels act transparently can be derived if we say that in such a case the low vowels would actually be low vowels with the variable element |∀̲|, on the assumption that the phonetic interpretation can simply leave an element uninterpreted. In other words, if the phonetic interpretation can produce (60a), why can it not also produce (60b)?

(60)


Van der Hulst & Smith did not face this problem. The reason for this is that they had in fact not released the 'abstractness genie', so that for them (60a) was not necessary. For reasons provided earlier, I now believe that the abstractness genie must come out of the bottle. This means that the present model must account for the opacity of the low vowel in Tangale in a different fashion. My suggestion is that (60b) is excluded because of the following interface condition:

(61) Naturalness Condition (revised)
Every licensed phonological object has a unique phonetic interpretation.

The principle in (61) states that while not every property of a phonetic event is rooted in phonology (although this can still be the null hypothesis), phonetics cannot freely *ignore* phonological elements. That a phonological object can 'understate' phonetics is of course hardly controversial (there are many properties in the phonetic signal that are not phonologically relevant). The revised Naturalness Condition puts a limit on abstractness, and thus keeps the abstractness genie in check. It effectively disallows the *diacritic specification* of phonological elements, allowing (60a) but barring (60b). From the learner's perspective this means that we cannot postulate an element for which there is no phonetic evidence (as in 60b), while we can fail to postulate an element for which the phonetics suggests that it should be present in the phonology (as in 60a). In other words, the phonetic interpretation can 'add', but not 'delete' (or 'ignore'). Needless to say, the hypothesis embodied in (61) needs further testing. As it stands, it explains the asymmetry that we find in vowel harmony systems, viz. that neutralization towards the harmonic element leads to 'transparency' (in the case of Finnish front vowels) while neutralization away from the harmonic element leads to opacity (as in Tangale).

It is perhaps useful to point out why Van der Hulst & Smith did not release the abstractness genie in their analysis of ATR harmony, and why, in Finnish palatal harmony, they did not posit underlying back vowels in those cases where surface front vowels fail to impose their frontness on following vowels.[31] In such cases, Van der Hulst & Smith assumed that /i/ and /e/ are underspecified for the element |I|, which is then filled in before phonetic interpretation. However, this approach must stipulate that in *initial* syllables /i/'s *are* apparently fully specified, in order to account for the fact that roots consisting of neutral vowels condition front vowel suffixes only. If this were universally true, then we could attribute this to the requirement that vowels in stressed syllables vowels be fully specified (Finnish has initial stress). But, as we have seen, it is not universally true that front vowel roots take front suffixes. In Hungarian we have a set of roots that take back suffixes (see (51)). This means that for those roots we would have to stipulate that the element |I| is not specified in the stressed syllable, which effectively means that we have a contrast between /i/ and /ɨ/ after all, thus unleashing the abstractness genie.

7.2 An alternative to transparency

Demirdache (1988) and Ritter (1995) propose a different account of transparency, which makes use of the head or dependent status of an element.

---

[31] I have been skeptical of this kind of abstractness ever after reading Kiparsky (1968), even though he considers the kind of use made of it here rather well motivated. Discussion with David Michaels has made me more receptive to abstractness, however.

For Finnish or Hungarian they propose that |I| in neutral vowels is a head element, while in other cases it is a dependent. I will refer to this use of headedness as 'diacritic headmarking', since headedness here is used to explain phonological behaviour rather than phonetic properties:[32]

(62)	/i/	/y/	/u/	/e/	/ø/	/o/	/ø/	/a/
				A	A	A	$\underline{\text{A}}$	A
	$\underline{\text{I}}$	I		$\underline{\text{I}}$	I		I	
		$\underline{\text{U}}$	U		$\underline{\text{U}}$	$\underline{\text{U}}$		

Representing the neutral vowels as in (62) allows the generalization that vowels with a head |I| do not trigger palatal harmony. To account for the fact that /i/ and /e/ in neutral vowel roots do trigger harmony of suffix vowels, it must be stipulated that non-initial /i/ and /e/ are not |I|-headed.

Demirdache also discusses the fact that Finnish /y/ and /ö/ are optionally transparent, as has been claimed in Campbell (1980). According to Demirdache, this is possible because in these vowels |I| *can* be specified as the head. Indeed, since GP argues that differences in headedness of |I| and |U| never result in phonemic contrasts (see section 2), headedness of |I| can be used diacritically to encode a difference in behaviour. Notice, too, that this approach predicts that /æ/ cannot be transparent, since marking |I| as head would neutralize the contrast between /æ/ and /e/. The data in Campbell suggest that this prediction is borne out.[33]

How can the alleged transparency of /ø/ and /y/ be accounted for in the present analysis? At first sight, it seems reasonable to suggest that front vowels in disharmonic roots can be represented with a variable rather than an invariable (I), as in (63):

(63)	a.	m	a rt	tyy	ri	-a
			$\underline{\text{A}}$			$\underline{\text{A}}$
				U		
				($\underline{\text{I}}$)	($\underline{\text{I}}$)	($\underline{\text{I}}$)
	b.	m	a rt	tyy	ri	-æ
			$\underline{\text{A}}$			A
				U		
				$\underline{\text{I}}$>>($\underline{\text{I}}$)>>		($\underline{\text{I}}$)

However, this account fails because in (63a) /y/'s variable (I) remains unlicensed, so that the structure would be interpreted as [u] rather than [y]. It would seem that in this case we cannot simply say that the frontness is added

[32] Notice that diacritic headmarking is similar to contrastive head-marking (as discussed in section 5). The crucial difference is that the former has no phonetic correlates but is a purely diacritic device.

[33] Nevins (2010: 177) attributes this to the low vowel being a "sonority hurdle".

by the phonetic interpretation, because structures containing {∀̲ U} are interpreted as [u] in other cases. We do not want to assume that phonetic interpretation is 'erratic'. It would seem, therefore, that in the present approach there is no way in which the non-harmonic behaviour of /y/ and /ø/ can be accounted for. The non-harmonic behaviour of these vowels would seem to be due to the fact that the words in question fail the harmony system altogether.

7.3 Unexpected behaviour of neutral vowels

Van der Hulst (1988b) examines a variety of cases in which vowels that are incompatible with the harmonic element appear to be transparent, as well as cases in which vowels that are compatible with the harmonic element fail to be transparent. Here I discuss briefly how such cases can be handled in the present approach.

Given locality of licensing, we expect that one specific situation should not be able to occur, viz. a Tangale-type case in which the low vowel is transparent. For a while it was believed that this was the case in Kinande (see Schlindwein 1987). However, it has subsequently been shown that the low vowel does in fact undergo ATR harmony (see Gick et al. 2006; Kenstowicz 2008). Hence, there is no constraint against a low ATR vowel in this language.

The most interesting challenge to Van der Hulst & Smith's approach to opacity comes from Mongolian rounding harmony, in which /u/ and /ʊ/ do not act as harmonic triggers, whereas /i/ is skipped (cf. Van der Hulst & Smith 1988).[34] Both facts are seemingly at odds with Van der Hulst & Smith's approach. The Mongolian vowel system is given in (64):

(64)	i	u
		ʊ
	e	o
	a	ɔ

If rounding harmony is triggered exclusively by /o, ɔ/, and targets low vowel suffixes only, then we may conclude that it is dependent on both licensor and licensee having the element |A|. This is also the reason why /i/ can be skipped, and /u/ and /ʊ/ are opaque. In Van der Hulst & Smith's approach, the explanation for this pattern would involve establishing a licensing relation between low vowels for the element |U|. An intervening non-low vowel that

[34] Mongolian also has ATR harmony, which is ignored here.

lacks |U|, viz. /i/, does not block this licensing relation, but a non-low rounded vowel (i.e. /u/ or /ʊ/) does. This is illustrated in (65):

(65) a. m ɔ r i -tɔ i ‘horse-COMP’

A A
(U)>>>(U)
I I

b. ɔr ʊː l aːd ‘enter-CAUS-PERF’

A A
(U) U (U)

The only solution that seems possible here would be to take Steriade’s (1981) notion of ‘parasitic harmony’ literally, and to assume that the licensing relation in (65) is *relative* to the |A|-tier. This would mean that the relation in (65a) is local, in that it holds between two adjacent |A| elements; the intervening /i/ is simply invisible. In (65b), on the other hand, the licensing relation between the initial |U| and the |U| in the suffix is blocked on account of an intervening |U| specification, which blocks the licensing relation. Notice also that there is no licensing relation between this intervening |U| and the variable |U| in the suffix, since these do not share an |A| element.[35]

On a final note, Paul Kiparsky (p.c.) suggests that there are Finno-Ugric languages where neutral /i/ and /e/ consistently impose frontness on a following suffix vowel, even when they are preceded by a back vowel. The present model does not exclude this possibility; it can be accounted for by assuming that such neutral vowels contain an invariant rather than a variable instance of |I|. This issue is discussed in more detail in Van der Hulst (2012b).

8 Conclusion

The RcvP model proposed in this article is minimal in the sense that it uses a set of just four monovalent elements (and dependency), and does not require any form of underspecification. Vowel harmony is accounted for in terms of a licensing relation between elements. Variable elements propagate the harmony if they are licensed; if they are not, they remain ‘mute’, i.e. phonetically uninterpreted. The behaviour of neutral vowels as either transparent or opaque falls out naturally from the fact that licensing relations

[35] Other cases of this sort are reported in Li (1996); I suspect that these can be analyzed in a similar fashion (see Van der Hulst 2012b).

are local. The present paper has sketched the general outline of this approach, which originates in joint work with Norval Smith; it is examined in more detail, and applied to a more extensive set of empirical data in Van der Hulst (2012b).

References

Anderson, Stephen R. (1974): *The Organization of Phonology*. – New York: Academic Press.

Aronoff, Mark (1994): *Morphology by Itself: Stems and Inflectional Classes*. – Cambridge, MA: MIT Press.

Anderson, John M. (1992): *Linguistic Representation: Structural Analogy and Stratification*. – Berlin: Mouton de Gruyter.

Anderson, John M. & Colin J. Ewen (1987): *Principles of Dependency Phonology*. – Cambridge: Cambridge University Press.

Anderson, John M. & Jacques Durand (1988): “Vowel harmony and non-specification in Nez Perce.” – In: Hulst, Harry van der & Norval S.H. Smith (eds.): *Features, Segmental Structure and Harmony Processes*. Vol. 2, 1–18. Dordrecht: Foris.

Anderson, John M. (2006): “Structural analogy and universal grammar.” – In: Bemúdez-Otero, Ricardo & Patrick Honeybone (eds.): *Phonology and Syntax – The Same or Different*? *Lingua* 116, 601–633.

Anderson, Stephen R. (1980): “Problems and perspectives in the description of vowel harmony.” – In: Vago, Robert M. (ed.): *Issues in Vowel Harmony*, 1–48. Amsterdam: John Benjamins.

Archangeli, Diana (1984): *Underspecification in Yawelmani Phonology and Morphology*. – PhD dissertation. Cambridge, MA: MIT.

Archangeli, Diana & Douglas Pulleyblank (1994): *Grounded Phonology*. – Cambridge, MA: MIT Press.

– (2007): “Harmony.” – In: de Lacy, Paul (ed.): *The Cambridge Handbook of Phonology*. 353–378. Cambridge: Cambridge University Press.

Backley, Phillip & Toyomi Takahashi (1996): “Activate α: harmony without spreading.” – In: *UCL Working Papers in Linguistics* 8, 487–518.

Botma, Bert (2004): *Phonological Aspects of Nasality: An Element-based Dependency Approach*. – PhD dissertation, University of Amsterdam. Utrecht: LOT Publications.

Campbell, Lyle (1980): “The psychological and sociological reality of Finnish vowel harmony.” – In: Vago, Robert M. (ed.): *Issues in Vowel Harmony*, 245-70. Amsterdam: John Benjamins.

Clements, George N. (1985): “The geometry of phonological features.” – *Phonology Yearbook* 2, 225–252.

– (1991): “Place of articulation in consonants and vowels: a unified theory.” – In: *Working Papers of the Cornell Phonetics Laboratory* 5, 37–76. Ithaka, NY: Cornell University.

Demirdache, Hamida (1988): “Transparent vowels.” – In: Hulst, Harry van der & Norval S.H. Smith (eds.): *Features, Segmental Structure and Harmony Processes*. Vol. 2, 39–76. Dordrecht: Foris Publications.

Dienes, Peter (1997): “Hungarian neutral vowels.” – In: *The Odd Yearbook 1997*, 151–180.

Dresher, B. Elan (2009): *The Contrastive Hierarchy in Phonology*. – Cambridge: Cambridge University Press.

Dresher, B. Elan & Harry van der Hulst (1998): “Head–dependency in phonology: complexity and visibility.” – In: *Phonology* 15, 317–52.

Ewen, Colin J. & Harry van der Hulst (1986): “Single-valued features and the nonlinear analysis of vowel harmony.” – In: Bennis, Hans & Frits Beukema (eds.): *Linguistics in the Netherlands 1985*, 39–48. Dordrecht: Foris Publications.

Gick, Bryan, Douglas Pulleyblank, Fiona Campbell & Ngessimo Mutaka (2006): “Low vowels and transparency in Kinande vowel harmony.” – *Phonology* 23, 1–20.

Goldsmith, John (1976): *Autosegmental Phonology*. PhD dissertation, MIT.

Halle, Morris & Kenneth N. Stevens (1971): “A note on laryngeal features.” – In: *Quarterly Progress Report* 101, 198–213. Research Laboratory of Electronics, MIT.

Hooper, Joan B. (1976): *Introduction to Natural Generative Phonology*. – New York: Academic Press.

Hudson, Grover M. (1974): “The representation of non-productive alternations.” – In: Anderson, John M. & Charles Jones (eds.): *Proceedings of the First International Conference on Historical Linguistics*. Vol. 2, 203–229. Amsterdam: North-Holland.

Hulst, Harry van der (1988a): “The dual interpretation of |i|, |u| and |a|.” – In: *NELS* 18, 208–222.

– (1988b): “The geometry of vocalic features.” – In: Hulst, Harry van der & Norval S.H. Smith (eds.): *Features, Segmental Structure and Harmony Processes*. Dordrecht: Foris. 77-126.

– (2005): “The molecular structure of phonological segments.” – In: Carr, Philip, Jacques Durand & Colin J. Ewen (eds.): *Headhood, Elements, Specification and Contrastivity*, 193–234. Amsterdam/Philadelphia: John Benjamins.

– (2012a): “An outline of Radical cv Phonology.” – Ms., University of Connecticut.

– (2012b): “Asymmetries in vowel harmony.” – Ms., University of Connecticut.

Hulst, Harry van der & Norval S.H. Smith (1986): “On neutral vowels.” – In: Bogers, Koen, Harry van der Hulst & Maarten Mous (eds.): *The Phonological Representation of Suprasegmentals*, 233–279. Dordrecht: Foris.

Hulst, Harry van der & Norval S.H. Smith. (1988): “Tungusic and Mongolian vowel harmony: a minimal pair.” – In: Coopmans, Peter & Aafke Hulk (eds.): *Linguistics in the Netherlands 1988*, 79–88. Dordrecht: Foris.

Hulst, Harry van der & Jeroen M. van de Weijer (1995): “Vowel harmony.” – In: Goldsmith, John (ed.): *The Handbook of Phonological Theory*, 495–534. Oxford: Blackwell.

Jakobson, Roman, Gunnar M. Fant & Morris Halle (1952): *Preliminaries to Speech Analysis*: *The Distinctive Features and their Correlates* (2^{nd} edn.). – Cambridge, MA: MIT Press.

Ka, Omar (1994): *Wolof Phonology and Morphology*. – Lanham, MD: University Press of America.

Kaye, Jonathan (2000): “A user’s guide to Government Phonology (GP).” – Ms., University of Ulster.

Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud (1985): “The internal structure of phonological elements: a theory of charm and government.” – In: *Phonological Yearbook* 2, 305–328.

– (1990): “Constituent structure and government in phonology.” – In: *Phonology* 7, 193–232.

Kenstowicz, Michael (2008): “Two notes on Kinande vowel harmony.” – Paper presented at the annual meeting of the Linguistic Society of America, Chicago.

Kiparsky, Paul (1981): “Vowel harmony.” – Ms., MIT.

– (1985): “Some Consequences of Lexical Phonology.” – In: *Phonology Yearbook* 2, 83–138.

Krämer, Martin (2003): *Vowel Harmony and Correspondence Theory*. – Berlin: Mouton de Gruyter.

Li, Bing (1996): *Tungusic Vowel Harmony: Description and Analysis*. – PhD disseration, University of Amsterdam. The Hague: Holland Academic Graphics.

Melis, Ed. (1976): “Fonologische verschijnselen in onderlinge samenhang: een hypothese.” – In: Koefoed, Geert & Arnold Evers (eds.): *Lijnen van Taaltheoretisch Onderzoek*, 367–380. Groningen: H.D. Tjeenk Willink.

Nevins, Andrew (2010): *Locality in Vowel Harmony*. – Cambridge, MA: MIT Press

Postal, Paul (1968): *Aspects of Phonological Theory*. – New York: Harper and Row.

Pulleyblank, Douglas (1996): “Neutral vowels in Optimality Theory: A comparison of Yoruba and Wolof.” – In: *Canadian Journal of Linguistics* 41, 295–347.

Ringen, Catherine & Orvokki Heinämäki (1999): “Variation in Finnish vowel harmony: An OT account.” – In: *Natural Language and Linguistic Theory* 17, 303–337.

Ritter, Nancy A. (1999): “The effect of intrasegmental licensing conditions on elemental spreading.” – In: Hannahs, S.J. & Michael Davenport (eds.): *Issues in Phonological Structure*. Amsterdam: John Benjamins. 55–74.

Ritter, Nancy A. (1995): *The Role of Universal Grammar in Phonology: A Government Phonology Approach to Hungarian.* – PhD dissertation, New York University.

Sagey, Elizabeth (1986): *The Representation of Features and Relations in Nonlinear Phonology*. – PhD dissertation, MIT.

Salting, Don (2005): “The geometry of harmony.” – In: Oostendorp, Marc van & Jeroen M. van de Weijer (eds.): *The Internal Organization of Phonological Segments*. Berlin: Mouton de Gruyter. 93–120.

Schane, Sanford (1984): “The fundamentals of particle phonology.” – In: *Phonological Yearbook* 1, 129–55.

Scheer, Tobias (2004): *A Lateral Theory of Phonology*. – Berlin/New York: Mouton de Gruyter.

Schlindwein, Deborah (1987): "P-bearing units: a study of Kinande vowel harmony." – In: McDonough, Joyce & Bernadette Plunkett (eds.): *Proceedings of NELS 17*, 551–567. Amherst, MA: University of Massachusetts, GLSA.

Scobbie, James M., John S. Coleman & Steven Bird (1996): "Key aspects of Declarative Phonology." – In: Durand, Jacques & Bernard Laks (eds.): *Current Trends in Phonology: Models and Methods*. Vol. 2, 685–710. ESRI/Manchester: University of Salford.

Smith, Norval S.H. (2000): "Dependency Phonology meets OT: a proposal for a new approach to segmental structure." – In: Dekkers, Joost, F. van der Leeuw & Jeroen M. van de Weijer (eds.): *Optimality Theory: Phonology, Syntax, and Acquisition*, 234–276. Oxford: Oxford University Press.

Steriade, Donca (1981): "Parameters of metrical harmony rules." – Ms., MIT.

– (1995): "Underspecification and markedness." – In: Goldsmith, John (ed.): *The Handbook of Phonological Theory*, 114–174. Cambridge, MA: Blackwell.

Stevens, Kenneth N. & Samuel J. Keyser (1989): "Primary features and their enhancement in consonants." – *Language* 65, 81–106.

Törkenczy, Miklós (2011): "Hungarian vowel harmony." – In: Oostendorp, Marc van, Colin J. Ewen & Keren D. Rice (eds.): *The Blackwell Companion to Phonology* (Vol. 5), 2963–2990. Malden, MA/Oxford: Wiley-Blackwell.

Trubetzkoy, Nikolaj S. (1939[1977]): *Grundzüge der Phonologie* (6th edn.). – Göttingen: Vandenhoeck and Ruprecht.

Walker, Caitlin (1995): "ATR-harmony as H-Licensing." – In: *SOAS Working Papers in Linguistics and Phonetics* 5, 107–120.