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RESEARCH

Headedness in Element Theory: The case for multiple heads

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Like distinctive features, elements identify natural classes and model the structure of segments. But unlike features, they combine asymmetrically in expressions, with head-dependent relations between elements making a significant contribution to the expressive power of representations. Most versions of Element Theory follow the general principle that a structural domain—such as a segmental expression—can have just one head element. In Backley (2011), however, element structures are permitted to have two heads. Multiple headedness is a consequence of allowing *dual interpretation*, where each element has two different phonetic realisations depending on its head or non-head status. While dual interpretation is better equipped to capture natural classes and explain phonological processes, its by-product is the need for double-headed expressions, which present a challenge to element-based theory. It is proposed that the six elements (|I|, |U|, |A|, |H|, |L|, |ʔ|) naturally form three pairs of opposing (dark vs light) values, each pair being associated with one of three *fundamentals* of spoken language: colour, resonance, frequency. It is then argued that headedness relations refer separately to each fundamental property. So, if there are three fundamentals in a melodic structure, then there is the potential for up to three heads in any one expression. The implications of this approach are considered with regard to segmental markedness and language typology.

Keywords: Element Theory; melodic headedness; marked element combinations; dark versus light

1 Introduction

This paper discusses the nature of headedness in Element Theory (ET; e.g. Harris 1994; Scheer 1999; Kaye 2000; Backley & Nasukawa 2009a; Cyran 2010), arguing for a view of headedness which departs from standard assumptions about head-dependent relations between elements. Element Theory—one of several representational approaches in which headedness plays a role (van der Hulst & Ritter 1999)—has always distinguished between head elements and non-head (or dependent) elements, this distinction being just one manifestation of the asymmetric relations that characterise phonological structure in general (Anderson & Ewen 1987; van der Hulst 1989).

Elements offer an alternative to distinctive features for describing the internal structure of segments. Like features, they define natural classes of sounds, which allows them to express lexical contrasts and to represent the properties that are active in phonological processes. Unlike features, however, they are associated with acoustic patterns in the speech signal rather than with properties of articulation. The relevant acoustic patterns are those that are believed to serve a linguistic function by carrying information about the identity of morphemes. Most scholars working with elements agree that we need to recognise six such patterns, and therefore, that there are six elements in the phonological grammar.[1] Some of these elements predate Element Theory itself; for example, the

[1] For an alternative view of the element set, see Pöchtrager & Kaye (2013).

elements |A|, |I| and |U| have their origins in early Dependency Phonology (Anderson & Jones 1974). The remaining elements |H|, |L| and |ʔ| were first introduced in the early Government Phonology literature (e.g. Kaye et al. 1985).

Although Element Theory (hereafter ET) has evolved and diversified over time (Backley 2012), current versions of ET agree on at least one point: head-dependency relations remain integral to element-based representations. In most forms of ET, headedness is a relational property with scope over a single expression; it identifies one element as the head of the expression and all other elements as non-heads. The difference between heads and non-heads is important because it affects the way an expression is phonetically interpreted, with heads typically making a bigger contribution than non-heads to the overall phonetic outcome.[2] Moreover, the head versus non-head distinction has a linguistic motivation, in that the two have different functions. Head elements define broad melodic categories; for example, the class of low vowels is identified by headed |A| (by convention, head elements are underlined). Meanwhile, dependent elements describe additional properties that further specify a segment within its broad category; for example, the expression |A I| represents a low vowel (headed |A|) which is also front (non-headed |I|), i.e. [æ] or [ɛ]. On this basis, making a distinction in the grammar between headed and non-headed elements seems to be well motivated.

There are, however, differing views on the nature of this head/non-head asymmetry and on the way that headedness functions as a structural property. Acknowledging the diversity that now exists within element-based phonology, this paper focuses on the version of ET described in Backley (2011). In many respects, this version follows ET conventions: it uses the standard set of six elements (|I|, |U|, |A|, |H|, |L|, |ʔ|) and it allows each element to appear in either its headed or non-headed form. Yet in one respect, its use of headedness departs from the standard view of headedness found in most formulations of ET. As already noted, headedness is usually seen as a relational property involving all the elements in an expression: one (head) element dominates the expression while any number of other (dependent) elements may combine with it. That is, within the domain of a melodic expression only one element can be a head. In Backley (2011), however, the distinction between headed and non-headed is treated differently—not as something which refers to whole expressions but as an inherent property of individual elements. This allows a compound expression to have more than one head element.

Multiple headedness presents a conceptual challenge not just to the ET model but to any representational approach that relies on head-dependent asymmetry, since it runs counter to the tacit assumption that a structural domain (in any part of the grammar) should have just one head. The aim of this paper is therefore to motivate the need for multiple headedness in element representations and to show how ET can accommodate this by rethinking the way elements are organised in relation to one another. The paper is set out as follows. The next section compares the approach to headedness in Backley (2011) with the standard view found in most versions of ET. It also introduces typological data which call for representations containing more than one headed element. Then in Section 3 the discussion turns to the question of relatedness between elements, focusing on a polar relation within the element set between dark elements and light elements. Section 4 argues that multiple headedness may be incorporated into the ET model by assuming the existence of three fundamental properties which underlie language sound systems and which determine the size and appearance of the element set. These fundamental properties also reveal how the element set divides into two natural groupings, light and dark. The discussion concludes in Section 5 with a summary of the main points.

[2] See Nasukawa & Backley (2015a) for an alternative view of the roles of heads and dependents in melodic and prosodic structure.

2 Two approaches to headedness

Most current versions of ET follow early formulations of the element-based approach (e.g. Kaye et al. 1985) in assuming that headedness refers to the asymmetry between a head element and its dependent element(s). This approach sees headedness as a relational concept, since it captures the relations between elements within the same segmental structure. It also sees the domain for headedness as being an entire melodic expression. Note how this view of headedness follows linguistic convention by assuming that each structural domain has a single head, as in the example structures in (1).

(1) a. [p] |U̲ H ʔ|
[s] |H̲ A|

b. [ɒ] |A̲ U|
[o] |U̲ A|

It has already been pointed out that the headedness properties of an expression can influence phonetic interpretation. This is because head elements typically show greater acoustic salience than dependents, so they are relatively prominent when a complex expression is realised phonetically. Consider, for example, the structures for [p] and [s] in (1a), which both contain the |H| element. Headed |H̲| in [s] contributes strong (fortis) frication, giving [s] a perceptually salient sibilance. By contrast, non-headed |H| in [p] is interpreted with less phonetic prominence as non-aspirated stop release.

If headedness is related to phonetic interpretation, then it follows that a given element may have more than one phonetic identity—that is, it has a dual interpretation— depending on whether it is headed or non-headed. For instance, headed |L̲| represents voicing in a voiced obstruent, while non-headed |L| is interpreted as nasal resonance (Nasukawa 2005).[3] In the case of the |A| element, headed |A̲| is associated with the high F1 value that inheres in low vowels such as [a ɑ æ], whereas non-headed |A| is present in vowels with a less prominent F1 value such as the mid vowels [e o].

Turning to the version of ET described in Backley (2011), however, we see headedness taking on a more central role than it does in the standard ET approach just described. Not only does the idea of dual interpretation apply to all elements, but this is fully exploited as a means of identifying natural classes and explaining certain phonological patterns. To illustrate this, Table 1 shows how this alternative form of ET views the main consonantal characteristics of each element in its headed and non-headed forms.

Table 1: Phonological characteristics of headed/non-headed elements in consonants.

		phonological category	
element	***acoustic property***	***non-headed***	***headed***
|I|	high F2 converging with F3	(some) coronals	palatals
|U|	low frequency energy in F1–F3	velars	labials
|A|	high F1 converging with F2	(some) coronals	uvulars, pharyngeals
|ʔ|	abrupt drop in amplitude	stops	ejectives, implosives
|H|	aperiodic noise	obstruents	fortis/aspirated obstruents
|L|	periodic murmur	nasals	voiced obstruents

[3] Some scholars (e.g. Breit 2013) assert precisely the opposite, i.e. that headed |L̲| expresses nasality while non-headed |L| represents obstruent voicing. Whichever way the headedness of |L| is analysed, the fact remains that this element is thought to have a dual interpretation.

In some cases, headed versus non-headed expresses the relation of *general category* versus *specific category*. For example, non-headed |ʔ| identifies the general category of stops while headed |H| describes specific kinds of stops, i.e. ejectives and implosives. The same is true of |H|, where non-headed |H| roughly equates to the general category *obstruent* while headed |H| specifies the subset of strong (fortis or aspirated) obstruents. Arguably, |I| also functions this way if we assume the existence of a general place category *non-peripheral* which includes both coronal and palatal resonance.

On the other hand, headed versus non-headed can also represent two quite distinct categories that are related primarily by their acoustic attributes. For example, |U| is associated with a falling formant pattern in which acoustic energy is concentrated at low frequencies. This pattern is present in labials and in velars, appearing stronger (i.e. showing a greater modulation of the carrier signal) in headed labials and weaker in non-headed velars (Backley & Nasukawa 2009b). Acoustic similarity is not the only reason for associating labials and velars with the same element, however. There is also a phonological link, in that the two categories are seen to pattern together in some phonological (notably, diachronic) processes (Backley 2011: 79). In |A| and |L| too, the headed and non-headed forms of each element represent categories which, at first sight, appear to be unrelated. For example, there is no obvious link between nasality (non-headed |L|) and obstruent voicing (headed |L|) in terms of articulation, but there *is* acoustic and phonological motivation for representing them using the same element (Nasukawa 2005).

What emerges from this approach to headedness is the idea that category distinctions can be made by referring to just the head/non-head status of a single element. For instance, a consonant will be a palatal if it contains headed |I|, no matter which dependent elements |I| is associated with. Similarly, a vowel will be categorised as low if it contains headed |A|, regardless of which other elements are present in its structure. This suggests the need to review our assumptions regarding the domain for headedness—from being a property of whole expressions to being a property of individual elements. The examples in Table 2 confirm this by showing the representation of glides as simplex melodic expressions. Note how the phonetic realisation of a lone element changes depending on whether it appears in its headed or non-headed form.

One consequence of treating headedness as a property of individual elements, rather than of whole expressions, is that it allows a complex expression to have more than one head. For example, according to Table 1 labial consonants have headed |U| while fortis/aspirated obstruents have headed |H|. But there are many languages, including English, in which these two properties combine to form an aspirated labial stop [pʰ]. The expectation is that, in the model of ET described in Backley (2011), [pʰ] should be represented by the double-headed expression |U H ʔ|, where headed |U| contributes labiality and headed |H| contributes aspiration. And indeed, this is what the model claims. The problem, however, is that this structure breaks with the conventions of ET with respect to headedness, since ET has always assumed that a melodic expression can have only one head element. Note that [pʰ] is not an isolated case; it is easy to conceive of other segments which require double-headed structures too, including those in (2).

Table 2: Glides as simplex representations.

	|I|	**|U|**	**|A|**
non-headed	[ɾ]	[ɰ]	[ɹ]
headed	[j]	[w]	[r], [ɽ]

(2) a. [ʃ] |I A H| voiceless palato-alveolar sibilant fricative
(|I A| = palatal resonance; |H| = fortis frication)

b. [b] |ʔ U L| fully voiced labial stop
(|ʔ| = occlusion; |U| = labial resonance; |L| = obstruent voicing)

c. [q^h] |A U H ʔ| aspirated uvular stop
(|ʔ| = occlusion; |A U| = uvular resonance; |H| = aspiration)

For this version of ET, then, the challenge is to explain how the use of double-headed expressions is possible within a framework which otherwise adheres to the general principle of one head per structural domain. One approach to this question is described in the following sections, where it is proposed that ET's six elements be organised into three pairs. The claim is that each pair is made up of two naturally opposed elements, and that these opposing properties together form a headedness domain. This allows head-dependency to remain as a strictly binary relation, and it also allows for the possibility of multiple headedness in a single melodic expression.

3 Dark versus light elements

In standard versions of ET, the six elements all have autonomous status in the grammar; this gives each element the freedom to participate in distributional patterns and phonological processes independently of the others. Having said that, many ET practitioners also follow the convention of dividing the set of elements into the two groups shown in Table 3. This division is based on the elements' phonetic characteristics and phonological distribution.

This split between vocalic and consonantal elements reflects a difference in the kinds of acoustic properties associated with each group. The resonance elements |A|, |I| and |U| are associated with formant structure patterns and represent place properties in both vowels and consonants. For example, headed |U| is interpreted as rounding in vowels and as labiality in consonants.[4] By contrast, the laryngeal/source elements |H|, |L| and |ʔ| refer to

Table 3: Vocalic and consonantal elements.

	distribution	***acoustic properties***	
elements	vocalic	resonance	|I|, |U|, |A|
	consonantal	laryngeal/source	|H|, |L|, |ʔ|

Table 4: Dark and light elements.

	perceptual quality	***acoustic energy***	
elements	dark	low frequency	|A|, |U|, |L|
	light	high frequency/dispersed	|I|, |H|, |ʔ|

[4] The elements are described here in familiar articulatory terms such as *labial, round, high* and *voiceless*. It will be recalled, however, that in the ET tradition elements are associated not with properties of articulation but with acoustic patterns in the speech signal; for example, |A| is associated with high F1, |I| with high F2, and |U| with lowered F1 and F2. Strictly speaking, therefore, labels such as *labial* and *round* do not describe the identifying properties of elements; rather, they describe the articulatory gestures that speakers adopt when trying to reproduce the relevant acoustic pattern for a given element.

other aspects of the speech signal such as periodicity. They represent manner and laryngeal properties, e.g. headed |H| is present in voiceless obstruents and in high tone vowels.

However, there is also another way of dividing the element set along phonetic lines. This refers to the difference between *dark* and *light* elements (Backley 2011: 195), as shown in Table 4.

The dark elements |A|, |U| and |L| share a tendency for their acoustic energy to be concentrated at lower frequencies. By contrast, the light elements |I|, |H| and |ʔ| show a different pattern in which low-frequency energy is either less prominent or absent altogether; instead, energy may be concentrated at higher frequencies or it may be distributed more evenly across the spectral range. From a listener's perspective, the general impression is of a difference in timbre or sound quality: dark elements sound warm and mellow, whereas light elements sound bright, thin, and in some cases hissy. The difference can be illustrated by comparing the dark and clear realisations of *l* in English. Dark-*l* gets its dark character from the presence of |U| in its structure (Backley 2011: 175), where |U| is non-headed and contributes velar resonance and a back quality. In contrast, clear-*l* has light features that derive from the presence of |I|, which in some languages represents coronal resonance resulting from a front, apical articulation.[5]

The terms *dark* and *light* do not refer to formal linguistic categories. Nor do they identify structural units such as class nodes, which group together elements showing similar behaviour. Moreover, they have no precise definition—it is difficult to capture their characteristics other than in relative or impressionistic terms. (In this sense, a suitable parallel might be the distinction between warm colours and cold colours in the visual dimension.) Nevertheless, the notion of dark-light can still be useful for describing sound patterns. For example, Jakobson et al. (1952) refer to dark and light in the description of the acoustic features [grave] and [acute], stating that "[t]wo phonemes contrasted as grave and acute (e.g. /u/ vs. /y/, or /ɨ/ vs. /i/, or /f/ vs. /s/) are easily identified as dark and light respectively by responsive subjects" (Jakobson, Fant & Halle 1952: 32). This suggests that dark and light may play a role in speech perception, perhaps by helping listeners to make broad perceptual distinctions before they try to discriminate between specific sound categories.

If the split between dark and light is relevant to speech perception, then we might expect it to have a bearing on diachronic phonology, given that perceptual factors are thought to be instrumental in triggering certain sound changes (e.g. Ohala 1981, 1993). In fact, the historical phonology of the Germanic languages provides illustrations of how a sound change can be sensitive to the dark-light distinction. The most well-known case is that of *i*-mutation (Campbell 1959; Lass 1994) in Germanic and early Old English, where back vowels were fronted and low vowels were raised before [i]/[j] later in the word. Both these changes involve a shift from a dark to a lighter vowel, triggered by the presence of the light element |I| in the following [i]/[j]. The effects of *i*-mutation are preserved in modern English dark-light pairs such as *full-fill, man-men, tooth-teeth, tale* (= OE [tɑlu])-*tell*. Another dark-light process is the shift [ɑ]→[æ] in pre-Old English known as First Fronting or Anglo-Frisian Brightening (Campbell 1959). This change occurred spontaneously, but was blocked by a following *w*, a nasal cluster, or a back vowel in the next syllable. In structural terms these three blocking environments appear to have nothing in common, and therefore do not make a natural grouping. In perceptual terms, however, they are brought together by the fact that they all have a dark acoustic quality—dark |U| in *w*, dark |L| in nasals, and dark |A| or |U| in back vowels—which evidently prevented dark [ɑ] from being fronted to light [æ].

[5] In Backley (2011: 72ff.) it is proposed that coronal consonants are represented by |I| in some languages and by |A| in other languages, depending on their phonological behaviour (see Table 1).

Aside from its influence on historical change, the dark-light distinction is relevant to melodic descriptions because it plays a role in determining how elements combine in expressions (Backley & Nasukawa forthcoming). It also relates to the present discussion because it reveals something about the nature of element headedness. In Section 4 it will be described how the distinction between dark and light can ensure that melodic structure maintains head-dependent relations that are strictly binary, i.e. a maximum of one dependent per head.

Before turning to multiple headedness, however, let us consider the motivation for distinguishing between dark and light elements by focusing on element combinations. In principle, any element is free to combine with any other element within the same expression. In practice, however, some combinations are more marked (e.g. cross-linguistically rarer) than others. The clearest cases of marked combinations are those in (3).

(3) a. |U| + |I| (formant lowering + high F2)
b. |A| + |ʔ| (high F1 + reduction in acoustic energy)
c. |L| + |H| (low fundamental frequency + high fundamental frequency)

Their marked status derives from the fact that they involve opposing or contradictory acoustic properties, as described on the right-hand side in (3). In (3a) |I| raises the frequency of F2, while |U| introduces a lowering of all formants including F2. In (3b) |A| increases overall resonance by raising F1, while |ʔ| produces a rapid drop in acoustic energy causing a momentary loss of resonance. In (3c) |L| concentrates energy at low frequencies while |H| does so at higher frequencies. When these conflicting acoustic cues co-occur in a single segment, it results in an expression that can be difficult for speakers to produce and for listeners to perceive, since the relevant cues tend to mask one another. Not surprisingly, then, many languages avoid such combinations in the interests of communicative efficiency. To reflect their opposing properties, the element combinations in (3) have been dubbed *antagonistic pairs* (Backley 2011; van der Hulst 2015).[6]

Antagonistic pairs influence the shape of sound inventories by identifying certain segmental categories as being universally disfavoured. Having said that, there is no outright ban on their appearance in the grammar (Backley 2011: 195). For example, the categories in Table 5 function contrastively in at least some languages, even though they contain antagonistic element pairs.

Notice that these categories are all relatively uncommon, their marked status deriving from the fact that they contain antagonistic element combinations. Compare the front vowels [y] |I U| and [e] |I A|, for instance. Both have the same number of elements in their structure, yet [y] is cross-linguistically much rarer than [e]; the difference comes down to the presence or absence of an antagonistic relation—in this case, between |I| and |U|. As another example, consider the combination of |L| and |H| in consonants. Individually,

Table 5: Antagonistic element pairs.

antagonistic pair	*melodic category*	*example*	
|U| + |I|	front rounded vowels	[y]	|I U|
|A| + |ʔ|	uvular stops	[q]	|U A H ʔ|
|L| + |H|	voiced aspirated stops	[gʱ]	|U L H ʔ|

[6] Expressing melodic properties in terms of opposing pairs is by no means a new idea: acoustic features in the Jakobsonian tradition show a similar polarity, e.g. [grave] vs. [acute], [compact] vs. [diffuse].

each refers to an unmarked category: non-headed |L| represents nasality and non-headed |H| represents frication, as shown in (4a). When |L| and |H| combine, however, they create categories such as those in (4b), which are all marked to varying degrees.[7]

(4)	a.	|L U ʔ|	[m]	nasals
		|H U|	[f]~[ɸ][8]	plain fricatives
	b.	|L H U|	[v]~[ß]	voiced fricatives
		|L H U ʔ|	[bʱ]	voiced aspirated (breathy voiced) stops
		|L H U ʔ|	[m̥]	voiceless nasals[9]

It is evident that the relationships between |I| and |U|, between |A| and |ʔ|, and between |L| and |H| are in some sense special and require explanation. What distinguishes them from other relations in melodic structure is the fact that they involve elements which are not merely different from each other (i.e. contrastive), but rather, which express contrasting values with respect to the same basic property. Following Backley (2011), I refer to these basic properties or *fundamentals* using the informal labels *colour, resonance* and *frequency*.[10]

The claim is that colour, resonance and frequency are three fundamental aspects of spoken language that contribute to the overall identity of speech sounds. In phonetic terms these are gradient properties; but in linguistic terms only their polar values are relevant to sound contrasts. In the case of frequency, for example, the presence of high-frequency energy and low-frequency energy are both linguistically significant, whereas other values (e.g. mid-frequency, variable frequency) are not. The grammar must therefore have the means of referring to low and high frequency as independent melodic properties—which is the precisely role of the elements |L| and |H|.

The same applies to colour and resonance. In its broadest sense *colour* refers to the timbre or quality of a physical sound independently of other acoustic properties such as pitch and intensity. However, when it comes to characterising language sounds, only two values for colour are relevant: dark (|U|) and light (|I|). The difference between them forms the basis for several broad distinctions within melodic systems such as the split between back (|U|) vowels and front (|I|) vowels and the division between peripheral (|U|) consonants and coronal (|I|) consonants (Dixon 1980: 139; Backley & Nasukawa 2009b). Again, |U| and |I| mark the two extreme and opposing values of a single fundamental property. Finally, *resonance* is another aspect of spoken language that is relevant to language only in terms of its polar values. The |A| element is associated with a peak of resonance and is present in sounds of high sonority such as low vowels, while its opposing value |ʔ| marks a sudden drop in acoustic energy and a momentary loss of resonance. Speakers create this break in resonance by interrupting the airflow, which causes vocal fold vibration to cease. It is therefore associated with the hold phase of stops.

It has already been suggested that the division between dark and light may play a role in speech perception. And this idea is supported by the fact that it functions as a cue to the location of prosodic and morphological boundaries (Nasukawa & Backley 2015b). In general, there is a tendency for light elements to appear at the left boundary of a prosodic

[7] That is, voiced fricatives are marked relative to voiceless fricatives, voiced aspirated stops are marked relative to voiced unaspirated stops, and voiceless nasals are marked relative to spontaneously voiced nasals.
[8] On the distinction between bilabial and labiodental place, see Backley (2011: 98).
[9] The status and typology of voiceless nasals is discussed in Bhaskararao & Ladefoged (1991).
[10] Van der Hulst (2015: 155) refers to the same three fundamentals as "phonetic dimensions", which he labels *place, manner* and *laryngeal*, respectively. These terms align with the articulatory classes of sub-segmental organisation employed in his Radical CV Phonology model.

domain; this allows listeners to use them as cues to the onset of a syllable or the beginning of a word domain. For example, stops (with light |ʔ|) typically occupy onsets rather than codas, as do palatals such as [ʃ] and [ʤ] (with light |I̲|). Obstruents (with light |H|) are also favoured in onsets and at the left edge of a word. By contrast, dark elements naturally occur non-initially. In many languages such as Japanese, nasals (with dark |L|) function as the definitive (or the only) coda consonant, while effects such as consonant velarisation (involving dark |U|) tend to occur domain-finally (e.g. *call* [kɔːɬ], *filled* [fɪʊd] in varieties of British English). And low/non-high vowels (with |A|) are associated exclusively with the syllable nucleus (cf. high vowels, which frequently have onset (glide) realisations). Given that dark and light elements have differing patterns of distribution, it is reasonable to expect listeners to exploit these differences in order to locate syllable domains—and then, in order to segment the speech stream into word-sized chunks.

The difference between dark and light is also relevant to the description of certain phonological patterns. In element compounds there is a tendency for dark elements to combine with other dark elements, while light elements prefer to combine with light. This is evident from the way languages use melodic enhancement to increase the acoustic prominence of segments. The purpose of enhancement is to make segments more distinctive or salient. So, to enhance the salience of a light segment (i.e. a segment consisting mainly of light elements), a language will typically add another light property. This occurs in Navajo, where the syllable onset supports a contrast between the dark glide [ɰ] and the light glide [j]. To increase the perceptibility of this contrast, Navajo speakers have the option of reinterpreting [j] as a fricative [ʝ] (Hoijer 1945): in element terms, the palatal glide [j] represented by |I̲| is enhanced by the addition of another light element |H| to become a palatal fricative |I̲ H|.[11]

Further arguments in support of the division between dark and light elements can be found in Backley (2011) and van der Hulst (2015). What concerns the present discussion is the way in which the dark-light division can contribute to our understanding of headedness relations in compound element structures. This is the focus of the next section.

4 Multiple headedness

It has already been suggested that a special relation holds between the elements in an antagonistic pair because they both refer to the same fundamental property—colour, resonance or frequency, as shown in Table 6. For example, |U| and |I| express opposing (dark versus light) values, but the fact that they both refer to the same fundamental means that they are related to each other in a way that, say, |U| and |A| are not: the relation between |U| and |I| is contrastive and polar, whereas the relation between |U| and |A| is merely contrastive. This section shows how this difference is relevant to the issue of headedness, where headedness encodes the relative prominence of an element when two elements are combined.

Table 6: Three fundamentals of spoken language.

	dark			light	
fundamental	***value***	***element***		***value***	***element***
colour	dark	|U|	vs.	light	|I|
resonance	resonant	|A|	vs.	non-resonant	|ʔ|
frequency	low	|L|	vs.	high	|H|

[11] By contrast, we do not expect to find languages enhancing |I̲| by adding, say, the nasal element |L| (resulting in a palatal nasal [ɲ]). This can be ruled on the grounds that |I̲| is light whereas |L| is dark.

(5)

	expression		*salient property*
a.	|U A|	[o]	colour
	|U A|	[ɔ]~[ɒ]	resonance
b.	|U H|	[v]~[ß]	colour
	|U H|	[x]	frequency

Consider the examples in (5a), both of which combine the colour element |U| with the resonance element |A|. Following the general assumption that concatenation is always asymmetric, this combination may take one of two possible forms: either the |U|-headed expression |U A| or the |A|-headed expression |U A|. In |U A| colour is more salient than resonance because the head element |U| refers to the colour fundamental, while in |U A| resonance is stronger than colour because the head element |A| refers to the resonance fundamental. Similarly, in (5b) there are two options for making a compound of |U| and |H|: in |U H| colour dominates the entire expression (again, because |U| is a colour element), while in |U H| frequency is more salient because the head element |H| refers to the frequency fundamental. In the latter case, headed |H| is associated with voicelessness (aperiodic energy) in the acoustic signal, giving a voiceless/fortis fricative [x], while the velar resonance in [x] comes from |U|. Note that velar resonance is represented by non-headed |U| whereas labial resonance in [v]~[ß] (see footnote 8) comes from headed |U| (Backley & Nasukawa 2009b).

As discussed in Section 2, the convention in standard versions of ET is to isolate one element as the head of an entire expression. Alternatively, however, headedness could be viewed as the property of a fundamental—colour, resonance, or frequency—and we could require every fundamental in a representation to have a head. In this way, contrastiveness would derive from whether each fundamental is dark-headed or light-headed, as illustrated in (6) and (7). In fact, it will be argued that this is the only head-dependent relation that is relevant to melodic structure. This approach to headedness means that melodic structure contains two kinds of information, as shown in (6): it states which elements are present in an expression, and in addition, it states whether the fundamental associated with each of those elements is dark-headed or light-headed.

(6)

	a. [o]	b. [ɒ]	c. [x]
colour	|U|, dark head	|U|, light head	|U|, light head
resonance	|A|, light head	|A|, dark head	– –
frequency	– –	– –	|H|, light head
structure	|U A|	|U A|	|U H|

The vowel [o] in (6a) is specified as containing |U| and as having dark-headed colour. Since the dark value for the colour fundamental is |U| (see Table 6), and colour is specified as being dark-headed in this expression, it follows that [o] must have headed |U| in its structure. This is realised as acoustic prominence, which comes in the form of stronger, more salient acoustic cues. [o] is also specified as containing |A| and as having light-headed resonance. Given that the light value for the resonance fundamental is |ʔ|, and that the element |ʔ| is not present in [o], it follows that resonance cannot be interpreted as a headed property in this expression. The dark resonance element |A| which *is* present must therefore be realised in its dependent form and the overall structure has the shape |U A|. The structures |U A| (for [ɒ]) and |U H| (for [x]) are derived in the same way. The following paragraphs show how this approach to headedness can help explain why languages usually avoid certain element combinations.

Assigning head or dependent status to a fundamental, rather than to an individual element, has two consequences. First, if a complex expression refers to more than one fundamental in its structure, then it should be possible for it to have more than one head. Second, if an expression contains both the elements of an antagonistic pair, only one of those elements can be headed, e.g. |L H| and |L H| are possible but |L H| is not. Each of these outcomes is now considered in turn. The first says that, in principle, an expression may have up to three heads. This is because it has a structure which may contain at least one colour element, at least one resonance element and at least one frequency element, with each fundamental being independently specified as dark-headed or light-headed.[12] An example of a structure with two head elements is given in (7c).

(7)		a. [ɒ]	b. [x]	c. [χ]
	colour	|U|, light head	|U|, light head	|U|, light head
	resonance	|A|, dark head	– –	|A|, dark head
	frequency	– –	|H|, light head	|H|, light head
	structure	|U A|	|U H|	|U A H|

(7a) (repeated from (6b)) shows the lexical structure for [ɒ], which has a headed resonance element |A|. Then (7b) (repeated from (6c)) shows the structure for the fortis velar fricative [x], which has a headed frequency element |H|. Now consider the uvular fricative [χ] in (11c).[13] As a fortis obstruent, [χ] contains the headed frequency element |H|, and as a uvular it has the headed place specification |U A| (Backley (2011: 98ff.). The result is a double-headed structure |U A H|, in which the two head elements are permitted to coexist because they belong to different fundamentals. Multiple headedness of this kind is made possible by the fact that each fundamental has autonomous status; that is, each constitutes an independent structural unit and a separate domain for headedness.

The examples in (8) and (9) further illustrate how contrasts are expressed using the proposed system of headedness.

(8)		a. [u]	b. [ʊ]	c. [ø]
	colour	|U|, dark head	|U|, light head	|I|, |U|, light head
	resonance	– –	– –	|A|, light head
	frequency	– –	– –	– –
	structure	|U|	|U|	|I U A|

The difference between (8a) and (8b) is relevant in languages that have vowel contrasts based on the difference between tense and lax. In (8a) the only specified element is |U|, the dark realisation of the colour fundamental; and because (8a) is also specified as having dark-headed colour, |U| appears in its headed form |U| and is realised as tense [u]. (8b) has the same element |U|, but the colour fundamental is now marked as having a light head. The structure contains no |I| element (i.e. no light realisation of colour), so colour cannot be interpreted here as a headed property. The colour element |U| therefore appears in its dependent form and is realised as lax [ʊ]. In (8c) both colour elements are present, but because the expression is specified as having light-headed colour it is |I| which is headed, giving |I U A| for the front vowel [ø].

[12] While triple-headed structures are grammatically possible, most melodic contrasts are expressed using structures that are either non-headed, single-headed or double-headed.

[13] ET has always maintained that any element should be able to appear in both consonant and vowel expressions. In (7a) the element combination |U A| is interpreted as the low vowel [ɒ] in a syllable nucleus and as uvular resonance/place in a syllable onset—see (2).

The same principles allow us to derive the non-headed consonant expressions in (9a) and (9b): |I A| for (clear) [l] and |I L ʔ|[14] for [n], respectively.

(9)

	a. [l]	b. [n]	c. [d]
colour	|I|, dark head	|I|, dark head	|I|, dark head
resonance	|A|, light head	|ʔ|, dark head	|ʔ|, dark head
frequency	– –	|L|, light head	|L|,|H|, dark head
structure	|I A|	|I L ʔ|	|I L H ʔ|

(9c) shows the representation for [d] in languages such as French, where obstruent voicing functions as a marked property.[15] The expression |I L H ʔ| contains the two frequency elements |L| and |H|, and because the frequency fundamental is specified here as dark-headed, |L| appears in its headed form |L| and is realised as obstruent voicing (Nasukawa 2005) (cf. dependent |L| as nasality in (9b)).

As already mentioned, the second consequence of assigning head or dependent status to a fundamental is that, in an expression containing antagonistic elements, only one of those elements can be a head. This is because each fundamental is specified lexically as being either dark-headed or light-headed—it cannot be both. So, a structure ought to be ill-formed if it contains the two heads |U| and |I|, or the two heads |A| and |ʔ|, or the two heads |L| and |H|. To help determine whether this is really the case, (10) lists the phonological categories that are usually associated with these headed elements.

(10)

a.	*colour*	|U|	back rounded Vs, labial Cs
		|I|	front Vs, palatal Cs
b.	*resonance*	|A|	low Vs, uvular Cs, pharyngeal Cs
		|ʔ|	ejective Cs, implosive Cs
c.	*frequency*	|L|	voiced obstruent Cs
		|H|	voiceless/aspirated obstruent Cs

In general, it seems that languages avoid combining antagonistic elements if the two elements in question are both heads. The expressions resulting from such combinations rarely function as contrastive categories, and when they do occur in languages, they are highly marked. Beginning with |U| + |I|, it is surprising that any language should make use of a vowel category that combines the back quality of |U| with the front quality of |I|. In articulatory terms *back* and *front* are clearly incompatible; and in acoustic terms too there is a conflict between the formant lowering associated with |U| and the raising of F2 associated with |I|. Even the well-known case of high vowel contrasts in Norwegian is expressible without the need for double-headed representations (Backley 2011: 199), as shown in (11).

(11) *Norwegian* (Backley 2011: 199)

do	[du]	'toilet'	|U|	back, protruded lips
du	[dʉ]	'you (SG.)'	|U I|	fronted, compressed lips
dy	[dy]	'forbear!'	|U I|	front, protruded lips
ti	[ti]	'ten'	|I|	front, spread lips

[14] In languages where nasals pattern with obstruent stops, |ʔ| is present in both categories. However, there are also languages in which nasals behave as continuants, in which case they presumably lack |ʔ|. For discussion, see Botma (2004) and Mielke (2005).

[15] On the issue of laryngeal realism, see Honeybone (2005) and references therein.

[y] and [ʉ] are both round and front(ed), so each must be represented by a combination of |U| and |I|. But they differ in the relative prominence of each element. The phonetic characteristics of [y] suggest that this is, in effect, a front vowel *i* (headed |I̲|) with additional rounding (dependent |U|), resulting in the structure |U I̲|. By contrast, [ʉ] has a different lip shape and a weaker palatal quality which identify it as a back rounded vowel *u* (headed |U̲|) with some degree of additional fronting (dependent |I|). For the reasons already stated, the marked combination of headed |U̲| and headed |I̲| is avoided in the vowel system of Norwegian—and perhaps, universally.

The same applies to consonant systems, where it is rare to find headed |U̲| (labial resonance) and headed |I̲| (palatal) in the same expression. Each may function independently as a secondary articulation, producing a labialised or palatalised consonant; but significantly, there is a strong tendency for labialisation and palatalisation to target coronals (e.g. [tʷ nʲ]) and velars (e.g. [gʷ kʲ]) rather than palatals (e.g. [ʧʷ ʒʷ]) or labials (e.g. [bʲ mʲ]). This bias appears to be based on whether the target segment has a headed or non-headed place property. Coronals (|I|) and velars (|U|) both have a place element that is non-headed, so they readily acquire headed |I̲| or |U̲| as a secondary place property. By contrast, palatals (|I̲|) and labials (|U̲|) already have a headed colour element, and these do not easily combine with another headed |I̲| or |U̲|. Consequently, labials rarely undergo palatalisation and palatals rarely undergo labialisation. Note that, although palatalised labials are reported in a minority of languages (e.g. Scots Gaelic, Russian), their status as singletons (cf. consonant-glide sequences, for instance) is open to question (Gussmann 1992).

Like |U| + |I|, the antagonistic combination |A| + |ʔ| involves a conflict between opposing physical properties. In the case of |A| + |ʔ|, the relevant property is resonance. While all sonorant sounds produce resonance—that is, they allow air in the vocal tract to vibrate naturally at certain frequencies—it is in the low and mid vowels (containing |A|) that vocal tract resonance is most easily perceived. By contrast, oral stops (with |ʔ|) display very low audible resonance: they have a hold phase during which airflow is interrupted, causing acoustic energy to drop sharply and vocal fold vibration to cease. By removing the sound source in this way, the resonance frequencies of the vocal tract become inaudible. The acoustic cues for |A| and |ʔ| are therefore in opposition, and this can affect their ability to combine.

If |A| and |ʔ| are both in their weak, non-headed form then they can freely co-occur. For example, in languages such as English where coronals are represented by |A|,[16] the coronal stop [t] has the representation |A H ʔ|. Once headedness is introduced into the structure, however, the outcome is always a more marked expression (Backley 2011: 196): the categories in (12b), with headed |ʔ̲|[17] or headed |A̲|, have a much narrower distribution cross-linguistically than the plain stop in (12a), while those in (12c) are extremely rare—only a handful of possible examples have been reported.

(12)	a.	non-headed	[t]	|A H ʔ|	coronal stop
	b.	single-headed	[ʡ]	|A̲ H ʔ|	pharyngeal stop
			[tʼ]	|A H ʔ̲|	ejective coronal stop
	c.	double-headed	[ʡʼ]	|A̲ H ʔ̲|	pharyngeal ejective stop
			[ɠ]	|A̲ U L ʔ̲|	uvular implosive stop

[16] There is a typological split between languages in which coronal resonance is represented by |A| (e.g. English) and languages where |I| represents coronal resonance (e.g. Japanese). The choice of |A| or |I| depends more on the phonological behaviour of the consonant in question than on its acoustic properties. For a discussion of |A| and/or |I| in coronal consonants, see Backley (2011: 72ff.) and footnote 5.

[17] When an element is headed, its acoustic properties show greater prominence in the overall expression. Headed |ʔ̲| in ejectives and implosives corresponds to the prolonged and more prominent hold phase that predominates in these sounds.

The rarity of the categories in (12c) reflects the anomalous nature of their double-headed structures. If headedness increases the prominence of a fundamental, then we can express this prominence in one of two ways, i.e. by strengthening either its dark value or its light value. There is, however, nothing to be gained from strengthening both values in the same expression because their respective acoustic cues are in conflict—the increased prominence of one set of cues will be masked by the increased prominence of the opposing set of cues. Applying this to the resonance fundamental, it rules out a combination of headed |A| and headed |ʔ| on perceptual grounds. It is also supports the claim that melodic head-dependency refers to fundamentals (colour, resonance, frequency) and not to individual elements.

Finally, the antagonistic combination |L| + |H| is analysed in a similar way to |U| + |I| and |A| + |ʔ|. It has already been shown that |L| and |H| mark the opposing (dark versus light) values of the frequency fundamental. This suggests that listeners pay attention to changes in the distribution of acoustic energy when they are decoding running speech, focusing on points of low frequency (in nasals, voiced stops and low-tone vowels, all containing |L|) and points of high frequency (in fricatives, voiceless stops, and high-tone vowels, all containing |H|). So again, there is a polar relation between the acoustic cues for |L| and those for |H|, and this affects their ability to combine. This is illustrated in (13), where all the categories are marked to varying degrees. They owe their marked status to the co-occurrence of |L| and |H|.

(13)	*marked* (|L| + |H|)	*example*		*cf. less marked* (|L| or |H|)		
	voiced fricative	[ʒ]	|A I̲ H L̲|	plain fricative	[ʃ]	|A I̲ H̲|
	breathy voiced stop	[bʱ]	|U̲ H L̲ ʔ|	voiced stop	[b]	|U̲ L̲ ʔ|
	voiceless nasal	[n̥]	|A H L ʔ|	nasal	[n]	|A L ʔ|
	aspirated nasal	[m̤]	|U̲ H̲ L ʔ|	nasal	[m]	|U̲ L ʔ|

Note that, in the case of |L| + |H|, it is unclear as to whether *any* languages allow |L̲| and |H̲| to co-exist when both are heads. Should such a combination be found, the category in question would be expected to show the highly unusual behaviour of patterning with fully voiced obstruents (with |L̲|) and also with voiceless aspirates (with |H̲|). In terms of markedness this would place it alongside other highly marked categories that are (tentatively) associated with a double-headed antagonistic structure, e.g. palatalised labials with |U̲| + |I̲| and uvular implosives with |A̲ U| + |ʔ̲|.

5 Conclusion

This paper contributes to the ongoing debate on the issue of headedness in ET by challenging the tacit assumption that complex melodic expressions can have just one head element. In fact, it argues for an approach to segmental representation in which there is a need to posit element structures containing two heads. The system of element representation described in Backley (2011) views headedness as a property of fundamentals rather than of whole melodic expressions. It also sees dual interpretation as the norm—that is, a single element has two different phonetic interpretations depending on whether it is headed or non-headed. And with dual interpretation comes multiple headedness: to represent certain segmental categories—even some unmarked categories which are common to many of the world's languages—it is necessary for the grammar to permit element structures with two headed elements.

Double headedness presents a conceptual challenge to standard theories of segmental structure, and indeed, to theories of linguistic structure in general. It therefore requires justification on at least two levels. First, the need for double headedness must be made

clear, by presenting language data that can best (or can only) be accounted for by appealing to double headedness. Second, the way double headedness is implemented in the grammar must be consistent with existing principles of structural and grammatical well-formedness. Regarding this second point, it has been argued here that double headedness is incorporated into the ET grammar by organising the element set into three pairs of opposing elements, with each pair marking out the polar values of three fundamental properties of spoken language: colour, resonance, and frequency. Within each pair, one element displays the characteristics of a light element and the other the characteristics of a dark element. Moreover, the distinction between light and dark serves as the domain for headedness; that is, in a given expression each fundamental property is specified as being either light- or dark-headed.

Because melodic structure recognises three fundamental properties, there is the potential for up to three heads in one element expression (though in practice, most languages express all the segmental categories they need by using just non-headed, single-headed and double-headed structures). This is possible because each fundamental has autonomous status—it is individually specified as dark-headed or light-headed. While this approach to headedness allows the two elements in an opposing pair to co-occur in the same expression, it rules out the possibility of both being heads. That is, the double-headed combinations $|\underline{U}| + |\underline{I}|$, $|\underline{A}| + |\underline{?}|$, and $|\underline{L}| + |\underline{H}|$ are, in principle, disallowed. Whether this is universally the case or not is an empirical question which can only be answered by analysing more language data. For now, it seems prudent to settle for the claim that such combinations *may* be unattested, but if they are found to exist then they must belong to expressions that are particularly rare or unusual.

Abbreviations

ET = Element Theory, OE = Old English, SG = singular

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