

Features and Recursive Structure*

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Abstract

Based on the cross-linguistic tendency that weak vowels are realized with a central quality such as ə, i, or u, this paper attempts to account for this choice by proposing that the nucleus itself is one of the three monovalent vowel elements |A|, |I| and |U| which function as the building blocks of melodic structure. I claim that individual languages make a parametric choice to determine which of the three elements functions as the head of a nuclear expression. In addition, I show that elements can be freely concatenated to create melodic compounds. The resulting phonetic value of an element compound is determined by the specific elements it contains and by the head-dependency relations between those elements. This concatenation-based recursive mechanism of melodic structure can also be extended to levels above the segment, thus ultimately eliminating the need for syllabic constituents. This approach reinterprets the notion of minimalism in phonology by opposing the string-based flat structure.

1. Introduction

In theories of phonological representation which employ elements as melodic primes and licensing/government as a device for controlling dependency relations between phonological units (Kaye, Lowenstamm and Vergnaud 1990; Kaye 1990, 1992; Harris 1990, 1994, 1997; Charette 1991; Scheer 2004 and others), not only features (or elements) but also the syllable nucleus is phonetically interpretable. A nucleus may be phonetically realized when it is melodically empty — that is, if it has no features. An empty nucleus is silent when the appropriate conditions are met (e.g. when it is prosodically licensed as a result of being properly governed: Kaye 1990, Harris 1994), but otherwise it must be phonetically realized. A nucleus without any melodic material is typically pronounced as a central vowel of some kind, the precise quality of which is determined on a language-specific basis (Harris 1994: 109). In English, for example, this vowel is a mid central vowel ə (schwa), in Yoruba and Cilungu i and in Japanese u. According to this approach, these vowels are seen as providing an acoustic baseline onto which melodic primes are superimposed. Cross-linguistically, this baseline tends to have a central quality such as ə, i, or u.

It is generally assumed that the choice of central vowel is parametrically controlled, and thus varies between languages in an unpredictable way. So far, no attempt has been made to explain why these vowels (rather than non-central vowels, for example) serve as the realization of a featureless nucleus.

This paper attempts to account for this parametric choice in a non-arbitrary way by proposing that the nucleus itself is one of the three vowel elements |A|, |I| and |U|. These elements belong to a small set of monovalent, independently interpretable primes which function as the building blocks of melodic

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structure. It is proposed that, for a given language, one of these vowel elements determines the quality of the ‘featureless’ nucleus: in its acoustically weak form, |A| is phonetically realized as ə in English, |I| as i in Cilungu and |U| as u in Japanese. Accordingly, I claim that |A|, |I| and |U| are the head of a nuclear expression in English, Cilungu and Japanese, respectively. This helps to explain why the central vowel is always one of only three possibilities, rather than five or six.

In addition, this paper shows that elements can be freely concatenated to create melodic compounds. Take, for example, an expression which combines |I| and |A|. If it is labeled as one belonging to the |A| set then it is phonetically interpreted as the mid front vowel e , whereas if it belongs to the |I| set it has the interpretation ɛ . (Note that in this approach the mapping relations between structural headedness and its phonetic interpretation are the reverse of those conventionally used in other versions of ET. This point will be discussed in section 2.) Furthermore, these sets can be dominated by another set of the same kind: the set in which |A|(|I||A|) is dominated by |A|(|I||A|) is interpreted as a long vowel ee . The phonetic value of an element compound (phrase) is thus determined by the specific elements it contains and also the head-dependency relations (labeling) between those elements.

In this paper, I extend this concatenation-based mechanism of melodic structure to levels above the segment. In so doing, I will show that this approach ultimately eliminates the need for constituents such as segment, onset, nucleus, rhyme, syllable, and foot, all of which are generally assumed to be required below the intra-morphemic level. This leads to the proposal that elements, and not prosodic constituents, are the only variables of structural operations. This approach reinterprets the notion of minimalism in phonology by opposing the string-based flat structure pursued by Scheer (2004), Neeleman and van de Koot (2006), Samuels (2009) and others. Furthermore, within the framework developed by Hauser, Chomsky and Fitch (2002), the application of this recursive type of element-based structure at the intra-morphemic level suggests that phonology may belong in FLN rather than FLB, if it is maintained that the existence of recursive structure is a prerequisite for being placed in FLN.¹

The structure of this paper is as follows. In section 2, I introduce the phonological features employed in this paper and discuss the existence of recursive structure in intra-morphemic phonological structure. Then in section 3 I motivate the need for empty nuclei, and explain how they are phonetically interpreted in the frameworks of Dependency/Government Phonology and Element Theory. I continue in section 4 by arguing that the nucleus itself is one of the three vowel elements |A|, |I| and |U|, then in section 5 show the need for recursion in intra-morphemic phonology using an Element-based model of concatenation. Some concluding remarks are given in section 6.

2. Monovalent features: elements

A version of Element-based feature theory developed by Nasukawa (2012) regards features as the units which play a central role in building phonological structure. In this model, unlike Distinctive Feature Theory, but like most recent models based on Element Theory (Backley 2011), phonological features (called elements) are monovalent and therefore express privative oppositions. Each one is also fully interpretable on its own, and as such, does not require any support from other elements. This implies that there is neither template-like feature organization nor any universally-fixed matrix of features.

Like most types of features, elements are strictly phonological in nature and are viewed as mental or internal objects since they emerge through the observation of phonological phenomena and form the basis of lexical contrasts. As discussed in Harris and Lindsey (2000) and Backley (2011), element-based theories reject the speaker-oriented (production-based) view in favor of an alternative perspective in

¹Based on the Structural Analogy hypothesis, van der Hulst (2010) also assumes that recursion exists at intra-morphemic levels of phonological organization such as syllable and foot in the framework of Dependency/Government Phonology. He interprets codas as ‘syllables within syllables’ ($(V_{\text{syllable}}[C_{\text{onset}} V_{\text{rhyme}}[V V_{\text{coda}}[C_{\text{onset}} V\emptyset]])$) where the rhymal complement (V_{coda}) in the syllable (V_{syllable}) contains $C_{\text{onset}}+V\emptyset$ (= the syllable consisting of $C + V$), $V\emptyset$ being featureless. He also interprets feet as ‘syllables containing syllables’ ($(V_{\text{syl-ft}}[V_{\text{thy}} V_{\text{thy}}])$).

which features refer to attributes of the acoustic signal: that is, the phonetic exponence of elements stands in the hearer-oriented (perception-based) view in line with work of Jakobson (Jakobson, Fant and Halle 1952, Jakobson and Halle 1956). Support for the perception-based approach is firstly attributed to language acquisition, in which speech perception is an indispensable stage on the acquisition path: it is generally assumed that infants begin to build mental representations for their native lexicon primarily on the basis of perceiving adult inputs. Furthermore the hearer-oriented approach to features is able to capture important phonological generalizations that cannot be expressed by employing articulatory features, such as the close association between labials and velars: they are linked in acoustic terms by a similar ‘dark’ spectral pattern (cf. the feature [grave] in labials and velars which indicates a concentration of acoustic energy at the lower end of the spectrum, as discussed in Jakobson and Halle (1956)).²

In an element-based theory which adopts a perception-based view of the phonetic exponence of primes (Backley 2011), melodic structure is described by using the six monovalent elements [A I U ? H N], which are assumed to be active in all natural languages. The elements are listed below, along with their principal phonetic properties.

(1)	<i>Elements</i>		
	<i>label</i>	<i>manifestation as a consonant</i>	<i>manifestation as a vowel</i>
	[A] ‘mass’	uvular, pharyngeal POA	non-high vowels
	[I] ‘dip’	dental, palatal POA	front vowels
	[U] ‘rump’	labial, velar POA ³	rounded vowels
	[?] ‘edge’	oral or glottal occlusion	creaky voice (laryngealized vowels)
	[H] ‘noise’	aspiration, voicelessness	high tone
	[N] ‘murmur’	nasality, obstruent voicing	nasality, low tone

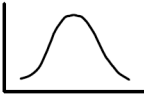

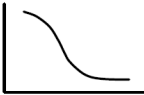
The first three elements [A I U] are often grouped together as so-called resonance elements; they are typically associated with vocalicness and prosodic phenomena such as pitch and intonational patterns. The remaining three elements [? H N] are relevant to non-resonance phenomena such as occlusion, aperiodicity and laryngeal-source effects. In traditional terms, [A I U] tend to be associated with vocalic characteristics and [? H N] with consonantal characteristics. Only the vocalic group [A I U] is directly relevant to the following discussion.

The terms shown in quotation marks on the right of the elements in (2) are the names of their acoustic patterns found in their phonetic exponences. As examples, the spectral shapes and schematic filter response curves of *a*, *i* and *u*, which are phonetic manifestations of [A], [I] and [U] respectively, are illustrated below.

²For a comprehensive summary of how Element Theory and Jakobsonian ideas are related, see Krämer (2012).

³The close association between labials and velars is highlighted by, for example, the historical relatedness between labial and velar Cs in Germanic languages and in Japanese, the dialectal variation involving labial and velar Cs in Swedish, the assimilation between velar and labial fricatives in Finnish, and the tendency for labialization to target velars rather than coronals. For a detailed discussion, see Backley and Nasukawa (2009).

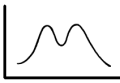
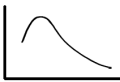
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(2)	<i>Typical acoustic exponence of elements</i> (Harris 2005: 126, cf. Harris and Lindsey 2000)		
	<i>Elements</i>	<i>Spectral shapes</i>	<i>Schematic filter response</i> (y-axis=amplitude, x-axis=frequency)
	a. A ‘mass’:	mass of energy located in the center of the vowel spectrum, with troughs at top and bottom	
	b. I ‘dip’:	energy distributed to the top and bottom of the vowel spectrum, with a trough in between	
	c. U ‘rump’:	marked skewing of energy to the lower half of the vowel spectrum	

Regarding the pattern ‘mass’ in (2a), there exists a concentration of energy (the convergence of F1 and F2) in the center of the spectrum relevant to vowel quality, with troughs at the top and bottom. With respect to the spectral pattern ‘dip’ in (2b), it shows energy which is distributed both to the top (the convergence of F2 and F3) and the bottom (the convergence of F0 and F1) of the vowel spectrum, with a trough in between. As for the ‘rump’ pattern in (2c), it exhibits a marked skewing of energy to the lower half of the vowel spectrum (the convergence of F1 and F2).

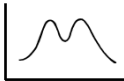
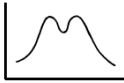
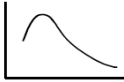
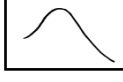
Spectral patterns similar to those above are also observed in consonants, typically glides. As discussed in Backley (2011: 65-67), for example, the ‘dip’ pattern (and a high F2) is identified in palatals (typically the palatal glide *j*) and coronals, and the ‘rump’ pattern in labials (typically the labial glide *w*) and velars (cf. Jakobson, Fant and Halle 1952). Accordingly, as shown in (1), the ‘dip’-class unites front vowels, palatals and coronals while the ‘rump’-class unites rounded vowels, labials and velars. In other words, with respect to both consonant and vowel segments, all ‘dip’-class segments contain |I| while |U| is involved in all ‘rump’-class segments.

The simplex spectral patterns for the corner vowels *a*, *i*, *u* may combine with each other, resulting in complex spectral patterns. For example, the front mid vowel *e* is a combination of the ‘mass’ and ‘dip’ patterns: as illustrated in (3a), there is an energy gap between F1 and F2 although it is closer than in the ‘dip’ profile, and there is also a concentration of energy in the central region although there is a slight energy gap between F1 and F2 which is not found in the ‘mass’ pattern. The back mid vowel *o*, on the other hand, is viewed as a combination of the ‘mass’ and ‘rump’ patterns: (3b) exhibits a marked skewing of energy towards the lower end of the vowel spectrum even though the peak energy is found at a point above the bottom of the vowel spectrum, which allows us to identify a trough-like shape as found in the ‘mass’ pattern.

(3)	<i>Typical acoustic exponence of elements</i> (Harris 2005: 126, cf. Harris and Lindsey 2000)		
	<i>Elements</i>	<i>Complex spectral shapes</i>	<i>Schematic filter response</i> (y-axis=amplitude, x-axis=frequency)
	a. <i>e</i> A and I :	‘mass’ + ‘dip’	
	b. <i>o</i> A and U :	‘mass’ + ‘rump’	

The simplex elements |A|, |I|, |U| and the complex expressions |A I| and |A U| are employed in five-vowel systems which typically contain only two mid vowels (*e* and *o*).⁴ When the element-based theory is used to represent languages which, for example, have more than two contrastive mid vowels, it calls upon an asymmetric relation between features. The asymmetry can be observed in relations between the spectral profiles of the two components. Examples include the pairs *e-ε* and *o-ɔ* in Italian. As seen in (4a), the energy gap between F1 and F2 in *e* is wider than that in *ε* (4b), which implies that the ‘dip’ pattern is stronger or more prominent than the ‘mass’ pattern in *ε*. The same relation between melodic components is identified in the spectral profile of *ɔ* in (4b): the ‘mass’ pattern is stronger or more prominent than the ‘rump’ pattern, in comparison with *o* in (4c).

(4) *Typical acoustic exponence of elements* (Harris 2005: 126, cf. Harris and Lindsey 2000)

	<i>Elements</i>	<i>Complex spectral shapes</i>	<i>Schematic filter response</i> (y-axis=amplitude, x-axis=frequency)
a.	<i>e</i> A and I :	‘mass’ > ‘dip’	
b.	<i>ε</i> A and I :	‘mass’ < ‘dip’	
c.	<i>o</i> A and U :	‘mass’ > ‘rump’	
d.	<i>ɔ</i> A and U :	‘mass’ < ‘rump’	

The asymmetry relations observed between the spectral profiles of the two elements in (4) is often considered to be a reflection of *head-dependency* relations between the categories. Since the first appearance of the triangular (A I U) model of vowel representation in Anderson and Jones (1974), it has been assumed that phonetic prominence corresponds to structural headedness and phonetic recessiveness to non-headedness or dependent status. Under this assumption, the literature (Anderson and Ewen 1987, Harris 1994, Backley 2011, *et passim*) has claimed that the contrast between two mid vowels such as *e-ε* be accounted for as follows (head elements are underlined).

- (5) *The traditional view of the mapping between head-dependency and prominence-recessiveness relations: the case of |A| and |I|*
- a. *e*: |A, I| |I| is a head, so its acoustic properties display greater prominence than those of |A| and make a greater contribution to the phonetic quality of the resulting vocalic expression.
 - b. *ε*: |A, I| |A| is a head, so its acoustic properties display greater prominence than those of |I| and make a greater contribution to the phonetic quality of the resulting vocalic expression.

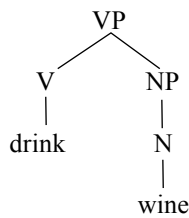
⁴Combining |I| with |U| is typologically marked, which may be attributed to the preference for combining units which belong to different classes. In ET, |I| and |U| naturally form a class of ‘colour’ or ‘timbre’ elements (Schane 1984, 1995); this excludes the |A| element, which by itself constitutes the ‘aperture’ class. Combining either |I| and |A| or |U| and |A| is therefore preferred over combining |I| and |U|. The ET literature has attempted to depict this by employing a representational operation called |I|-|U|-tier conflation (Harris 1994: 100–102) or by referring to a co-occurrence restriction*|I U| (Nasukawa, Forthcoming).

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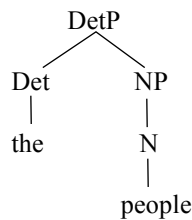
The idea that headedness and phonetic prominence are closely connected has widespread acceptance, yet it has rarely been discussed explicitly in the literature. It has been simply attributed to the common assumption that the basic and structurally necessary unit *head* must be mapped onto a prominent/strong part of the overall phonetic quality of a vocalic expression. Given that (i) heads are necessary (important) for building or maintaining well-formed structure and (ii) prominence is an additional piece of linguistic content which contributes to (prosodically- and melodically-defined) lexical contrast, constituent heads in phonology are important in both structural and content terms.

By contrast, constituent heads in morpho-syntax display the opposite tendency to the one just described for phonology. Heads in morpho-syntax, like those in phonology, have an important structural role because they support dependent structure. But on the other hand, their content role is unlike that of phonological heads because they are relatively unimportant in the sense that they usually bear less linguistic (e.g. lexical) content than dependents. In terms of structural roles, for example, heads in morpho-syntax are structurally necessary whereas complements are usually optional. And the properties of a head project up to the next structural level whereas those of a complement do not. In terms of linguistic content, however, this consistency falters when we compare heads and complements in morpho-syntax with those in phonology. Heads in syntax (e.g. verbs, determiners) are often weak or recessive, in that their content is predictable or of low content value. For instance, in *I drank wine* the verb *drank* is partly predictable from its complement *wine*, while in the determiner phrase *the people* the determiner *the* carries no lexical content at all.

(6) a. ‘drink coffee’



b. ‘the garden’

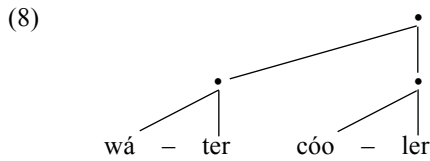


By contrast, as already noted, heads in phonology have inherent strength or prominence, and in addition, tend to be rich in content, e.g. the head of a foot may be stressed, or otherwise, may support a wide range of segmental contrasts. The mismatch between heads/dependents in phonology and morpho-syntax is summarised below.

(7)	<i>Phonology</i>	<i>Morpho-syntax</i>
a. <i>Heads</i>	structure-building, content-rich	structure-building, content-poor
b. <i>Dependents</i>	non-structure-building, content-poor	non-structure-building, content-rich

Yet most scholars would feel that a mismatch such as this goes against current linguistic thinking, which strongly favors generalisations over idiosyncrasies – even across different modules of the grammar. On this basis, Nasukawa and Backley (2014, Forthcoming) attempt to see heads displaying similar characteristics in both syntax and phonology; likewise dependents should share similar properties across the grammar as a whole. They then describe a way of achieving a greater degree of uniformity between phonology and syntax by redefining the roles of heads and dependents in phonological structure. They claim that phonological structure be re-interpreted so that, to achieve a parallel with syntax, head

categories are naturally weak (and linguistically impoverished) whereas complements are strong (and linguistically rich). So in the word *water* ['wɔ:tə], for example, the traditional left-headed (trochaic) structure is recast as right-headed (iambic), consisting of a complement *wa-* ['wɔ:] and a head *-ter* [tə]. As a head, [tə] is segmentally weak with a reduced vowel [ə] and an unaspirated/weakened stop [t]/[r]. Yet it is structurally strong, sanctioning a complement *wa-* and projecting to the next level, as in (8).



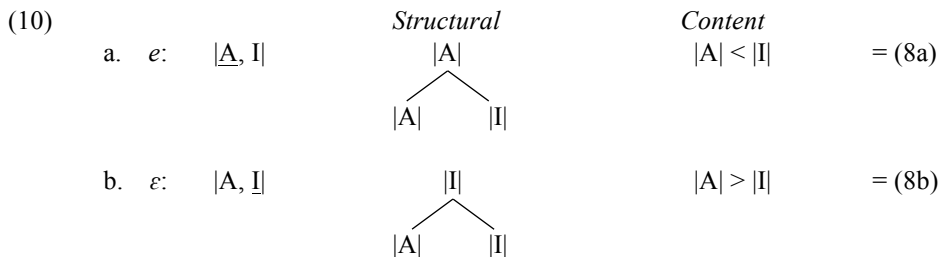
In contrast, the complement *wa-* ['wɔ:] is segmentally rich (lexical stress, full vowel) but structurally recessive. The complement ['ku:] in *cooler* ['ku:lə] receives a similar analysis (i.e. stress, full vowel, aspirated stop). Nasukawa and Backley (2014, Forthcoming) propose the generalisation that heads in phonology are, like those in morpho-syntax, necessary for structural well-formedness but relatively unimportant in terms of the linguistic (e.g. lexical) content they support.

Across different modules of the grammar, they claim that heads assume a primarily structural role whereas the main function of dependents is to express linguistic content; dependents are optional, in the sense that they are not necessary for building or maintaining well-formed structure. In effect, the presence of an optional dependent introduces additional complexity into a structure, for which we can expect some kind of trade-off. The ‘compensation’ for this added complexity, they suggest, comes in the form of additional linguistic content, either segmental or prosodic.

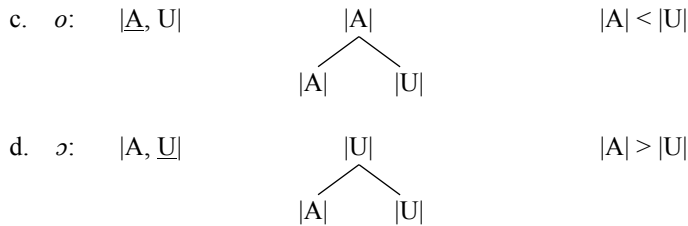
The present paper extends this view to segment-internal structure by assuming that, even in segment-internal structure, heads are important for structure-building but are content-poor, whereas dependents are unimportant for structure-building but are content-rich. Given this, it is argued that the contrast between the two mid vowels *e* and *ɛ* be captured as follows.

- (9)
- a. *e*: |A, I| |I| is a dependent which is content-rich and is acoustically mapped onto its greater salience in the overall phonetic quality of the resulting vocalic expression. On the other hand, the head element |A| plays an important role in structure-building but is impoverished in terms of content.
 - b. *ɛ*: |A, I| |A| is a head which is content-rich and is acoustically mapped onto its greater salience in the overall phonetic quality of the resulting vocalic expression. On the other hand, the head element |I| plays an important role in structure-building but is impoverished in terms of content.

The same applies to the contrast between *o* and *ɔ*, the former being |A|-headed (10c) and the latter |U|-headed (10d).



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As (10) shows, head-dependency relations traditionally shown in Government Phonology and Element Theory by the presence or absence of underlining can be reinterpreted as tree diagrams of the sort used to represent syllable/prosodic and morpho-syntactic structure, where heads are represented as the node labels (in traditional terms, heads are said to be projected to the next level of structure). As a result, head-dependent relations are integral to various grammatical modules (e.g. syntax and phonology) and sub-modules (suprasegmental and segment-internal structures). Crucially, at these different grammatical levels the main characteristics of heads and complements are fairly consistent.

Below it will be argued that it is the elements |A I U|, rather than syllable nuclei, which are structurally basic and which play a central role in building phonological structure.

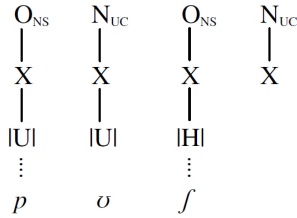
3. Empty nucleus and epenthetic vowels

3.1 *The phonetic realization of empty nucleus*

In theories of phonological representation which employ elements as melodic primes and licensing/government as a device for controlling dependency relations between phonological units (Kaye, Lowenstamm and Vergnaud 1990; Kaye 1990, 1992; Harris 1990, 1994, 1997; Charette 1991; Scheer 2004 and others), not only features (or elements) but also the nucleus is phonetically interpretable. This is attributed to the theoretical mechanism that allows a nucleus to be melodically empty: a nucleus can stand alone even if it has no features. The nucleus is phonetically silent when the appropriate condition is met (e.g. when it is prosodically licensed by being properly governed: Kaye 1990, Harris 1994). Otherwise, it must be phonetically realized. Normally a nucleus without any melodic material manifests itself phonetically as the language-specific central vowel of the system in question (Harris 1994: 109). In English, for example, this vowel is a mid central vowel ə (schwa), in Yoruba and Cilungu *i*, and in Japanese *u*. In the theory, these vowels are considered to be a baseline onto which melodic primes are superimposed.

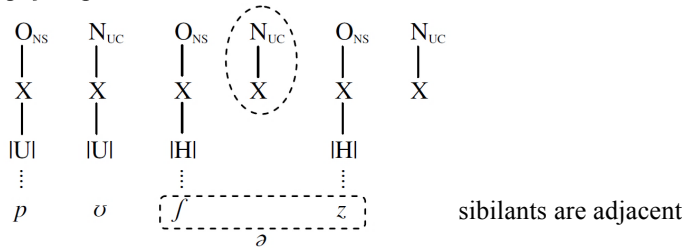
A typical context where a melodically empty nucleus is allowed to appear is domain-final position. In the theories employing elements and the notions of licensing and government, the minimal prosodic domain is the onset-nucleus (CV) sequence, which means that morphemes never end with a non-nuclear position (C): morphemes are universally assumed to end with a nucleus (V). In English, for example, the representation of the word *puʃ* ‘push’ contains an empty nucleus word-finally, as in (11).

(11) *puʃ* ‘push’



The final empty nucleus remains silent in accordance with the positive setting of the final-empty-nucleus parameter (Harris 1994: 162, cf. Kaye 1995) in English. When this word undergoes regular plural formation, the suffix *-z* <-(e)s> is added to the end of the word. Since this produces an impossible sequence of sibilants *fz*, it is traditionally assumed that the epenthesis of a vowel breaks up the sequence in accordance with the OCP, which bans two successive sibilants. The epenthetic vowel is typically *ə* (sometimes *i*, depending on the accent). In the element-based framework, the epenthetic vowel is considered to be the phonetic realization of an empty nucleus which is flanked by two sibilants. Under this account, *ə* is not inserted: its phonological shape (empty nucleus) is already part of the lexical structure.)

(12) *puʃəz* ‘pushes’



Another example which refers to empty nucleus is found in the literature on unstressed vowel reduction. A typical example is stress-shift in a set of English words that are etymologically related.

- (13) a. *ˈfəʊtəɡrɑːf* ‘photograph’
fəˈtɒɡrəfi ‘photography’
 b. *ˈætəm* ‘atom’
əˈtɒmɪk ‘atomic’

As shown in (13), full vowels appear when stressed while a weak vowel schwa appears when unstressed (c.f. contextually sometimes *i*: see Backley 2011: 50–53). In Harris (1994, 2005), the appearance of *ə* is the phonetic manifestation of an empty nucleus where lexically-specified elements are all suppressed in unstressed weak positions. He also claims that not only in English, but also in other stress-accented languages that exhibit centripetal unstressed vowel reduction, the *ə*-appearance in weak positions is regarded as a result of total element suppression.

3.2 Epenthetic vowels in loanwords

A type of vowel epenthesis used to break up illicit sequences in the nativization of loanwords can also reveal something about the phonetic quality of empty nuclei. In fact the quality of an epenthetic vowel in loanwords differs from language to language. Uffmann (2007) argues that the quality of an epenthetic

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vowel is determined by complex rules involving the interaction of processes such as (i) the insertion of default vowels (features) (default quality), (ii) the copying of features from neighbouring vowels (vowel harmony) and (iii) the copying of features from adjacent consonants (consonant-vowel assimilation). Limiting the present discussion to (i), Lee (2008) argues that languages typically exhibit one of the vowels *ə*, *i*, *ɪ*, *u*, the choice being determined by the status of these vowels in the vowel system in question. The chosen epenthetic vowel is typically the most central vowel in the system: for example, *ə* in English and Thai, *i* in Yoruba and Fijian, *ɪ* in Korean and *u* in Japanese.

Some examples of default epenthetic vowels are given below. In the case of English, epenthetic *ə* is inserted before word-initial NC sequences, which are impossible in English, when NC is word-initial in the relevant loanword, as shown below.

(14) *Borrowings with initial NC* (Nasukawa 2013)

<p>a. <i>ə</i> as an epenthetic vowel</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20%;">Mpumalanga</td> <td style="width: 30%;">əm,pu:mə'læŋgə</td> </tr> <tr> <td>mbeki</td> <td>əm'beki</td> </tr> <tr> <td>Ndola</td> <td>ən'dəʊlə</td> </tr> <tr> <td>nguni</td> <td>əŋ'gu:ni</td> </tr> <tr> <td>Nkomo</td> <td>ən'kəʊməʊ</td> </tr> </table>	Mpumalanga	əm,pu:mə'læŋgə	mbeki	əm'beki	Ndola	ən'dəʊlə	nguni	əŋ'gu:ni	Nkomo	ən'kəʊməʊ	<p>b. <i>British English monophthong inventory</i></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">i:</td> <td style="width: 33%;">u:</td> </tr> <tr> <td>ɪ</td> <td>ʊ</td> </tr> <tr> <td>e</td> <td>ɜ:</td> </tr> <tr> <td>æ</td> <td>ʌ</td> </tr> <tr> <td></td> <td>ɑ:</td> </tr> </table>	i:	u:	ɪ	ʊ	e	ɜ:	æ	ʌ		ɑ:
Mpumalanga	əm,pu:mə'læŋgə																				
mbeki	əm'beki																				
Ndola	ən'dəʊlə																				
nguni	əŋ'gu:ni																				
Nkomo	ən'kəʊməʊ																				
i:	u:																				
ɪ	ʊ																				
e	ɜ:																				
æ	ʌ																				
	ɑ:																				

In order to break up illicit sequences, Thai also employs *ə* as an epenthetic vowel.

(15) *Thai loanwords from English* (Lee 2008: 96, Lombardi 2003)

<p>a. <i>ə</i> as an epenthetic vowel</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20%;">skæn</td> <td style="width: 20%;">'scan'</td> <td style="width: 20%;">sʰkɛ̃ɛn</td> </tr> <tr> <td>spɒn'sə</td> <td>'sponsor'</td> <td>sʰpɔ̃ɔnsə̃</td> </tr> <tr> <td>skæn</td> <td>'spare'</td> <td>sʰpɛ̃e</td> </tr> <tr> <td>skri:n</td> <td>'screen'</td> <td>sʰkrɪ̃n</td> </tr> </table>	skæn	'scan'	sʰkɛ̃ɛn	spɒn'sə	'sponsor'	sʰpɔ̃ɔnsə̃	skæn	'spare'	sʰpɛ̃e	skri:n	'screen'	sʰkrɪ̃n	<p>b. <i>Thai vowel inventory</i></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">i</td> <td style="width: 33%;">ɪ</td> <td style="width: 33%;">u</td> </tr> <tr> <td>e</td> <td>ə</td> <td>o</td> </tr> <tr> <td>ɛ</td> <td></td> <td>ɔ</td> </tr> <tr> <td></td> <td>a</td> <td></td> </tr> </table>	i	ɪ	u	e	ə	o	ɛ		ɔ		a	
skæn	'scan'	sʰkɛ̃ɛn																							
spɒn'sə	'sponsor'	sʰpɔ̃ɔnsə̃																							
skæn	'spare'	sʰpɛ̃e																							
skri:n	'screen'	sʰkrɪ̃n																							
i	ɪ	u																							
e	ə	o																							
ɛ		ɔ																							
	a																								

In the case of Japanese, *u* (*i*) is employed as an epenthetic vowel, as depicted in (16).

(16) *Japanese loanwords from English*

<p>a.</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20%;">pli:z</td> <td style="width: 20%;">'please'</td> <td style="width: 20%;">p<u>u</u>riiz<u>u</u></td> </tr> <tr> <td>slim</td> <td>'slim'</td> <td>s<u>u</u>rim<u>u</u></td> </tr> <tr> <td>kli:n</td> <td>'clean'</td> <td>k<u>u</u>riin</td> </tr> </table> <p>b.</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20%;">teɪst</td> <td style="width: 20%;">'taste'</td> <td style="width: 20%;">tees<u>u</u>t<u>o</u></td> </tr> <tr> <td>pə'trəʊl</td> <td>'patrol'</td> <td>pat<u>o</u>roor<u>u</u></td> </tr> <tr> <td>kɑ:d</td> <td>'card'</td> <td>ka<u>o</u></td> </tr> </table>	pli:z	'please'	p <u>u</u> riiz <u>u</u>	slim	'slim'	s <u>u</u> rim <u>u</u>	kli:n	'clean'	k <u>u</u> riin	teɪst	'taste'	tees <u>u</u> t <u>o</u>	pə'trəʊl	'patrol'	pat <u>o</u> roor <u>u</u>	kɑ:d	'card'	ka <u>o</u>	<p>c. <i>Japanese vowel inventory</i></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">i</td> <td style="width: 33%;">u(i)</td> </tr> <tr> <td>e</td> <td>o</td> </tr> <tr> <td></td> <td>a</td> </tr> </table>	i	u(i)	e	o		a
pli:z	'please'	p <u>u</u> riiz <u>u</u>																							
slim	'slim'	s <u>u</u> rim <u>u</u>																							
kli:n	'clean'	k <u>u</u> riin																							
teɪst	'taste'	tees <u>u</u> t <u>o</u>																							
pə'trəʊl	'patrol'	pat <u>o</u> roor <u>u</u>																							
kɑ:d	'card'	ka <u>o</u>																							
i	u(i)																								
e	o																								
	a																								

As (16a) shows, the default epenthetic vowel in Japanese loanword adaptations is *u*. As illustrated in (16b), however, *o* also functions as an epenthetic vowel in one specific context: when preceded by *t* or *d*, *u* is replaced by the phonologically and phonetically similar vowel *o* in order to avoid creating the sequences *tu* and *du*, which are ungrammatical in Japanese.

Interestingly, languages often exploit *i* when they have no vowels in the central region of their vowel system. Typical examples are found in Yoruba, Fijian (Kenstowicz 2007) and Cilungu (Bickmore 2007). In Yoruba, for example, it is *i* that is used as an epenthetic vowel since its phonetic quality is the

least salient and it is the shortest (Uffmann 2007); the use of *i* appears to minimize the amount of distortion to the phonetic properties of the original sound sequence in the donor language.

(17) *Yoruba loanwords from English* (Lee 2008: 90, Pulleyblank 1988)

a.	<i>i</i> as an epenthetic vowel			b.	<i>Yoruba vowel inventory</i>		
	'draɪvə	'driver'	dírɛ̀bà		ɪ (ĩ)		u (ũ)
	'slɪpəz	'slippers'	sílípààsì		e		o
	bɾɪk	'brick'	bíríkì		ɛ (ě)		ɔ (õ)
	fɔ:k	'fork'	fóòkì			a	
	'fɪlɪp	'Phillip'	fílípì				
	ja:d	'yard'	jààdì				

Although there are exceptions, we observe a tendency for languages to exhibit one of the vowels *ə*, *i*, *u*, the choice between them being determined by the status of the vowels in the vowel system in question.

It should be noted that, among the four default epenthetic vowels (*ə*, *i*, *ɪ*, *u*), it is the use of *ɪ* in particular which shows variation. For example, *ɪ* sometimes refers to the English vowel produced at a point somewhere between *ə* and *i*, as in the case of the epenthetic vowel found at inflectional boundaries such as between a noun and the plural suffix “-es” (e.g., kiss + -es → [kɪsɪz]). It also denotes a vowel produced at a point somewhere between *ə* and *u*, as in the case of the Korean epenthetic vowel (e.g., loanword adaptation of English word ‘kiss’ → [kɪsɪ]) and that of the Moroccan Arabic epenthetic vowel (e.g., ktb ‘to write’ → ktɪb ‘(he/she) writes’, kɪtbu ‘they write’). It seems that the use of the symbol *ɪ* depends more on the traditions of phonetic transcription than on the precise phonetic quality of the vowel in question. In this paper, therefore, I regard *ɪ* as a variant of the other three default epenthetic vowels *ə*, *i*, *u*.

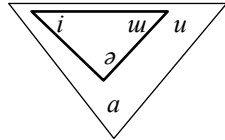
The vowel *e* also deserves comment, as it too has been claimed to function as an epenthetic vowel in some languages, such as Spanish. In this language, word-initial consonant clusters beginning with *s* in the donor language receive an additional *e*, e.g. *estrés* “stress”. In Spanish, *e* is often referred to as a typical epenthetic vowel, although all the other vowels in the Spanish vowel inventory are also said to be epentheticized in clusters consisting of a stop and a flap or a fricative and a flap.⁵ However, Ramírez (2006) reports that epenthetic vowels occur far more frequently and also appear in natural speech. He further notes that the epenthetic vowels all have phonetic qualities associated with the central region of the Spanish vowel space, approximating to schwa *ə* even though they seem to gain some phonetic colouring from neighbouring (nucleic) vowels. Ramírez (2006) claims that this is the result of a post-cursor effect (Rosner & Pickering 1994). In reality, then, it seems that the default epenthetic vowel in Spanish is actually schwa *ə* rather than *e*, in which case the insertion of *e* before *sC* clusters may be regarded as a special case. Given the evidence, it is difficult to regard *e* as the default epenthetic vowel in this language: it has a restricted distribution, and is related to historical development. Although I have not checked if other languages traditionally associated with epenthetic *e* employ this vowel as a default, it is at least reasonable to assume that the epenthetic *e* in well-documented languages such as Spanish may be regarded as a non-default epenthetic vowel.

It is interesting to note that the typical epenthetic vowels *ə*, *i* and *u* occupy a front, non-low, non-back region of the vowel space rather than a central (i.e. non-high, non-low, non-front, non-back) position. Furthermore, the set includes no rounded vowels.

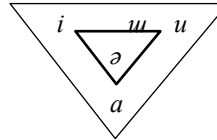
⁵It is generally thought that epenthesis within clusters occurs only in emphatic speech. However, Ramírez (2006) has observed the same effect in natural speech too.

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(18) a. *Typical default epenthetic vowels*



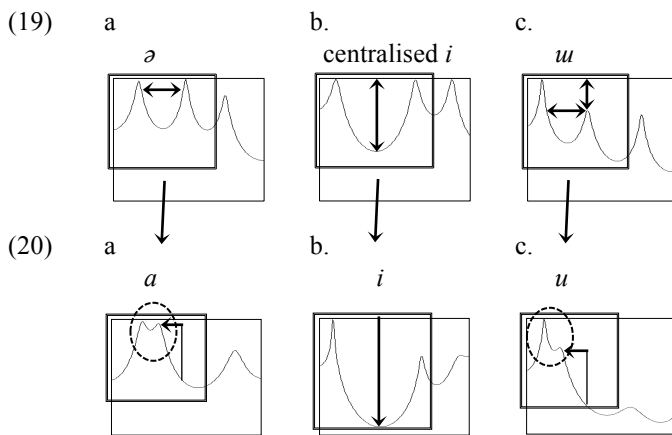
b. *The central vowel*



The triangle formed by the default vowels has *i* as its pivot or stable point, and can be read as a smaller version of the triangle which is formed by the three peripheral vowels *a*, *i* and *u*.

3.3 *Epenthetic vowels and their acoustic correlates*

The spectral shapes of the epenthetic vowels *ə*, *i*, *u* also display certain correlations with those of the peripheral vowels *a*, *i*, *u*. I begin by focusing on *ə* and *u*. The spectral shapes of these vowels are shown in (19a) and (19c), while those of their peripheral counterparts *a* and *u* are given in (20a) and (20c); it may be seen that the acoustic patterns for *a* and *u* are exaggerated versions of those for *ə* and *u*: the distance between the F1 and F2 peaks in *ə* is much greater than in *a*, which exhibits the ‘mAss’ pattern.



The distance between the F1 and F2 peaks in *u* is also greater than in *u*, even though the relation between the heights of F1 and F2 are the same in both *u* and *u*. This suggests that *u*, which shows the ‘rUmp’ pattern, may also be interpreted as an exaggerated form of *u*.

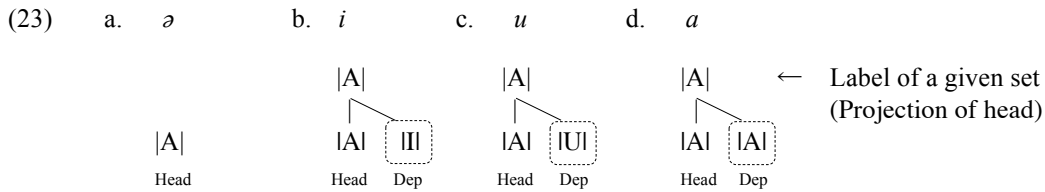
The remaining default epenthetic vowel *i* exhibits the ‘dIp’ spectral shape shown in (20b). Its centralized counterpart in (19b) can be regarded as a weaker form of *i* since the depth of the trough shape in (19b) is shallower than that in (20b). Since *i* functions as a pivot or stable point in the default triangle, the degree of enhancement required to create the salient spectral properties of *i* in (20b) is weaker than in *ə* (20a) and *u* (20c).

Given that the cross-linguistically common peripheral vowels *a*, *i* and *u* are phonologically represented by the elements |mAss| (|A|), |dIp| (|I|), and |rUmp| (|U|), as discussed in section 2, *ə*, *i* and *u* must be also represented by the same elements. The following section considers what kind of melodic structure is appropriate for representing the default epenthetic vowels.

4. |A I U| as the head of the nuclear expression

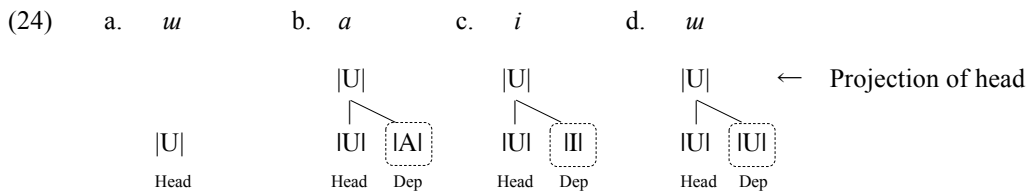
In the licensing/government-based model of prosodic representation, the default epenthetic vowels (*ə*, *i* and *u*) are typically regarded as the phonetic manifestation of an empty nucleus. In the literature on

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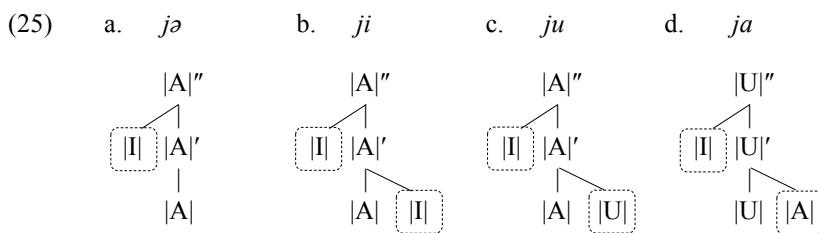


Given the configuration (23a) for English, a sole |A| determines the quality of the default epenthetic vowel and is phonetically interpreted as *ə*. In other words, when |A|, the foundation of the structure, appears alone, it is phonetically realized as *ə*, providing the baseline timbre for English. On the other hand, when the element in question possesses a dependent element, the acoustic pattern of the dependent element is superimposed onto this baseline resonance. For example, it phonetically manifests itself as a segment which exhibits the ‘dIp’ pattern when the element |I| is taken as a dependent, as shown in (23b). The same interpretation is taken in the cases of (23c) and (23d): when |U| and |A| are specified under the head |A|, as in (23c) and (23d), the resulting expression is phonetically interpreted as a peripheral or more prominent vowel (*u* and *a*, respectively). This is attributed to the argument given in section 2 that heads (which are important for structure-building) lack phonetic prominence while dependents (which are unimportant for structure-building) are phonetically prominent. Following notational conventions, the head of a given set is positioned at the top of the tree diagram and labels the entire structure.

In addition to |A| (for English), the other elements |I| and |U| can also be parametrically selected as the foundation of a segmental structure. In the case of Japanese, for example, the baseline (head) is |U|, so the structure formed by the sole head |U| is phonetically realized as *u*, as in (24a). When the head |U| takes |A|, |I| or |U| as a dependent, the acoustic signature of the baseline is masked by the dependent element and the overall structure is phonetically interpreted as *a* (24b), *i* (24c) or *u* (24d), respectively.



In line with other linguistic components and other domains in phonology, I assume that the head element can take an element as an argument in a further projected position (e.g., the Spec). Below I give examples from English using the element |I|.

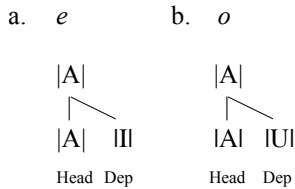


Following the X-bar approach to syllable structure, an item in the Spec is assumed to be phonetically interpreted as a consonant. Given this, |I| in the Spec phonetically manifests itself as a palatal glide *j*, the consonantal persona of |I|. (Likewise, if |U| rather than |I| occupies the Spec then this is phonetically realized as the labio-velar glide *w*.) So, the structure is interpreted as *jə* when |A| takes only |I| in the Spec, as in (25a). On the other hand, when |A| takes any one of the three elements in the Comp, then the structure is realized as *j* + a peripheral vowel: *ji*, *ju* and *ja* as in (25b), (25c) and (25d) respectively.

5. Recursion in compound expressions

This section considers the representation of vowels such as *e* and *o* using the proposed configuration. As illustrated in (10), these vowels are viewed as compounds of two elements: *e* and *o* are the realisation of the |A|-headed set of |A I| and the |A|-headed set of |A U| respectively, as illustrated below.

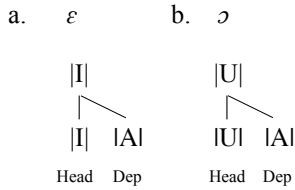
(26) Representing *e* and *o*



In (26a) |A| and |I| are asymmetrically concatenated to form a vocalic expression, where |A| is the head while |I| is its dependent (modifier) in the Dep. Since the head characterizes the set to which it belongs (endocentric dependency), as illustrated above, the head |A| is considered to be projected onto the next level above: the |A|-labeled set of |A| and |I|. In the same way, (26b) shows the set of |A| and |U|, which is interpreted as the mid back vowel *o* and is |A|-labeled.

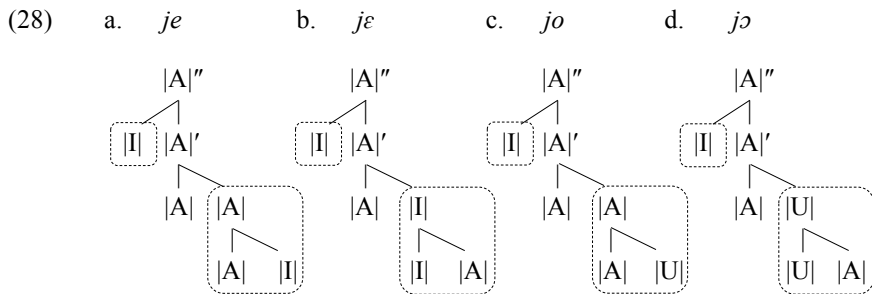
On the other hand, the reverse labeling yields *ε* and *ɔ*, as shown in (27a) and (27b).

(27) Representing *ε* and *ɔ*



The difference in phonetic manifestation is thus attributed to the difference in labeling: the acoustic pattern of the (labeled) head element is less prominent than that of the (non-labeled) dependent in the resulting acoustic pattern.

Given these structures for mid vowels, the palatal glide + mid vowels are represented as in (28), where all the configurations in (26) and (27) appear in the Dep.



It is apparent that the proposed element-based structures of melodic representation involve recursion, which involves embedding a constituent in another constituent of the same type. Another typical example is given in (29).

demonstrated that the apparent direction is determined by the relation between structural strength in prosodic structure and structural complexity in segment-internal structure.

Likewise, in order to validate the proposed model of melodic representation, we are required to investigate whether other phonological phenomena (such as palatalisation and labialisation) that are traditionally handled by referring to a particular domain and assimilatory directionality can be analysed by referring to only head-dependency relations in morpheme-internal sound structures but no precedence relations. This will be future research.

7. Concluding remarks

At this point, let me consider whether syntax-like recursion exists in intra-morphemic phonology. As phonology is concerned with the well-formedness of sound structure, it is naturally assumed that one of the roles of phonology is to construct well-formed intra-morphemic structure. Coupled with the structural composition of elements, I assume that phonology is responsible for the sound aspects of lexicalization, which may correspond to structure-building in morpho-syntax, since recursion and the unlimited concatenation of elements both take place in the examples described above. In these element-based examples of melodic structure, the length of a morpheme (that is, the limit of recursive concatenation) is not constrained by phonology. The limits on recursive structure in the actual form of morphemes are imposed by performance factors such as memory, not by competence.

As you may notice, the structural approach I have proposed may be viewed as a phonological implementation of bare phrase structure. That is, this model reinterprets the notion of minimalism in phonology by opposing the string-based flat structure pursued by Scheer (2004), Neeleman and van de Koot (2006), Samuels (2009) and others. Although there are representational differences, the present research concurs with those studies using a string-based flat structure for intra-morphemic phonology that there can be no intra-morphemic prosodic structure.

Finally, let me discuss some implications of adopting the structures proposed here. Within the framework developed by Hauser, Chomsky and Fitch (2002), the existence of element-based recursive structure implies the possibility that phonology is placed in FLN rather than FLB if they maintain the view that the existence of recursive structure is a prerequisite for being placed in FLN. Within Pinker and Jackendoff's framework, where phonology is in any case assumed to be unique to language (part of FLN), the existence of element-based recursive structure serves as evidence to support the recursion-only hypothesis of FLN which Pinker and Jackendoff have denied. In either case, the existence of the proposed recursive structure suggests that intra-morphemic phonology is part of FLN.

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