Headship as Melodic Strength*

* Phillip Backley and Kuniya Nasukawa

1. Introduction

All languages show lenition effects of one kind or another, either historical or synchronic, which suggests that all language users must have a certain instinctive or subconscious knowledge about strength differences in their own sound system. One of the goals of an explanatory theory of phonology must therefore be to capture these strength relations in a non-arbitrary way.

When addressing the issue of strength, it emerges that we need to refer to two levels of structure: melodic and prosodic. Accordingly, this paper begins by considering the relation between strong prosodic positions and strong melodic expressions. It then goes on to discuss the distinction made in Element Theory (Harris and Lindsey 1995; Backley and Nasukawa 2006; Nasukawa and Backley 2008) between headed and non-headed melodic expressions, and argues that some obstruent categories – aspirates, ejectives, fully voiced stops – must be represented as headed melodic expressions. Finally, it shows how headed expressions function as strong acoustic cues in the speech signal; these cues help listeners to identify prosodic constituents such as feet and words, and thereby facilitate language processing. It will be argued that lexical access is made more efficient by knowing where prosodic domains begin and end, the central claim being that headed melodic expressions assist language users in locating these prosodic boundaries.

2. Approaches to strength and lenition

The labels ‘phonological strength’ and ‘lenition’ are both imprecise terms, leading to some varied usage in the literature. Nevertheless, generalisations

* An earlier version of this paper was presented at the workshop Strength Relations in Phonology held at Tohoku Gakuin University, Japan, in September 2006. We thank participants at the workshop for their constructive comments. This research was partially funded by the Japanese government’s Ministry of Education, Culture, Sports, Science and Technology under grants 16520254, 16720117 and 18520390.
do emerge from this variation. The common consensus is that lenition – a
reduction in strength – may bring about an alternation or a sound change in
one or more of the following directions:

A: an increase in sonority along some established sonority scale
B: a decrease in oral occlusion
C: a loss of phonologically marked properties

These effects share the assumption that lenition should be described
primarily in segmental terms; in other words, it is assumed that lenition
alters melodic structure in some way. This melodic approach to lenition
will be described here as the standard view, where a typical description of
segmental weakening also includes some mention of the prosodic context
where the lenition process takes place. For example, frequent reference is
made to the inherently weak positions where lenition is expected to occur,
such as intervocalic and word-final. So the standard approach characterises
lenition by referring to (i) differences in melodic strength, represented as
feature change or feature loss, and also (ii) differences in prosodic or posi-
tional strength, which are usually stipulated. Some of the most common
lenition processes are listed below (for a comprehensive survey, see Gure-
vich 2004).

Table 1. Common lenition processes

<table>
<thead>
<tr>
<th>process</th>
<th>examples</th>
<th>effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>spirantisation</td>
<td>Tiberian Hebrew (Idsardi 1998): e.g. t→θ katab [kaθaθv] ‘write (3ms.perf.)’</td>
<td>A, B</td>
</tr>
<tr>
<td></td>
<td>Scots Gaelic: e.g. k→x c[k]as ‘steep’, glé ch[x]as ‘very steep’</td>
<td></td>
</tr>
<tr>
<td>vocalisation</td>
<td>Estuary English: e.g. l→u tell [teu] (cf. telling [teling])</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Modern Persian (Hayes 1986a): e.g. v→w [nowruːz] ‘New Year’ (cf. [nowiːn] ‘new kind’)</td>
<td></td>
</tr>
</tbody>
</table>
In this paper, as in the standard approach, we acknowledge that effects relating to phonological strength must be characterized in both melodic and prosodic terms. However, in the alternative approach to be presented here, we suggest that it is neither useful nor desirable to discuss melody or prosody in isolation, since the two are fundamentally linked. Specifically, we argue that strength is essentially a prosodic property, which is then reflected directly in melodic structure. We claim that the distribution of strong and weak sounds has a linguistic function, which is to convey information about prosodic structure. But in order for this information to be transmitted during communication, it must be converted into a form that listeners can perceive and interpret; in other words, it must be expressed in melodic terms and encoded in melodic structure.

Of course, it has been recognized for some time that the realization of a sound can be sensitive to its prosodic position (Fougeron and Keating 1997; Cho and Keating 2001). Yet this is normally viewed as a purely phonetic effect because it typically involves small, gradient changes in articulation. For example, Keating et al. (2003) propose an analysis of domain-initial strengthening on the basis of slight increases in duration and VOT. By contrast, in this paper we argue that such differences in melodic strength are linguistically significant, that they carry important linguistic information for listeners, and that they should therefore be incorporated into the phonology. Below we demonstrate how these melodic strength differences may be formalized in the context of an Element Theory approach to melodic representation.
3. Prosodic strength and melodic strength

Let us clarify our own understanding of the term ‘strength’, first from a prosodic angle and then from a melodic point of view.

In describing prosodic strength we refer to a growing body of evidence from the psycholinguistics literature which indicates that listeners rely on the identification of prosodic categories when interpreting speech. Experimental evidence indicates that, in order to recognize words quickly and process language efficiently, listeners give priority to locating the edges of prosodic domains (Cutler and Norris 1988; Jusczyk et al. 1993). Assuming this is the case, there are two questions that need to be addressed. First, if prosodic categories are important for language processing, how do listeners locate them in running speech? The claim that we develop below is that the constituents of prosodic structure are indicated by the presence of strong prosodic positions; in other words, the positions which are generally considered to be strong are the ones which carry the responsibility for demarcating the edges of prosodic domains. In most cases it is the left edge of a domain which is marked out, and again the psycholinguistics literature offers some explanations for this preference (Marslen-Wilson and Tyler 1980). So, word-initial position is expected to be prosodically stronger than word-final position, for example, and syllable-initial position (i.e. onset) stronger than syllable-final (i.e. coda).

If listeners are assumed to pay particular attention to strong prosodic positions, the second question to be addressed is this: how do listeners identify strong positions? We proceed by assuming that they can distinguish between prosodically strong and weak positions because this information is reflected directly in melodic structure – and ultimately, in the acoustic signal. More precisely, we claim that listeners pay attention to certain cues in the acoustic signal which indicate the presence of a strong position. And in turn, these cues help listeners to locate the edges of prosodic word domains (or, less frequently, of foot or syllable domains). Once again we echo the views expressed in various psycholinguistic studies and assume this is the information that listeners rely on for segmenting utterances into words and then for sharpening the process of lexical access.

So, our own view of prosodic strength relies crucially on recognizing a distinction between those positions which lie at the boundaries of prosodic domains (i.e. strong positions) and those which are domain-internal (i.e. weak positions). This distinction does not directly facilitate the communication process, however, for the simple reason that the primary function of prosodic structure is organizational, not interpretative. Its chief roles are to convey information about the relations holding between sounds and to
identify higher structural units that may be relevant to the suprasegmental aspects of speech. As an organizational construct, prosodic structure is not usually subject to direct phonetic interpretation; rather, it influences the way in which interpretable material (i.e. melodic structure) is interpreted. Now extending this assumption, we wish to pursue the argument that prosodic strength cannot be described independently of melodic strength. Let us therefore clarify our understanding of melodic strength, and at the same time examine the nature of this key relation between prosody and melody.

It has already been suggested that differences in prosodic strength must be audible in some way – that is, we take it that there are certain acoustic cues present in the speech signal which serve to indicate the presence of a prosodically strong position. Now, because these cues are linguistically significant – that is, they carry important information about linguistic structure – it should be the case that they are expressed formally in phonological representations. Here, we propose that such cues are encoded specifically in segmental structure, and below we illustrate this point using an Element Theory approach to melodic representation (Harris and Lindsey 1995; Backley and Nasukawa 2006). Indeed, it appears that the element-based model is ideally suited to conveying prosodic information of this kind. In comparison, while there may be a way of using traditional distinctive features to encode strength relations in segmental structure, it is not immediately obvious how this should be done.

4. Headship in Element Theory

For independent reasons the Element Theory framework makes an important distinction between headed and non-headed melodic expressions, which is explained below. Our claim here is that this headship distinction also reflects differences in prosodic strength: the acoustic cues which indicate strong prosodic positions are those corresponding to headed melodic expressions, while weak positions only contain segments represented by non-headed expressions. The notion we wish to formalize is that melodic headship is one of the strategies that languages use to indicate prosodic strength. This, in turn, assists listeners in locating the prosodic constituent boundaries that help to make language processing more efficient.

So, our central claim is that one of the functions of melodic headship in Element Theory is to express differences in prosodic strength. And in §5-8 below we present evidence from a variety of languages to support this view that melodic strength reflects prosodic strength. The pattern that will emerge is one where headed expressions show a distributional bias towards
prosodically strong positions. Clearly, however, the validity of our claim rests largely on whether or not the notion of headedness in melodic structure is a valid one. We therefore proceed with an outline of Element Theory itself and some generalisations concerning the role of headship. Then we go on to demonstrate how the use of headship can be extended in a specific way: we propose that a headed melodic structure is essential to the representation of certain obstruent categories—namely, aspirated stops, ejective stops and fully voiced stops. We claim that these three classes are formalized by the presence of headed [H], headed [ʔ], and headed [N] respectively. In describing these categories, we show how the distribution of headed melodic expressions reveals a direct connection with prosodic strength.

Element Theory is a restrictive model of segmental structure in which segments are represented by combinations of features or ‘elements’ drawn from the six-member set [A I U H N ḷ]. Elements are single-valued units of phonological structure, each standing for a universal property which exhibits active phonological behaviour and which is mapped on to an information-bearing pattern in the speech signal. Although any element can in principle appear in any syllabic position, the set of six elements naturally divides into two groups. The ‘resonance’ group consists of the three resonance elements [A I U], which are primarily involved in the description of vowel contrasts. Clearly, this aspect of the theory owes much to earlier work in Dependency Phonology (Anderson and Durand 1986), Particle Phonology (Schane 1984) and other related frameworks. The remaining elements [H N ḷ] comprise the ‘laryngeal-source’ group and describe the laryngeal and manner properties of consonants. Each element may stand alone in an expression, or, as already indicated, may combine with other elements in either equal or unequal proportions. An unequal combination creates a head-dependent relation between the elements concerned.

The resonance elements [A I U] provide the linguistic code for describing vowels: they create vowel contrasts, they shape vowel systems, and they participate in dynamic phonological processes. Physically, the vowel elements are associated with the peripheral vowels [a i u]—i.e. the three extreme points in the acoustic vowel space; in addition, they stand for the three basic speech signal patterns that are fundamental to vowel systems. In terms of their phonological behaviour, [A I U] are regularly active in dynamic processes such as assimilation, coalescence and diphthongization, which strengthens the view that these properties have primitive (i.e. element) status. When two or more elements combine, the result is a compound segment. This is a compound in two senses: physically the compound expression is associated with multiple patterns in the speech signal,
Headship as melodic strength

and phonologically it represents a segment belonging to more than one natural class.

Although [A I U] are chiefly associated with vowel structure, the same elements also contribute ‘place of articulation’ properties in consonant representations. This highlights one of the central assumptions of the Element Theory view – that a single element may have more than one possible interpretation, depending on its context; this allows important cross-category groupings (e.g. front vowels and palatal consonants) to be captured in a non-arbitrary way.

While the resonance elements [A I U] provide place properties in consonants, the laryngeal-source elements [H N ?] cover all remaining aspects of consonant structure. Traditionally, these other aspects are described using informal labels relating to ‘manner of articulation’ (stop, fricative, nasal, approximant, etc.) and ‘glottal state’ (voicing, aspiration, etc.). Within Element Theory, however, this division between manner and glottal state is not especially relevant and is therefore not formally expressed. This is due, in part, to the way that elements have different phonetic interpretations across different consonant categories. For example, in §7 we shall see how [N] is responsible for nasality in sonorant consonants and also for contrastive voicing in obstruents. It is also partly due to the way Element Theory carves up the consonant space along the boundaries of linguistic categories, and not according to phonetic classification. For instance, an element-based representation cannot overtly express the fact that sonorants are usually voiced, because their voicing properties do not carry significant linguistic information. In what follows, therefore, we introduce the consonant elements [H N ?] by describing their intrinsic phonological properties; these properties do not necessarily correspond to established phonetic categories.

The [H] element is also known by its descriptive label stiff vocal folds, and broadly defines the class of obstruents since it is usually present in stops and fricatives. Its typical manifestation is voiceless, and it functions as the active laryngeal property in English, Swedish and other so-called aspiration languages (see §5). The [?] (or stop) element, on the other hand, represents a drop in amplitude of the kind which is present in the spectral profile of oral stops, nasal stops and some laterals. In acoustic terms, [?] corresponds to a momentary ‘empty’ slice in the spectral profile. This is discussed more fully in §6. Finally, the element [N], also known by its descriptive label slack vocal folds, serves the dual function of contributing nasality in nasal stops and obstruent voicing in fully voiced stops. In §7
we describe how these two quite different manifestations of [N] are distinguished phonologically.

The motivation for recognising the elements [H] and [N] derives in part from the arguments which relate to voice onset timing (Backley and Nasukawa 2006). However, Harris (1994: 134) also introduces further evidence for the primary status of these elements.\(^1\) In acoustic terms, the two glottal states *stiff vocal folds* and *slack vocal folds* correspond to raised and lowered fundamental frequency, respectively. This, in turn, suggests a parallel with tonal contrasts in vowels. Although this claim requires further investigation, it appears that some phonological processes indicate a correlation between stop aspiration and high tone on a following vowel, as well as between obstructed voicing and a neighbouring low tone vowel (Matisoff 1973). Here we follow this view of laryngeal contrasts, although our discussion will reveal how the basic categories [H] and [N] must be modified in order to accommodate the specific characteristics of aspiration languages and voicing languages.

Almost since its inception, Element Theory has incorporated into its melodic representations some form of head-dependency relation holding between elements in the same expression. This headship relation serves two important purposes: first, it increases the number of possible melodic expressions – and thus, the number of contrasts – that the model can generate; second, it permits a situation in which one element (i.e. the head) dominates all others (i.e. dependents) in an expression, allowing this dominant element to manifest a stronger set of acoustic cues and thus predominate in the physical interpretation of the resulting melodic expression. It is this head-dependent asymmetry that will be shown to play the key role in our formulation of melodic strength.

To illustrate the workings of melodic headship, let us review a standard example involving compound vowels. The vowel element [I] has the effect of increasing the value of F2 in any expression where it is present; in articulatory terms, this broadly translates into vowel frontness. So when [I] occurs alone, its typical interpretation is as a high front vowel [i] – a vowel with high F2 but no other salient linguistic properties. Consider now the element [A], which is associated with a high F1 value; this suggests an open articulation, and indeed its usual interpretation is as a low vowel such as [a] or [α]. When [I] and [A] combine in the same expression, the result is a blend of – in effect, a compromise between – their respective properties high F2 and high F1. While symmetrical fusion is possible, it is very com-

---

\(^1\) The [N] element is referred to as [L] in some sources including Harris (1994).
Headship as melodic strength

mon for elements to combine unequally, and in such a case one element is designated the head of the expression. Should |I| predominate as the head of this |I A|^2 combination, then this element makes a greater contribution to the resulting compound: the outcome is a high front vowel (high F2) which has been lowered to [e] through the influence of the dependent element |A|. On the other hand, if |A| acts as the head of a compound |I A|, then the result is [æ] – a low vowel (high F1) onto which vowel fronting from |I| has been superimposed.

In this paper we aim to show how the same principle of melodic headship may also be applied to the representation of consonants. Specifically, we will demonstrate how the three laryngeal-source elements are subject to the same headed versus headless distinction already described for vowels. In §5 we argue that |H| (i.e. |H| as a headed element) represents aspirated stops, while in §6 we show how headed |P| classifies the category of ejective stops. Then §7 discusses the role of headed |N| in identifying the class of fully voiced stops. In conclusion, we will argue that the headed status of aspirated stops, ejective stops and fully voiced stops provides an explanation for why these obstruent categories show a natural affinity for strong prosodic positions.

5. Headed |H| in aspirated stops

Most versions of Element Theory recognize two laryngeal-source elements |H| and |N|. The |N| element is assumed to be active in ‘full voicing’ languages such as Russian and Spanish, and is interpreted as non-spontaneous voicing or even pre-voicing in obstruents. In terms of its phonetic interpretation and also its distributional properties, |N| behaves in a similar way to the privative [voice] feature of Lombardi (1994). In §7 we return to a discussion of |N| in consonant representations.

By contrast, the |H| element appears in ‘aspiration’ languages like English, German and Korean. Its distribution broadly corresponds to features such as [asp] (Lombardi 1994), [spread glottis] (Iverson and Salmons 1995) and [+tense] (Jessen 1998). The usual interpretation of |H| is voicelessness, but in certain environments |H| can also be interpreted in other ways, such as aspiration on plosives or as vowel shortening before fortis consonants. The Element-based representations in (1) show |H| as a con-

---

^2 In a compound expression, the head element is underlined.
trastive property in English.\(^3\) Note that aspiration languages like English have lenis stops such as [\(\beta \delta\)], which are produced without voicing. Moreover, lenis stops are phonologically neutral in the sense that they have no active laryngeal/voicing properties. For this reason, (1b) has no [\(N\)] element or other property referring to voicing (Backley and Nasukawa 2006).

\(1\) The contrastive function of [\(H\)]

a. fortis [\(p^h\)] post, appear… [? U H]

b. lenis [\(\beta\)] brief, about… [? U ]

The contrast in (1) oversimplifies the situation, however. A closer look at the laryngeal behaviour of English stops reveals that the simple presence or absence of [\(H\)] is insufficient by itself to account for all the laryngeal patterns attested in English. These are given in (2). What we actually find is that the fortis series has the two contextually determined forms in (2a,b), while the lenis series shows the alternations in (2c,d):

\(2\) Laryngeal contrasts in English

<table>
<thead>
<tr>
<th>aspirated</th>
<th>voiced</th>
<th>context</th>
<th>examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>[(p^h)]</td>
<td>yes</td>
<td>no foot-initial</td>
<td>pass, appear</td>
</tr>
<tr>
<td>[(p)]</td>
<td>no</td>
<td>no foot-internal,</td>
<td>wrapper, spy</td>
</tr>
<tr>
<td>[(\beta)]</td>
<td>no</td>
<td>no foot-initial</td>
<td>best, about</td>
</tr>
<tr>
<td>[(\beta)]</td>
<td>no</td>
<td>yes foot-internal</td>
<td>ruby, cupboard</td>
</tr>
</tbody>
</table>

The fortis stop in (2a) is aspirated in the archetypal strong environment of foot-initial position, but loses its aspiration in weaker positions such as those described in (2b). Nevertheless, both expressions are voiceless and consequently both should contain [\(H\)]. Yet (2a) and (2b) are distinct in terms of their phonetic interpretation and also their distributional patterns; we therefore expect them to have different representations. What the standard Element Theory model lacks, however, is a means of referring to aspiration independently of voicelessness, which seems necessary if we are to succeed in capturing this aspirated/non-aspirated difference. A further complication arises from the apparently alternating behaviour of the lenis

\(^3\) The representation of labial stops also contains the element [\(U\)], which contributes labial resonance in consonants, and the stop element [?], which represents the drop in amplitude associated with oral/nasal stops and some laterals. For a brief description, see §4 above. For details see Harris and Lindsey (1995).
stop. In strong positions, the voiceless unaspirated stop [h] in (2c) shows physical characteristics that are similar to those of the weakened (i.e. de-aspirated) stop [p] in (2b). The lenis stop [b] is also subject to weakening, however, especially in foot-internal contexts where it becomes a fully voiced [b]. As it stands, [H] alone seems quite unable to register this full set of laryngeal patterns.

One possible way of marking a phonological distinction between voicelessness and aspiration is to retain [H] for representing voicelessness but to introduce another laryngeal element uniquely for aspiration. For several reasons, however, this option is best avoided. There is sufficient evidence from dynamic phonological processes to support the assumption that English, like other aspiration languages with a two-way laryngeal distinction, uses only [H] as an active laryngeal property. In fact, [N] is the only other laryngeal element available within the Element Theory framework, and there is no indication that [N] behaves as an active property in English. Furthermore, the introduction of an additional element increases the generative capacity of the model unnecessarily, and also brings about the existence of a new, supposedly natural class of sounds for which there is no obvious empirical support.

On the other hand, it could be argued that the presence/absence of aspiration and full voicing should be a matter for phonetic realisation rather than for phonological representation. After all, in Germanic languages the choices between [pʰ] versus [p] and between [b] versus [b] are entirely predictable. We take issue with this suggestion too, and instead follow the line of thinking set out in Harris and Urua (2001), who equate ‘lexical’ information with ‘linguistic’ information, whether this information is contrastive or predictable. They argue that representations convey information about the speech signal, this information being manifest in the form of acoustic cues that serve as the input to a listener’s auditory-perceptual system. This position clearly departs from the prevailing view that phonological structure encodes facts about articulation. As just indicated, Harris and Urua make a further departure from the standard articulatory-based position by assuming that representational information is not limited to the description of melodic contrasts; it can also include other salient linguistic cues. Expressed in traditional terms, we might say that they recognise no division between phonemic and allophonic differences. This is because some sound properties, despite being non-contrastive, still turn out to have a linguistic role to play, and are therefore highly salient in perceptual terms. Aspiration may be considered a case in point:
“The high cue potential of certain supposedly redundant properties rests to a large extent on their very predictability. English aspiration is not only paradigmatically informative, acting as the most robust local cue to the ‘voice’ identity of plosives, but it is also syntagmatically informative to the extent that it adheres to the onset of a stressed syllable and thus demarcates the left edge of a foot” (Harris and Urua 2001: 76).

On this basis, we shall assign equal status to the aspiration difference \([\text{p}^\text{h}] - \text{[p]}\), the fortis/lenis difference \([\text{p}^\text{h}] - \text{[b]}\), and the voicing difference \([\text{b}] - \text{[b]}\). All are similar in terms of their linguistic significance. We therefore need a way of representing phonologically the four-way laryngeal split shown in (2). Ideally, however, this should be achieved by referring just to \([H]\), which is the only laryngeal element which is active in the structure of English obstruents. In addition, we would like the resulting representation to reflect the fact that, at least in Germanic languages like English, aspiration and voicelessness are apparently related in the sense that aspiration implies voicelessness (i.e. lenis stops are not usually aspirated). In fact, below we will show how this close relation between the two properties is central to their Element-based representations.

The behaviour of its laryngeal properties defines English as an aspiration language; it therefore refers to the presence/absence of \([H]\) in expressing the difference between fortis and lenis stops. This much is clear. But with regard to the difference between aspirated \([\text{p}^\text{h}]\) and unaspirated \([\text{p}]\), a distinction in terms of melodic structure is not obvious, since both are voiceless and therefore both have \([H]\). So this is not a question of the presence or absence of an element. Rather, the issue concerns the relative prominence of \([H]\) in the overall expression. In phonetic terms, the laryngeal categories in (2) may be expressed as follows:

(3) Representation of laryngeal categories in English

<table>
<thead>
<tr>
<th>category</th>
<th>laryngeal property</th>
<th>representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ([\text{p}^\text{h}]) (aspirated)</td>
<td>long voicing lag</td>
<td>([H]) prominent →([H])</td>
</tr>
<tr>
<td>b. ([\text{p}]) (unaspirated)</td>
<td>short/no voicing lag</td>
<td>([H]) present →([H])</td>
</tr>
<tr>
<td>c. ([\text{b}]) (neutral)</td>
<td>short/no voicing lag</td>
<td>([H]) present →([H])</td>
</tr>
<tr>
<td>d. ([\text{b}]) (voiced)</td>
<td>spontaneous voicing</td>
<td>laryngeal inactive →</td>
</tr>
</tbody>
</table>
exaggerated in aspirated stops owing to the presence of [H]. This is consistent with our understanding of headed expressions in general, where the acoustic properties of a head are expected to be stronger and more prominent than when same element is a dependent.

This dominance relation between elements is reminiscent of other head-dependent asymmetries which have long been recognised, particularly in prosodic structure. In fact, the parallel between prosodic headship and melodic headship seems fairly robust. In prosody, it is common for head status to be reflected in some property of the speech signal; for example, in the head-dependency relation holding between the two nuclei that define a binary foot, it is typical for the head nucleus to be perceptually stronger than the dependent nucleus and acoustically more prominent (cf. strong versus weak units in stress systems). Similarly, in melody we expect the head-dependency relation to have direct phonetic consequences: the head element in a melodic structure makes a greater contribution to the overall acoustic profile of an expression than do other elements. So in the case of aspirated stops, the defining characteristic of voicing lag is reinforced through melodic headship.

It will be recalled that in this paper we are attempting to stress the inseparable nature of melodic strength and prosodic strength. Therefore the next question to arise is this: if headship has the effect of strengthening a melodic expression, how does this relate to prosodic strength? We have already made three claims. First, melodic strength reflects prosodic strength. Second, melodic strength is achieved through headship. And third, prosodically strong positions are those that aid language processing by indicating the location of various prosodic domains. Applying these insights to English, it appears that the relevant prosodic domain is the foot, since aspirated stops (which are headed expressions) are distributed in a way that marks the left edge of a foot domain. We note here that stress in English can also help listeners in the identification of foot domains, since the distribution of stressed syllables is linked directly to foot structure. In fact, a good deal of evidence resulting from psycholinguistic experimentation (Cutler and Norris 1988; Echols et al. 1997; Jusczyk et al. 1993) indicates that users of stress-timed languages rely on stress patterns in order to segment continuous speech into words – which is, of course, needed before lexical retrieval can take place.

4 The prosodic word domain also seems to be significant in English, as aspiration is regularly interpreted word-initially even when this position is not foot-initial: e.g. *potato* [pʰɔtəʊ].
Returning to the matter of representations in Element Theory, let us summarise the argument so far. We have claimed that aspirated stops have a representational structure containing the headed element $\text{[H]}$, and further, that headed expressions in general serve the function of conveying information about the location of prosodic domain boundaries. Thus it is unlikely to be a coincidence that aspirated stops in English occur systematcally at the left edge of word and foot domains, given that listeners are able to process the incoming speech signal more efficiently when they have this prosodic information at their disposal.

So, there are grounds for assuming that aspirates contain a headed $\text{[H]}$. Let us now extend this assumption by making the further claim that not only aspirated stops but all fortis stops lexically contain headed $\text{[H]}$; this includes unaspirated fortis stops such as those in (3b). Put simply, we claim that all voiceless stops are potential aspirates. However, this potential aspiration – represented in element terms as a ‘strong’ or headed expression – can only be realised in prosodically strong positions (Backley and Nasukawa 2006; Vaux and Samuels 2005). Recall that strong positions are those which are rich in linguistic/prosodic information because they mark out the left edge of a prosodic domain. In case this prosodic strength requirement is not met, the result is a weaker or lenited interpretation of the same structure.

Now, the lenition of a segment generally involves some loss of its defining properties: for example, stops can lose their place of articulation, fricatives can lose their audible friction, and vowels can lose their peripheral quality. In Element Theory, a lenited expression occurring in a weak position shows a reduction in the amount of acoustic information it expresses, where a loss of acoustic information typically results from a loss of melodic/structural material from its representation. In many cases, a loss of melodic material amounts to the loss of one or more elements (Harris and Lindsey 1995). In other instances, such as the present case of de-aspiration, however, it can result in a loss of headedness. In fact, if headed expressions are associated with strong positions, then it is only to be expected that a lenition process taking place in weak positions would target and remove the headed status of an expression.

To illustrate how and when this process of de-aspiration takes place, consider again the relevant English data:
(4) Laryngeal properties in English

<table>
<thead>
<tr>
<th>aspirated</th>
<th>voiced</th>
<th>context</th>
<th>examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>[pʰ]</td>
<td>yes</td>
<td>no</td>
<td>foot-initial</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pass, appear</td>
<td></td>
</tr>
<tr>
<td>[p]</td>
<td>no</td>
<td>no</td>
<td>foot-internal, s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wrapper, spy</td>
<td></td>
</tr>
<tr>
<td>[b]</td>
<td>no</td>
<td>no</td>
<td>foot-initial</td>
</tr>
<tr>
<td></td>
<td></td>
<td>best, about</td>
<td></td>
</tr>
<tr>
<td>[b]</td>
<td>no</td>
<td>yes</td>
<td>foot-internal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ruby, cupboard</td>
<td></td>
</tr>
</tbody>
</table>

The expression [ʔ U H] in (4a) is interpreted in full – i.e. without any loss of acoustic or linguistic information – because it appears in foot-initial position. But in weaker positions like foot-internal and word-final, headedness and the aspiration associated with headedness no longer has any prosodic function to perform, so it drops. Accordingly, aspiration is lost but voicelessness (as non-headed [H]) remains. Retaining [H] means that this lenited form potentially overlaps with the lenis stop in (4c), although the distribution of each remains distinct. However, the form in (4d) indicates that even lenis stops are susceptible to weakening in foot-internal position. In this case the lenition process targets the laryngeal specification [H]; and once [H] is suppressed, its associated property ‘short/no voicing lag’ is also removed from the expression, thereby allowing spontaneous voicing to be heard.

To conclude this section, consider the distribution of stop categories in Swedish. This is another aspiration language, and therefore we assume that [H] is active as a laryngeal property in Swedish, as it is in English. We also analyse Swedish aspiration as we did for English, where aspirated stops are represented by headed structures containing [H]. The distribution of aspirated stops in Swedish seems to support this analysis, because once again it appears to be prosodically conditioned. In the case of Swedish, however, it is the beginning of the word domain that supports aspirated stops, while in intervocalic and final positions the headed expression loses its headed status and is interpreted as fortis unaspirated (Ringen and Helgason 2004; Petrova et al. 2006):

(5) Laryngeal properties in Swedish

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
</tr>
<tr>
<td>[pʰ]</td>
<td>pack’</td>
</tr>
<tr>
<td>[ʔ U H]</td>
<td>word-initial</td>
</tr>
<tr>
<td>b.</td>
<td></td>
</tr>
<tr>
<td>kö[p]a</td>
<td>buy’</td>
</tr>
<tr>
<td>[ʔ U H]</td>
<td>word-medial</td>
</tr>
<tr>
<td>c.</td>
<td></td>
</tr>
<tr>
<td>kö[p]-te</td>
<td>bought’</td>
</tr>
<tr>
<td>[ʔ U H]</td>
<td>obstruent cluster</td>
</tr>
</tbody>
</table>
The forms in (5a–c) show an alternation between aspirated and non-aspirated which is similar to the one observed in English. In Swedish, however, word-initial is the only prosodically strong position where aspiration (from headed [H]) can be interpreted, as in (5a). Elsewhere the fortis stop remains fortis (as indicated by the presence of [H]) but loses aspiration. In fact we do find some degree of phonetic variation in the interpretation of this lenited expression, which is unaspirated for some speakers but slightly pre-aspirated for others.

6. Headed [?] in ejective stops

In the preceding section we highlighted a relation between prosodically strong positions and melodically headed expressions involving a headed [H]. But to determine whether this relation is part of a more general pattern, we need to examine other headed expressions and observe their behaviour with respect to prosodic structure too. Here we focus on the distribution of expressions containing a headed [?], then in §7 we turn to the behaviour of structures with headed [N].

The element written as [?] is dubbed the ‘stop’ element because it represents the drop in amplitude which is present in the spectral profile of oral stops, nasal stops and some laterals. Now, if [H] can contribute to an expression as either a head or a non-head, like we have just seen in §5, then we expect the same to be true of [?]. And similarly, we expect the difference between [?] and [?] to carry some linguistic significance. Taking these points into account, we follow recent proposals (Backley and Nasukawa 2006; Bellem 2004) and argue that in a structure containing a headed [?] the relevant acoustic cue – namely, a sharp decrease in amplitude – dominates the expression. Headedness renders the amplitude drop more sudden, perhaps longer, and perceptually more salient. In phonological terms, this suggests a suitable representation for the series of ejective stops found in many languages of Eastern and Southern Africa as well as the Americas.

It may be felt that this offers too straightforward a solution to the representation of ejectives, and that the relatively rare status of ejectives is not compatible with this level of formal simplicity. In fact, ejectives are more common cross-linguistically than is generally acknowledged – around

---

5 Although more phonological evidence is needed, it may be that (pre-)glottalised stops are also represented by structures containing a headed [?]. Like ejectives, their acoustic profile is dominated by their occlusion properties.
15% of languages make a contrast between plain and ejective stops; this fact gives ejectives a relatively unmarked status as a consonant category. As such, it seems entirely appropriate that the relatively simple structure [ʔ] should be used to represent this relatively unexceptional class of sounds, and we therefore maintain that languages with an ejective series of stops employ a headed [ʔ] in their melodic structure. Additionally, and in line with the previous discussion of aspiration and voicelessness, our proposal for the interpretation of headed [ʔ] has the advantage of capturing an implicational relationship between ejectives and plain stops, such that the description of an ejective stop (containing enhanced or headed [ʔ]) subsumes the description of a plain oral stop (with [ʔ]), but not vice versa.

Extending the analysis of [ʔ] to the behaviour of ejectives in other languages, let us consider the case of Korean. This language has a set of fortis stops usually labelled ‘tense’, which we claim to be the interpretation of [ʔ]-headed expressions. This tense series belongs to the well-documented three-way laryngeal split among voiceless stops in Korean: lenis (or lax) vs. fortis (or tense) vs. aspirated. Various sources (e.g. Kagaya 1974; Cho and Keating 2001) argue that the fortis and aspirated sets are marked by their own positive laryngeal properties, which, in the above sources, are mainly described in articulatory terms. Importantly, these marked laryngeal properties are assumed to be absent from the lenis series. It therefore seems appropriate to have this asymmetry reflected in the phonology by referring to the difference between headed and non-headed expressions. We propose the following structural distinctions:

(6) Laryngeal distinctions in Korean

<table>
<thead>
<tr>
<th>category</th>
<th>description</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [p]</td>
<td>lenis light aspiration</td>
<td>[ʔ U H]</td>
</tr>
<tr>
<td>b. [p’]₆</td>
<td>fortis glottal reinforcement</td>
<td>[ʔ U H]</td>
</tr>
<tr>
<td>c. [pᵇ]</td>
<td>aspirated heavy aspiration</td>
<td>[ʔ U H]</td>
</tr>
</tbody>
</table>

Just as in English and Swedish, the presence of headed expressions in Korean is conditioned by prosodic structure. Word-initial position behaves as prosodically strong, informationally rich and perceptually significant, as reflected in the way it supports the maximal three-way laryngeal

---

⁶ The literature sometimes refers to the fortis series as ‘glottalised’, which is a more suitable label to use in the present analysis. Moreover, this description is backed up by studies of the physical properties of these stops (Hirose et al. 1974; Dart 1987).
contrast shown in (6). Predictably, these neutralise to a lenis stop in standard weak positions such as the syllable coda, word-finally, and before another obstruent. The literature does show some variation in the precise phonetic interpretation of these neutralised stops, with reports describing a range of realisations from ‘unreleased’ through ‘weakly released’ to ‘released with a brief burst.’ However, we do not see this variation as bearing any linguistic importance. Rather, each possible interpretation suggests the absence of any predominant laryngeal specification, which we assume corresponds to the non-headed structure $[\emptyset U H]$ given in (6) for the lenis series. This neutralised structure contains the melodic content common to all three stop categories, but without any headedness relation. Of course, headedness is removed from these weak positions because it is precisely in these positions that headedness ceases to have any prosodic marking function to carry out.

One final point should be mentioned about obstruent weakening in Korean – namely, that lenis stops are phonetically voiced between vowels (e.g. *papo* [pabo] “fool”). Yet in all other respects, the phonology of Korean gives no indication that voicing is an active property in the obstruent system of this language. For this reason it would be a costly move, from the standpoint of any restrictive theory, to introduce a marked voicing feature at this point. One solution would be to treat this effect as nothing more than a case of spontaneous voicing; this is the kind of voicing that obstruents regularly undergo in intervocalic contexts, as observed in many unrelated languages. Alternatively, a phonological explanation does present itself if we assume that the neutralised structure $[\emptyset U H]$ undergoes further lenition to $[\emptyset U]$, resulting in suppression of the element $[H]$. (It will be recalled that lenition within Element Theory involves the loss of some structural material from a segment’s representation, this material being either headedness or an element itself.) The effect of losing the voicelessness of $[H]$ is that we remove the only property that offers any resistance to the natural and spontaneous voicing that characterises sonorant expressions, where ‘sonorant’ includes vowels, glides, approximants, nasals – in fact, any expression without $[H]$ in its element structure.

It was noted earlier that ‘ejective’ is by no means uncommon as a phonological category. At the same time, however, ejective stops typically show a limited distribution: while functioning as contrastive sounds in syllable onsets, they have a tendency to be excluded from (i.e. neutralised in) syllable codas. This is true for a number of languages of the Americas such as Klamath, Cuzco Quechua, Maidu, Navajo and Dakota (Rimrott 2003). Significantly, this same distributional property is also seen in other laryn-
Headship as melodic strength

realised classes such as aspirated stops – a situation that is unsurprising if ejectives and aspirates are indeed united as a set by their headed melodic structures.

To close this section, let us consider the behaviour of ejective stops in (Cuzco) Quechua. In this language too, there are clear indications that ejectives are associated with strong prosodic positions. And by maintaining the assumption that ejectives are represented using a headed melodic structure (containing [ʔ]), this language further supports the proposal that information concerning the location of prosodically strong positions can be conveyed through melodic headedness. Like Korean, Quechua makes a lexical distinction between three series of stops (Parker 1997; Rimrott 2003):

(7)  Laryngeal distinctions in (Cuzco) Quechua

a. voiceless  [p t tʃ k q]  [tanta] ‘collection’
b. aspirated  [pʰ tʰ tʃʰ kʰ qʰ]  [tʰanta] ‘old, used up’
c. glottalised/ejective  [p’ t’ tʃ’ k’ q’]  [t’anta] ‘bread’

As already mentioned, the three-way contrast in (7) operates only in syllable onsets. Specifically, the appearance of aspirated and ejective stops is limited to onset position, so that in the syllable coda all laryngeal distinctions are neutralised and only the voiceless stop can appear: for example, [maqt’a] ‘young man’ but *[maq’ta]. Further prosodic restrictions also apply to the headed expressions in (7b) and (7c). For instance, if a word contains a stop which is aspirated or glottalised, this will always be the first (onset) stop of the word: for example, [p’atay] ‘to bite’ but *[pat’ay]. In many cases this restriction has the effect of marking the left edge of a word domain as a strong position, as already observed in (5) for Swedish.  

Additionally, aspirated and glottalised stops appear in roots but never in suffixes (Quechua has no prefixes); on the assumption that morphological concatenation involves an asymmetric head-dependency relation with the root as the head, this again reflects the way these headed melodic structures are naturally drawn to strong prosodic units. And Quechua is not an isolated case. Among other affixing languages, we regularly see a full set of

---

7 The presence of an aspirated or ejective stop does not provide an entirely reliable way of identifying the beginning of a word domain, since a word-initial onset may contain a contiguous consonant that cannot contain either of the laryngeal specifications [H] or [ʔ]: for example, [hayk’a] ‘how many’.
lexical contrasts and suprasegmental properties being supported in roots while only a subset of these is maintained in affixes. Yet what seldom occurs is the reverse situation in which the full contrastive set belongs exclusively to affixes. In Japanese, for instance, lexical pitch accent is specified on verbal and adjectival roots but not on their suffixes. And in the Bantu language Chichewa (Mtenje 1985), which has a standard 5-vowel system, lexical mid vowels can appear in roots but not in suffixes. Element Theory (Harris and Moto 1994) provides a straightforward explanation for the Chichewa pattern based on the distinction between /e o/ as compound expressions (containing two elements each) and /i u a/ as simplex expressions (containing a single element each): the relative complexity of /e o/ requires them to be licensed by a prosodically strong position associated with a root form, while those weaker positions associated with a dependent suffix form are able to license only simpler structures involving a single element. In Chichewa, then, melodic strength (in the form of segmental complexity) mirrors an asymmetry in prosodic strength as established by the head-dependent relation holding between a root and its suffix.

So, the evidence from Japanese and Chichewa indicates a difference in prosodic strength between roots and affixes, which is further supported by the facts of Quechua. In this language we have noted how ejective stops, which contain a headed [ʔ] in their melodic representation, are distributed in a way that shows a clear bias towards prosodically strong positions. This, in turn, lends support to the central claim of this paper, that prosodic strength is directly reflected in melodic strength, so that any headed melodic structure will have a natural tendency to be interpreted in stronger rather than weaker positions. We have now shown this to be the case for expressions containing headed [H] and [ʔ]: and in the following section we demonstrate how the same can be said for segments containing a headed [N] in their representation.

7. Headed [N] in voiced obstruents

Now consider one further series of obstruents for which a headed element structure has been proposed. In line with the theme of this paper, we again expect the distribution of these headed expressions to reflect prosodic strength relations.

According to standard versions of Element Theory, the laryngeal-source element [L] identifies the set of voiced obstruents in ‘full voicing’ languages such as Japanese, Russian, Spanish and French. These all main-
tain a two-way contrast between true voicing (i.e. long voicing lead) and neutral voicing (i.e. no voicing lag), which strongly suggests that the element [H] is not involved in laryngeal-source contrasts. Using Japanese as an example, (8) illustrates the contrastive function of [L] in obstruents:

(8)  Laryngeal distinctions in Japanese

[p]  neutral  no voicing lag  [paN] 'bread'  |? U |
[b]  fully voiced  long voicing lead  [baN] 'evening'  |? U L|

For some time, however, there has been a movement within Element Theory towards abandoning [L] from melodic representations. For example, Cabrera-Abreu (2000) has proposed that [L] be removed from the representation of intonation patterns. Her arguments are based on the observation that low tone (= [L] in nuclear position) does not behave like a true phonological category, but rather, should be assigned by default to those prosodic boundaries that have no associated high tone [H]. This idea is in line with the wider goal of generative restrictiveness and with the general preference for reducing the overall size of the element set.

The obvious question then arises as to how, in the absence of the element [L], fully voiced obstruents are to be represented. Nasukawa (1995, 2005) offers convincing evidence to support a merger of voicing and nasality under a single element [N] (formerly referred to as the ‘nasal’ element). One key advantage of this move is that it reflects the strong cross-linguistic correlation between nasality and voiced obstruents. This relation becomes apparent from the observation of the nasal-voice correlation in nasal harmony, as well as from processes such as postnasal voicing assimilation, the prenasalisation of voiced obstruents and voiced velar obstruent nasalization. By taking voicing lead to be the salient acoustic cue provided by [N], and by employing headedness as we have already done for [H] and [?], then the three-way laryngeal division in (9) is able to incorporate both voicing and nasality within the scope of a single element:

(9)  Degrees of voicing lead

[p]  neutral (no/short voicing lag)  |  (= laryngeal unspecified)
[m]  nasal (short voicing lead)  [N]  (= [N] present in signal)
[b]  fully voiced (long voicing lead)  [N]  (= [N] prominent in signal)
Once more, the structural difference between a headed and a non-headed expression reflects the relative strength of the acoustic cue provided by the element in question; in the present case it is the \([N]\) element, and its primary acoustic cue is voicing lead. In (9) the absence of \([N]\) is interpreted as neutral voicing, which represents the default laryngeal state. Then if \([N]\) is present in its non-headed form, it is interpreted as nasality. But if the same element is headed and therefore prominent in the acoustic signal, it is interpreted as full obstruent voicing.

Nasukawa (2005: 26) provides evidence to support the choice of assigning head status to voicing rather than to nasality. First, an implicational universal exists between the two properties:

(10) Typology of nasal and long voicing lead

<table>
<thead>
<tr>
<th></th>
<th>nasal</th>
<th>long lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quileute</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Finnish, English</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>(none)</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Dutch, French, Thai</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

As (10) shows, we never find a language which has no nasals but which does have plosives with long-lead voicing. In other words, the presence of long-lead voicing implies the presence of nasal. This implicational universal is reflected in the headship relation, such that the existence of a headed element (here, \([N]/\text{voicing}\)) implies the existence of its non-headed counterpart (here, \([N]/\text{nasality}\)). Second, there is the question of universality. Almost all languages exploit nasality as a contrastive property, whereas long lead voicing is parametrically controlled. The optional status of voicing is reflected in the similarly optional status of headedness: in some languages \([N]\) is permitted to act as the head of an expression, while in others this is not a structural possibility. Third, Element Theory assumes there is a difference in complexity between nasality and voicing – when an element exists as a head, this adds to its structural complexity. And in the analysis of prenasalisation and velar nasalization (Nasukawa 1999), nasality is shown to be less complex than voicing, since the latter is often suppressed in weak intervocalic contexts and nasality is interpreted in its place. This occurs in several Bantu languages, as well as in some Western Indonesian languages and dialects of Japanese. As we have demonstrated throughout this paper, and as Harris (1994, 1997) has discussed in detail, segmental structure is typically less complex in weak positions than in strong positions.
Having motivated the representation of nasality as \[ N \] and voicing as \[ \overline{N} \], let us close this section by analysing data from a dialect of Japanese in order to demonstrate the three degrees of voicing lead described in (9). The Northern Tohoku dialect of Japanese (henceforth NTJ) in (11) provides a useful illustration, as its laryngeal system displays positional alternations involving the distribution of headedness. This is similar to the headship alternation that we have already noted for \[ \overline{H} \] and \[ \overline{L} \]. In NTJ we observe how the distribution of headed \[ N \] is sensitive to prosodic strength, where the relevant prosodic domain is the foot:

(11) Laryngeal properties in Northern Tohoku Japanese

<table>
<thead>
<tr>
<th></th>
<th>Foot-Initial</th>
<th>Foot-Internal</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>[b] fully voiced</td>
<td>[bin] ‘bottle’</td>
</tr>
<tr>
<td>b.</td>
<td>[m] prenasalised</td>
<td>[sa\textsuperscript{m}bi] ‘rust’</td>
</tr>
<tr>
<td>c.</td>
<td>[p] neutral</td>
<td>[petto] ‘pet’</td>
</tr>
<tr>
<td></td>
<td>foot-internal</td>
<td>[papa] ‘daddy’</td>
</tr>
</tbody>
</table>

Because foot-initial position is prosodically strong in NTJ, the form in (11a) allows the fully voiced [b] to appear. This is the interpretation of a headed melodic structure containing \[ N \]. In contrast, the form in (11b) shows the same expression in a weak intervocalic position, interpreted as the prenasalised stop \[ \text{[m]} \]. Following a similar line of argument as above, this suggests that \[ \text{[m]} \] is a lenited form of [b], which is expressed phonologically by the change in headship status from headed to non-headed. So once more, headedness is retained and interpreted by a prosodically strong position, because it is fulfils its role of marking out the edge of a prosodic domain. But when no such boundary is present (e.g. in foot-internal position), headedness is lost and a weaker form of the stop is interpreted. As expected, the neutral stop in (11c) shows no alternation of headedness according to its position, because it is lexically non-headed and has no laryngeal specification. Although singleton [p] has no place in the native lexicon of Japanese, this pattern does emerge in loanwords (e.g. [petto] ‘pet’, [pea] ‘pair’) and mimetic words (e.g. [papa] ‘daddy’, [potapota] ‘dribbling”).

8. Further examples of melody-prosody interaction

Finally, we end this study of the relation between prosodic and melodic strength by considering data from Thai and Bengali. These two systems provide further support for the claim that the location of prosodic domain
boundaries is indicated by the presence of headed melodic structures. Thai and Bengali have been chosen because each has more than one stop series requiring a headed representation, and in both cases the headed series show similar behaviour in serving as prosodic markers.

Thai displays the three-way laryngeal-source contrast shown in (12). Following our earlier analysis, we assume here that headed \( \text{H} \) and headed \( \text{N} \) are both active in the phonology of this system:

(12) Laryngeal-source contrasts in Thai

<table>
<thead>
<tr>
<th>category</th>
<th>example</th>
</tr>
</thead>
<tbody>
<tr>
<td>[p] voiceless unaspirated</td>
<td>? U H</td>
</tr>
</tbody>
</table>

The word-initial stops in (12) are interpreted in their full lexical form, as they occur in a prosodically strong position. Like the analyses given above for \( \text{H} \) in English, \( \text{R} \) in Korean and \( \text{N} \) in Japanese, the element structure and headedness of the stop remain intact when the segment in question has the function of marking out the left (strong) edge of the prosodic domain.

While this three-way contrast is maintained word-initially, only stops from the voiceless unaspirated series may appear in other positions. In fact, owing to the morphological characteristics of Thai, any consonant which is not word-initial is typically word-final – an archetypal weak position. The failure of aspirated and voiced stops to appear word-finally results in laryngeal neutralisation (Abramson 1972), as shown in (13):

(13) Domain-final neutralisation in Thai

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[kop] ‘mat rush’</td>
<td>? U H</td>
<td>*[kopʰ], *[kob]</td>
</tr>
<tr>
<td>[kot] ‘push’</td>
<td>? R H</td>
<td>*[kotʰ], *[kod]</td>
</tr>
<tr>
<td>[kok] ‘flog’</td>
<td>? @ H</td>
<td>*[kokʰ], *[kog]</td>
</tr>
</tbody>
</table>

As already observed, an expression occurring in a weak position has no prosodic function to perform; and to reflect this, we expect some loss of linguistic information from that expression. In §5-7 we showed how this

\(^8\) Here we follow the Element Theory tradition of employing \( \text{R} \) to represent coronal resonance and \( \text{@} \) to represent velar. For an alternative view of resonance elements in consonants, see Nasukawa and Backley (2008).
was brought about by suppressing some of the melodic material in the segment’s representation; the target was typically melodic headedness, since a headed expression was taken as a clear indicator of prosodic strength, not weakness. The same is true of Thai, where headed \([N]\) is suppressed entirely at the right edge of a prosodic domain, thereby disallowing voiced stops, and \([H]\) loses its headed status. The remaining non-headed \([H]\) is associated with the audible release phase of the neutralised forms \([p\ t\ k]\).

As a final illustration of the correlation between melodic and prosodic strength, consider the system of laryngeal-source contrasts patterns in Bengali (Indo-Aryan). The stop system of Bengali is unusual in typological terms – though typical of its own language group – in that it supports a four-way laryngeal-source distinction in stops:

(14) Laryngeal distinctions in Bengali

<table>
<thead>
<tr>
<th>category</th>
<th>examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>[pʰ] voiceless aspirated</td>
<td>? U H</td>
</tr>
<tr>
<td>[b] voiced unaspirated</td>
<td>? U H N</td>
</tr>
</tbody>
</table>

The examples in (14) indicate that the full set of laryngeal contrasts is supported in the inherently strong word-initial position; this is true not just for the labial stops shown but for the stop system as a whole, including the dental, retroflex, palato-alveolar and velar series. The first three laryngeal categories in (14) are structurally identical to those given in (12) for Thai. What distinguishes Bengali is the way it also allows the headed elements \([H]\) and \([N]\) to be interpreted in the same consonant expression, creating a ‘breathy voiced’ or ‘voiced aspirated’ category. As the latter term suggests, this category combines the full voicing properties of \([N]\) with the aspiration properties of \([H]\) within a single melodic expression.

So, voiced aspirates like \([bʰ]\) contain two headed elements \([N]\) and \([H]\), rather than just a single head.⁹ On the one hand, double headedness appears to give such expressions a relatively marked status in consonant inventories. And on the other hand, given our proposal that headedness increases a segment’s melodic strength, it renders these expressions particu-

⁹ Further investigation is needed on the question of whether an expression containing two headed elements is grammatical or not. Here, however, the data suggest that this is a structural possibility in some languages.
larly strong and suggests that they should show a particular affinity with prosodically strong positions. Conversely, when a voiced aspirate appears in a weak position we predict that it should be especially prone to lenition; we further predict that a lenition process will target the very source of the expression’s melodic strength, namely its headed elements. As (15) shows, this is what happens in Bengali (data from Kenstowicz 1994: 193–4):

(15) Effects of morphological concatenation in Bengali

\[ \text{[pətʰ] ‘road’ } + \text{ [dækʰa] ‘seeing’ } \rightarrow \text{ pəd-dækʰa} \]
\[ \text{[mač] ‘fish’ } + \text{ [dʰora] ‘catching’ } \rightarrow \text{ məj-dʰora} \]
\[ \text{[pəč] ‘five’ } + \text{ [gun] ‘times’ } \rightarrow \text{ pəj-gun} \]
\[ \text{[labʰ] ‘profit’ } + \text{ [kəra] ‘making’ } \rightarrow \text{ lap-kəra} \]
\[ \text{[sat] ‘seven’ } + \text{ [bʰali] ‘brothers’ } \rightarrow \text{ šad-bʰali} \]
\[ \text{[lobʰ] ‘greed’ } + \text{ [tʰaka] ‘remaining’ } \rightarrow \text{ lop-tʰaka} \]
\[ \text{[məd] ‘alcohol’ } + \text{ [kʰaoa] ‘drinking’ } \rightarrow \text{ mət-kʰaoa} \]

The morphologically complex forms (rightmost) contain medial CC sequences in which the second consonant position supports a full set of laryngeal contrasts whereas the first supports none. However, this difference makes sense once we take into account the unequal prosodic status of the two respective positions. The second consonant occupies a strong position – the domain-initial position of the latter morpheme – which allows any headed expression (containing [N] or [H] or both) to be interpreted in full (e.g. šad-bʰali). In contrast, the first consonant in the CC sequence occupies the weak domain-final position marking the end of the first morpheme, and it is in this position that we find the four-way laryngeal contrast neutralised to a voiceless unaspirated stop (e.g. lap-kəra). In fact, this choice of a voiceless unaspirated stop as the neutralising form is expected, on the basis that this is the only category in (14) not represented by a headed melodic expression. In this way, Bengali provides further evidence in support of the connection between strong/weak prosodic positions and headed/non-headed melodic expressions.10

10 An independent process of regressive voicing assimilation is also operating in (15), resulting in forms such as məj-dʰora (*mač-dʰora). As expected, the source of [N]-assimilation is the strong (second) consonant position in the CC sequence.
8. Summary

This paper has examined the notion of phonological strength from both the prosodic and melodic angles, and has highlighted some important ways in which these two are closely linked. In fact, the connection between prosodic strength and melodic strength appears to be so strong that one cannot be fully explained without reference to the other.

By adopting an Element Theory approach to segmental structure we have been able to exploit one of the characteristics of this model – melodic headship – in our formal definition of melodic strength. An element whose acoustic properties dominate an expression is deemed the head of that expression, and we have argued that having a melodic head contributes to an expression’s melodic strength: the presence of a head element renders the whole expression acoustically more prominent and perceptually more salient. Furthermore, we have claimed that the distribution of headed expressions is sensitive to prosodic strength. Although the general literature makes frequent reference to strong and weak prosodic positions, it has shown little interest in explaining why this distinction exists. In this paper, however, we have developed a definition of prosodic strength in which a strong position is one that assists language processing by indicating to listeners the location of a prosodic (typically foot or word) domain. It draws attention to the (usually, left) edge of the domain by making this position sound perceptually more prominent, where perceptual prominence is achieved by allowing a strong (i.e. headed) melodic structure to be interpreted in that position.

To demonstrate the intrinsic relation between melodic and prosodic strength, we first argued that aspirated stops, ejective stops and fully voiced stops all require headed structures in their respective melodic representations. We then considered data from a range of languages which showed how these headed structures are naturally interpreted in strong prosodic positions. Conversely, when the same expressions appear in weak environments we observe alternation effects whereby they lose their headed status. This loss of headedness operates as a means of redressing the balance between the strength of the melodic structure and the strength of the position where that structure is interpreted. In the future we would like to extend the scope of this study by examining whether a similar melody-prosody relation controls the distribution of vowel expressions too.
References


Headship as melodic strength

Harris, John, and Francis Moto

Harris, John, and Geoff Lindsey

Harris, John, and Eno-Abasi Urua

Hayes, Bruce

Hirose, Hajime, C.Y. Lee, and Tatsuiro Ushijima

Idsardi, William J.

Iverson, Gregory K., and Joseph C. Salmons

Jessen, Michael
1998 Phonetics and Phonology of Tense and Lax Obstruents in German. Amsterdam: Benjamins.

Joseph, Brian D., and Richard D. Janda

Jusczyk, Peter W., Anne Cutler, and Nancy J. Redanz

Kagaya, Ryohei

Keating, Patricia A., Taehong Cho, Cecile Fougeron, and Chai-Shune Hsu

Kenstowicz, Michael
Lombardi, Linda

Marslen-Wilson, William D., and Lorraine K. Tyler

Matisoff, James A.

Mtenje, Al

Nasukawa, Kuniya

Nasukawa, Kuniya, and Phillip Backley

Parker, Steve

Petrova, Olga, Rosemary Plapp, Catherine Ringen and Szilárd Szentgyörgyi

Rimrott, Anne

Ringen, Catherine, and Pétur Helgason

Schane, Sanford A.
Shimkin, Demetri B.

Vaux, Bert, and Bridget Samuels