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MORAS AND OTHER SLOTS

Donca Steriade
UCLA

1. Overview

This paper deals with the status of the syllable nucleus. It argues that a distinction must be recognized between nuclear and non-nuclear segments, which does not reduce to that between moraic (or weight-bearing) and non-moraic segments. The argument will consist of showing that segments which are non-nuclear yet carry weight can be identified in Ancient Greek and in a number of other languages.

The question will then be raised as to whether this distinction between nuclear and non-nuclear segments favors non-moraic theories of syllable structure (such as Levin's 1985 X-theory and its CV antecedents), which can straightforwardly distinguish the two classes with the help of a subsyllabic constituent, the Nucleus. My conclusion on this point will be that we need not give a structural interpretation to the notion of **nuclear segment:** instead of defining a structure - the Nucleus - that can in turn identify the class of nuclear segments, we can pinpoint a nuclear segment by combining structural information (such as **the segment is dominated by a mora**) with information about its segmental contents (such as **the segment is a sonorant**). Going one step further, we can show that the known cross-linguistic properties of nuclear segments favor in fact a version of the moraic theory (Hyman 1985, McCarthy and Prince 1986, Hayes 1989, Zec 1989 et alii): one of the identifying characteristics of nuclear segments is that there can be at most two nuclear slots in one syllable (two segments or a single long one). We shall see that this fact can be made to follow rather simply from an axiom of the moraic theory; but that it cannot be explained in the framework of a non-moraic theory which allows any number of slots per syllable.

2.1. Moraic and non-moraic theories of syllable structure

Although the main point of this study - documenting the nuclear/non-nuclear distinction - can be discussed independently of one's choice of syllable representation, I will at several points address issues that distinguish two rival approaches to syllable weight and subsyllabic constituency: the mora theory and the X (or earlier CV) theory. Here is then, in bare outline, a statement of the differences between the two approaches. For the purposes of this comparison I will use the neutral term **slot**, represented graphically as a dot (.), to refer to all weight units.

2.1.1. Leading ideas: representing weight

In outlining the differences between the X-theory and the μ-theory, it is useful to distinguish leading ideas from execution (see Chomsky 1981:2). The leading idea of the X-theory is that syllable weight is determined by the presence - or absence - of a branching structure. But since neither the number nor the presence of onset segments will affect the weight of a syllable, this branching structure must be located in the rime: a syllable is heavy if it contains a branching rime, light otherwise.

2.1.2 Execution: Segment-to-slot and slot-to-syllable associations

To implement its leading idea, the µ-theory limits the maximal number of slots per syllable to exactly two. Correspondingly, it must assume that the total number of segments per slot is, in principle, unlimited.

In contrast, the X-theory has no limits on the number of slots a syllable may contain, since a rime will branch regardless of whether it contains two or more than two slots. For this very reason, the X-theory can impose a strong constraint on the range of associations between segments and slots, a constraint that has no counterpart in the µ-theory: segments must project at least one slot. Earlier versions of the X-theory, in particular the CV theory of Clements and Keyser (1983) and a version of it adopted in Steriade (1982), allow as a marked option the association of several segments to a single slot as a means of representing "contour segments", i.e. affricates or prenasalized stops. Recent research into this subject (Hualde 1989, Lombardi 1990, Steriade 1990) has revealed that both affricates and the "nasal contour" consonants should be represented phonologically as single segments. Since no compelling evidence for other contour segments has been produced so far, this allows us to assume that the X-theory can be formulated so as to require at least one slot for every segment.

2.1.3 Onset segments and their slots

The X-theory assumes that onset segments have the same range of segment-to-slot associations as rime segments. Although they have slots, onset segments fail to render a syllable heavy because, ex hypothesi, only rime structure will determine weight[1]. In the µ-theory, the onset segments either fail to project their own slots or, if projected, fail to retain them. On this point, two versions of the µ-theory must be distinguished: that of Hyman (1985) and Zec (1989), which essentially denies the usefulness of the concept **onset** by associating all segments up to and including the first syllabic to the first mora, yielding representations like (1) a; and that discussed in Hayes (1989) and Steriade (1988a), which associates onset segments directly to the syllable node, as in (1)b:

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1. Much has been made of the fact that the X-theory stipulates the weightlessness of onsets, a property allegedly predicted by the µ-theory. I fail to see this particular advantage of the moraic approach: it is no more explanatory to assume that onsets have no slots than it is to assume that their slots are present but not counted in determining weight. Hayes (1989) claims that the moraic stipulation is the better one because it predicts certain restrictions on the patterns of compensatory lengthening, restrictions which cannot be made to follow from the X-theory. This is clearly a separate issue, which does not affect the point made here: namely that neither theory explains the basic onset/rime asymmetry in weight computation.

(1)

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a.  drink            b. drink
    \|/\/               |\/
     . .                . .
      \ /               \ /
       σ                 σ
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We opt here for (1)b and will refer throughout to notions like rime and onset, which, in moraic terms, correspond to the status of being or non being associated to a slot.

2.1.4 Hierarchical structure

One clear advantage of the moraic assumption that syllables are limited to a maximum of two slots is that it drastically limits the structural distinctions among syllables. Granting some uniform solution to the issue of onset structure, i.e. either (1) a or b but not both, syllables can display only two structural variants: with one slot or with two slots. And a two-slot syllable cannot differ in bracketting from another two-slot syllable. (I am assuming here that the moraic theory must adopt a structural constraint which requires all post-onset segments to be dominated by some slot. In the absence of such a constraint one **could** in fact introduce a number of unwanted structural distinctions, such as the following: **dr**$[\mathbf{i}]_\mu[\mathbf{nk}]_m$ vs. **dr**$[\mathbf{i}]_\mu\mathbf{n}[\mathbf{k}]_\mu$ vs. **dr**$[\mathbf{i}]_\mu$**nk** vs. **dr**$[\mathbf{ink}]_\mu$.)

The one source of structural variation allowed in current moraic theory is that between say mono-moraic **dr**$[\mathbf{ip}]_\mu$ and bimoraic **dr**$[\mathbf{i}]_\mu[\mathbf{p}]_\mu$. This distinction - discussed by Hayes (1989) and Zec (1989) - arises mostly from language-specific variation in the class of segments that can project slots. If all segments do, then a syllable like **drip** will have the maximum allowable number of two slots. If only some segments do - typically the most sonorous - then structures like monomoraic **dr**$[\mathbf{ip}]^\mu$ can be created, since non-sonorous **p** will not project a slot of its own. With this proviso, subsyllabic structure above the slot level plays no role in current versions of moraic theory.

In contrast, the larger number of slots per syllable allowed in the X-theory permit the latter to define subsyllabic constituents: the nucleus, the coda, the rime, the appendix, etc. Syllables will then be able to differ in the way they bracket their segments: thus a string like **ment** can be bracketted either as **m[[en]t]** - with a Nucleus **en** - or as **m[[e]nt]** - with a Nucleus **e**. The fact that such formal options exist doesn't mean necessarily that the X-theory is committed to exercising them; but the most articulated version of the X-theory in existence - that of Levin 1985 - does in fact exploit two of these subconstituents, the rime (or N') and the nucleus (N). The need for rime as a constituent has been mentioned above: it allows the X-theory to isolate the portion of the syllable within which weight distinctions apply. This paper discusses the need for nucleus.

3.1. Arguments for nuclear segments: the outline

We will observe in what follows that a number of languages display a restriction to exactly two high sonority segments within the rime. English, for instance, allows no more than two vocoid slots in its rimes, a long vowel or two short ones. The high sonority segments subject to this restriction tend to be - or perhaps are invariably - the tone bearing units of the language. Moraically speaking, both these observations would follow from the assumption that the high sonority segments in question are all and only the moraic segments of the language: that is, the segments which can project slots. There can be only two of them in a syllable because there can be only two slots per syllable; and they are tone-bearing because all slots are (cf. Hyman 1985:10).

This interpretation is however untenable because the high sonority segments in question are not the only ones to contribute to the weight of the syllable: English for instance, though displaying the limitation to two vocoids per rime, allows all rime consonants - including the obstruents - to bear weight. This section is devoted to establishing this fact, starting primarily from observations on the syllable structure of Ancient Greek. The conclusion will be that a three-way distinction must be recognized by any theory of syllable structure: that between the **syllabic** segments, which must be present in order for a syllable to exist; the **nuclear** segments, which are the tone bearing units of the language and display the limitation of two-per-syllable; and the **moraic** segments, which may contribute to the weight of the syllable[2].

3.2. Heavy syllables and tone-bearing units in Ancient Greek

During all reconstructible stages of Ancient Greek, closed syllables - including those closed by obstruents - were heavy.

One indication of this is the position of the so-called recessive accent, which falls on the penultimate syllable when the final is heavy and on the antepenultimate when the final is light[3]. Thus, in words ending in VVC$_0$ or VCCC$_0$ sequences (such as **anthro:'pois** 'men-DAT', **anthro:'po:n** 'men-GEN', **anthro:'po:** 'two men-NOM/ACC' or **lipo'thriks** 'balding') the accent falls on the penultimate syllable. In words ending in either V or VC, the accent falls on the antepenultimate: **a'nthro:pe** 'man-VOC', **a'nthro:pos** 'man-NOM'. The pattern is derived by assuming extrametricality of a final consonant: this explains the metrical equivalence of word-final VC and V sequences as well as the fact that VCC, VVC and VV rimes all count as heavy. Relevant here is only the fact that VCC rimes such as **iks** in **lipo'thriks** - rimes closed by obstruents - are as heavy as the VV or VVC rimes. This establishes that even the lowest sonority segments carry weight in Greek.

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2. As noted in Zec (1989) - who distinguishes however only syllabic and moraic segments - these segmental classes stand in a subset relation such that the syllabic segments are a subset of the moraic ones. Zec further observes that this subset relation reflects the sonority of the two classes, with the syllabic class being the most sonorous.

3. For further analysis and details on Greek accentuation see Steriade (1988b) and references there; see also Sauzet (1989); and Golston (1990) for alternative analyses of the pattern.

A distinct argument to the same effect is that the Greek quantitative meter - at all stages in the history of the language - counts as heavy any closed syllable, including those closed by obstruents (cf. Allen 1973:203 and passim; Korzeniewski 1968 and references there).

Finally, as Golston (1990) points out, Greek appears to have inherited from Indo-European a minimal root constraint that points in the same direction: monosyllabic nominal roots must be heavy, i.e. $C_0V{:}C_0$ or C_0VCC_0. Where general processes of phonological attrition apply to derive a root of subminimal weight, the vowel lengthens compensatorily. Thus **pod-s** 'foot-NOM' and **kher-s** 'hand-NOM' became regularly intermediate **pos** and **kher**, both subminimal roots once the extrametricality of the final consonant is taken into account: the vowel lengthened in both cases yielding **pous** and **kheir**[4]. There was however no vowel lengthening in monosyllabic nouns such as **thriks** 'hair-NOM', and this is can be understood once we assume that the coda obstruent **k** was sufficient to render the syllable heavy.

There is then little doubt that all segments could contribute to the weight of a syllable at all stages in the history of Greek[5].

We may consider now the tone bearing units of the language. On this point, there are several revealing processes, all of which demonstrate that only vowels can carry tone in Classical (Attic) Greek. The clearest of these phenomena involves the distribution of a High tone that appears on the last syllable of words followed by enclitics. If the last syllable is light (i.e. CVC or CV) and an enclitic word follows, a High tone appears on the final in words with antepenultimate or penultimate accent:

(2)
a. a'ngelos; a'ngelo's tis, a'ngelo's tinos
   messenger some messenger someone's messenger
b. o'ikos; o'iko's tis, o'iko's tinos
   house some house, someone's house
c. do'oron; do'oro'n ti, do'oro'n tinos
   gift some gift someone's gift

(Here and below VV sequences are tautosyllabic if either identical or if the first vowel is non-high and the second high. For a tautosyllabic VV sequence, the notation V'V indicates that a HL tonal melody is associated to it; the notation VV' indicates a LH melody. On the distribution between HL and LH see below.)

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4. The orthographic diphthongs in these cases stand for long tense vowels.

5. The essentials of the Greek quantitative meter and the minimal root constraint are phonological properties inherited from Indo-European: this is sufficient to establish that there was no prehistoric stage of Greek during which the set of weight bearing segments differ from that of Classical Greek.

However, if the enclitic follows a penultimate-accented word whose penult contains only one vowel, no High tone will surface on the final syllable:

(3)

phi´los; phi´los tis; phi´los tino´s
friend; some friend; someone´s friend

A simple tonal explanation for the contrast between **o'iKo's tis** and **phi'los tis** is offerred by Golston (1990,) who assumes that enclitic words carry floating High tones that normally associate to the first available - i.e. tonally unspecified - syllable in the domain. The association is however governed by the Obligatory Contour Principle: it cannot yield a sequence of High tones associated to adjacent tone-bearing units. This explains why **phi'los tis** does not surface as **phi'lo's tis**[6].

(4)

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angelos tis    oiKos tis     philos tis
|  |   \       ||   \          |
H  L    H      HL    H         H    (H)
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The important point here is that non-vowels do not count as tone-bearing units in Classical Greek, as shown by the enclitic accentuation of the phrases in (5), all of which pattern like **phi'los tis**, despite the fact that their penultimate syllables are heavy.

(5)

a´llos tis   e´ntha te   a´stu ti

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allos tis    entha te    astu ti
|            |           |
H    (H)     H    (H)    H   (H)
```

3.3. A first argument: nuclear segments and Osthoff's Law in Greek

The Classical Greek pattern presented above illustrates one of the uses of the distinction between nuclear and weight-bearing segments. All rime segments carry weight in Greek but only the most sonorous rime segments - the vocoids - bear tone. A simple distinction between moraic and non-moraic segments will not suffice here. By contrast, an analysis framed in terms of Levin's (1985) theory of the syllables has enough structure to distinguish between rime - the constituent within which syllabic weight is determined -

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6. For a roughly equivalent metrical account see Steriade 1988b. Several other aspects of the paradigm under discussion are also explained in that study, including the fact that only light final syllables are subject to the association of the enclitic-induced High tone and the fact that no High tone surfaces on the initial syllable of the enclitic words (i.e. the absence of ***phi'los ti's, *phi'los ti'nos.**

and nucleus – the constituent within which tone-bearing units are found. Below are the structures assigned by Levin's theory to the first syllables of **entha** and **dooron:** both syllables **en** and **doo** are heavy, as they contain branching rimes (N' nodes in Levin's notation), but only one – **doo** – has two slots in its Nucleus (N) and thus two tone-bearing units:

(6)

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   e  n
   |  |
[[[X]_N X]_N' ]_N"

  d     o
  |    /\
[ X  [[XX]_N ]]_N' ]]_N"
```

One assumption underlies the structures shown in (6): that Classical Greek allows only vocoids in its nucleus. Sonority sequencing explains why nuclear segments are located at the more sonorous end in the hierarchy of possible rime segments. But Levin's theory does not preclude a different choice of nuclear segments and it is possible to envision languages in which a different subset of highly sonorous segments emerge as the nuclear ones. One such language is an earlier variety of Greek, reconstructible from the accentual traces it left in Homeric Greek as well as from comparative evidence. I will refer to it in what follows as Early Greek[7].

It was noted by Vendryes (1945) and Allen (1973) that an earlier pattern of enclitic accentuation can be reconstructed within Greek from Homeric phrases such as **a'llo's tis** and **e'ntha' te**. In these forms, the presence of a sonorant in the penultimate rime appears to make it possible for the enclitic High tone to attach to the final syllable. The suggestion then is that rime sonorants could bear tone in Early Greek[8].

(7)

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a'llo's tis        e'ntha' te

allos tis          entha te
||    \             ||   \
HL     H            HL    H
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7. Other languages which in the relevant respects follow the Early Greek pattern are Kwakwala (Zec 1989 and references there) as well as Danish and Lithuanian (both analyzed moraically by Zec 1989). Lithuanian will be discussed briefly below.

8. Both Vendryes and Allen interpret the available accentual evidence as indicating that only sonorants could bear tone in Early Greek: although a handful of forms accented like **o'phra' toi** are attested, they are assumed to be analogical extensions of the more common **e'ntha' te** pattern introduced into the manuscripts by later grammarians and scribes.

Allen supports this interpretation of the accentual data by pointing out that Early Greek also displayed a constraint limiting the number of sonorant slots within the rime to two. This is the so-called Osthoff's Law[9], whose effect was to shorten long vowels in rimes containing sonorants. Some of the alternations due to Osthoff's Law are shown below. Note that word-final sonorants, being extrametrical, did not have a shortening effect.

(8)
gra:u-s -> graus 'old woman' (cf. gra:u-os -> gra:wos -> gra:os)
gno:-nt-es -> gnontes 'knowing-NOM pl' (cf. gi-gno:-sko:)
e-phan-e:-nt -> ephanent -> ephanen 'appear-Aorist-3pl' (cf. e-phan-e:-n)

In contrast to Early Greek, Classical Greek allows more than two sonorant slots within its syllables. In particular long vowels followed by a non-final rime sonorant are relatively frequent, as in **zdo:nnu:mi** 'belt-1sg', **ti:mo:ntos** 'value-ppl-GENsg', ta:lla 'the-other-pl', lele:mmenos 'leave-perf-ppl-NOMsg'. Also possible at this stage are rimes containing a diphthong followed by a sonorant, as in **dunainto** 'be able-OPT-3pl'.

Following Allen's suggestions, we can combine the accentual evidence with Osthoff's Law and reach the following conclusion: unlike Classical Greek, Early Greek required that all rime sonorants belong to the syllable nucleus. Since the Nucleus is limited to at most two slots[10], a long vowel could not coexist within the same rime with another sonorant. As usual in such cases, the compromise solution was to shorten the vowel, since this allowed the maximum number of underlying **segments** to surface. The same assumption that explains Osthoff's Law explains the fact that rime sonorants could bear tone in Early Greek: rime sonorants must be nuclear and, universally, the nuclear segments are the tone bearing units.

The interest of this analysis is that it is compatible with the facts of syllable weight reviewed earlier: a syllable like the initial one of **as.tu** 'citadel' is heavy even though it contains a single nuclear segment and, hence, a single tone-bearing unit. Recall that Classical Greek and Early Greek do not differ in the way they compute syllabic weight: both count as heavy closed syllables as well as syllables with long nuclei. They differ only in the composition of their nuclei: Early Greek requires that all and only rime sonorants be nuclear whereas Classical Greek allows only vocoids to be nuclear. From this follow the surface differences involving tonal patterns (Early **e'ntha' te** vs. Classical **e'ntha te**) and Osthoff's Law (Classical **ti:mo:ntos** without shortening, vs. Early **gno:ntes** shortening to **gnontes.**)

The same analysis can be given for the Lithuanian data discussed within a moraic framework by Zec (1989). Sonorants in Lithuanian rimes are tone-bearing. And Lithuanian is subject to Osthoff's Law: sonorants in the rime shorten a long vowel. Zec suggests that both facts stem from the fact

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9. An extensive bibliography on Osthoff's Law appears in Collinge 1985.

10. On this, see Levin 1985 and below.

that all and only the sonorants are moraic in Lithuanian. But this analysis does not account for the fact that, like Greek and other Indo-European languages, Lithuanian lacks monosyllabic roots consisting of a short open syllable[11]. Thus monosyllabic roots can take the form CVC (e.g. **kis-** 'to stuff', **lip-** 'rise, climb') or CVV (e.g. **siu:-** 'sew', **se:-** 'sow') or $CVCCC_0$ (**telp-/tilp-** 'enter', **kranks-** 'gurgle, snore') or $CVVCC_0$ **du:ks-** 'be mad', **reiks-** 'reveal'): but there are no Lithuanian roots of the form CV. This reveals a minimal weight condition that requires roots to be heavy, if monosyllabic. But **heavy** in this case means - as in Greek - either closed or containing a long nucleus. The "non-moraic" obstruents in roots such as **lip-** are sufficient to render a syllable heavy and satisfy the minimal root constraint. **3.4. Nuclear = moraic ?**

The evidence reviewed above indicates that we must distinguish two classes of weight-bearing segments: nuclear and non-nuclear. The characteristic properties of nuclear segments are (a) their high sonority; (b) the fact that they are subject to the two-slot-per-rime limitation and (c) the fact that they are the tone-bearers of the language. The ability to contribute to the weight of the syllable is not however an exclusive property of nuclear segments: in the languages reviewed so far all segments can carry weight.

A standard moraic analysis of this type of data fails because it lacks the means to draw the appropriate distinctions. Consider languages like Early Greek and Lithuanian and suppose that all segments can project a slot, i.e. are moraic. Then why is it that sonorants but not obstruents condition Osthoff's Law: why is **a:s** but not ***a:n** a well-formed rime ? Suppose, alternatively, that only sonorants can project slots. Then why are obstruent-closed rimes like **as** heavy ?

3.5. A second argument for nuclear segments: light and heavy diphthongs in Greek

Classical Greek, and probably Early Greek as well, had two classes of diphthongs, traditionally called **light** and **heavy**. We will observe in what follows that the term **light diphthong** is a misnomer: both types have the syllabic weight one expects of branching rimes. The difference between the two classes of diphthongs involved not weight but nuclear status: we will see that the heavy diphthongs had two nuclear segments, whereas the light ones had a short nucleus followed by a coda segment.

The heavy diphthongs of Greek include **ai, oi, eu** sequences, as well as the homorganic diphthongs **ou** and **ei**, which in Classical Greek became long tense vowels **e:, o:**. The heavy diphthongs may occur anywhere in the word. They have two tone-bearing units, as can be seen from the fact that they display either a HL or a LH tonal sequence: **o'ikos** 'house' (HL) vs. **oi'koin** 'house-GEN/DAT dual' (LH); **basileu's** 'king' (LH) vs. **basile'u** 'king-VOC' (HL). The presence of two tone-bearing units in a heavy diphthong can also

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11. This was first pointed out to me by Draga Zec, in personal communication. A reading of Senn (1966) and Bender (1921) confirms the observation.

be deduced from their effect on the tonal contour of an accented syllable that they follow. The general rule on the tonal realization of accent is this: if the accented syllable contains two tone-bearing units, it surfaces as HL when followed by at most one tone bearing unit within the same word; otherwise it surfaces as LH[12].

(9)

a. No TBU following the accented syllable
   basile'u 'king-VOC'
   khoora'in 'land-GEN/DAT dual'
   hodo'on 'road-GEN pl'

b. One TBU following the accented syllable
   o'ikos 'house'
   do'oron 'gift'
   do'ora 'gift-NOM/ACC pl'
   le'ukos 'white'
   pho'iniks 'phenix'

c. Two TBU's following the accented syllable
   oi'koin 'house-GEN/DAT dual'
   oi'kois 'house-DAT pl'
   oi'kou 'house-GEN sg'
   oi'koo 'house-NOM/ACC dual'
   luu'esthe 'untie-2pl-middle'
   akou'ontes 'hear-ppl-NOMpl'

d. Three TBU's following the accented syllable
   pe-pai'deuka 'educate-perf-1sg'
   ee'kousan 'hear-aorist-3pl'
   katee'launon 'chase forth-3pl'

There are a number of possible interpretations of this distribution of tonal contours, the most recent ones being those of Steriade 1988 and Sauzet 1989. We shall not review them here, since they all recognize the only point relevant for this argument: namely that heavy diphthongs, like the long vowels, contain two tone-bearing units and thus induce a LH contour on a preceding accented syllable. Note that accentuations like **pho'iniks** or **tho'oraks** - with a HL contour preceding a heavy VCC rime - indicate that it is the number of tone-bearing units rather than the light or heavy quantity of the final syllable that determine the tonal realization of the accent.

Yet another diagnostic behaviour of heavy diphthongs is the fact that, when in the final syllable, they attract accent onto the penultimate. In this respect, the heavy diphthongs behave like the word-final $V{:}C_0$ or $VCCC_0$ rimes.

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12. This general rule is overridden in word-final position by a grammatically-conditioned regularity: the Nominative and Accusative word-endings must, if accented, surface as LH (as in **basileu's** 'king-NOM').

(10)

ange´loin	thala´ttais	Kalu´ptei	ange´lou
´messenger-GEN/DAT dual´	´sea-DAT pl´	´hide-3sg´	messenger-GENsg´

(compare with -V:C_0 and -VCC finals:

Kappa´doKs	ange´lo:n	ange´lo:	epha´ne:n
´Cappadocian´	´messenger-GENpl´	´messenger-NOM/ACC dual´	´appear-aorist-3sg´)

The light diphthongs are limited to the maximally heterorganic sequences **oi** and **ai** - whose members differ from each other in height as well as backness - and occur only in absolute word-final position. They behave as if containing a single tone-bearing unit. If accented, they do not allow a HL/LH tonal contrast and surface either as H if accented (**hodoi´** ´roads-NOMpl´, **KaKai´** ´bad-fem-NOMpl´) or as L if unaccented (**anthrooopoi**, **thalattai**). Further, if unaccented, they induce on an immediately preceding long accented nucleus the HL contour:

(11))

lu´usai	o´iKoi	mo´irai
´untie-aorist infinitive´	´house-NOMpl´	´fate-NOMpl´

(compare final -VC_0 rimes:

pho´iniKs	o´iKos	mo´ira
´phenix´	´house´	´fate´)

The effect on metrical structure of a light diphthong is identical to that of final V(C) rimes in that it allows accent to recede to the antepenultimate syllable.

(12)

tha´lattai	a´ngeloi	luu´somai
´sea-NOMpl´	´messenger-NOMpl´	´untie-future-1sg´

(compare final -V(C) rimes:

tha´latta	a´ngelos	luu´esthe
´sea-NOMsg´	messenger-NOMsg´	´untie-2pl´)

One last detail should be mentioned: light diphthongs are limited to word-final **-oi** and **-ai** but not every word-final **-oi** and **-ai** is a light diphthong. The optative and locative endings **-oi** and **-ai** are heavy, as seen below:

(13)

a. lamba'noi 'take-optative-3sg'
b. paideu'oi 'educate-optative-3sg'
c. oi'koi 'house-LOC'
(compare **o'ikoi** 'house-NOMpl', ending in light diphthong)

It is possible to explain at least the behavior of the optative **-oi, -ai** as due to the fact that the i of these diphthongs was originally not word-final but rather followed by a laryngeal (cf. Rix (1976:231)). This suggests strongly that a similar explanation must be given for the less well understood locative endings, with the ultimate result that all historically word-final **-oi, -ai** will emerge as having contained light diphthongs.

Throughout our comparison between the two diphthong types, we have noted that light diphthongs act as VC rimes, whereas heavy ones constitute VV nuclei. This explains both differences in the number of tone-bearing units they contain and differences in their effect on metrical structure: the light diphthongs are VC final rimes, which count as light for purposes of accent because their final C is extrametrical. In contrast, the heavy diphthongs, even when word-final, are VV rimes and therefore not subject to consonant extrametricality. We assume this in what follows.

It is important to note that, when consonant extrametricality cannot enter into play, the light and heavy diphthongs do not differ in syllabic weight. In the Greek meter the quantity of individual syllables is not affected by word-final consonant extrametricality, because the meter reflects phrase-level rather than word-level syllabification (cf. Korzeniewski 1968:4-25; Steriade (1982: chapter 4): a phrase-medial word-final C cannot be extrametrical, because it is no longer peripheral. Thus a phrase such as **anthro:poi tines** 'some men' will be scanned σσσσσ, exactly as **anthro:pon tina** 'some man-ACCsg': the light diphthong **oi** counts here as heavy as the VC rime **on** in preconsonantal position. Both **anthroopoi** and **anthroopon** - along with all words ending in VC sequences - are scanned σσσ when they precede a vowel-initial word within a metrical line: this fact is due to the phrase-level resyllabification which invariably assigns an intervocalic consonant to the onset position of the second syllable.

This reinforces our informal suggestion that light diphthongs are VC rimes, in contrast to the VV structure of heavy diphthongs: the final C of a light diphthong can be extrametrical in the proper environment, in contrast to the final element of a heavy diphthong which, by its very nature, cannot be subject to consonant extrametricality.

But how can this suggestion be formally implemented? One thing has been made clear: we cannot analyze the difference between light and heavy diphthongs as one involving mora numbers. We have shown above that, when the effects of consonant extrametricality are set aside, both light and heavy diphthongs emerge as heavy rimes, hence bimoraic. Once again, the difference appears to be that between structures containing two vs. one nuclear elements: VV vs. VC. This is reflected in the number of tone-bearing units contained in the diphthongs as well as in the ability of their last element to be subject to consonant extrametricality. Our preliminary analysis of light diphthongs is then to exempt a word-final i from nucleus incorporation, when the head of the nucleus is a [-high, +back] vowel. Equivalently, a word-final **i** in a rime headed by a [-high, +back] vowel moves out of the nucleus: the latter alternative is depicted below, using Levin's X'-notation. Following Levin's suggestions, we identify a C as an X dominated by N' but not by N, a coda slot. Consonant extrametricality will therefore target such slots.

(14)

$$[-high,+back]i]_{N}]_{N'}]_{N''} \rightarrow [-high,+back]]_{N}\ i]_{N'}]_{N''} / \_\#$$

The effect of (14) will be to create a rime structurally equivalent to VC: one containing a single tone-bearing unit and ending in a potentially extrametrical segment. A side question that arises here is whether the phenomenon responsible for the Greek light diphthongs is of wider generality. We can only point out that English, another language subject to consonant extrametricality, treats all word-final diphthongs as VV rather than VC sequences: witness for instance the fact that all English words ending in -oy (the only clearly underlying diphthongal sequence of English) have either primary stress or secondary stress on this syllable (e.g. **emplo'y, e'nvo`y, a'llo`y** etc.) The demotion of a final glide to non-nuclear status appears then to be peculiar to Greek.

To sum up, a standard moraic analysis will fail to characterize the properties of light diphthongs: they can be heavy, i.e. bimoraic, but they contain only one tone-bearing unit. Their structural similarity to VC rimes - in particular the fact that their last segment is extrametrical when peripheral - is also impossible to characterize in moraic terms.

4.1. Where the X-theory fails

The data reviewed above demonstrate the need for a distinction betwen nuclear and non-nuclear segments. Does this represent grounds to choose X's over moras? Probably not. We turn now to an essential property of nuclear segments that can only be explained in moraic terms: the fact that, in general, a syllable may contain at most two nuclear slots.

We mentioned above, in connection with Osthoff's Law, that the Early Greek and Lithuanian shortening of long vowels before tautosyllabic sonorants stemmed from the requirement that the nucleus contain at most two slots, which in the case of syllables like **a:n**, conflicts with the requirement that every rime sonorant be nuclear. The solution is to shorten the vowel: **a:n** -> **an**. The conditions which lead to Osthoff's Law are not peculiarities of Greek and Lithuanian. Most languages display either a limitation of two vocoid slots per rime or, less frequently, a limitation of two sonorant slots per rime. A well-known example of the former condition is English, a language where long vowels can precede a tautosyllabic consonant - including a sonorant - but not a glide (e.g. ***u:y** from underlying **o:y**, in contrast with well-formed **oy**) and where sequences of three vocoids cannot coexist within the same rime (e.g. ***aui** or ***aiu**). A different instance of the same constraint is the Tahitian condition that two adjacent short vowels or a single long one form a syllable, to the exclusion of longer vocoid sequences. The following is Tryon's (1970:5) statement on this point: "Where a sequence of three vowels occurs, the first two should be taken as one syllable, except when the [first or] second vowel is long ". Thus **oia** 'he, she' is syllabified **oi.a**, whereas **fara:oa** 'bread' is syllabified **fa.ra:.oa**, not ***fa.ra:o.a** and **a?ahia:ta** 'dawn' is **a.?a.hi.a:.ta**, not ***a.?a.hia:.ta**. The same conclusion emerges from looking at Tryon's table of tautosyllabic vowel sequences (1970:3) which includes basically any pair of short vowels, plus long vowels not accompanied by any other vocoids. The significance of the Tahitian data is that, unlike in English, any sequence of two vowels can be tautosyllabic: cf. **tia.re** 'flower' and **rai.ti** 'rice'. Thus no featural cooccurrence conditions can account for the fact that a three vowel sequence, e.g. **iai** or **aia**, cannot be tautosyllabic: the constraint excluding these strings as possible rimes is structural. The same point can be made about the Piraha data presented by Everett (1988): there are no observable restrictions on the **kinds** of vowels that may be tautosyllabic in this language, but it is clear that at most two vowels can cooccur within a syllable. Thus **hoaooii** 'firearm' is indicated by Everett to be trisyllabic **hoa.oo.ii** rather than disyllabic or monosyllabic[13].

Turning now to the equivalent constraint involving sonorants, we note that in Nootka, a language where only sonorants render a rime heavy for accentual purposes (Stonham 1990), the long vowels **may** co-occur with tautosyllabic obstruents but not with tautosyllabic sonorants: e.g. **ni:tk?ato** '(whale) dips bodily down in water", **c'i:sKmin** 'rattle' but **?i:nax-** 'ready, dressed up' is shortened in **?inxa:** 'getting ready', when **n** becomes tautosyllabic with the long vowel[14]. Nootka, as well as the related WaKashan language Kwakwala, are identical in this respect to Early Greek and Lithuanian. Our suggestion is that all an only the sonorants are nuclear in these languages: this explains the Osthoff's Law effects. The fact that accent computes syllable weight based only on the presence of rime sonorants may simply indicate that in WaKashan, as in many other languages, it is only the structure of the nucleus that determines whether a syllable is heavy or light. We will return to this point below.

Extrapolating from these cases, let us tentatively assume that the following state of affairs obtains universally: in any given language, there is a class of highly sonorant segments which are subject to the condition that only two - or a single long one - may belong to the same rime. These are the vocoids of English and Tahitian, the sonorants of Early Greek and

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13. The standard moraic interpretation of such data - for instance Zec's (1989) - is that in languages like Tahitian and Piraha only vowels can be moraic. I reject this interpretation because it fails to generalize to languages like English and Greek, where consonants are moraic too - i.e. weight-bearing - but where the same restriction to two vocoid slots is observed.

14. Data from Sapir and Swadesh 1939. One regular class of exceptions to this generalization are the non-native mid vowels **e:** and **o:**, which do cooccur with nasals within the same syllable. The existence of these exceptions, though harmless for the generalization proposed here, may explain why Sapir did not mention it.

Nootka[15]. This two-sonorous-slot-per-syllable condition is directly related to a different fact, discussed earlier by Hyman (1985) and Levin (1985): in languages that require a one-to-one relation between tones and tone-bearing units, no more than two distinct tones can surface on a single syllable. In other words, while there are many languages which allow one tone in V rimes and two tones in VX (VVC_0 or VCC_0) rimes, there are no languages that allow one tone in V rimes, two tones in VV, VC rimes, three tones in VVC, VCC rimes, etc.

Moraic theory, even if deficient in the ways discussed, is poised to explain both facts: its fundamental tenet is that a syllable, no matter how long, cannot contain more than two slots. The slots, or a subset of them, are the tone-bearing units: therefore no more than two tones can occur on a syllable in languages with one-tone-per-slot limitations. The Osthoff's Law phenomena would also follow from the fact that syllables cannot exceed two slots, provided that we appropriately limit the class of segments that project the slots.

X-theory, in Levin's version, attempts to derive both phenomena from the principle that the Nucleus node cannot dominate more than two slots. But this condition has no organic connection with the rest of the theory: if X-theory has a central claim, it is that numerical limitations on slots play no role in phonology. Thus syllables may contain either one onset consonant or any number of them: in the latter case, Clements and Keyser (1983) and Steriade (1982) note that the observable numerical restrictions to two or three segments follow from independent pairwise featural cooccurrence conditions on adjacent segments. Similarly, Levin (1985) observes that coda segments are either limited to exactly one or else are, in principle, unlimited in number. Why then should nuclear segments be limited to no more than two slots ?

There is a different reason to reject X-theory's attempt at deriving the properties of nuclear segments. In any given language, we can identify the nuclear segments by two properties: they are highly sonorous, sonorants or vocoids, and they belong to the rime. It is this combination of segmental specifications and structural position that defines the nuclear segment.

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15. It is unclear to me whether the existence (e.g. in Sanskrit and Attic Greek) of long vowels followed by a tautosyllabic glide counterexemplifies this proposal. For one thing, most of these sequences arise from contraction - the merger of adjacent nuclei - rather than from initial syllabification. For another, the relevant sequences (**a:i, e:i, o:i, e:u**) of Ancient Greek were very unstable phonologically and went rather fast from being heterosyllabic **o:.i** etc. to losing their final glide altogetner: by the 3rd century BC, Greek had replaced **o:i** with **o:**, **e:u** with **e:** etc. Their phonetic realization is obviously impossible to determine. A different category of problematic data involves the very small number of languages reported to allow a three-way distinction of length among vowels: normal (short) a, long **a:** and superlong **a::**. Of these, Yavapai (Shaterian 1984, Thomas 1990) is the best documented and appears the represent the greatest challenge to the claim that only two nuclear slots are permitted universally.

What this suggests is that the nucleus may be redundant as a constituent: we can always reinterpret the statement **x is a segment in the Nucleus** as **x is a high sonority segment in the rime**, provided that the class of high sonority segments is unambiguously defined. Where the Nucleus might look indispensible as a constituent is in explicating structural ambiguities of the type discussed earlier between the VV syllable **ai** and the homophonous VC structure **ai**. We will see below that neither the Greek instance of VV/VC ambiguity nor other similar phenomena reported in the literature require the adoption of a subsyllabic structure Nucleus.

4.2. Improving μ-theory: conditionally and unconditionally moraic segments

The theory of morification expounded in Hayes (1989) and Zec (1989) distinguishes moraic from non-moraic segments. The former project slots, the latter cannot and must find a place on an existing slot. We have seen above that this distinction is insufficient.

The alternative is to distinguish two types of moraic segments: conditional and unconditional. Unconditionally moraic segments **must** project a slot, modulo onset satisfaction. Conditionally moraic segments **can** project a slot, and will, subject to onset satisfaction and the upper limit of two slots per syllable. The two sets correspond to two sonority classes: what I shall call here **high sonority** and **low sonority** segments. I will assume that, aside from the better known scalar property of relative sonority, every language imposes a dual sonority classification among its segments: the attested options are sonorants vs. obstruents and vocoids vs. consonants[16]. High sonority segments are unconditionally moraic, in the sense defined. Low sonority segments are conditionally moraic.

English vocoids, for instance, are unconditionally moraic: each will project at least one slot under all circumstances, except in contexts where it can be assigned to onset position. In contrast, an English consonant is only conditionally moraic: it will project a slot if it cannot be assigned onset status and if the syllable it must belong to does not already contain two slots. Thus an English sequence **oi** (as in **boy** or **loin**) will be syllabified as a single two-slot syllable. Each of the vocoids projects one slot. Both can, since neither can occupy the onset position, and both must, since they belong to the unconditionally moraic category. The two vocoid slots must form a single syllable, due to the principle of maximality of prosodic structure assignment (Ito 1989). In an underlying sequence **o:i**, three slots would have to be projected, leading either to a heterosyllabic sequence **o:.i** or to Osthoff-style shortening and thus **oi**. Either way, the lack of English **o:i** diphthongs would be explained. Finally, we may compare the syllabification of **n** in English sequences like **loin** and **son**. Recall that n, like any other consonantal sound, is conditionally moraic in English. In both strings considered, **n** cannot be an onset; and, due to the maximality principle, it cannot be syllabic either. The only question then is whether **n** will project a slot. In a string like **son** it can, without exceeding the

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16. See also below for possible examples of languages in which this division is inoperative and all segments behave as high sonority.

two-mora maximum, and therefore it will; but in a string like **loin** it cannot and thus will not. This approach explains the special status of vocoids in English rimes without incorrectly claiming that only vocoids have weight. The same approach will explain the special status of sonorants in Early Greek, Lithuanian and Nootka, provided that we assume that the entire class of sonorants is unconditionally moraic in these languages[17].

One point on which this proposal differs from some of the earlier research (Hayes 1989 but not Zec 1989 or Hyman 1985) is the fact that no segment, not even an unconditionally moraic one, is automatically guaranteed a slot: the syllabification algorithms compatible with our proposal (Steriade's 1982, 1984, Hyman's 1985 and Zec's 1989) will simultaneously weigh onset and rime status for any given segment and will grant a segment its slot only if it cannot be an onset. For this reason, a sequence like **ana** will be syllabified **a.na**, with onset **n**, even in languages where **n** belongs to the unconditionally moraic set.

A different question that must be raised is the predictability of Osthoff's Law: under what circumstances will a language where vocoids are unconditionally moraic syllabify strings like **o:i** as disyllabic **o:.i**, as in Tahitian and Piraha; and when will it enforce monosyllabic assignment and therefore shortening of **o:i** -> **oi**. The same question arises in languages where sonorants are unconditionally moraic: when will strings like **o:n** surface as heterosyllabic and when will they cause shortening to **on** ? The answer suggested by the languages considered here is that occurrence of shortening depends entirely on the well-formedness of onsetless syllables in a given language. At the time when Osthoff's Law was productive in Greek and Lithuanian, these languages disallowed onsetless syllables in word-medial position. There was no option then to syllabify either **o:i** or **o:n** as a sequence of distinct syllables[18]. The languages discussed here where such assignments are possible are Tahitian and Piraha, both of which obviously permit onsetless syllables to surface as such. Classical Greek also allows onsetless syllables in intermediate stages: of the resulting V.V strings, a large number but not all are then subject to contraction to a single long

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17. It should be emphasized that **unconditionally moraic** does not necessarily mean **potentially syllabic.** All sonorants are potentially syllabic in English, but only vocoids are unconditionally moraic. Conversely, only vocoids are potentially syllabic in Lithuanian, but all sonorants are unconditionally moraic. There appears to be no relation between the two classes of segments, though it is clear that both sets are at the top of the sonority scale within a given language.

18. This argument appears circular but isn't. By observing that old Indo-European languages, like Early Greek and Lithuanian, disallow medial onsetless syllables we refer not only to the monosyllabic status of the sequences under discussion but also to the total absence of vowel sequences which were not allowed to be tautosyllabic either. Thus the only possible diphthongs of Indo-European involve non-high vowels followed by high vowels. Other vowel sequences are not permitted either within a syllable or, and here the ban on onsetless syllables plays its role, as heterosyllabic strings.

vowel. As a result, strings such as o:on 'egg' surface without shortening. I have no evidence on the behavior of trimoraic sequences in languages where onsetless syllables can be created but are then provided with inserted onset segments.

I summarize below the analysis proposed so far, using as examples Early and Late Classical (Koine) Greek:

(15)

	Early Greek	Late Classical Greek
high sonority segments:	sonorants	vocoids
therefore		
unconditionally moraic:	sonorants (R)	vocoids (V)
conditionally moraic:	all other	all other
onsetless syllables ?:	no	yes
Effects derived		
Syllable phonotactics:		
V:R rimes:	shorten to VR	remain V:R
VVR rimes:	ill-formed	well-formed
V:V sequences:	ill-formed	syllabified V:.V
VVV rimes (e.g. aiu):	ill-formed	ill-formed
Syllable weight:		
VC rimes:	heavy	heavy
VV rimes:	heavy	heavy

It was suggested above that the notion of nuclear segment need not be defined entirely in structural terms. Among the nuclear properties for which we do not provide a structural account is the fact that they can bear tones: our proposal is to define the tone-bearing units as moras associated with high sonority segments[19].

We turn now to the class of non-nuclear segments, characterized by our proposal as belonging to the low sonority set. Aside from being unable to bear tone, these segments are also set apart by the fact of being subject to consonant extrametricality. A non-structural account of this fact is also possible. We note that, with minor exceptions, the trend of segmental

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19. In some languages, for instance Luganda and Hausa, all segments in the rime can bear tones regardless of sonority (cf. Hyman 1985). It seems significant that, in these same languages, all segments behave as unconditionally moraic, in the sense that only VC and VV rimes are allowed. Perhaps languages like Luganda and Hausa simply do not divide their segments into a high and low sonority class at all, with the result that all segments have the properties associated with high sonority: tone-bearing and unconditionally moraic status.

extrametricality appears to be the following: either all final segments are extrametrical (as in Spanish (Harris 1983), Romanian (Steriade 1984)) or only the consonants are (as in English and Ancient Greek). Segmental extrametricality seems then to target in preference the lower end of the sonority scale. In the absence of explanation for this fact, we can simply record it for the moment as a stemming from the ternary choice given below:

(16) Segmental extrametricality options:
no segment;
low sonority segments;
all segments.

We can address now the problem posed by the Greek distinction between VC and VV diphthongs. In the absence of a constituent such as the Nucleus, our analysis of this contrast must involve the claim that the second element of VC diphthongs is a segment belonging to the low sonority class. Such a segment will project a mora, though not a tone-bearing mora, and it will be subject to consonant extrametricality. But it is clearly against the spirit of our proposal to establish sonority distinctions among segments that have identical feature specifications, such as word-internal and word-final **i**. The following account will resolve this and other problems. The demotion of certain word-final i's from the high to the low sonority class was due to a rule of final devoicing. As voiceless approximants and nasals generally pattern as obstruents (cf. Kingston 1985 for the voiceless sonorants of Klamath) this devoicing was sufficient to remove the the final i from the high sonority class. This hypothesis explains why devoicing affected, among the vowels, only short i, arguably the shortest vowel in the Greek inventory, and why it happened only in word-final position, the likely locus of devoicing rules. The fact that word-final short syllabic i was unaffected (cf. forms like **andri'** 'man-DATsg' which indicate that syllabic i could be tone-bearing) is probably due to the greater phonetic length of syllabic vs. non-syllabic sounds. More significantly, this hypothesis can explain why devoicing did not affect the **ei** diphthongs, but only **ai** and **oi**[20]: if we assume that within a single syllable identical feature specifications are shared, **ei** diphthongs differ fundamentally from **ai** and **oi** in that their members **e** and **i** contain multiply linked [-back] values.

(17)

```
      oi                     ai                 ei

[+back]  [-back]      [+low]  [-back]
[-high]  [+high]              [+high]      [-high]  [+high]
   |        |            |       |            |        |
```

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20. The contraction of **ei** to **e:** is fairly late - 6th cent. BC according to Rix 1976 - and therefore we cannot explain the fact that i in **ei** was unaffected by devoicing by claiming that **ei** was already a monophthong at the time of devoicing. Devoicing must have been a much earlier sound change, since it was sensitive to the presence of a word-final laryngeal in the optative endings discussed above.

pl pl pl pl pl pl

\ /

[-back]

It is possible to attribute then the failure of devoicing in **ei** diphthongs to the multiply linked nature of these structures: for instance Hayes' (1986) Linking Constraint would prohibit a devoicing rule targetting **i** from applying to **ei**, if we assume the representations given above.

Devoicing rules generally target the least sonorous segments of a language: we would therefore expect that segments less sonorous than **i** were also affected by final devoicing. Since independent conditions insure that only voiceless obstruents will surface at the end of Greek words, the interesting part of this prediction is then that word-final sonorants were also voiceless and non-nuclear. It is impossible to verify this for Classical Greek, because consonantal sonorants such as **n**, **l**, **r** belonged to the low sonority set during this period of the language: devoicing them would therefore not affect their status as nuclear segments. But in Early Greek the consonantal sonorants belonged to the high sonority class and behaved, in word-internal position, as nuclear segments. If these segments had undergone final devoicing we would expect them to act as non-nuclear in word-final position. And indeed they do. Recall that word-final sonorants do not trigger Osthoff's Law in Early Greek: rimes such as **o:n**, **e:r**, **o:i** are abundant word-finally (e.g. **pate:r** 'father-NOMsg', **megalo:i** 'big-DATsg', **mikro:n** 'small-GENpl') and remained unaffected by shortening. We have attributed this to the effects of final consonant extrametricality: but, if the sonorants belong to the set of high sonority segments in Early Greek, they should be unaffected by consonant extrametricality. This paradox is resolved once we assume that all final segments of sonority equal to or less than that of i were subject to devoicing and thus became non-nuclear.

We have a seen then that a large number of details surrounding the fate of the Greek VC diphthongs is explained by the devoicing scenario. Given this, we are confirmed in the belief that no structural distinction is necessary between nuclear and non-nuclear segments. The account of VC diphthongs given above can therefore be replaced by the following devoicing rule, in which the Nucleus constituent plays no role:

(18)

[ ] -> [-voice]/ μ μ#

|

—

Condition: applies to segments of sonority equal to or lower than i

Devoicing will turn the affected vocoids into obstruents, and will thus account for their transfer to the low sonority class. This in turn will explain the non-nuclear behavior of final i in VC diphthongs: its inability to bear tone and its being subject to final extrametricality.

The Greek contrast between VC and VV diphthongs is relatively rare but not unprecedented: Hausa (Hyman 1985) and Slovak (Kenstowicz and Rubach 1987) are two languages with similar oppositions. The Greek case is however unique, as far as I can tell, in that we cannot plausibly claim that the VV and VC diphthongs are featurally distinct in underlying representations. We cannot claim this because, unlike in Slovak and Hausa, the VC diphthongs of Greek are restricted in distribution and nearly complementary in occurrence with the VV diphthongs: in cases like this a rule creating the VC diphthongs is necessary. In contrast, the Slovak and Hausa VC diphthongs can be analyzed, as Hyman (1985) suggests, as containing a segmentally different last member from the VV diphthongs. We will not further discuss this matter here, leaving open the issue of underlying segmental differences between glides and vowels.

We close this section by noting that the non-structural analysis of nuclear segments proposed here makes it impossible to distinguish between VC and VV long vowels, a contrast which Clements and Keyser (1983) and, in a different theoretical framework, Levin (1985) have sought to document. We share with these authors the belief that any long vowel is a monosegmental sequence of two slots. Given this, our proposal that nuclear and nonnuclear slots differ from each other only in the sonority of the segments that occupy them, not in their structure, predicts that the two slots occupied by a long segment will always have the same sonority index and therefore the same nuclear or non-nuclear status. It should follow then that there are no VC long vowels. Without pursuing this point in detail, we note that Levin's best example of VC vowels comes from Ancient Greek and involves the heavy diphthongs **ei ou** after they contracted to long tense vowels **e:**, **o:**. Levin assumes that the contrast between long tense **o:**, **e:** and long lax **ɛ:**, **ɔ:** was underlyingly a contrast of structure: VC vs. VV. Whatever the analysis of this contrast may be, one thing is clear: both the long lax and the long tense vowels were VV structures, in the sense that both their halves behaved as nuclear slots, able to bear tone and immune to consonant extrametricality. The criteria outlined in our discussion of Greek accent and tonal melodies associated with the accented syllable classify the tense mid long vowels as long nuclei. This is shown by the penultimate accent in forms such as **Kalu'pte:** 'hides', **ange'lo:** 'messenger-GENsg' and by the LH melody of the accented syllable in forms such as **anthrOO'po:**. This casts considerable doubt on the existence of this or any other structural distinction among long vowels.

5. Improving the μ-analysis of weight distinctions

We turn now to a different challenge that moraic theory must face: explicating the syllable structure of languages in which closed VCC_0 syllables count as light for metrical purposes.

First a brief summary of the phenomenon, in which we follow Hayes (1982). In some languages, such as Mongolian and Huasteco, stress rules count as heavy only syllables containing long vowels and diphthongs; closed syllables with short nuclei count as light. More frequently, in languages like English and Latin, both VC and VV rimes count as heavy. The X-theory account of this cross-linguistic difference is that stress rules interested in determining the weight of a syllable may consider either the presence of a branching structure in the nucleus alone, or the presence of branching anywhere within the rime. In the former case we get Mongolian, in the latter we get English. The important part of this analysis is that a VC rime in English is structurally identical to its Mongolian VC counterpart: the difference is one residing in the stress rules alone.

Since Hyman (1985), μ-theorists have found this account unsatisfactory and have proposed instead that VC rimes in languages like Mongolian are monomoraic: C's in such languages are claimed to be non-moraic segments. This suggestion has the benefit of maximal restrictiveness, as pointed out by Hayes (1989): once we locate the difference between English and Mongolian at the level of a permanent structural distinction, μ-theory makes additional predictions where X-theory makes none. Thus μ-theory predicts that every syllable-sensitive rule of Mongolian should reflect the monomoraic status of VC rimes; and every syllable sensitive rule of English should reflect the bimoraic status of VC rimes. In contrast, X-theory predicts nothing on this point: the same language may have some rules that look at the branching structure in the nucleus and others that look at branching in the rime. In the absence of empirical evidence, the current μ-account is clearly to be preferred.

There is however good evidence that two weight computations may coexist in the same language: some phenomena count VC as heavy and others as light. The following is no more than a summary of the better-known cases[21]. In English, the final syllable can be extrametrical iff light, where light means lacking a long nucleus; foot construction, however, depends on VC rimes, as well as VV, counting as heavy. In Mongolian, as mentioned, stress assignment counts as heavy only rimes with long vowels or diphthongs. On the other hand, Mongolian roots appear to be subject to the same minimal weight constraint as their Indo-European counterparts: the roots found in Street (1963), mostly monosyllabic, are either closed syllables or contain long nuclei. Monosyllabic CV roots lack entirely. From this point of view, even obstruents appear capable of projecting slots in Mongolian. In Tübatulabal (Swadesh and Voegelin 1939) stress distinguishes only long from short vowels, as if only vowels are moraic. But punctual reduplication prefixes a heavy ?VC or ?VV syllable, as the examples below indicate:

(19)

yu:ta:	?u:-yu:ta:	'crush'
pana	?am-pana	'close'
ttikka	?i-t.tikka	'eat'

A further indication that the vowels cannot be the only moraic segments in this language, despite the testimony of the stress system, is the very presence in Tübatulabal of consonantal geminates, as in **ttikka** above, which cannot be represented as anything except monosegmental two-slot sequences. Finally, Menomini appears to be a language in which only vowel length may affect the initial assignment of feet but where the distinction between closed and open syllables is needed for further prosodic processes which

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21. Levin (1990) has assembled a long list of such cases. The ones presented in the text are complementary to those she discovered.

alter the shape of stressed syllables (cf. Pesetsky 1979 for a preliminary analysis.)

It appears then that more than one weight computation is routinely possible in a single language. Before we count this as an argument for the Nucleus as a constituent, we must note a number of tentative generalizations that both theories considered here have so far left unexplained. I list these below:

(20) a. If a language has two ways of computing syllable weight, the one used for stress/accent assignment is the one which counts VVC_0 rimes as heavy, VC_0 rimes as light.

b. So far there are no clear cases of the VVC_0 : VC_0 weight distinction used for anything other than stress/tone assignment. In particular, meter, minimal word or morpheme requirements and templatic morphology do not employ this computation except in the rare cases where they refer to foot constituents actually built by the foot construction rule (e.g. Lardil, for which see Wilkinson 1988 and Hayes 1989).

c. By far the most frequent weight computation in stress assignment is the one which counts both VVC_0 and VCC_0 rimes as heavy.

These generalizations are admittedly drawn from a small sample of relevant languages, but they nonetheless strike me as worth considering. If they hold up, it is likely that their explanation will necessarily resolve the issue of dual weight computations such as those of Tubatulabal or Mongolian. The following proposal appears to do this. Let's assume that all segments are potentially moraic in all languages, that is that all segments are either unconditionally or conditionally moraic but never non-moraic. There are then no differences between the representation of VC rimes in any two languages: such rimes are always bimoraic. But, let's further assume, languages may restrict the set of stress bearing segments: they may require that stress bearing segments also be tone-bearing, for reasons that are clearly related to the fact that pitch is one of the main realizations of metrical prominence. If so, in languages of this type, e.g. Mongolian or Tubatulabal, a heavy syllable may not necessarily contain two stress-bearing elements if it does not also contain two tone-bearing segments. This will explain why Mongolian and Tübatulabal VC rimes are not "heavy" for stress assignment but are heavy for all other purposes. It will also explain the generalizations in (20): whether a heavy syllable contains one or more tone bearing units and can thus support a complex tonal sequence will be relevant for stress but not for meter or templatic phenomena.

If this proposal is on the right track, there will be no need to refer to the Nucleus as a constituent within which syllabic weight is determined. Nuclear segments will continue to be definable for all phonological purposes as moras of high sonority, projected by unconditionally moraic segments.

6. Conclusion

The outcome of this study can now be summarized. A distinction between nuclear and non-nuclear segments is needed, which does not reduce to the distinction between moraic and non-moraic segments. This distinction should probably not be interpreted structurally by means of a Nucleus constituent, but rather within the framework of the moraic restriction of two slots per rime. The distinction neeeded formally is that between conditionally and unconditionally moraic segments. These classes, as well as their tone-bearing status and their potential for segmental extrametricality, are defined by relative sonority. Finally, all segments are potentially moraic in all languages.

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