PROSODIC CATEGORISATION

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ABSTRACT

The structural elements of the prosodic hierarchy and the ways in which phonological generalisations make reference to them are investigated. Assuming, as argued, that these elements constitute a universal set of primitives, the different types (categories) of such elements, especially the syllable, are examined more closely. Specifically, the traditional weight dichotomy of 'heavy' vs. 'light' syllables is shown to be empirically inadequate for the explanation of the diversity of stress systems attested in natural languages.

Rejecting functional explanations of syllable weight, this thesis proposes a structure-based alternative within the framework of Optimality Theory (OT). It is demonstrated that grammars may distinguish up to six or more syllable weight categories by means of a small number of ranked and violable constraints. This also accounts for reference to categories of elements other than the syllable. Both prosodic structure and properties of elements, especially segmental sonority, are shown to be factors in distinguishing categories.

Here, as well as more generally, the Strict Layering Hypothesis is found to be both too restrictive and empirically inadequate as a constraint on which elements of prosodic structure are available to phonological processes. It is replaced with a more general Prosodic Accessibility Hypothesis, which in effect extends prosodic reference to minimal non-adjacency.

Finally, it is demonstrated that weight-related constraints form a constraint hierarchy of their own – *W* – within the OT constraint component CON. *W* interacts with other constraint hierarchies subject to a proposed Hierarchy-Constraint Translation Hypothesis. It is argued that there are many more such independent constraint hierarchies, and that, consequently, CON is highly structured.

This thesis has implications for the study of syllable weight, syllable structure, prosodic categorisation, and the organisation of the grammar.

Keywords: Optimality, Phonology, Prosody, Stress, Syllable, Syllable Weight.

I hereby state that this thesis is entirely my own work.

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ACKNOWLEDGMENTS

"*Swa cwæð snottor on mode, gesæt him sundor æt rune.*
… ne sceal næfre his torn to rycene
beorn of his breostum acyþan, nemþe he ær þa bote cunne,
eorl mid elne gefremman." [*The Wanderer*, 111-114a]

["Whilst sitting apart in secret meditation, the wise man said in his mind:
… a man must never be hasty to make known
his heart-felt anxieties, unless he knows a remedy beforehand,
and can effect the cure with courage."]

I am grateful to those who commented on an earlier version of this thesis: Alan Prince, Matt Gordon, John McCarthy, Donca Steriade, Bernard Tranel, and Scott Allan. I also owe thanks to Bruce Hayes, Michael Kenstowicz, Dan Everett, and Catherine Kitto.

Above all, though, my supervisor Harry Leder is most deserving of thanks, having guided this work through its several metamorphoses since I first believed it to be 'almost finished' eight months ago. I hope that the commendable parts of this thesis are an adequate testimony to his skilful teaching and supervision.

As for the languages discussed herein, I owe special thanks to Brett Baker, Perry Schlie, and François Dell. Thanks are also due to Laszlo Cseresnyesi, Elizabeth Hume, Peter Michaelove, David and Judith Payne, Jack Reuter, Tapani Salminen, Wharepapa Savage, Ronald Sprouse, Trond Trosterud, and Moira Yip.

Throughout the thesis-writing process I received much support from my parents, Reg and Mary. Their encouragement has meant a great deal to me throughout.

I dedicate this thesis to the memory of my brother.

PAUL DE LACY August 1997

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1 INTRODUCTION

Since the advent of autosegmental theory phonological representation has occasioned much interest and debate. After two decades of research, a reasonably clear theory of prosodic structure has emerged, employing elements such as the mora, syllable, and foot. In addition, it has become evident that reference to different *categories* of prosodic elements is common in many phonological processes. For example, in the Maori language primary stress is placed on syllables that contain a long vowel in preference to other syllable types (§3.1.1).

Explaining how different prosodic categories are distinguished and referenced by the grammar is a necessary part of any theory of natural language. For some time, it was believed that prosodic categorisation – identifying the categories of a prosodic element – was a straightforward process, simply requiring evaluation of the immediate internal structure of the prosodic element in question. More specifically, categories of a prosodic element were defined by whether that element 'branched' or not. In autosegmental terms a node α 'branches' if there are two association lines from α to elements that α dominates (see §2.2 for discussion). This view is dubbed the 'branching' theory here.

More recent developments in stress theory have resulted in rejection of this idea by some researchers. Instead, the categorisation of prosodic elements is seen as not referring to prosodic structure but rather to a phonetically-grounded notion of 'prominence'. These approaches to prosodic categorisation are discussed fully in §1.3.

This thesis rejects both the branching and phonetically-grounded theories of prosodic categorisation. Instead, it is proposed that the categorisation of a prosodic element α is dependent upon the evaluation of structure internal to α.

Unlike the branching view, the notion of ‘internal structure’ here refers to more than just immediate internal associations. Instead, any node β may be a factor in the categorisation of α as long as β is sufficiently local, a notion to be made precise in §1.1.3.

This thesis is organised as follows. The remainder of this chapter outlines the theory of representation (§1.1) and computation (§1.2) assumed in this work. In addition, previous approaches to prosodic categorisation are discussed and shown to be inadequate (§1.3). Chapter two presents a theory of prosodic categorisation. This theory is supported empirically through the analyses of a number of languages in Chapter three. The aim of chapter four is to integrate the theory of prosodic categorisation proposed herein with Optimality Theory. In Chapter five, the role of syllable weight in secondary stress and non-stress phenomena is considered. In addition, prosodic categorisation is discussed with respect to elements other than the syllable. This is followed in Chapter six by a summary of the main proposals of this thesis and a discussion of their implications for phonological theory.

1.1 PHONOLOGICAL REPRESENTATION

Any theory of prosodic categorisation is necessarily part of a theory of phonological representation. Accordingly, this section outlines the theory of prosodic structure assumed throughout this thesis. The aim of this section is not to introduce any new concepts of prosodic structure; in large part it is a restatement of the conclusions of research into prosodic structure over the past two decades. Discussion of the featural plane and elements higher than the Prosodic Word are avoided as they are not central to the issues examined in this work.

In Chomsky and Halle’s (1968) seminal work on phonology, it was claimed that phonological representation consisted of a single string of ordered elements. This was challenged by Goldsmith’s (1976) theory of autosegmental phonology.[1] This theory rejects the idea of a *single* string of elements, claiming instead that phonological representation contains a number of such strings. These strings are separated into different groups known as ‘tiers’. An element in a string may be a member of only one tier. Furthermore, there may be relations between members of different strings. These relations are termed ‘autosegmental associations’. For example, let us take two strings of ordered elements {a,b,c} and $\{\alpha,\beta,\gamma\}$. Since an autosegmental association holds between two elements on different tiers, acceptable autosegmental associations include (a,α), (b,β), and (c,γ).[2] This can be shown pictorially:

(1)

$$\begin{array}{cccl} a & b & c & \text{Tier A} \\ | & | & | & \\ \alpha & \beta & \gamma & \text{Tier B} \end{array}$$

Here, there are two strings of elements arranged on different tiers, and the lines between two elements indicate that the elements are in an autosegmental relation.[3] The lines are termed ‘autosegmental association lines’; autosegmental relations will be termed ‘associations’, in line with this terminology.

Another important concept is that of the autosegmental ‘plane’. A plane is simply a grouping of tiers. For example, the tonal plane is a grouping of the tonal and moraic tiers, while the prosodic plane contains the melodic tier and all

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[1] For precursors of Goldsmith’s work, see Harris (1944) and Firth (1957).

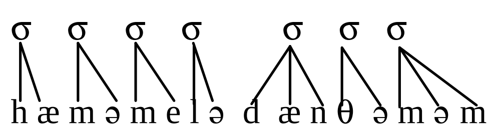
[2] There are a number of other possible autosegmental relations: e.g. (a,β), (b,α), (c,β). Autosegmental associations in any representation are limited by a constraint on ‘association line crossing’ (Goldsmith 1976). In the above representation, this means that, for example, (a,β) and (b,α) cannot co-exist in a representation. For discussion see Sagey (1988), Hammond (1988), Coleman & Local (1991), and Archangeli & Pulleybank (1994).

[3] Autosegmental relations may exist underlyingly or result from phonological processes. For example, in moraic theory it is assumed that morae are associated to vowels in underlying representation (i.e. in

prosodic tiers, such as those containing morae, syllables, feet, and Prosodic Word nodes, discussed below (Selkirk 1984, McCarthy & Prince 1986). If a representation contains more than one plane, which they most often do, these planes are linked by sharing tiers. For example, both the prosodic plane and the tonal plane contain the moraic tier, so these two planes are linked.

After the introduction of Goldsmith's theory, a number of additions were made to the inventory of tiers. Kahn's (1976) proposal that melodic elements are grouped into syllables motivated the postulation of an element called the syllable node, represented as σ. Soon, σ nodes were seen as forming a tier of their own, as in the following representation:

(2)



‘hamamelidanthemum’[4]

In this representation, syllable nodes dominate melodic elements, also known as ‘segments’. In autosegmental theories, the melodic tier contains root nodes – elements that serve as a locus for featural association (Sagey 1986, Clements 1985, Clements & Hume 1995). The structure of featural representation is of no concern here, and will not be discussed in this work. It is enough to note that the melodic tier contains root nodes. Root nodes will be termed ‘segments’ in the remainder of this work.

After Kahn, syllable structure continued to provoke much interest, but work also focussed on higher prosodic structure. Prince (1976) and Selkirk (1980) proposed a unit called a ‘foot’ (Ft) which dominates syllable nodes. The existence of feet was motivated mainly in the context of stress theory (e.g. Hayes

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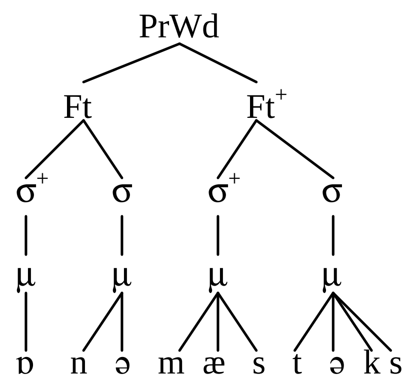
the lexicon), but syllable nodes are associated by phonological processes.

[4] The string of melodic elements here is not meant to represent the underlying form, but the form after processes such as vowel reduction have applied. The representation given here is from the dialect of English spoken in New Zealand.

1981).[5] In addition to feet, Selkirk (1982, 1984) introduced the Prosodic Word (PrWd) – a node that dominates all feet in a word.

By the mid-1980s, the prosodic plane was taken to consist of a melodic tier, a σ tier, a Ft tier, and a PrWd tier, hierarchically arranged in this order with PrWd at the top. A final addition to the prosodic plane was made by Hyman (1985), McCarthy & Prince (1986), Zec (1988), and Hayes (1989). These researchers argued that a further element intervened between the syllable and melodic elements, termed the mora (symbolised by ‘μ’). This is shown in the prosodic representation of the word ‘onomastics’ [ɒ.nə.mæs.təks]:[4]

(3)



The first syllable in this word is more prominent than the second for a variety of reasons: the first syllable has more amplitude than the second, and vowel reduction to schwa only occurs in the second syllable. To recognise this difference in phonological representation, the notion of headedness is employed (McCarthy 1979, Halle & Vergnaud 1980, Hayes 1981). Every prosodic node is marked as a head or non-head. We will take this mark to be a feature [±head].[6] Nodes that bear the feature [+head] are marked with a superscript ‘+’ in the

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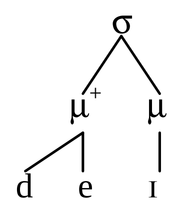
[5] The other major approach to stress is metrical theory (Liberman & Prince 1977, Prince 1983, 1985, Halle & Vergnaud 1987, Hayes 1995). A number of findings in this theory have been adopted in autosegmental approaches (e.g. in foot form: Hayes 1985, 1995 cf McCarthy & Prince 1986, 1993a,b).

[6] While this treats headedness as an overt feature, it could conceivably be regarded as a derived property given the setting of some interpretive parameter such as ‘the leftmost syllable in a foot is a head’. This will not be discussed further as it is outside the scope of this work.

diagram above. A head syllable dominated by a head Ft is phonetically realised bearing primary stress, while head syllables in non-head feet are realised as bearing secondary stress.

Of course, there are also head *morae*. Consider the representation of the word [deɪ] 'day':

(4)



[e] is dominated by the head mora, while [ɪ] is dominated by the non-head mora. Empirical evidence for a distinction between morae can be found in languages in which the set of elements that head and non-head morae may dominate are different. For example, Zec (1988:25ff) shows that the head mora in Lithuanian may only dominate vowels, while the non-head mora dominates vowels, liquids, and nasal consonants.

The final level to consider with regard to headedness is the melodic tier. As mentioned above, the melodic level contains segments, abbreviated as *seg* here. The issue of whether segments can bear the feature [+head] has received little attention. For consistency's sake, it will be assumed that this is possible. This is supported in §4.2.4.

It is generally agreed that sonority is relevant for melodic elements. Unlike headedness, sonority is not a bi-valent feature. Instead, there are many degrees of sonority, and these degrees are ranked. For example, vowels are taken to be more sonorous than liquids, and liquids are more sonorous than obstruents. Sonority is a transitive relation, so vowels are therefore more sonorous than obstruents. Much more will be said regarding sonority in chapters 2 and 4. For the moment it is enough to recognise the position taken herein: sonority is not a feature, but a *property* of a segment (cf Selkirk 1984's treatment as a multi-valued feature). In other words, the sonority of a segment is a function of its features (Clements 1990). This idea will be further refined in §4.2.

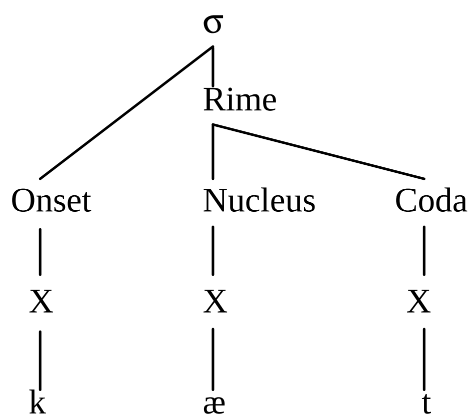
Sonority is useful as a categorising tool for the grammar. For example, in Pukapukan (Salisbury 1993) there is a restriction on syllables such that the non-head mora may only dominate an element that is of equal or less sonority than that dominated by the head mora (cf Zec 1988,1995). Given a sonority scale of °a > e,o > iu > …° a syllable containing the sequence [ie] is prohibited as [e] is *more* sonorous than [i]. Sonority will play an important role in prosodic categorisation (see §2.1).

So far, the elements of the prosodic plane, also called the Prosodic Hierarchy, have been presented and the notion of headedness introduced. However, while the elements of the Prosodic Hierarchy have been discussed the *possible associations* between them has not received any attention. The following sections discuss this and show that autosegmental associations are limited, though not as limited as was originally believed.

1.1.1 SYLLABLE STRUCTURE

The internal structure of the syllable has been the most contentious representational issue in autosegmental theory (Pike & Pike 1947, Halle & Vergnaud 1980, Selkirk 1982, Clements & Keyser 1983, Hyman 1985, McCarthy & Prince 1986, Itô 1988, Zec 1988, Hayes 1989, Steriade 1990, Tranel 1991, Hayes 1995). Above, the syllable was taken to be composed of morae and segments. However, many other models have been proposed. One of the most enduring is the following:

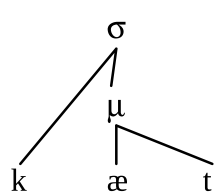
(5)



The basic aspects of this model were proposed by Pike & Pike (1947).[7] Among its interesting characteristics is the division into onset, nucleus, and coda constituents, and the further grouping of the nucleus and coda into another constituent – the rime. While this 'traditional' model allows a number of phonological facts to be stated easily, it is far more complex than the moraic model and for this reason it will not be adopted here. The traditional model is only mentioned as it is an essential part of one theory of syllable weight (Blevins 1995, §1.3.1). In addition, the traditional model supplies some of the terms that will be used informally below.

The moraic model of the syllable is far simpler than the traditional model, having only three tiers (σ, μ, seg)[8]:

(6)



There are a few points to note regarding the moraic syllable. Firstly, consider the difference between the syllables /pk/ and /pæk/. In English, the first sequence is

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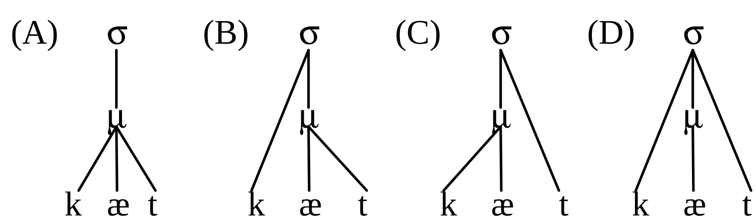
[7] Also see Hockett (1947), Fudge (1969, 1987), Levin (1985), McCarthy (1979), Halle & Vergnaud (1980).

an impossible syllable, while the second is admissible. The reason for this is that a mora must dominate a segment of a certain sonority. In English, these segments must be sonorants. Since neither /p/ nor /k/ is a sonorant in the syllable /pk/, a mora cannot dominate them. This leaves a fatal gap in the prosodic hierarchy so that a syllable without a sonorant, and concomitantly without a mora, cannot be produced in English. Let us dub these segments that are essential for the existence of a mora 'mora-licensing' segments. This term is not a formal grammatical notion, but merely a convenient term that I will find occasion to use.

It is well to introduce a few other informal terms at this point: 'onset consonants' are those consonants in a syllable that appear to the left of the first mora-licenser in that syllable. For example, in /pæk/ the first mora licenser is the vowel /æ/, so /p/ is an onset consonant. Similarly, all segments that appear to the right of the rightmost mora-licensing segment in the same syllable are 'coda consonants': /k/ in /pæk/ is a coda consonant, and /k/ in /paik/ 'pike' is a coda consonant since /i/ licenses a (non-head) mora.

Returning from this digression, let us consider the form of the moraic syllable. Given a syllable node, morae, segments, and other requirements on syllable-internal association, there are a number of different associations that can exist between these elements.[9] For example, consider the number of possible representations of /kæt/ 'cat':

(7)



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[8] See Hyman (1985), McCarthy & Prince (1986:56), Zec (1988), and Hayes (1989) for discussion.
[9] The requirements on syllable-internal association are that a σ node must dominate a μ node, and a μ node must dominate a *seg*.

The most popular moraic models in the literature are types A (Hyman 1985, Zec 1988:7) and B (McCarthy & Prince 1986). However, the following discussion will argue that type C is empirically superior.

Given the four possible models above, we are in need of a diagnostic to determine which is the best. The following will consider a number of diagnostics that have been proposed, pointing out that the majority are inadequate, and finally offering a resolution.

One approach to determining the best syllable model is to assume that the Strict Layer Hypothesis is correct (Selkirk 1984). This states that nodes on tier *x* may only dominate nodes on tier *x*-1. As such, σ may only dominate μ; σ cannot dominate *seg* as *seg* is two tiers below σ. Inspecting the syllable representations, only type A obeys strict layering; all other types have associations from σ to *seg*.

Unfortunately, the validity of Strict Layering is in question. Itô & Mester (1992) argue that the Strict Layer Hypothesis is too restrictive, a point discussed in detail below (§1.1.3). It suffices for the moment that the Strict Layer Hypothesis is at best a tendency, not an absolute requirement, and so cannot be a reliable test for the best representation of the syllable.

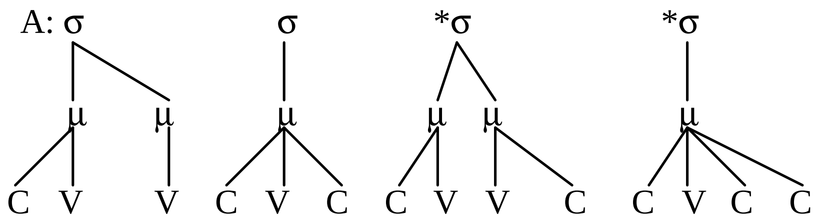
Another possibility, discussed by Hayes (1995:53), relates to the moraic licenser, discussed above. The idea is that the moraic licenser must be identifiable in the phonological output. The easiest way to identify this element is to require that morae dominate only moraic licensers. In this case, every element dominated by a mora is then a moraic licenser. In this respect, model D is the best as it is unambiguously obvious which element licenses the presence of a mora in the output form. However, as Hayes points out, this is argument is easily subverted since more than just structure is available in determining the identity of the moraic licenser. If moraic licensers are marked as [+head] segments or if segmental sonority is considered, they will be unambiguously identifiable in any of the syllable configurations above. So, this notion cannot be used to determine the best syllable model.

Hayes' other diagnostic for moraic representation relies on the ease of determining syllable weight. For Hayes, a syllable is 'heavy' if it is bi-moraic. For syllable A, if the σ node branches it is heavy, whereas in models B, C, and D a syllable is heavy if the σ node branches *with respect to nodes of type m*. For Hayes, this extra requirement means that syllable type A is superior. While on the surface this seems like a reasonable argument, this thesis will show that the category heavy cannot be defined simply by whether the σ node branches. Further to this, it will be demonstrated in §2.2 that the evaluation of any prosodic relations must crucially refer to two arguments. So, in defining any category, it is not enough to claim that α 'branches' but that α branches *with respect to b*. This effectively renders this diagnostic worthless.

So far, a number of possible diagnostics have been dismissed as inadequate. In fact, there is no diagnostic that I know of that is entirely satisfactory. Even so, a possibility will be discussed here.

It has been observed that there are many processes in natural language that refer to non-onset, or 'rime', elements in a syllable. While many of these processes have been shown to be easily dealt explained within a moraic model (McCarthy & Prince 1986:56-61, Hayes 1989, Broselow 1995), one onset-rime asymmetry that is yet to be entirely explained is that of maximal syllable length (see also Blevins 1995:215). In many languages, though not all (Fudge 1987), there is a limit on the number of non-onset elements, not on the number of elements in a syllable as a whole. For example, take a language with bi-moraic (C)VV and mono-moraic (C)VC syllables (e.g. Southeastern Tepehuan §3.1.3). Here, the syllable types *(C)VVV, *(C)VVC, and *(C)VCC are prohibited. (C)VVV syllables can be ruled out in all models by banning syllable with three morae. This leaves the ban on (C)VVC and (C)VCC syllables to be explained. Let us consider the structure of each model with regard to these configurations:

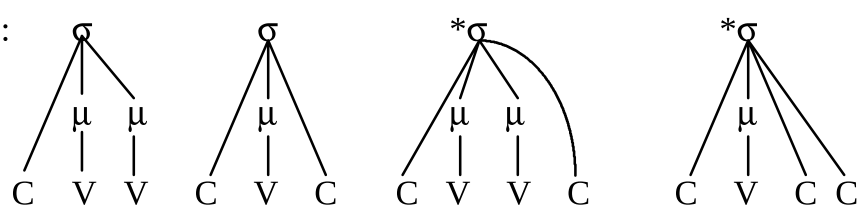
(8) A:



It is difficult to make a simple statement regarding the restriction to VV and VC syllables using type A. Perhaps the best way of stating this restriction is: ‘A syllable may maximally have two morae and the non-head mora must not branch *or* a syllable may have one mora, and that mora may contain only one segment to the right of the mora-licenser.’ We cannot simply say ‘..and that mora may contain only two segments’ because this would prohibit CVC syllables. Also, in this definition it is necessary to refer to ‘mora-licensers’, and to the notion of ‘to the right of’. It is questionable whether either should be permitted as formal notions in a prosodic theory.

Model D poses other problems:

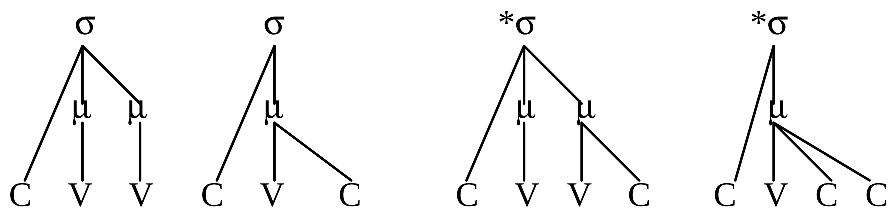
(9) D:



Here, maximum syllable length is constrained by a statement such as ‘A σ node may have a maximum of three association lines’. The problem with this is that it refers to ternary branching, a notion that is very suspect with respect to prosodic structure (see §2.3).

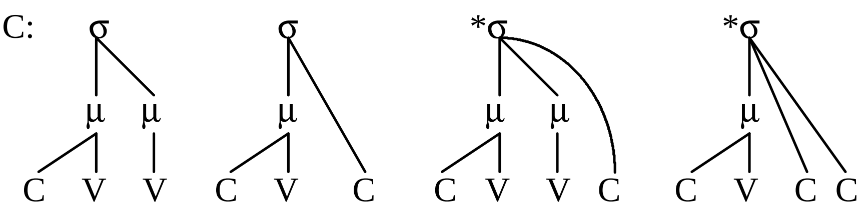
Model B offers different complexities:

(10) B:



Here, the relevant statement is ‘A syllable may contain two non-branching morae *or* one binary-branching mora.’ This restriction is more desirable as it refers to elements and relations that are needed elsewhere: σ,μ and association lines. However, even this is complex when compared with that needed for syllable model C:

(11) C:



Here, all that is needed is the following simple stipulation: ‘There may be only two associations from the σ node.’ From the point of view of simplicity, model C provides the easiest method of restricting the number of syllabic elements.

Although this diagnostic does not provide as clear a result as one would desire it is of some value in providing an initial hypothesis about syllable structure. Accordingly, this model will be adopted in the remainder of this thesis.

At this point, however, a word needs to be said regarding objections to this model. Of most significance are those arguments against associating onset consonants to the initial mora. Firstly, Hayes (1989:298) discusses ‘rime-internal’ processes such as English /r/ dropping and Cuban Spanish /n/ velarisation. These processes only apply to segments in the rime of a syllable.

Hayes argues that "if we assume that onset consonants depend directly from the syllable node.., rather than from the first mora, then the notion of 'rhyme-internal segment' can be reformulated as 'segment dominated by μ'". Processes such as English /r/ dropping and Cuban Spanish /n/ velarisation do not involve *both* morae but only the second mora. So, the English case can be restated as a restriction on the content of the second (i.e. non-head) mora in a syllable: $*[r]_{\mu-}$ 'a non-head mora may not dominate /r/'. So, requiring the association of the onset consonant is irrelevant here. In fact, there is little evidence for phonological processes that refer directly to rime-segments (see also Clements & Keyser 1983:19-24, McCarthy & Prince 1986:57). Most are more specific, as above, referring to segments dominated by *a certain mora*, not morae *per se*.

Another argument against attaching onsets to the initial mora arises from language games. In Pig Latin, for example, 'dog' /dɒg/ becomes 'og-day' /ɒgdei/. This seems to be a case of postposing the onset after the rime and suffixing 'ay'. If onsets attached to the syllable node, we could state this as 'postpose all segments attached to the syllable node after those segments attached to morae'.

However, language games offer contradictory evidence in this regard: there are two language games in which attachment of onsets to the initial mora is supported. Consider the result of a language game in Hanunoo (Bagemihl 1989):[10]

(12) rig.nuk > nug.rik 'tame'

The head mora in the first syllable contains /ri/ and the head mora of the second syllable contains /nu/. Using a model that attaches onset consonants to the initial

[10] The symbol '.' marks a syllable boundary here and in the remainder of this work.

mora, the change can be stated as ‘exchange head morae’. This statement is far more convoluted using a model where onsets associate to the σ node.

Another example of this kind is a language game in Finnish (Clements & Keyser 1983):

(13) sakalaisia hätyytettiin → häksäläisiä satuutettiin ‘The Germans were attacked’

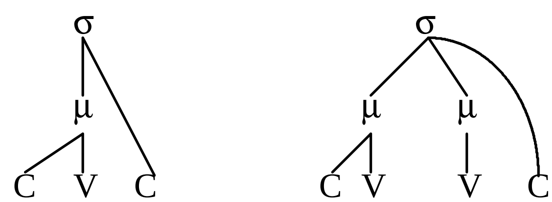
tykkään urheilusta → ukkään tyrheilusta ‘I like sports’

Here, the initial CV sequences of the words are exchanged. Again, this can simply be stated as ‘Exchange the initial mora between words’, assuming that onset consonants are associated to morae. So, language games provide contradictory evidence for syllable models.[11]

In summary, there is no good evidence against attaching onset consonants to the initial mora. In fact, the statement of maximal syllable constraints is far easier given the Type C model. Accordingly, this structure will be used throughout the remainder of this thesis.

To recapitulate the conclusions of this section, all σ nodes must dominate at least one mora each, and all morae must dominate at least one segment each. In addition, the initial non-syllabic elements in a syllable must associate to the initial mora, and final non-syllabic elements must associate to the σ node. This is illustrated by the following two syllables:

(14)



[11] Katada (1990) also cites a Japanese language game in support of onset association to the initial mora, and Itô (1989) uses this idea to provide an account of epenthesis sites (cf Broselow 1992).

1.1.2 HIGHER STRUCTURE

The elements higher than the syllable on the prosodic plane are the foot and the Prosodic Word (PrWd). One of the most interesting questions with respect to feet relates to the number of syllables a foot may contain. Early research concluded that feet were of two types: bounded and unbounded (Hayes 1981). Unbounded feet could incorporate an unlimited number of syllables while bounded feet could consist of one, two, or three syllables (Halle & Vergnaud 1987).

Thereafter the foot inventory was reduced considerably. It was pointed out that unbounded feet could easily be replaced by binary feet, thus simplifying the foot inventory (Prince 1985, Hayes 1985, 1995, McCarthy & Prince 1986). In addition, a number of arguments were raised against permitting ternary feet. This effectively reduced the foot inventory to either mono- or di-syllabic feet.

In 'quantity-insensitive' languages, feet are indeed either mono- or di-syllabic. The situation is more complicated for 'quantity-sensitive' languages. In these languages, the moraic content of feet is significant. It is common for there to be a ban on 'degenerate feet': mono-syllabic feet where the syllable contains a single mora. If a foot contains two morae, only the head syllable may be bi-moraic. Further restrictions were identified by Hayes (1995), resulting in the following inventory of possible feet:

(15) Syllabic Trochee: σ́ σ

Moraic Trochee: ĹL, H́

Iamb: LĹ, LH́, H́

Hayes regards the foot inventory as primitive to the phonology, being motivated by psychological considerations, not phonological ones. Attempts to make the foot inventory follow from phonological parameters or principles have been made by Käger (1993) and Prince (1991). Although interesting in itself, this issue is not of concern in this thesis.

The final supra-syllabic prosodic constituent discussed here is the PrWd. The PrWd has not received as much attention as the Ft and σ in terms of its internal associations. However, Itô & Mester (1992) argue that a restriction on wordform is operative in Japanese, namely that certain types of words must be binary at the PrWd or Ft level. This prohibits forms with a mono-syllabic foot (even if this syllable is bi-moraic), and allows forms with either two feet, a foot and a single unfooted syllable, or a single di-syllabic foot. Apart from this, there has been little research on PrWd restrictions. This is unfortunate as a number of languages seem to exercise conditions on the form of PrWds, especially with regard to maximality. This is discussed further in §5.4.

At this point it is interesting to consider the restrictions placed on the constituents σ, Ft, and PrWd. We have seen that moraic models of the syllable restrict the number of morae to two, feet may only contain two syllables, and there are even case where the PrWd is limited to binary branching (Itô & Mester 1992). It is indeed interesting that prosodic structure has at least a strong tendency to binarity. This point will be raised again in the context of prosodic categorisation in chapter 3.

1.1.3 PROSODIC ACCESSIBILITY

Up to this point there has been one important omission in the discussion of prosodic structure: the issue of prosodic accessibility. ‘Prosodic accessibility’ refers to the possible associations between prosodic nodes. For example, μ is accessible to σ, and σ is accessible to Ft since associations may exist between these elements. In contrast, μ nodes cannot be associated to PrWd nodes. This limitation on accessibility requires explanation.

Early theories of the prosodic hierarchy restricted prosodic accessibility by the Strict Layering Hypothesis (SLH – Selkirk 1980, 1984). The SLH allows a node on tier α to associate to a node on a tier *immediately adjacent* to α. So, a Ft may only associate to PrWd and to σ. Similarly, PrWd may only associate to Ft; an association from PrWd to σ, for example, is impossible.

Challenges to the SLH arose almost inadvertently by the simplification of foot structure. In early stress theory, a language with a single stress per word would employ an unbounded foot. So, a five syllable word would have a foot containing five syllables. However, when the foot inventory was restricted to binary feet this made it impossible to associate all σ nodes to Ft nodes in some forms. For example, in a five syllable word with a single stress, only two syllables would be footed, leaving three unfooted.

However, unfooted syllables cannot just remain unassociated –they need to be dominated by *something* otherwise they would be in an analogous situation to floating features and other unassociated elements, thereby being phonetically unrealisable. Of course, the only contender to dominate these unfooted σ nodes is the PrWd. So, an association from PrWd to σ *is* possible, contrary to the predictions of the SLH.

This change in prosodic accessibility remained unaddressed for a number of years until Itô & Mester (1992). Among other things, Itô & Mester point out something that is of direct relevance to prosodic categorisation:

(16) ‘**Syllable Opacity:** Syllable internal structure is opaque for word-level conditions’.

In present terms this means that when characterising a PrWd for some phonological process or constraint only the nodes PrWd and Ft and their immediate internal structure may be referred to. In fact, this is analogous to feet: the categories of foot in the foot inventory may only refer to the syllable and the mora: feet are defined as [σσ], $[[\mu\mu]_\sigma]$, $[[\mu]_\sigma[\mu]_\sigma]$, and so forth, but they cannot refer below the moraic level: there are no feet of the type $[[[a]_\mu]_\sigma\sigma]$ as segments are too far from the foot tier. In effect, Itô & Mester extend the SLH, permitting non-adjacent tiers to be mutually accessible. However, these tiers must be *minimally* non-adjacent. In other words, elements on a tier α can access elements on tier α-1 and α-2.[12]

Itô & Mester generalise syllable opacity to the following locality condition:

(17) **Hierarchical Locality**: A condition operating at prosodic level C_i has access only to structural information at C_i and at the subjacent level C_{i-1}.

[Itô & Mester 1992:32]

As an example, they point out that "foot internal structure is visible at the word-level (e.g. branchingness can be determined), but syllable structure is opaque; only at the level of the foot can syllable-internal structure be directly accessed." (p.33).

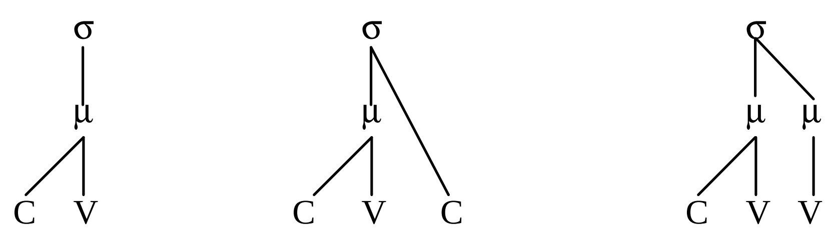
Although, Itô & Mester's Hierarchical Locality hypothesis is obviously more adequate than the SLH, there are a number of unclear issues. Perhaps the point in need of most clarification is the notion of 'structural information'. In their example (cit. above) they refer to 'branchingness', but is this all that counts as structural information?

---

[12] I note without further discussion the similarity between this and 1-subjacency in syntax (Chomsky 1986:30).

There is good reason to believe that reference to branching structure alone is inadequate. Let us consider the internal structure of feet with respect to a language with bi-moraic CVV syllables and mono-moraic CV and CVC syllables (e.g. St Lawrence Island Yupik – Krauss 1975, Hayes 1995:240ff.). In this language, feet are quantity-sensitive, so a mono-syllabic foot can only be of the type [CVV]. Di-syllabic feet can contain two of CV and CVC, including [CV.CVC] and [CVC.CV] since both CV and CVC are mono-moraic. Of course, [CVV.CVV] feet are excluded. Now, foot form is a condition operating at the foot level, so by Hierarchical Locality it can access information at the Ft and σ level. Thus, the condition can distinguish between a branching (di-syllabic) and a non-branching (mono-syllabic) foot; it can also distinguish between a branching and a non-branching syllable. However, herein is the problem: a branching syllable is not identical to a bi-moraic syllable. Consider the following representations:

(18)



In both CVV and mono-moraic CVC syllables, the σ node is branching: there are two associations from the σ node. However, CVC and CVV are not treated as the same by the language. The crucial difference here is *not branching*, but *branching with respect to morae*.

Let us consider what ‘branchingness’ is. We have established that it cannot be simply stated that a node is ‘branching’, but that it is branching *with respect to x*, where *x* is a certain type of node. A non-branching syllable has only *one* autosegmental association between σ and μ. In comparison, a branching syllable has *more than one* autosegmental association from σ to μ nodes. In sum, the notion of ‘structural information’ is not isomorphic with ‘branchingness’, but instead refers to the number of autosegmental associations between nodes.

This allows Hierarchical Locality to be stated in a more precise manner:

(19) **<u>Prosodic Accessibility Hypothesis (PAH)</u>:**

A node β is accessible to node α if:

(1) β is α

OR

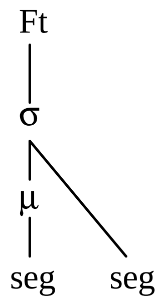
(2) (i) ASSOCIATION:
α immediately dominates β
OR α immediately dominates γ, and γ immediately dominates β.

AND (ii) LOCALITY:
α is tier-adjacent to β
OR α is tier-adjacent to γ and γ is tier-adjacent to β.

A few examples will suffice to show the workings of the PAH. We have seen above that both σ and μ nodes are significant in the categorisation of feet. The PAH predicts this should be so since both σ and μ are accessible to Ft. For the σ node, Ft immediately dominates σ, satisfying the ASSOCIATION clause, and Ft is tier-adjacent to σ, satisfying LOCALITY. Similarly, Ft immediately dominates σ and σ immediately dominates μ, meaning that μ is accessible to Ft by the ASSOCIATION clause. For LOCALITY, μ is tier-adjacent to the σ level and the σ level is tier-adjacent to the Ft tier. So, both σ and μ are accessible to Ft. This can be compared with *seg*s, which are not accessible to feet. The reason for this is that LOCALITY is violated: *seg*s are tier-adjacent to the moraic level, which is *not* tier-adjacent to the Ft level.

The PAH cannot be further simplified – both the ASSOCIATION and LOCALITY clauses are necessary. The following structure can be used to demonstrate this:

(20)



If only ASSOCIATION is used then *seg* is accessible to Ft – an incorrect result. LOCALITY cannot be used alone as it says nothing about the associations of elements: for any Ft node, *all* syllable nodes are tier-adjacent. So, using LOCALITY alone would mean that any syllable could be used in the categorisation of any foot (see §2.3).

The PAH has a direct bearing on the concerns of this thesis. The PAH limits prosodic reference. Therefore, anything that refers to prosodic information must obey the conditions of the PAH. So, all distinctions between prosodic categories must be constrained by the PAH; this will be shown to be a major component in restricting the factors that play a part in distinguishing between prosodic categories and in limiting the number of constraints relevant to prosodic categorisation (see Chapter 2).

1.2 OPTIMALITY THEORY

The previous sections have outlined the representational assumptions made in this thesis. This still leaves the issue of phonological computation. While the basic proposals regarding syllable weight in this thesis are relatively free from any theory of computation (but not of representation), the explanation of stress and related phenomena is couched in the constraint-based theory of grammar called Optimality Theory (OT – Prince & Smolensky 1993). In fact, the theory of computation of prosodic categories presented in this thesis utilises constraints that are both *violable* and *ranked*; these characteristics are shared with OT.

In the conception of phonological processes proposed in Chomsky & Halle (1968), the phonology was believed to take a lexical item and then apply ordered rules to produce an output. In later theories, sets of rules were grouped together forming 'levels' (Kiparsky 1982, Mohanan 1984, 1986). In the 1980s the need for phonological rules – operations on phonological forms – was questioned. Instead, phonological structures were permitted to generate freely as long as output forms did not violate any well-formedness statements, also called *constraints*. Since constraints are requirements on the *output* form, the order of constraints within a level became irrelevant.[13]

While Optimality Theory is radically different from Chomsky & Halle (1968), it can be seen as the culmination of trends in phonological theory since that work. OT is entirely constraint-based in its evaluation of output forms and there is no conception of ordering: all evaluation of different possible outputs occurs simultaneously.

Like many theories of grammar, OT posits a repository of lexical items called the 'lexicon'. The lexicon inputs a form into a component called GEN(erator). GEN then creates multiple output candidates from the one input. GEN is constrained in what it can produce by universal absolute conditions on well-formedness such as the requirement that a syllable must dominate a mora. In the words of Prince & Smolensky (1993:4) GEN "contains information about the representational primitives and their universally irrevocable relations."[14] Significantly, GEN does not contain language-specific information.

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[13] For further discussion on the nature of constraints see Chomsky & Lasnik (1977). The underlying premise of an entirely constraint-based theory is expressed well in this work: "the consequences of ordering, obligatoriness, and contextual dependency can be captured in terms of surface filters." (Chomsky & Lasnik 1977:433).

[14] All these 'universally irrevocable relations' have not yet been identified. They include the requirement, stated above, that a σ node must be associated to a μ node, and a μ node to a *seg*.

The output candidates enter the component called CON, which contains constraints. These constraints are drawn from Universal Grammar, and are of a small number of basic types. There are markedness constraints which refer to substantive hierarchies such as the sonority hierarchy or featural markedness hierarchies. There are also constraints on prosodic structure such as NOCODA which prohibits a syllable from containing a coda consonant. The third type is Faithfulness constraints, which require agreement between input and output forms.[15] Finally, there are constraint predicates such as ALIGN, discussed in detail below (§1.2.1).

The purpose of CON is to provide a set of violation marks for each candidate. After this is done, the evaluation algorithm EVAL can apply to determine which candidate is *most optimal*. A form's optimality is measured in terms of constraint violations. In a simple case, if a candidate A violates a constraint more times than another candidate B does, then B is more optimal than A. However, in practice the computation of optimality is far more complex: not just one constraint figures in optimality evaluation, but all the constraints in CON.

An additional complexity is constraint ranking. If a constraint C_1 is ranked above a constraint C_2, violations of C_1 have more significance than violations of C_2. Consider the following scenario: A constraint C_1 is ranked above a constraint C_2. A candidate A violates C_1 but not C_2, and a candidate B violates C_2 but not C_1. This is represented in tableau form below:

(21)

	C_1	C_2
A	x	
B		x

[15] Also between base and reduplicant. Faithfulness constraints do not play any role in the following discussion. See McCarthy & Prince (1995) for a further details.

Obviously, comparing violations of A and B will not tell us which candidate is more optimal since both incur one violation. However, since C_1 is ranked above C_2, a single violation of C_1 is more significant than any number of violations of C_2. So, B is more optimal than A as B's violations are of less importance than A's.

When constraints are discussed in the text, they are written in small capitals. Constraint hierarchies are enclosed by single vertical lines. The symbol '»' signifies ranking. For example, $|C_1 \gg C_2|$ stands for the constraint hierarchy above.

At this point it may seem that OT *counts* constraint violations in identifying the optimal candidate. Actually, this is not the case. The optimal form can be determined by using the following lemmas:

(22) (i) "**Cancellation Lemma**:

Suppose two structures [candidates] S_1 and S_2 both incur the same mark [constraint violation] *m. Then to determine whether $S_1 > S_2$, we can omit *m from the list of marks of both S_1 and S_2 ('cancel the common mark') and compare S_1 and S_2 solely on the basis of the remaining marks. Applied iteratively, this means we can cancel *all* common marks and assess S_1 and S_2 by comparing only their unshared marks.

(ii) **Cancellation/Domination Lemma**:

Suppose two parses [candidates] B and C do not incur identical sets of marks. Then B > C if and only if every mark incurred by B which is not cancelled by a mark of C is dominated by an uncancelled mark of C."

[Prince & Smolensky 1993:221]

Applied to a set of candidate forms and their violations, the above will identify the most optimal candidate. It is significant that the Cancellation and Cancellation/Domination Lemmas do not *count* constraint violations. In no way are violations tallied and then the numerical figures compared. Instead, optimality is computed by comparison of single constraint violations.

The preceding discussion has briefly outlined the basic tenets of Optimality Theory. It remains at this juncture to consider some conventions of representation. Consider the following tableau:

(23)

	C_1	C_2	C_3
$cand_1$	x!		
$cand_2$		x x	x!
☞ $cand_3$		x	x

Constraints are ranged along the topmost row and candidate forms appear in the leftmost column. If there is a solid line (as between C_1 and C_2), the constraints to the left of the line are ranked above all constraints to the right of the line. If constraints are unranked with respect to each other, a dotted line intervenes (as between C_2 and C_3). An 'x' signifies a constraint violation, and an exclamation mark signifies a crucial violation – a violation that means a form cannot be the most optimal candidate. A crucial violation of a constraint C means that all other constraints ranked lower than C are effectively irrelevant, marked by shading (as for $cand_1$). The most optimal form is marked with the pointer '☞'.

1.2.1 STRESS AND ALIGNment

In derivational approaches to stress theory there are two major parameters – direction and iteration (Prince 1983, Hayes 1981, 1995, Halle & Vergnaud 1987). Since stress plays a major role with regard to syllable weight, and is the focus of attention in chapters three and four, this section is devoted to discussing the OT analogue of direction and iteration.

In some languages there is only one stress per word (e.g. Maori §1.3.1, §3.1.1), while in others there are more than one (e.g. Kara §3.2.1). This distinction between one and many stresses has been attributed to the process of *footing*: in a language with a single stress, there is a single foot, while in a language with many stresses there are many feet. This was taken to be a parametrised option termed ‘iterativity’ in derivational stress theories (See Käger 1995 for discussion). If a language set the parameter as [-iterative] only one foot would be built, while [+iterative] allowed many feet in a word form.

In addition, it was discovered that stresses tend toward a certain edge of a domain. for example, in Pintupi (Hansen & Hansen 1969, 1978, Hayes 1995:63,64) stress falls on the initial syllable and every other syllable scanning from *left to right*. This is compared to Ngenone (Tryon 1967) where stress falls on the penult and every other syllable scanning from *right to left*. The difference between these languages was taken to involve alternative settings of a Direction parameter.

In OT the effects of these two parameters have been largely subsumed by one constraint called ALIGN, repeated here from McCarthy & Prince (1993b:2):

(24) Align(Cat1, Edge1, Cat2, Edge2) =

$_{\text{def}}$ ∀Cat1 ∃Cat2 such that Edge1 of Cat1 and Edge2 of Cat2 coincide.

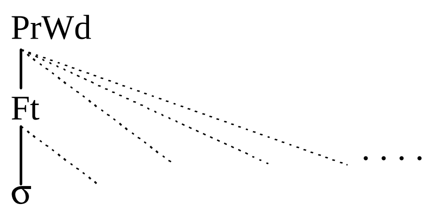
Where Cat1, Cat2 ∈ PCat ∪ GCat

Edge1, Edge2 ∈ {Right, Left}

(i) PCat and GCat are, respectively, sets of prosodic and grammatical (morphological and syntactic) categories.

Throughout this thesis ALIGN(*x*, Edge1, *y*, Edge2) will be abbreviated to ALIGN-*x*-Edge1 for convenience. For example, ALIGN(Ft,L,PrWd,L) is abbreviated to ALIGN-Ft-L. ALIGN-Ft-L requires the left edge of all feet to be aligned with the left edge of a PrWd. This is only satisfied in the following structure:

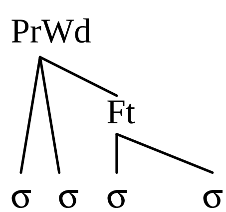
(25)



(i) Dotted lines are optional associations.

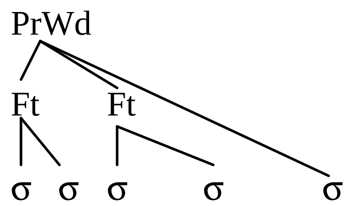
If the foot is not leftmost then violations are incurred depending on the foot's distance from the left edge. One violation is incurred for every intervening syllable. For example, the following structure would result in two violations:

(26)



Since the constraint requires that *all* feet be aligned leftmost in a PrWd, the constraint evaluates *every* foot for leftmostness. Consider the following:

(27)



Align(Ft, L, PrWd, L) is violated twice. This is because not *all* feet are aligned with the left edge of the PrWd – the second foot is two syllables (hence two violations) away from it. From this, it is evident how the parameter of Direction is subsumed by ALIGN. The requirement that all feet align at the *left* edge of a PrWd is equivalent to requiring feet to be built from *left to right*. For example, the representation above incurs two violations of ALIGN. However, if feet were built over the rightmost four syllables, *three* violations of ALIGN would result, effectively banning feet that are not *as leftmost as possible*.

Of course, this assumes that as many feet must be built in a word as possible – i.e. that the process is [+iterative]. However, ALIGN is inherently [-iterative]: requiring that *all* feet be built at a certain edge means that any form with two or more feet will be less optimal than a form with one foot (compare the two figures above). To require iterativity then, another constraint is needed. This is PARSE-σ: ‘Syllables must be parsed into feet’. If PARSE-σ outranks ALIGN, it will be more optimal to have many violations of ALIGN than to have a single violation of PARSE-σ. Consider the following tableau:

(28)

	PARSE-σ	ALIGN-FT-L
(σ σ) σ	x!	
☞(σ σ)(σ)		x x

This ranking effectively replaces the [+iterative] parameter. However, it does not mean that the ALIGN constraint has no effect on the output candidate. Consider the case where degenerate feet are banned by a high ranking constraint, called FT-BIN (Prince & Smolensky 1993). From the following tableau, it is evident that ALIGN-FT-L is crucial in determining the correct candidate, in spite of its low ranking:

(29)

	FT-BIN	PARSE-σ	ALIGN-FT-L
(σ σ)(σ σ) (σ)	x!		xx xxxx
☞(σ σ) (σ σ) σ		x	xx
(σ σ) σ (σ σ)		x	xxx!
σ(σ σ) (σ σ)		x	x xxx!

In summary, ALIGN subsumes the direction and [-iterative] parameters assumed in earlier work on stress theory. Ranking of PARSE-σ above ALIGN simulates the effect of a [+iterative] parameter setting. The importance of the ALIGN constraint will become evident in chapter four.

This ends the discussion of the theory of computation assumed in the remained of this thesis. In summary, OT is an entirely constraint based theory, and constraints are both violable and ranked.

1.3 APPROACHES TO SYLLABLE WEIGHT

Having examined the representational and computational theories assumed in this work, it remains to address the subject of this thesis – the process of prosodic categorisation.

It is well known that phonological processes make reference to prosodic structure. Phonological constraints often apply to the syllable or the foot, or their effects are bounded within these domains. However, some phonological processes do not simply refer to a prosodic constituent but to a certain category of prosodic constituent. The method by which the grammar distinguishes between these categories is the subject of the remainder of this thesis.

The most well studied example of prosodic categorisation is syllable weight. A significant amount of this thesis is devoted to explaining the distinctions between different ‘weights’ (categories) of syllables found cross-linguistically. This may come as a surprise since one of the more enduring assumptions about syllable weight is that there are only two possible weights – termed ‘heavy’ and ‘light’ – and that these are distinguished in terms of their moraic content alone. Both these assumptions will be shown to be incorrect, with languages that utilise as many as six distinctions of weight and distinguish those weights by a variety of factors other than moraic content.

So, the aim of this and the following chapter is to present an alternative theory of prosodic categorisation, with a focus on syllable weight. One would hope that any new theory would be ‘better’ than previous ones – either more empirically adequate, more theoretically parsimonious, or both. A fruitful place to begin in constructing such a theory is to identify the failures of previous approaches.

Theories of prosodic categorisation can be broadly divided into two types: the formal and the functional. Formal approaches attempt to differentiate syllable weights by appealing to phonology-internal information such as autosegmental associations. In contrast, functional approaches see the motivating force behind syllable weight categorisation as residing in some other component of the grammar, usually in the phonetic component.[16] Both types of approaches will be considered, beginning with the formal.

1.3.1 FORMAL THEORIES

(30) "Light syllables contain one mora, heavy syllables two."

McCarthy & Prince (1986:7)

It is difficult to find a better example of theoretical simplicity married with conceptual elegance than the definition of syllable weight above. Unfortunately, the definition has one flaw: it is incorrect.

The statement makes two significant presuppositions: that there are only two categories of syllable weight and that syllable weight is defined in terms of morae.[17] It is fairly easy to show that this is not the case. In fact, both claims can be refuted empirically by examining the syllable weight distinctions in a single language: Maori.

Maori is a Polynesian language, spoken in New Zealand. Of present interest is its stress rule (for details see §3.1.1, §4.1, §4.4, Appendix 2.2):

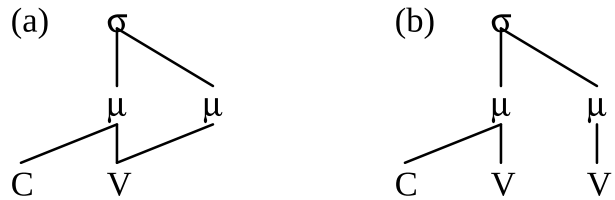
(31) Stress the leftmost long vowel,
Else the leftmost diphthong,
Else the leftmost syllable.

[16] I use the term 'functional' following Hayes (1996). The use of this term is unfortunate given its somewhat different use in syntax. Perhaps 'Grounded' would be a better term (Archangeli & Pulleyblank 1994).

[17] For the traditional view that syllable weight has only two categories defined solely by moraic content see Hyman (1985) and McCarthy & Prince (1986). For the view that there are multiple syllable weights, see Everett and Everett (1984), Davis (1988), Everett (1988), Woodbury (1985, 1987), Blevins (1995), and Hayes (1995). For the view that a notion such as 'syllable weight' is not significant for the grammar at all see Halle & Vergnaud (1987) (cf Tanaka 1989).

It is obvious that Maori employs *three* distinctions of syllable weight, distinguishing between long vowels, diphthongs, and short vowels. This is a straightforward refutation of the claim that a language can have only two syllable weight categories. In addition, it is not moraic context alone that distinguishes weights. Consider the following representations of syllables in this language:

(32) (a) (b)

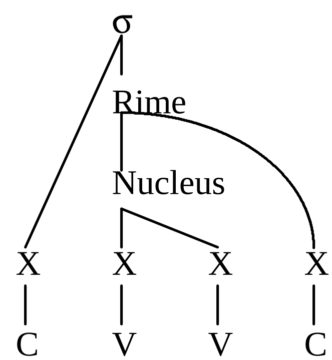


In terms of moraic content, the syllable with the long vowel (a) is identical to the syllable containing the diphthong (b). So, the approach that relies on moraic content alone as the sole factor in distinguishing weight predicts that the Maori distinction between (a) and (b) is impossible. Altering the moraic structure does not help. If, for example, the diphthong structure only contained one mora this would render it indistinguishable from CV syllables, which also contain one mora.

So, Maori is a significant – even insurmountable – challenge to the moraic-content view of syllable structure. This suggests that the number of different syllable categories should be increased at least to three. In addition, reference to moraic content alone is evidently inadequate.

For somewhat different reasons, Blevins (1995) arrived at these same conclusions. Blevins allows three categories of weight: Light, Heavy, and Heaviest. She argues that the moraic model cannot adequately categorise syllable weights since it can only make two distinctions. For Blevins this is evidence that a more traditional model of the syllable is needed:

(33)



Given this, syllable weights are distinguished by the levels at which they branch: a *heaviest* syllable has a branching nucleus – (C)VV(C), a *heavy* syllable a branching rime and a non-branching nucleus – (C)VC, and a *light* syllable does not branch at either level – (C)V (Blevins 1995:215).

From a theory-internal point of view, one can ask why only three categories should be permitted. For example, we could add the category 'Super-Super-Heavy' which has *both* a branching rime and a branching nucleus – (C)VVC. Also, one could ask why a branching *syllable* node does not figure in this categorisation, making syllable weight onset-sensitive. These restrictions do not seem to follow from any other principle of the theory, but rather need to be independently stipulated. So, from a theory-internal point of view, it is difficult to see why there should be only three weight distinctions.

From an empirical point of view, it is also evident that this model is overly-constrained. This is shown through the syllable-weight system of Kara, discussed in more detail in §3.2.1. In Kara the rightmost heaviest syllable is stressed, else the leftmost syllable. The interesting aspect is that there are four gradations of 'heaviest syllable':

(34) Ca: > Ca$\underline{\text{V}}$, CaC > Ca > C$\underline{\text{VV}}$, C$\underline{\text{V}}$C

(i) $\underline{\text{V}}$ is any vowel except /a/

Here, as in Maori, a long vowel is heavier than all other types. Also similarly, CVV and CVC syllables are heavier than CV types. However, there is another factor to take into account: syllables containing /a/ are heavier than syllables without /a/. This shows that syllable weight is not defined solely by structure, but also by the properties of the segments it contains. As it stands, Blevins' model is inequipped to make this distinction.

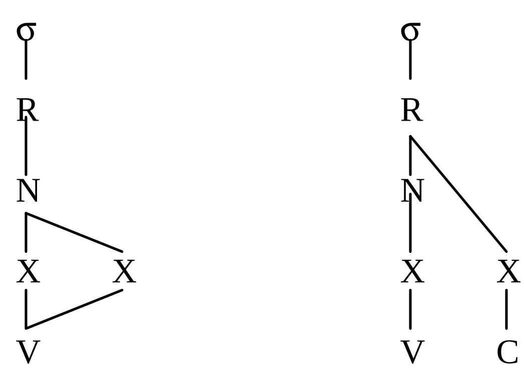
Blevins' model also cannot account for the stress system of Tiberian Hebrew (McCarthy 1979, §3.1.4). In this language, primary stress falls on the ultima if it ends in a consonant, otherwise on the penult. Significantly, primary stress is not attracted to the ultima if it contains a long vowel:

(35) ka.táb 'he writes' cf ka.tá.bu: 'they wrote'

[From McCarthy 1979:139]

This means that CVC syllables are heavier than CVV syllables. However, by Blevins' model this is an impossibility. Consider the representation:

(36)



Here, the CV: syllable has a branching nucleus, and the CVC syllable a branching rime. By Blevins' rules, a language with two weight distinctions defines the 'heaviest' category by a branching nucleus. This would incorrectly rank CV: above CVC in this case. Tiberian Hebrew is not an isolated case; there are a number of languages with a similar weight distinction (§2.6). In any event, it is obvious that a theory that allows the Tiberian Hebrew system is of more value than one that does not.

The final objection to Blevins' model relates to syllable structure. As discussed above (§1.1.1) the moraic model is structurally simpler than the traditional model. From the point of view of parsimony it would be unfortunate to abandon it. Also, one can take issue with Blevin's contention that the moraic syllable can only make two weight distinctions. It is not the limits of the moraic *model* that permit only two distinctions to be made, but the inadequacy of previous *assumptions* relating to prosodic categorisation. This point will be discussed fully in the following chapter.

In summary, the approach to syllable weight based solely on moraic content is inadequate. In fact, even an approach based on a more complex syllable model is too restrictive.

1.3.2 Functional Theories

The conclusions of the preceding section are not entirely novel: a number of other researchers have pointed out the inadequacy of the formal approaches to syllable weight so far proposed (Everett and Everett 1984, Woodbury 1985, 1987, Davis 1988, Everett 1988). In fact, over the past half-decade it has become increasingly popular to eschew the idea that syllable weight can be explained in phonological terms at all (McCarthy & Prince 1993a, Prince & Smolensky 1993, Hayes 1995, Gordon 1997).

One of the most important recent proponents of this idea is Hayes (1995). Hayes' work has since provoked further research in the same vein (see esp. Gordon 1997, Appendix 3). While Hayes' proposals are partly pre-empted by work that appealed to phonetic 'salience' in determining weight (Prince 1983:58, Halle & Vergnaud 1987:224-6, Everett 1988:235-238), his theory is unique in a number of ways.

Hayes' proposals identify two different aspects of syllable weight – quantity and prominence. 'Quantity' refers to moraic content, distinguishing between mono-moraic and bi-moraic syllables. In comparison, prominence is a phonetic notion, described as "perceptual salience" (p.271).

As an illustration of the use of prominence, consider the oft-discussed language Pirahã (Everett & Everett 1984, Halle & Vergnaud 1987, Davis 1988, Everett 1988, Hayes 1995, §3.2.2). In this language, whichever one of the last three syllables in a word is 'heaviest' according to the following hierarchy receives primary stress:

(37) KVV > GVV > VV > KV > GV[18]

K = voiceless consonant, G = voiced consonant.

This language presents a significant problem for the strictly two-way conception of syllable weight espoused in earlier work.

Hayes proposes to deal with these multiple weights by means of a grid which represents prominence (cf Everett & Everett 1984, Davis 1989). His formalism requires that the more prominent a certain type of syllable is, the more marks it will project on a grid. This prominence grid is akin to the metrical grid except it has no constituent structure and is only present for computing prominence, playing no other role in the phonology. For Pirahã a set of rules are required that specify the prominence grid projections of each type of syllable:

---

[18] Pirahã has no V syllables (Everett 1988:209).

(38) KVV: *****
GVV: ****
VV: ***
KV: **
GV: *

For Hayes, the rules are a formal instantiation of a phonetic reality. In other words, KVV syllables are the most significant type in the phonology because they are the most *phonetically* salient. This is an example of what Hayes' (1995, 1996) terms 'phonologization' of phonetic properties – i.e. the translation of phonetically salient elements into phonological constructs.

The stress algorithm of Pirahã needs only to refer to the prominence grid in order to achieve the correct stress pattern: the syllable with the greatest number of grid marks in the last three syllables of a word projects a mark onto the metrical (stress) grid.

This has profound implications for conceptions of syllable weight. In effect, two co-present mechanisms are at play in defining syllable weight – quantity and prominence. However, quantity and prominence differ in a number of ways. Most significantly, the domains of prominence and quantity are distinct: quantity can apply at the level of foot construction, whereas prominence is relevant for the placement of primary stress (§5.1, 5.2).

Proposing the existence of a 'prominence grid' has more significance than simply providing a theoretical construct to adequately explain empirical facts. The prominence grid presupposes that phonetic information plays a significant, and almost direct, role in phonological computation. This can be seen as part of a recent trend toward incorporating more phonetically-dependent constructs and explanations into phonological theory (e.g. Archangeli & Pulleyblank 1994, Hayes 1996 and references cited therein). This is not to say that this is a novel idea – the idea has been employed in the theory of Natural Phonology (Stampe 1973) and in a number of other works (e.g. Ohala 1974, 1983, Ohala & Ohala 1993). This leads to the Hayesian notion of 'prominence'. While the prominence *grid* is formally definable, the elements that project onto the prominence grid, or rather their properties, are not definable in phonological terms. Consider Hayes' description of prominence:

(39) (i) "…raw prominence or perceptual salience. Heavy syllables, or syllables with high tone, or syllables with low vowels, and so on, tend to sound louder than other syllables. Normally, this variation is phonologically irrelevant, but it appears that some languages take differences in prominence and phonologize them, making them the basis of true phonological stress rules."

[Hayes 1995:271]

(ii) "As to what factors can render a syllable more prominent, the following apparently must be included: heavy syllable quantity, lowness in vowels, high tone, the presence of syllable-final /ʔ/, and the presence or voicing of syllable-initial consonants."

[Hayes 1995:276]

In terms of evaluating Hayes' theory, it is difficult to show that the notion 'prominence' is empirically unjustified simply because it is difficult to determine what the notion of 'prominence' does not predict.

From the above it is evident that 'prominence' is merely a convenient cover term for a set of unrelated phonetic phenomena. There is no necessary and sufficient definition that constrains which phonetic phenomena count as prominent. To complicate matters further, Hayes notes that in some languages prominence is a *combination* of a few of the above factors. For example, the prominence inherent in the Pirahã syllable [KVV] is a combination of onset voicelessness and syllable duration. However, there is no explanation as to *why* these characteristics can combine in some stress systems and if there are any constraints on their combination.

A problem with prominence is that it results in significant formal redundancy. This is evident in Hayes' analysis of a Hindi dialect described by Kelkar (1968) (see §3.1.4.1). Hindi has three syllable weights: Superheavy (CV:C, CVCC), Heavy (CV:, CVC), and Light (CV). Hayes accounts for this by assigning the following prominences to syllable types:

(40)	Superheavy:	***
	Heavy:	**
	Light:	*

Further to this, Hayes argues that these syllable types are distinguished by moraic content – Superheavy syllables have three morae, Heavy syllables have two, and Light syllables one. He notes that this "might be generalised to something like 'translate weight into prominence' " (p.277). This comment is significant for a number of reasons. Firstly, it means that 'prominence' can refer to *phonological* structure – moraic content – as well as phonetic properties. Pursuing this line of thought, it raises the question of why moraic structure is necessary at all; if moraic structure can be represented by a prominence grid, what need is there of moraic structure in the first place? While some would argue that this is not a bad idea, it re-emphasises the importance of a constrained notion of prominence, something that Hayes' theory does not provide.

In sum, the components of 'prominence' are poorly defined. In effect, the set of elements that are prominent is infinite in Hayes' conception, including any possible phonetic nuance. Because ‘prominence’ is unconstrained as a theoretical notion, I recommend its abandonment, and along with it the prominence grid.[19]

The conclusions of the preceding sections do not bode well for stress theory. Formal attempts to account for syllable weight have been shown to be empirically inadequate, and Hayes’ functional attempt is unconstrained. The remainder of this work is devoted to supplying an alternative to the problem of prosodic categorisation.

[19] Hayes’ is not alone in presenting a functional theory of syllable weight. See also Gordon (1997), discussed in Appendix 3.

2 A THEORY OF PROSODIC CATEGORISATION

Previous formal approaches to syllable weight have failed in two respects: in overly limiting the *number* of weight distinctions possible in natural language and in overly restricting the *factors* by which weight is calculated. With regard to the first point, Kara is proof that the number of possible distinctions in any language is at least five. In fact, there is even a language with six weight distinctions (§3.2.3).

With such a range it is questionable whether there is any *stipulated* limit on the number of weight distinctions at all. Certainly, six is a rather arbitrary upper limit. Instead, it is more likely that the number of possible weights is not limited by any arbitrary stipulation, but principally by learnability and computational economy, and only to a lesser extent by theory-internal restrictions.

Previous approaches have disagreed with this last point, arguing that the maximum number of possible weight distinctions should follow entirely from the restricted number of *factors* that are relevant to prosodic categorisation. In the branching theory, for example, there are only two relevant factors – branching and non-branching structures, and so there can be only two weight categories for any given element.

However, in constructing a theory of syllable weight categorisation one must take care to avoid drawing incorrect implications. It is true that if a theory only permits *x* number of syllable weight distinctions to be made, then it predicts that only *x* syllable weight distinctions would ever be found in natural language. However, it is not necessarily the case that because a language has *x* number of weight distinctions, an adequate theory must be restricted to making *x* number of distinctions. For example, while Kara has five syllable weights; this does not mean that any adequate theory of syllable weight must be limited to allowing no more than five distinctions.

Conversely, if a theory allows *n* distinctions in weight, is it then reasonable to expect to find a language that has *n* syllable weights? This is not necessarily a fair expectation; other factors may limit the number, such as the cognitive ability to compute such a number of distinctions. So, it is not necessary for a theory of syllable weight to focus on matching the maximum number of distinctions predicted by that theory to the maximum number of known weight distinctions in natural language. Given the large number of distinctions attested – at least six in Wosera – it is a more pressing requirement that a theory of prosodic categorisation provide *enough* distinctions.

On the other hand, an adequate theory must be restrained in the *type* of distinctions it predicts. For example, if a theory predicts that two syllable weights can be distinguished on the basis of whether they contain the sequence /ba/ or not and no similar distinction is attested in natural language, then it is questionable whether the theory should allow such a distinction in the first place. So, emphasis must be placed on the factors that contribute to weight distinctions.

A variety of factors have already been mentioned as playing a role in distinguishing syllable weights. It is well known that some stress systems distinguish syllable weight in terms of moraic content. However, some weight distinctions are based on the presence of onset consonants (Aranda, Alyawarra §3.1.2, Pirahã §3.2.2), coda consonants (Hindi §3.1.4.1), long vowels (Maori §3.1.1), geminate consonants (Selkup §3.2.6), and high tone (Lithuanian §3.1.6). In addition, provision must be made for the interplay of sonority and stress, as in Asheninca, Kara, and possibly Pirahã (§ 3.2.5, 3.2.1, 3.2.2 resp.). Certain hierarchies also need to be accounted for, such as the distinction between long vowels, diphthongs and mono-vocalic syllables in Maori (§3.1.1), the preference of CVC syllables over CVV syllables in Tiberian Hebrew (§3.1.4), and of CVC syllables over geminate-final syllables in Ngalakan (§3.2.6.1.2). On the other hand, there is little evidence that reference to segmental features is necessary, although Madimadi is potentially problematic in this regard (§3.2.4).

There is no denying that these are diverse phenomena. Indeed, there is no readily identifiable surface (i.e. phonetic) relation between, for example, tone and the presence of an onset. However, this is only problematic if syllable weight is defined by phonetic characteristics. Instead, it will be argued that the diversity of these factors can be explained by reference to properties of phonological representation. More specifically, all syllable weight distinctions are based on the evaluation of two factors: prosodic structure and segmental sonority.

2.1 Sonority and Weight

In discussing syllable weight, Prince (1983:58) mooted the idea that "the heavy-light distinction is really one of sonority, not geometry". Further to this, he suggested that "finer distinctions in sonority might also be expected to play a role in determining the heavy and light classes for some languages." Unfortunately, Prince's suggestion, or – as he termed it – his 'vague hope', remained unexplored for some time. Indeed, no theory of syllable weight has ever attempted to incorporate sonority distinctions, with some explicitly rejecting this possibility (Levin 1985). While there is indisputable evidence that sonority does play a role in defining syllable weight, before demonstrating this it is necessary to consider the nature of segmental sonority.

For some time it has been recognised that in most languages only certain segments can appear as the nuclei of syllables. For example, in Maori (Bauer 1993) only vowels may serve as nuclei, while glides, liquids, nasals, and obstruents cannot. This grouping of nucleus elements is remarkably consistent cross-linguistically. In fact, studies of syllable nuclei have shown that certain conditional statements can be made, such as ‘if /i/ is a valid syllable nucleus, then /a/ is a valid syllable nucleus’. It is interesting to note that this is not bi-conditional: if /a/ is a nucleus, it does not follow that /i/ can also form a nucleus. Inspecting such implicata have resulted in scales such as the following (Clements 1990, cf Hooper 1976, Selkirk 1984):

(41) Vowels > Glides > Liquids > Nasals > Obstruents

Interestingly, the higher the element is in the hierarchy, the more phonetically ‘sonorous’ – perceptually salient, louder, and so forth – the element is.

The sonority hierarchy is not limited to typological generalisations over languages. In a series of studies Dell & Elmedlaoui (1985, 1988, 1992) showed that syllabification in Imdlawn Tashlhiyt Berber refers to a hierarchy broadly similar to the one above.

There have been two major problems with respect to the sonority hierarchy. In the first place, identifying the phonetic realisation of ‘sonority’ has proven elusive, leading many to suppose that the basis of the hierarchy is not phonetically grounded at all, but the result of the calculation of phonological features (Harris 1990, Rice 1992). The second problem is related to the categories of the hierarchy. For example, Dell & Elmedlaoui (1985) propose the following hierarchy:

(42)

$$\text{a} \rangle \begin{matrix}\text{e}\\ \text{o}\end{matrix} \rangle \begin{matrix}\text{i}\\ \text{u}\end{matrix} \rangle \text{liquid} \rangle \text{nasal} \rangle \begin{matrix}\text{voiced}\\ \text{fricative}\end{matrix} \rangle \begin{matrix}\text{voiceless}\\ \text{fricative}\end{matrix} \rangle \begin{matrix}\text{voiced}\\ \text{stop}\end{matrix} \rangle \begin{matrix}\text{voiceless}\\ \text{stop}\end{matrix}$$

Recent work has argued that there are further divisions. Kenstowicz (1996) claims that there are two parameters along which the sonority of vowels varies –

peripherality and height. This leads to the following sonority hierarchy for vowels:

(43) a > e, o > i, u > ə > ɨ

The peripheral vowels /i e a o u/ are ranked over the central vowels /ə/ and /ɨ/ and lower vowels are ranked over higher vowels (as a > e,o > i,u and ə > ɨ). Throughout this thesis, fine distinctions in the sonority hierarchy are recognised, following Kenstowicz' suggestions. Ultimately, it will be shown that syllable weight offers a number of insights into the place of the sonority hierarchy in the grammar (§4.2). For the moment, however, it is necessary to consider *how* the grammar refers to sonority in defining weight.

2.1.1 CONSTRAINING SONORITY

A number of observations can be made about sonority-sensitive weight. Firstly, a syllable with a less sonorous segment will never be heavier than one with a more sonorous segment. For example, the syllable /ti/ will never be heavier than /ta/ in any language since /i/ is less sonorous than /a/. This observation is captured in the following constraint:

(44) SON(α,β) 'A segment dominated by α is equally or more sonorous than β'

For example, SON(μ,/eo/) requires that a segment dominated by μ be at least equal to /e/ and /o/ in sonority – i.e. /e/, /o/, or /a/.

The formulation of this constraint raises a number of other issues. Firstly, the argument α is unspecified – in principle, α may be any prosodic node. In practice, though, since sonority is a property of segments, the only prosodic nodes that can directly dominate segments are σ and μ.

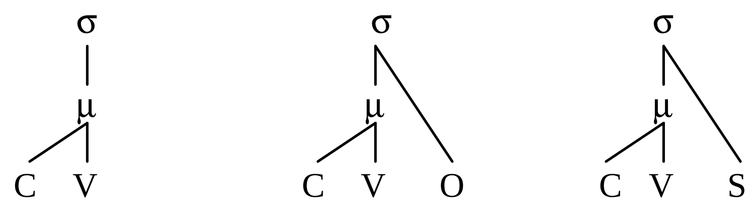
There are many examples of the constraint SON(μ,β) (§3.1.7). The use of σ as an argument of SON is supported in languages where non-moraic coda consonants play a role in defining syllable weight. For example, SON(σ, sonorant) requires that a segment immediately dominated by σ (i.e. a coda consonant) must have the sonority of at least a sonorant consonant.

As an example of the use of this constraint, consider the Inga Quechua language (Levinsohn 1976). Only CV or CVC syllables are permitted in this language. CVC syllables are divided into two categories for the purposes of stress: CVS syllables, where S is a sonorant consonant, and CVO, where O is an obstruent. Primary stress falls on a final CVS syllable. If there is no such syllable, then it falls on the penult:

(45) Final CVS – yu.kán ‘he had’
Final CVC – ɲám.bjag ‘path’
Final CV – wág.ra ‘cow’

A standard analysis would be that CVS syllables are bi-moraic while CVO and CV syllables are mono-moraic. However, Inga Quechua has a minimal word restriction: the minimal acceptable word is CVCV (Gordon 1997). Since minimal word requirements require bi-moraicity (McCarthy & Prince 1986, §5.3.1), this means that CVS syllables are not bi-moraic as they do not form an acceptable minimal word on the own. From this, Inga syllables must be mono-moraic:

(46)



So, the heaviness of CVS syllables is not dependent on moraic content. The only other factor evident is sonority: only CVS syllables satisfy the constraint SON(σ,sonorant) as only they have an autosegmental association from the σ node to a sonorant segment.

There is a marked similarity between SON(α,β) and Prince & Smolensky's (1993:72) HNUC constraint, which requires the nucleus of a syllable to be of a certain sonority. Indeed, the constraints are identical in function, and will later be shown to reduce to another constraint (§4.3). At this juncture, though, SON(α,β) is adequate for drawing distinctions between sonority-sensitive weights and so will be retained for the remainder of this chapter and for the case studies in chapter three.

To some extent, the above discussion accords with Prince's (1983) suggestion that sonority plays a decisive role in determining syllable weight. With this in mind, it is reasonable to inquire as to whether Prince's suggestions can be followed further, accepting that weight distinctions are based *entirely* on sonority and not on structure at all. In this view, a syllable is heavy because it "encloses significantly more (total) sonority than a light syllable." (Prince 1983:53).

Prince's conception of 'total sonority' is somewhat divorced from the idea of *segmental* sonority. Instead of total sonority being the property of a single segment, it is the summation of the sonorities of all segments in a syllable. This is the only way to express the weight difference between a syllable containing a single vowel and a syllable containing two vowels. In fact, this 'sonority summation' is even more complex. If it were a matter of simply summing sonority, a syllable containing /ai/ would be more totally sonorous than a syllable containing /i:/. This is because the summed sonority of /a/ and /i/ is greater than that of /i/ plus /i/ since /a/ is more sonorous than /i/. However, there is no language that shows this; in fact, /i:/ is heavier than /ai/ in Maori (§3.1.1). From this, total sonority does not result from a simple summation of segmental sonorities, but also seems to be heightened by being in certain structural configurations, such as long vowels. In sum, 'total sonority' is a complex algorithm in which segmental sonority is summed and contextually augmented.

Given the complexities of implementing such an algorithm, the notion of 'total sonority' is rejected here. Instead, syllable weight may only be sensitive to the sonority of a single segment; it is impossible to sum the sonorities of segments in drawing weight distinctions.

However, there are many languages – in fact the majority – in which syllable weight is *not* defined by sonority. This suggests that some other factor apart from segmental sonority must contribute to the heaviness of syllables. In fact, this 'other factor' is the one that has been recognised most often as contributing to syllable weight – prosodic structure.

2.2 PROSODIC RELATIONS

It has traditionally been thought that categories of syllable weight can only be defined in terms of very restricted configurations of prosodic structure (Halle & Vergnaud 1980, Hyman 1985, McCarthy & Prince 1986). For example, the branching theory allows weight to be sensitive to branching configurations, but only if such a structure involves syllable and mora nodes. Blevins' (1995) theory extends this, allowing sensitivity to branching of the σ, rime, and nucleus nodes.

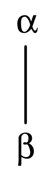
However, there is good reason to believe that this view of the relevance of prosodic structure is overly restricted.

Indeed, while there are languages in which heavy syllables are defined in terms of morae, there are also cases where a long vowel – a branching *segment* – defines a heavy syllable (e.g. Maori §3.1.1). In addition, in some cases it is not *branching* that is significant, but the *presence* of an element. For example, a syllable is heavy in Tiberian Hebrew if it contains a coda consonant (§3.1.4).

From this, it is evident that the belief that only σ and μ nodes are relevant for the computation of weight must be rejected. However, segmental features do not figure in defining heavy syllables, nor does the presence of any immediately *dominating* node have any influence. So, the nodes that may be referred to in the calculation of weight must be limited in some way, though not so limited as before. In addition, the idea that branching is the only prosodic configuration relevant for weight must be rejected otherwise it would be impossible to explain why syllables with a *single* high tone should be considered heavy in some languages since this does not involve a branching configuration. On the other hand, quantitative sensitivity to branching must be restricted, otherwise a heavy syllable could be defined in terms of ternary branching, or indeed any *n*-ary branching configuration. From this it is evident that the types of prosodic configuration to which weight calculation is sensitive must be limited in some way.

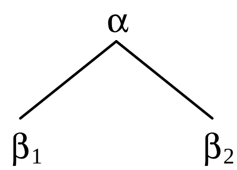
To address these issues, the nature of branching must be examined. To determine what the term 'branching' signifies in these terms, consider a non-branching node α, where there is an autosegmental relation between nodes α and β (Goldsmith 1976:28, §1.1):

(47)



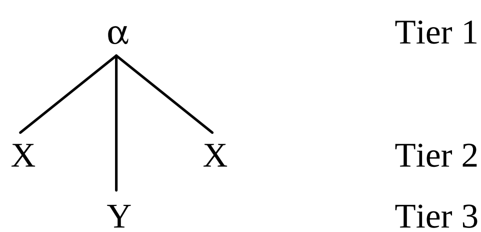
Compare this with a branching node:

(48)



This involves two autosegmental relations: $R(\alpha,\beta_1)$ and $R(\alpha,\beta_2)$, where R is the autosegmental relation. The crucial difference between this branching configuration and the non-branching configuration is in the *number of autosegmental relations* in which α is involved. In fact, it is not just the number of *all* autosegmental relations involving α, but in the number of relations between α and *nodes of type b*. Two nodes are of the same type if they are on the same tier, so β might be of the μ type, the σ type, the *seg* type, and so forth. Consider the diagram below:

(49)



In this, α is branching with respect to X, but non-branching with respect to Y. In sum, a node α is 'branching' if *the number of autosegmental relations from a certain a to nodes of type b is greater than 1*. For example, a σ node is branching with respect to μ nods if the cardinality (number) of autosegmental relations from σ to μ is greater than one. Putting 'branchingness' in terms of the cardinality of autosegmental relations does not add anything to prosodic theory – it is merely an expository aid. Even so, it allows some rather transparent parallels between seemingly disparate phenomena to be drawn, and it also allows some questions to be posed in very straightforward terms. Specifically, it facilitates the inquiry into how many autosegmental relations the phonology can count.

2.3 COUNTING ASSOCIATIONS

At the very least the phonology must distinguish between non-branching and branching configurations. In other words, the phonology must be able to distinguish between sets of one and sets of more than one autosegmental relations. This raises the question as to whether the phonology needs to be able to distinguish between any other number of associations.

Like any system, the phonology can only evaluate the cardinality of a set of relations within the limits of its system. In pure mathematics, with an infinite number of numerical distinctions, there is a possibility for the procedure evaluating the cardinality of any two sets S_1 and S_2 to always return a different value for S_1 and S_2. However, the phonological system does not have the power of pure mathematics. There is no evidence, for example, that the phonology can distinguish between a set of five elements and a set of four elements. In fact, there is even little evidence that the phonology can distinguish between sets of two and three elements.

It has been suggested that the phonology can 'count up to two' (McCarthy & Prince 1986:1). Syllable weight is be significant with respect to this issue: if a heavy syllable can be defined as one containing two associations from σ to μ this means that the phonology can not only count up to but *recognise* two. However, there is no reason to think that the phonology *can* distinguish a configuration with two autosegmental relations from other structures: there are no languages in which a syllable with two autosegmental relations from σ to μ is heavier than both tri-moraic and mono-moraic syllables. Instead, it is more restrictive to claim that the phonology can only distinguish between *one* and *greater than one*.

Proceeding in this manner, it may be asked whether the phonology can distinguish between *zero* and *not-zero*. In other words, can the phonology refer to whether an association *exists* or not? Recognition of such a configuration would be shown by a constraint such as 'There must be an association between α and β'; in other words the cardinality of relations between α and β must not be zero. Examples of this type of constraint abound: well-formedness constraints such as those requiring that every syllable must dominate a mora are such.

It is also possible to ask whether the phonology can distinguish between one and not-one. In other words, can the phonology require that there be an autosegmental relation between α and β, but that the number of these relations be *only* one? A likely contender is the constraint on non-head syllables in a foot in many languages: the non-head member of a quantity-sensitive foot may not branch, or in present terms the number of associations between a non-head syllable and morae must be one.

So, the phonology can distinguish between a number of different cardinalities of relations. It can tell if an association does not exist – i.e. that the number of autosegmental relations is zero, and if it does exist – if the number of associations is greater than or equal to one. In addition, it can distinguish between one, not-one, and greater than one cardinalities of sets of autosegmental relations. This is captured in the following constraints:

(50)

(I) ZERO(α,β) 'There are no associations between α and nodes of type β'

(II) MIN(α,β) 'The number of associations between α and nodes of type β is one'

(III) EXIST(α,β) 'The number of associations between α and nodes of type β is one or greater than one'

(IV) NOT-MIN(α,β) 'The number of associations between α and nodes of type β is greater than one'

These constraints employ the phonology's ability to 'count up to two' in a transparent manner.

With regard to the constraints themselves, an important prediction is that weight categorisations may not rank *n*-ary ($n > 2$) structures over binary structures since NOT-MIN(α,β) is equally true if there are five relations between α and β as if there are two such relations. For example, a syllable that has a three segment onset cannot be ranked above one with a two-segment onset, nor can a syllable with three morae be ranked above one with two morae (cf §3.1.4.1).

2.3.1 CARDINALITY AND MARKEDNESS

Although the phonological system contains the constraints proposed in the preceding section, not all are used in the calculation of syllable weight. The fact that there is no language in which a mono-moraic syllable is heavier than a bi-moraic one indicates that MIN(α,β) is not used in weight calculation. Similarly, there is no system where a syllable is heavier than another because of the *absence* of some element, meaning that ZERO(α,β) is not used. This leaves EXIST and NOT-MIN as the only constraints used in calculating syllable weight. Of course, it is only reasonable to ask why this should be the case.

The answer is related to structural markedness. It is well known that there are many near-oppositions between prominent and non-prominent elements.[20] Non-prominent positions are often structurally simple – a non-head syllable, for example, is always mono-moraic. *Almost* the opposite is true for prominent positions: prominent positions do not generally *require* structural complexity, but are not averse to it. In other words, non-prominent positions usually require that the number of associations be minimal, while prominent positions permit the number of relations to be *at least* one. Since heavy syllables are 'prominent', the relevant constraints to use in evaluating such positions are those constraints that do *not* require structural simplicity – i.e. EXIST(α,β) and NOT-MIN(α,β). So, the requirement that syllable weight only refer to EXIST and NOT-MIN is not an independent stipulation, but a more general result of the characteristics of prominent positions.

Now that the structural constraints that are used in the determination of syllable weight have been identified the second issue can be addressed – the identity of the constraints' arguments, termed α and β above.

2.3.2 INSIDE CONSTRAINTS: THE ARGUMENTS

So far, it has been argued that two constraint predicates play a part in weight categorisation: NOT-MIN(α,β) and EXIST(α,β). To explain syllable weight adequately, a further limitation on these constraints is necessary. It has already been mentioned that restricting these arguments to σ and μ is overly constrained. Other nodes that must be referred to are root and tonal nodes. On the other hand, there is no evidence that nodes such as the foot play a role in syllable weight

[20] For discussion of the term 'prominent position' see Beckman (1995, 1997). For the moment, a prominent element can be taken to be one that is marked as a head.

calculation, nor is there good evidence that weight is sensitive to segmental features. So, while the range of possible arguments must be extended, this extension must not be too drastic. Ideally, any such restriction would not be an arbitrary stipulation, but an independently motivated principle of the phonology.

The answer to this problem becomes evident once the nature of weight categorisation is considered. Hayes' (1981) and Zec & Inkelas' (1990:372) generalisation regarding prosodic weight is that a prosodic node is heavy if it branches. Significantly, the weight of any prosodic element is determined with respect to elements it dominates. From this, it is evident that any definition of the weight of a prosodic node can only ever refer to structural configurations dominated by that node. So, whether a syllable counts as heavy can never be contingent on the requirement that it be associated to a Ft node since Ft nodes are not dominated by σ. This is expressed in the following principle:

(51) **DOMINATION PRINCIPLE**:

Subcategorisations of x refer only to structural configurations internal to x.

(i) x is a prosodic node.

(ii) y is internal to x if x dominates y (directly or transitively).

This means that categories of syllables may only be defined in terms of syllable-internal structure. However, the above statement is far more unconstrained than Zec & Inkelas' definition since for them a subcategorisation of a prosodic node *p* can only refer to the relation (p,q), where *q* is dominated by *p* and is tier-adjacent to *p* (i.e. strict adjacency). In comparison the Domination Principle permits the identity of *p* and *q* to range over *all* elements dominated by σ, including morae, root nodes, segmental features, and so forth.

So the question still remains as to what will limit the set of possible arguments. At this point, it is interesting to note that the reason that only the relation (σ,μ) was used in the branching theory was due to the principle of Strict Layering. In other words, only morae were used in the calculation of weight because it was believed that only morae were *accessible* to the σ node. However, as argued in §1.1.3, the notion of accessibility must be extended. This extension is encompassed by the Prosodic Accessibility Hypothesis, repeated here:

(52) **Prosodic Accessibility Hypothesis (PAH):**

A node β is accessible to a node α if:

(1) β is α

OR

(2) (i) ASSOCIATION:
α immediately dominates β
OR α immediately dominates γ, and γ immediately dominates β.

AND (ii) LOCALITY:
α is tier-adjacent to β
OR α is tier-adjacent to γ and γ is tier-adjacent to β.

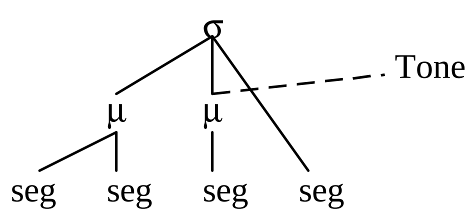
This provides the answer to limiting the identity of arguments with respect to syllable weight – the arguments of constraints on the weight of any prosodic element α must be *accessible* to α. This predicts that a possible relation that can take part in the evaluation of *syllable* weight is (μ,seg). μ is dominated by σ, and is tier-adjacent to σ; *seg* is dominated by μ, and is tier-adjacent to μ. So, both μ and *seg* are accessible to the σ node by the PAH. In comparison, (seg,[labial]) is not an accessible relation since the feature [labial] is not tier-accessible to σ. This effectively limits the identity of the arguments of NOT-MIN(α,β) and EXIST(α,β) to a finite set.[21]

[21] This also has bearing on SON(α,β). Segmental sonority is relevant to syllable weight because it is a property of segments. SON(μ, β) is a relation that places a restriction on the type of segment possible in a relation (μ,seg). Since it is the relation (μ,seg) that is being considered and (μ,seg) is accessible to σ, sonority is accessible to the evaluation of σ. For further discussion see §4.3.

There is one final issue, however: Can categorisations of syllable weight refer to root-contained features? It has been claimed that root nodes *contain* (in contrast to *dominate*) features such as [±vocoid], [±approximant], and [±sonorant] (Clements & Hume 1995). If this is the case, then it is a moot point whether weight constraints can refer to root-internal features. An example of this would be if a syllable was heavier than another because a vocoid was included in its onset. My initial answer is in the negative given empirical data. However, there are theoretical reasons either way, so this question must remain unresolved.[22]

Now that the set of the possible referents of the arguments α,β has been delimited, its members can be listed. Refer to the model of syllable structure below:

(53)



The model of syllable structure shows the possible arguments of the weight constraints NOT-MIN(α,β) and EXIST(α,β). Instead of being limited to σ and μ, segments may also be considered, along with any other nodes associated to μ and σ, such as tone. In addition, relations such as (σ,seg) and (seg,μ) may be used in the evaluation of weight.

---

[22] If sonority is seen to be a function involving these root contained features (Clements 1990), then there is good reason to believe that these features *are* accessible. However, this accessibility must be constrained in some way. See §4.2.4 for a possible method.

2.4 CONCLUSION

A final note needs to be made regarding the implementation of the constraints NOT-MIN and EXIST. Firstly, a system of prosodic weight may use as few or as many prosodic relations as it needs. ‘As few’ can mean none at all; indeed, some languages do not refer to different syllable weights. In contrast, a number of languages utilise one or two constraints, and some use as many as four. In addition, the weight constraints will be shown to be *ranked* with respect to each other. This conclusion is forced by the evidence that in some languages some relations are more important than others (e.g. Kara §3.2.1, Asheninca §3.2.6). In addition, constraints are *violable*; weight is defined in terms of the amount of constraint violation that a syllable type incurs. These points are developed and illustrated in the following two chapters.

In summary, this chapter has presented an alternative theory of syllable weight that relies on two factors: sonority and the evaluation of syllable-internal structure. These two factors are all that is needed to account for the syllable weight systems found in natural languages.

3 CASE STUDIES

The aim of this chapter is to provide empirical support for the theoretical claims made in chapter two. For each case study, the objective is to explain the syllable weight distinctions used in the language, not to account for the language's stress system. The integration of syllable weight constraints into the broader context of stress assignment is discussed in chapter four.

3.1 FACTORS IN SYLLABLE WEIGHT

The preceding chapter claimed that all sub-syllabic prominence relations can be used to distinguish syllable categories. The case studies in this section provide support for this claim. In addition, they show that the syllable weight constraints SON, NOT-MIN, and EXIST are violable.

3.1.1 MORAE AND LONG VOWELS: (σ,μ) AND (SEG,μ) IN MAORI

Of all the Polynesian languages, Maori has received the most linguistic attention (Hyman 1977, Biggs 1961, 1969, Hohepa 1967:10, Bauer 1993). Its stress system is almost unique in this group, and is described in the following algorithm:[23]

[23] The symbol ´ marks primary stress on a syllable. A syllable with secondary stress is marked by `. Another Polynesian language with a similar stress system is Rarotongan (de Lacy 1997a). Appendix 2.2 holds additional data for Maori.

(54) Stress the leftmost syllable containing a long vowel: (C)V:

e.g. ku.rí: ‘dog’, tú:.i: ‘parson bird’

Else the leftmost syllable containing a diphthong: (C)V_iV_k

e.g. tu.ái.na ‘twine, string’, páu.ra ‘powder’, tái.tei ‘Thursday’

Else the leftmost (C)V syllable.

e.g. hú.ka ‘foam, froth’, tá.ŋa.ta ‘man, person’

The syllable in Maori is maximally (C)V(V), with parentheses enclosing optional elements (Bauer 1981,1993, de Lacy 1996a,b). Like other Polynesian languages there is a Minimal Word restriction: acceptable mono-syllabic content words must either contain a long vowel (e.g. *pa:* ‘fort’) or a diphthong (e.g. *kai* ‘food, eat’) (de Lacy 1995). This suggests that these syllable types contain two morae.[24]

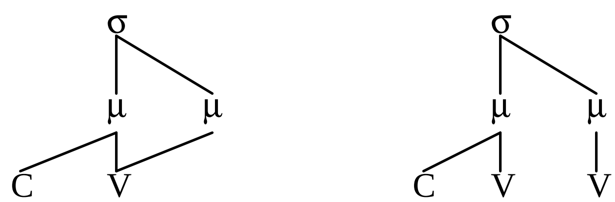
As discussed in §1.3.1, Maori poses a significant challenge to traditional assumptions about syllable weight. Apart from having *three* weight categories, it is obvious that moraic content is not the sole determinant of syllable weight as bi-moraic (C)V: are distinguished from bi-moraic (C)V_iV_k syllables.

The differences between the three syllable weights are evident once it is recognised that two different factors are involved. The first factor is moraic content, distinguishing between mono-moraic (C)V syllables on the one hand and bi-moraic (C)V: and (C)V_iV_k syllables on the other. To make this distinction the constraint NOT-MIN(σ,μ) can be employed; this requires that a syllable must be associated to more than one mora.

The difficulty is in identifying the second factor – the one that distinguishes diphthongs from long vowels. The following structure offers a clue:

[24] Other approaches to the formal explanation of Maori stress are Schütz (1985), and Barbour (1995). Maori stress is also mentioned in Hyman (1977).

(55)



With the long vowel (the leftmost structure), a single segment (V) is associated to two morae, whereas in the diphthong each vowel is associated to only one mora. This distinction can be explained by again employing a NOT-MIN constraint. This time, however, the arguments are *seg* and μ: NOT-MIN(seg,μ). This is only satisfied if the number of relations from a segment to morae is greater than one. Of course, only a syllable containing a long vowel can satisfy this since it is only in this configuration that there is a segment with more than one association to morae. In comparison, the diphthong only has non-branching associations from segments to morae.

Given this, the constraint system for Maori syllable weight consists of NOT-MIN(σ,μ) and NOT-MIN(seg,μ). From here, the differing weights can be easily defined in terms of violations:

(56) Super-Heavy (C)V: syllables: No constraint violations.
Heavy (C)V_iV_k syllables: One constraint violation.
Light (C)V syllables: Two constraint violations.

A more illuminating way of expressing this is that the heaviest syllable in a given domain is the *optimal one* – the one that best satisfies the set of constraints. This is shown in the following tableau:[25]

[25] For the interpretation of constraint tableaux see §1.2.

(57)

	NOT-MIN(σ,μ)	NOT-MIN(seg,μ)
(C)V:		
$(C)V_iV_k$		x
(C)V	x	x

This allows the Maori stress algorithm to be reduced to a simple directive: 'Stress the leftmost heaviest (i.e. most optimal) syllable in a word.' This in turn leads to the following hypothesis:

(58) **HEAVINESS HYPOTHESIS**:

> The heaviest syllable in a given domain is the syllable that best satisfies the syllable weight constraints in that domain.[26]

This hypothesis and its attendant notion of optimality owes much to the notion of violable constraints. Other examples will show that the *ranking* of constraints is also essential (§3.2). But for the moment it is enough that Maori has demonstrated the use of the weight constraint type NOT-MIN and the sub-syllabic relations (σ,μ) and (seg,μ). This refutes both the claim that there are only ever two syllable weights in any language and that only the relation (σ,μ) can be used to distinguish them.

3.1.2 ONSET SENSITIVITY: (μ,SEG) IN ARANDA AND ALYAWARRA

In addition to being sensitive to long vowels and moraic content, the proposals in chapter two predict that onset consonants can play a part in the calculation of syllable weight. Compare the onsetless syllable in (a) with the syllable in (b):

---

[26] There may be several 'heaviest' syllables in a domain. Which one of these receives stress is

(59) (a)

σ
|
μ
|
V

(b)

σ
|
μ
/ |
C V

The difference between the two configurations is that there is only a single association between the mora and segment in (a), while in (b) there is more than one such association. This distinction can be captured by employing the constraint NOT-MIN(μ,seg), which requires the number of relations from a μ to segments to be greater than one. From the representation above, it is evident that only syllables with onset consonants will satisfy this requirement.

This relation is used in a straightforward manner in the Australian languages Western Aranda and Alyawarra (Strehlow 1944 and Yallop 1977 resp.). Both Aranda and Alyawarra stress the leftmost syllable with an onset in words of three syllables or more:[27]

(60)	Western Aranda:	rín.bin.ba ‘beak, lips’	
		an.ká.ta ‘Jew lizard’	[Strehlow, p.47]
	Alyawarra:	pár.riy.ka ‘fence’	
		i.lí.pa ‘axe’	[Yallop, p.43]

In present terms, Western Aranda and Alyawarra stress the leftmost syllable that does not violate NOT-MIN(μ,seg).

Although a number of analyses of these languages do not refer to the onset, there is no reason why reference to the onset is not possible given the framework

determined by other stress-related constraints (see chapter 4).

[27] Di-syllabic words are always stressed on the first syllable in Aranda, while in Alyawarra stress falls on the second syllable. It is not immediately evident how to account for this, and in any case is not the concern of this thesis. I leave this issue unresolved (see Halle & Vergnaud 1987 and Goedemans 1994,

outlined above (cf Halle & Vergnaud 1980:93).[28] Western Aranda and Alyawarra show again that factors apart from moraic content can be used to distinguish weight.

3.1.3 BRANCHING ALONE: (σ,*x*) IN SOUTHEASTERN TEPEHUAN

The constraint NOT-MIN(σ,*x*) groups both bi-moraic syllables and mono-moraic syllables with a coda consonant (CVC) together. NOT-MIN(σ,*x*) requires that there be more than one association from a σ node to associated and accessible nodes – i.e. μ and *seg*. Consider the following representation:

(61)

In both these configurations, the σ node is associated to more than one element so satisfying NOT-MIN(σ,x).

In many cases it is difficult to be certain if this constraint is being used since a CVC syllable that counts as heavy for purposes of syllable weight is usually analysed as bi-moraic. However, there are some reasonably clear cases where this relation is necessary, one of which is Southeastern Tepehuan.

Southeastern Tepehuan is an Uto-Aztecan language of the Tepiman family, spoken in Mexico. It has a three-way weight distinction (Willett 1982, Goldsmith 1990:115,116). In this language, stress falls on the initial syllable unless the

---

cf Breen & Pensalfini 1996).

[28] Even if this onset-sensitive analysis of Aranda and Alyawarra is questioned there are other examples of onset-sensitivity, including Pirahã (§3.2.2), Madimadi (§3.2.4), Italian and English (Davis 1988), and

second is heavier. If they are equally heavy, stress falls on the first syllable. Heaviness is defined according to the following scale:

(62) ºCVV(C) > CVC > CVº

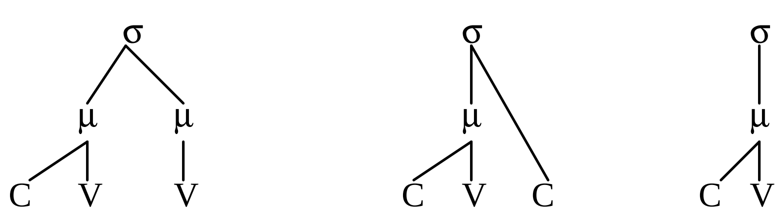
Examples:

(i) ºCVV(C) > CVCº	bá:.ban	‘coyotes’
	jiñ.ñú:.chix	‘my brother-in-law’
(ii) ºCVV(C) > CVº	gá:.’nga	‘looking for’
	ga.gá:t	‘bows’
(iii) ºCVC > CVº	tót.va	‘turkeys’
	sa.póc	‘story’

In this language, CV and CVC syllables have only one mora while CVV syllables have two.[29] To distinguish between CVV and the other syllable types the constraint NOT-MIN(σ,μ) can be employed.

This leaves a distinction to be made between CVC and CV syllables. The solution to this becomes evident once syllable structure is considered:

(63)



NOT-MIN(σ,*x*) is satisfied only if there are two associations from the σ node to other prosodic nodes. From the above representations it is evident that this is satisfied by both CVV and CVC. Employing these two constraints gives the correct ranking of syllable types:

---

possibly Gadsup (Frantz & Frantz 1973, Davis 1982, Levin 1985:320).

[29] The reason for CVC’s mono-moraicity depends on other factors discussed in chapter 5. Of relevance is Southeastern Tepehuan’s distinction between CVV reduplicants and other types.

(64)

	NOT-MIN(σ,μ)	NOT-MIN(σ,x)
CVV		
CVC	x	
CV	x	x

Southeastern Tepehuan shows that a relation from a specified node to an unspecified node is still of some use in categorising syllable weight. However, this 'branchingness' is limited in use, only distinguishing between C_oV syllables and all other types.

3.1.4 CODA SENSITIVITY: (σ,SEG) IN TIBERIAN HEBREW

A prosodic relation that has interesting effects is the one between a syllable and a segment: (σ,seg). Syllable weight distinctions can be made by employing the constraint EXIST(σ,seg) which requires that there be an association from a σ node to a segment. Using this constraint alone results in syllables with non-moraic coda consonants being treated as heavy. So, it is predicted that a possible stress system is one in which CVVC and mono-moraic CVC are heavy, and CVV and CV are light. In comparison, the approach that sees syllable weight as a wholly defined in terms of moraic content predicts that such a system is impossible.

Significantly, such a weight distinction is in attested in a number of languages, including Tiberian Hebrew, Tashlhiyt Berber (§3.2.6.1.1), and Ngalakan (§3.2.6.1.2). It is also possible that Seneca employs such a system.[30]

To exemplify this consider Tiberian Hebrew, the language in which most of the Hebrew Bible was written. McCarthy (1979:139) describes primary stress

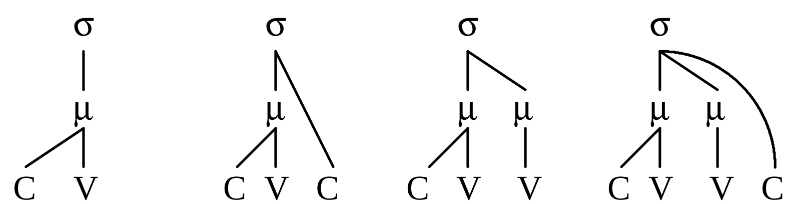
[30] The exact facts of Seneca are somewhat contentious and will not be discussed further here (Stowell

placement in the following terms: "Stress the ultima if it ends in a consonant, otherwise stress the penult." As discussed in §1.3.1, primary stress is not attracted to the ultima if it contains a long vowel:

(65) *ka.tá.bu:* 'they wrote' cf *ka.táb* 'he writes', *ya.qú:m* 'he writes'

To explain this, CVC and CV syllables must be treated as mono-moraic while CVV and CVVC are bi-moraic:[31]

(66)



As the diagram shows, only syllables with a final consonant have an association directly from the σ node to a segment. As outlined above using the constraint EXIST(σ,μ) alone will rank consonant-final syllables (CVC, CVVC) over all others, correctly distinguishing between heavy and light syllables in this language.

This finding is significant for a number of reasons. In the first place, Tiberian Hebrew offers evidence against the assumption that if a CVC syllable is heavy in a language, a CVV syllable must also be heavy (Jakobson 1962). In addition, by showing that EXIST(σ,seg) can be used to distinguish syllable weights, the belief that the unifying characteristic of heavy syllables is their reference to branching structure is demonstrated to be false. It is not branching that is important for syllable weight, but the constraints NOT-MIN and EXIST and sub-syllabic relations.

1979, Halle & Vergnaud 1987 cf Prince 1983, Hayes 1995).

[31] Support for the mono-moraic status of CVC syllables in Tiberian Hebrew is given in §5.1.

3.1.4.1 CODAS AND MORAE: HINDI AND ARABIC

The constraint EXIST(σ,seg) is used to significant effect in the dialect of Hindi described by Kelkar (1968) and in Cairene Classical Arabic (McCarthy 1979). However, unlike Hebrew EXIST(σ,seg) is not used alone but with NOT-MIN(σ,μ).

In Hindi, stress is assigned to the rightmost heaviest syllable in a word. ‘Heaviness’ is defined by the following hierarchy:[32]

(67) ᵒCV:C, CVCC > CV:, CVC > CVᵒ

Examples:

(i) ᵒCV:C, CVCC > CV:, CVCᵒ só:x.ǰa.ba:.ni: ‘talkative’

(ii) ᵒCV:, CVC > CVᵒ ru.pi.á: ‘rupee’

ki.d^{h}ár ‘which way’

The stress rule for Cairene Classical Arabic is slightly different, but the weight distinctions are the same:

[32] The stress system is somewhat more complex. See chapter 4 for discussion.

(68) 1. Stress the ultima if it is superheavy – CVCC or CV:C

e.g. ka.tábt ‘I wrote’

2. Else stress the penult if it is heavy – CVC or CV:

e.g. ka.táb.ta ‘you [m.sg.] wrote’

ha:.ðá:.ni ‘these [m.dual]’

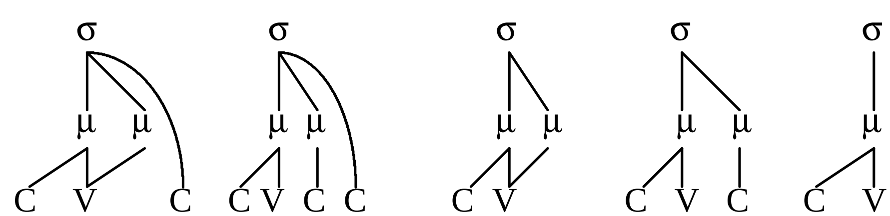
3. Else stress the penult or antepenult, whichever is separated by an even number of syllables from the closest preceding heavy syllable, or (if there is no such syllable) from the beginning of the word.

e.g. qat.tá.la ‘he killed’

ʔad.wi.ja.tú.hu ‘his drugs’

The ranking of syllable types in these two languages receives a straightforward explanation given the following representations of the syllable:

(69)



To distinguish CV syllables from the others the constraint NOT-MIN(σ,μ) is used. As in Tiberian Hebrew EXIST(σ,seg) distinguishes syllables with a coda consonant – CV:C, CVCC – from those without. This provides the following tableau:

(70)

	NOT-MIN(σ,μ)	EXIST(σ,seg)
CV:C, CVCC		
CV:, CVC		x
CV	x	x

As the tableau shows, the constraints correctly distinguish the three categories of syllable weight: the most optimal syllable types are CV:C and CVCC, followed by CV: and CVC, then by CV.

Some analyses of Hindi stress, most notably Hayes (1995:277), have suggested that the distinction between syllable types is mora-based: CV:C and CVCC are tri-moraic, while CV: and CVC are bi-moraic, and CV is, of course, mono-moraic. Given the proposals above, there is no need to assume that there are tri-moraic syllables in Hindi. In fact, if Superheavy syllables were tri-moraic, the present proposals could not explain its weight system as there is no constraint that could distinguish tri-moraic from bi-moraic syllables; NOT-MIN(σ,μ) is satisfied by both syllable types equally.

3.1.5 CONTRASTIVE RELATIONS

At this point, nearly all sub-syllabic relations involving members of the prosodic hierarchy have been considered. There are few relations left that are *contrastive* – that can distinguish one syllable from another. For example, the constraint EXIST(σ,μ) is non-contrastive as it is always satisfied – every syllable must dominate a mora. In fact, of all the EXIST(α,β) constraints, the only one that is not a well formedness condition is EXIST(σ,seg). A similar situation exists for NOT-MIN constraints, though not quite to the same extent. For example, the relation NOT-MIN(μ,*x*) is non-contrastive as a mora will always be associated to two elements: a σ and a segment.

The constraint NOT-MIN(σ,seg) is one of the few that remains to be discussed. This constraint is only satisfied by syllables with a complex coda. So far, I have been unable to identify any system which makes this distinction. However, this is hardly surprising given the small number of languages which permit multiple non-moraic coda consonants (Blevins 1995:217, Jakobson 1962). Even so, it is a prediction of this theory, and so should be possible in natural language.

3.1.6 TONE: (μ,TONE) IN LITHUANIAN AND MOLINOS MIXTEC

Having considered sub-syllabic relations involving elements from the prosodic hierarchy, there remain those relations involving other elements. Such a relation is that between morae and tone.

A number of languages require reference to tone in locating stress. For example, in Lithuanian syllables associated to a high tone attract stress (Halle & Kiparsky 1981). This stress system can be explained by supposing that high-tone bearing syllables count as heavy for syllable weight. Their 'heaviness' can be identified by their satisfaction of the constraint EXIST(μ,H) – 'There is a relation between a mora and a high tone'.[33]

A more complex case is found in the Molinos dialect of Mixtec, spoken in the Oaxaca district of Mexico (Hunter & Pike 1969).[34] This language

[33] Other languages that refer to high tone in stress placement are Serbo-Croation (Inkelas & Zec 1988) and Golin (Bunn & Bunn 1970).
[34] Thanks to Moira Yip for bringing this language to my attention.

distinguishes three levels of tone: high, mid, and low. Stress is attracted to the rightmost syllable containing the highest tone in a word:[35]

(71) ka^{M}.ndí^{H}.ha^{M}.de^{M}.ʒa^{L} 'he will obey God'

k^{w}i^{M}.ni^{L}.dé^{M}.ti^{L} 'he will see the animal'

This is again a syllable weight distinction, with weight characterised in terms of tonal association by using the constraints EXIST(μ,H) and EXIST(μ,M), with the former ranked over the latter:[36]

(72)

	EXIST(μ,H)	EXIST(μ,M)
σ^{H}		x
σ^{M}	x	
σ^{L}	x	x

There are other possible constraints involving tone such as NOT-MIN(μ,T), where T is a node on the tonal plane (i.e. a tone). This constraint differentiates between morae associated to one tone and morae associated to two or more tones. However, it is questionable whether any such configuration exists – it is generally assumed that there can only be one tonal association per mora. On the other hand, if the syllable node links to tones, then a constraint NOT-MIN(σ,T) would be able to differentiate between contour and simplex tones (see Odden 1995:448-452 for a discussion on the status of the syllable as a Tone Bearing Unit). This would predict that a stress system could treat a syllable as heavy if it bears a contour tone (i.e. two tonal associations).

---

35 The symbols ^{H}, ^{M}, and ^{L} mark high, mid, and low tone respectively on preceding vowels. If syllables have the same tone, they are equally stressed in this language. Final syllables never receive primary stress.

36 For further discussion of restrictions on the ranking of such constraints see §4.2.4.

Addendum: 12 January 1998

The language Ayulta Mixtec (Pankratz & Pike 1967, van der Hulst & Smith 1984:xv) offers an example of NOT-MIN(σ,Tone). Stress falls:

(i) on the first HL sequence, else

(ii) on the first ML sequence (there are no HM sequences), else

(iii) on the first H, else

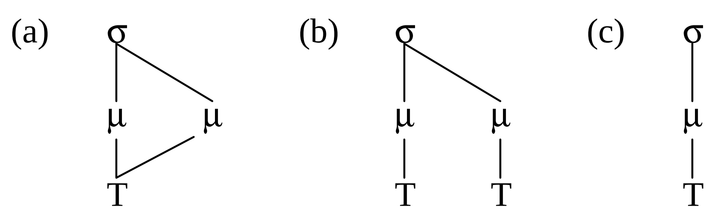
(iv) on the first syllable.

This four-weight distinction can be accounted for by the following constraints:

	NOT-MIN(σ,T)	EXIST(σ,H)
σ^{HL}		
σ^{ML}		x
σ^{H}	x	
σ^{L}	x	x

The other possible constraint NOT-MIN(T,μ) requires that there be more than one association from a certain tone to morae. This effectively ranks bi-moraic syllables with level tones over other types:

(73)



In the level tone case, (a), there is more than one association from the tone to morae, so satisfying NOT-MIN(T,μ). This contrasts with the configurations in (b) and (c) which have only single Tone to mora associations. I know of no language which fits this description. Even so, it is evident that any empirically adequate theory of syllable weight must allow tone to play a role, as the does the theory proposed herein.

3.1.7 SONORITY: SON(α,β)

Sonority also plays a significant role in distinguishing syllable categories in a number of languages. In fact, many of the most intricate weight hierarchies employ at least one constraint on sonority (see case studies in §3.2). This section will discuss a few languages which only employ sonority distinctions alone.

A simple case is that of the Jaz'va dialect of Komi (Itkonen 1955, Lytkin 1961).[37] Stress is attracted to the leftmost heaviest syllable containing a non-high vowel (/a e o/):

(74) mijánlan^j 'we'
buzginám 'we hit'

The relevant constraint is easily identifiable: SON(μ, /eo/). This requires that a syllable contain a nucleus with the sonority of /e/ and /o/ or higher (i.e. /e, o, a/). Thus, all syllables containing high vowels will fail this constraint, and all with non-high vowels will pass.

There are many stress systems with far finer distinctions than Komi. For example, the Paleo-Siberian language Chuckchee has a ternary weight distinction: syllables that contain non-high vowels are heavier than those with high vowels, while syllables containing schwa are lightest (Skorik 1961, Krause 1979, Davis

[37] Many thanks to Trond Trosterud, Peter Michaelove, Jack Reuter, and Laszlo Cseresnyesi for providing information on Komi stress.

1982, Kenstowicz 1996, Gordon 1997). Stress falls on the heaviest of the two final syllables of a base:

(75) Non-High > High: wéni-wen 'bell'
nuté-nut 'land'
High > Schwa : pipíqəlg-ən 'mouse'
γənín 'your'

Chuckchee evidently employs two constraints: SON(μ, /eo/) and SON(μ, /iu/):

(76)

	SON(μ, /eo/)	SON(μ, /iu/)
Ca, Ce, Co		
Ci, Cu	x	
Cə	x	x

An even finer gradation can be seen in Kobon, a Papua New Guinean language (Davies 1981). Kobon employs five distinctions of weight based on sonority, with the following ranking:

(77) Ca > Ce, Co > Ci, Cu > Cə > Cɨ[38]

(i) a > e,o kɨ.dol.máŋ 'arrow type'

(ii) e, o > i, u si.óg 'bird species'

(iii) i,u > ə wí.ər 'mango tree'

(iv) ə > ɨ gɨ.sə́ 'to tap'

[See Kenstowicz 1996:11 for further data and discussion]

[38] I regard reduced vowels as being ranked equally with the schwa or centralised high vowel. This allows languages that refer to a full-reduced distinction to simply use SON(μ, /iu/) (e.g. Lutshootseed — Hess 1976, Western Chemeris — Itkonen 1955, Chuvash — Krueger 1961).

Stress falls on the heaviest syllable of the final two syllables in an unaffixed word. When both syllables are equally heavy, stress falls on the penult. This requires four SON constraints: SON(μ, /a/), SON(μ, /eo/), SON(μ, /iu/), and SON(μ, /ə/):

(78)

	SON(μ, /a/)	SON(μ, /eo/)	SON(μ, /iu/)	SON(μ, /ə/)
Ca				
Ce, Co	x			
Ci, Cu	x	x		
Cə	x	x	x	
Cɨ	x	x	x	x

The examples above show that multiple SON(α,β) constraints can be used in distinguishing syllable categories, resulting in fine gradations of syllable weight. However, this raises a question about the status of the sonority hierarchy.

Weight distinctions as found in Kobon require fine distinctions to be made between vowels. Some versions of the sonority hierarchy, most notably that of Clements (1990), assume that no sonority distinctions need to be recognised among vowels. Even so, to explain the difference between the syllable weights sonority distinctions as fine as those used above need to be invoked. As Kenstowicz (1996) points out, one of the major distinctions in the hierarchy above is between peripheral and central vowels while the other dimension is that of height, with the former dimension being more important than the latter. Hence, a peripheral high vowel is more salient than a central mid vowel. In this thesis it is assumed that the sonority hierarchy does employ such fine distinctions, contrary to approaches such as Clements (1990).

This section has shown that sonority differences can play a significant role in distinguishing syllable types. This shows that structure is not the only factor involved in syllable weight – the properties of sub-syllabic elements are also significant.

The aim of the preceding sections was to provide empirical support for the claim that syllable weight can be determined by factors other than moraic content. A number of languages have been shown to verify this, distinguishing syllable categories by means of sonority, onset consonants, coda consonants, tone, and long vowels. In addition, both constraint types NOT-MIN and EXIST have been employed, adequately explaining a number of different weight hierarchies.

3.2 COMPLEXITIES IN SYLLABLE WEIGHT

The case studies in §3.1 show weight constraints and prosodic relations at work in a fairly elementary manner: most weight systems discussed so far only require the use of one or two equally ranked constraints. In the remainder of this chapter, more complex cases are examined. It is demonstrated that there are languages which use three and even four weight constraints. In addition, it is shown that in a number of systems weight constraints are necessarily *ranked*.

An additional aim of this chapter is to consider cases which seem to challenge the proposals in chapter 2. Among these are languages that seem to refer to segmental features (Madimadi §3.2.5). This is a problem for the present proposals as the Prosodic Accessibility Hypothesis prohibits segmental features from playing any role in categorising syllables.

One of the main points of the following case studies is that the constraints SON(α,β), NOT-MIN(α,β), and EXIST(α,β) can interact, resulting in complex distinctions of syllable weight. This provides insight into some long-standing problems in stress theory such as the weight systems of Pirahã and Asheninca (§3.2.2, §3.2.5 resp.), as well as explaining a number of other complex systems, including Wosera and Kara (§3.2.3, §3.2.1 resp.).

3.2.1 KARA AND CONSTRAINT RANKING

Kara is spoken in the Kavieng subdistrict of New Ireland, Papua New Guinea. Kara's syllable weight system is one of the most complex documented, employing five distinctions, ranked as follows (Schlie & Schlie 1993, Schlie – p.c.)[39]:

(79) (C)a:(C) > (C)a$\underline{V}$(C), (C)aC > (C)a > (C)$\underline{V}$C, (C)$\underline{VV}$ > (C)$\underline{V}$

(i) $\underline{V}$ is any any vowel apart from /a/.

(ii) For supporting data see Appendix 2.1.

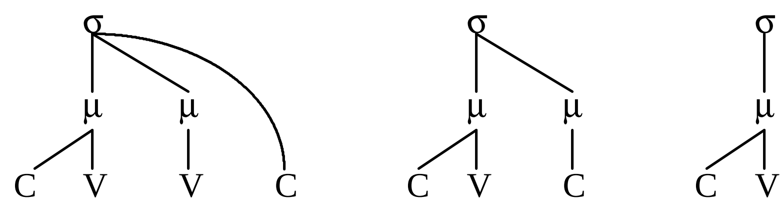
Stress falls on the rightmost non-(C)$\underline{V}$ syllable, otherwise on the leftmost syllable. The maximal Kara syllable is (C)V(V)(C), with parentheses enclosing optional elements. The only long vowel is /a:/. The first element of a diphthong cannot be a high vowel, and the second element must be a non-low vowel. Kara has the following syllable structure:[40]

---

[39] Thanks to Perry and Ginny Schlie for their correspondence and for providing additional data. Thanks to Wayne Lawrence for originally bringing this language to my attention. The ranking shown here is more complex than the description by Schlie & Schlie (1993). It arose from discussions with the authors and the examination of additional data (Schlie p.c., Appendix 2.1).

[40] Kara's syllable structure is justified from considerations of secondary stress. See chapter 5 and Appendix 2.1.

(80)



The five weight distinctions in Kara can be explained by recognising four factors: sonority, moraic content, and the presence of a long vowel. Firstly, the syllable type with a long vowel (i.e. Ca:(C)) is ranked above all others. This means that the constraint NOT-MIN(seg,μ) is in use. The second factor is that syllables containing /a/ are preferred over others. This can be explained by using the constraint SON(μ,/a/). The final constraint is one of moraic content. In general, bi-moraic syllables are heavier than those without: CaV and CaC outrank Ca, and CVV and CVC outrank CV. From the syllable structures above, this generalisation can be explained by using the constraint NOT-MIN(σ,μ).

Kara is significant as it shows that constraints on sonority and structure can be used in the same language. It is even more significant with regard to constraint *ranking*.

The constraints will not provide the correct weight distinctions if they are equally ranked. Specifically, (C)a and (C)VV syllables will incur the same number of violations, incorrectly grouping them as equally heavy:

(81)

	NOT-MIN(seg,μ)	SON(μ, /a/)	NOT-MIN(σ,μ)
CVV	x	x	
Ca	x		x

This can be avoided by ranking SON(μ,/a/) above the other constraints. Doing so will insure that syllables containing /a/ will be heavier than other types. This provides the correct number of distinctions, and categorises the syllable types accurately:

(82)

	SON(μ, /a/)	NOT-MIN(σ,μ)	NOT-MIN(seg,μ)
Ca:(C)			
Ca$\underline{V}$(C)			x
CaC			x
Ca		x	x
C$\underline{V}$C	x		x
C$\underline{VV}$(C)	x		x
C$\underline{V}$	x	x	x

Kara is a good example of how a complex weight system can be explained by using weight constraints. More significantly, Kara shows that weight constraints can be ranked with respect to each other. In fact, Kara has further implications for stress theory, providing insight into the interaction between syllable weight and feet.

3.2.1.1 CONTINUOUS COLUMNS

It is timely to consider one of Hayes' (1995) more interesting claims about prominence. Hayes proposes that prominence cannot affect footing in any way (p.272). To illustrate this, he hypothesises a language with a stress system that employs both prominence and foot structure (p.275). In this language, syllables that contain /a/ are prominent, resulting in prominence grids such as the one below:[41]

[41] More correctly, only those prominence projections should be shown which are the heads of feet (Hayes 1995:275). I will show all prominence projections since they form the basis of the argument against Hayes' proposals.

(83)

```
          *      *
 *   *   *  *   *   *  *
pi pu pa pi pa pu pi
```

Since prominence cannot figure in foot construction, Hayes points out that a system like this should have certain characteristics. To use Hayes' words, "a non-foot head, no matter how prominent, never receives main stress over [i.e. in preference to] a foot head." The reason for this is partly related to the Continuous Column Constraint. This constraint does not allow a grid mark to appear on a line if there is no grid mark directly below it. The result of this is that a syllable with high prominence can only project a mark onto the metrical grid if that syllable is a foot head. This is illustrated in (3.6.1.1):

(84)

```
(          x        )          METRICAL GRID
(.   x)( .  x)  (.   x)
pa pi pa pa pu pi
 *  *   *  *   *   *
 *       *  *                  PROMINENCE GRID
```

Here, right-headed (iambic) feet have been constructed on the foot-layer. Because /a/ is prominent in this system, every syllable containing /a/ projects two marks on the prominence grid. From here, a rule projects a metrical grid mark for all syllables that are most prominent – i.e. the all syllables containing /a/. However, the first two syllables containing /a/ cannot project a metrical mark because they are in the non-head position of a foot.

The problem for Hayes' proposal is that his hypothetical language is almost identical to Kara.

While the previous section only considered primary stress, Kara also has secondary stress (see Appendix 2.1). That foot construction is a necessary part of the Kara stress system is shown by the word [mə́.tʰə.ɸə.tʰə̀.mə] 'family'. Here, trochaic feet are constructed edge-in, grouping it into constituents: [(mə́.tʰə).ɸə.(tʰə̀.mə)].

The challenge to Hayes' proposals can be illustrated by the word [mə.tʰa] 'man'. The word is footed as [(mə.tʰa)] – a single moraic trochee with [mə] as its head.[42] Since Ca is more prominent than C<u>V</u>, [tʰa] will project more marks on the prominence grid than [mə]:

```
(85)        ( x   . )
            mə.tʰa
              *   *
                  *
```

Now, Hayes predicts that [tʰa] will not receive primary stress since it is in the non-head position of a foot. The problem is that it *does* receive primary stress, resulting in [mə.tʰá]:

```
(86)
        x                     x
     ( x   . )             .  x
     mə.tʰa       →      mə.tʰa
       *   *               *  *
           *                  *
```

This has a number of implications for Hayes' theory. Most obviously, it invalidates his claim that in stress systems with both footing and prominence rules, only foot-heads can project prominence onto the metrical plane (p.274). It

[42] Feet can only be defined by reference to moraic content, so both [mə] and [tʰa] are light in terms of feet, forming one iambic foot.

also casts doubt on the validity of the Continuous Column Constraint: (83) shows that a line 2 grid mark is projected without a mark below it.[43]

These factors indicate that Hayes' derivational approach to stress needs some revision. Even so, it will be shown that his distinction between quantity and prominence is a significant insight into the difference between differing notions of syllable weight (chapter 5).

3.2.2 PIRAHÃ AND ONSET SONORITY

Stress and syllable weight in the Amazonian language Pirahã have been a focus of much phonological attention (Everett & Everett 1984, Levin 1985:321ff., Halle & Vergnaud 1987:224-226, Davis 1988, Everett 1988, Hayes 1995:285-288). Stress in Pirahã falls on the rightmost heaviest syllable in the last three syllables of a word. The hierarchy of syllable types is given below:

(87) KVV > GVV > VV > KV > GV

K = voiceless consonant, G = voiced consonant

(i) KVV > GVV	ká:gai 'word'
(ii) GVV > VV	po:.gái.hi.ai 'banana'
(iii) VV > KV	pia.hao.gi.so.ái.pi 'cooking banana'
(iv) KV > GV	ʔí.bo.gi 'milk'

[data from Everett & Everett 1984, Everett 1988]

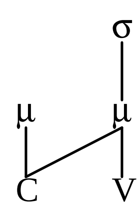
As with most cases of multiple syllable weights, the difficulty is to identify the factors by which the categories differ.

[43] I note that the convention of Halle & Vergnaud (1987:71) fills in grid marks of lower levels if a grid mark is placed on a higher level. The results of this section lend support to Halle & Vergnaud's claim.

3.2.2.1 THE STRUCTURAL APPROACH

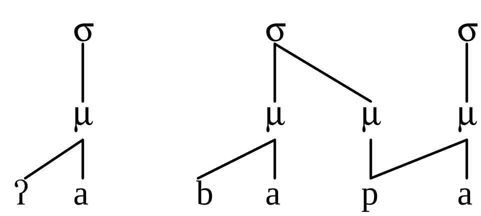
Everett and Everett (1984) (citing Grimes 1981) point out that voiceless consonants are phonetically longer in duration than voiced ones. This suggests that voiceless consonants are essentially syllable-internal geminate consonants.[44] The problem then lies in determining the correct moraic representation of syllable-internal geminates. Related to this, Hayes (1989:302-303) presents a number of possible representations for word-initial geminates, including the following:

(88)



While this may be true for geminates in general it is probably not adequate for Pirahã. If it were true that voiceless consonants are exactly like geminates then syllabification of the sequence [ʔabap:a] should result in [ʔa.bap.pa] ‘Amapá – a placename’:

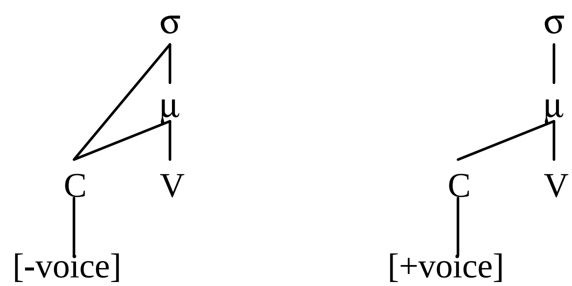
(89)



[44] This idea has also been explored by Everett (1988) and Levin (1985).

This effectively makes the second syllable bi-moraic contrary to fact. There is an alternative representation:

(90)



The doubly-linked voiceless consonant may seem somewhat exceptional at first.[45] Indeed, McCarthy & Prince (1986:70) suggest a ban on associating any one element to two distinct levels of prosodic structure. Even so, the above representation seems to be the only one in a moraic model that can express the fact that voiceless consonants are longer than voiced ones. With this it is a straightforward matter to draw the necessary distinctions between syllables.

Firstly, bi-moraic syllables outrank mono-moraic syllables (KVV, GVV, VV > KV, GV), meaning that NOT-MIN(σ,μ) is in use. In addition, syllables with an onset (KVV, GVV) outrank the onsetless VV syllable, suggesting that NOT-MIN(μ,seg) is used here. To distinguish between syllables with voiced and voiceless onset consonants, the constraint EXIST(σ,seg) can be used. As shown in the representations above, only syllables with voiceless onsets will satisfy this; notably, Pirahã syllables cannot contain coda consonants.

As in Kara, the constraints must be ranked with respect to each other. If this was not the case, VV and GV syllables would be incorrectly placed in the same category:

---

[45] As a note, the phoneme inventory is quite asymmetric in terms of place and voice: /p t ʔ s h/ *vs* /b g/. This may have something to do with the weight restriction, although this is unclear at this time.

(91)

	NOT-MIN(σ,μ)	NOT-MIN(μ,seg)	EXIST(σ,seg)
VV		x	x
GV	x		x

To resolve this, NOT-MIN(μ,seg) is ranked above the others:

(92) *Pirahã Constraint Hierarchy - Structural Approach*

	NOT-MIN(σ,μ)	NOT-MIN(μ,seg)	EXIST(σ,seg)
KVV			
GVV			x
VV		x	x
KV	x		
GV	x		x

While this provides an adequate explanation of Pirahã syllable weight distinctions, it is at the cost of proposing a rather exceptional syllable structure. There is an alternative solution to the Pirahã problem.

3.2.2.2 THE SONORITY APPROACH

On the surface, it seems that onset sonority plays a role in the Pirahã weight hierarchy, ranking voiceless consonants over voiced ones. In the languages discussed so far, only the sonority of *nucleus* segments has been significant for syllable weight. Even so, there is no reason why sonority of onset elements should not be a factor in syllable weight.

However, the evaluation of onset sonority is somewhat different from nucleus sonority. While a more sonorous segment is preferred in a nucleus, onsets prefer *less* sonorous segments (Jakobson 1962). This fact has been captured in a number of ways in previous frameworks (see esp. Prince &

Smolensky 1993 and §4.2, §4.3 below). For present purposes the constraint *SON(μ,β) can be employed, being violated if a segments dominated by a mora is *not* of a certain sonority. For example, *SON(μ, nasal) requires that some segment dominated by μ be of equal or less sonority than a nasal consonant. *SON is discussed further in §4.3. In the case of Pirahã, the constraint used is *SON(μ, voiceless C).

However, the form of this constraint assumes that the sonority hierarchy makes a division between voiced and voiceless consonants. This is not supported by some versions of the hierarchy; Clements (1990) argues that there is no sonority division in the class of obstruents at all, while Selkirk (1984) claims that this distinction is between fricatives and non-sonorant stops. However, this problem can be circumvented by claiming that sonority hierarchy is not a *unified* hierarchy but a combination of two: one for class/manner types, and one for voice (Goldsmith 1990:111-112). If this is the case then Pirahã refers to the Voicing hierarchy °voiced > voiceless°.

As discussed in the preceding section, the constraints NOT-MIN(σ,μ) and NOT-MIN(μ,seg) can be used in the Pirahã hierarchy, with NOT-MIN(σ,μ) outranking all others. This results in the following:

(93) *Pirahã Constraint Hierarchy II – The Sonority Solution*

	NOT-MIN(σ,μ)	NOT-MIN(μ,seg)	SON(μ,voiced)
KVV			
GVV			x
VV		x	x
KV	x		
GV	x		x

Like Kara, Pirahã shows that weight constraints can be ranked.

While the onset-sonority approach is an adequate solution, it requires altering current conceptions of the sonority hierarchy, effectively splitting it into a

Voicing hierarchy and a Class/Manner hierarchy. This proposal may seem to be an *ad hoc* solution to an otherwise intractable problem. However, there is no reason to reject it out of hand. I leave this matter of the fragmentation of the sonority hierarchy for future research.

3.2.3 WOSERA AND THE LIMITS OF COMPUTATION

The languages with the greatest number of weight distinctions discussed so far are Kara, Pirahã, and Kobon with five. Given the rarity of such complex systems, it might be tempting to infer that five is the greatest number of weight distinctions possible in natural language were it not for the case of Wosera.

Wosera is a dialect of the Abelam language, spoken in the Sepik district of Papua New Guinea. Before considering stress, a few other relevant factors must be considered. Firstly, there are only three vowel phonemes in this dialect: the central vowel /ə/, the mid back unrounded vowel /ʌ/, and the low back vowel /a/.[46] Syllable onsets must contain a consonant, which may be followed by a glide. Syllables may also end in a non-vocoid consonant. This is shown in the mono-syllabic word /kwan/ ‘slept’.

Laycock identifies two types of rime: complex and simple. Simple rimes consist of a single vowel. In comparison, complex rimes consist of a vowel and a glide (/j/ or /w/). The exception is that there are no complex rimes of the type /əj/ or /əw/, but Laycock identifies complex rimes consisting of a *single* glide: /j/ or /w/.

Despite Laycock’s claim, there is good reason to believe that the rime structure of Wosera is [V(j,w)] and that rimes of the type /əj/ and /əw/ do occur,

[46] To be more precise, /ə/ has high front and mid central allophones, and /ʌ/ has low central and mid

albeit underlyingly. Firstly, Laycock notes that tautomorphemic /ə/ and glide clusters fuse into a single glide of variable length: i.e. /əj/ is realised as [i(j)] and /əw/ is realised as [u(w)]. This is exemplified in the phrase /mənə wʌ/ 'you there!', which is realised as [menuwo̯]. Even as complex nuclei, the glides are realised as glide-vowel sequences, as shown in /wnə/ 'I', which is realised as [wʊne]. This suggests that complex nuclei consisting of glides alone are at least longer than simple nuclei, and should be represented as bi-moraic. What is more likely is that all complex nuclei consisting of vowels alone are underlying /ə/+glide sequences, and that the schwa is delinked with concomitant spreading of the following glide. In summary, complex rimes consist of a vowel followed by a glide – /j/ or /w/.

Having established the form of Wosera rimes, the stress system may be considered. Laycock (1965:29-30) describes the placement of primary stress as being "wholly conditioned by the syllable and nuclear structure of the phrase" (p.29). Primary stress occurs on the heaviest of the first two syllables of a phrase. Wosera's hierarchy of syllable types is exceptional in the number of categories:

(94) aG > ʌG > əG > a > ʌ > ə

While six is certainly a large number of syllable weights, there is evidence that there are even more distinctions. Consider Laycock's description of what happens in the case of a tie:

(95) "… if both N [i.e. syllables] are equal in rank the first N bears primary stress *unless the second syllable ends in a consonant* or the phrase has

---

back allophones. The allophones of these phonemes show that /ʌ/ is lower and more peripheral than /ə/.

> more than two syllables, in which case the second N bears the primary stress."
>
> [p.30, italics mine]

It seems that there are two different stress rules: one applies to di-syllabic words, while the other applies to longer words. In di-syllabic words, Laycock's claim that coda consonants are significant in assigning stress doubles the number of syllable weights. For example, in the word /kəw.pə́wk/ 'three' both syllables have the same nuclei. However, stress does not fall on the default first syllable, but on the second since it ends in a consonant. This can be compared with /mə́.nə/ 'you' where the first of two syllables of the same type is stressed as the second does not contain a coda consonant.

This effectively expands the syllable hierarchy to a total of twelve distinctions:

(96) aGC > aG > ʌGC > ʌG > əGC > əG > aC > a > ʌC > ʌ > əC > ə

This hierarchy can be decomposed into different constraints by firstly recognising the division between rimes with glides and those without. Assuming that /VG/ rimes are bi-moraic, this distinction can be made by NOT-MIN(σ,μ). To distinguish between syllables with coda consonants and those without the constraint EXIST(σ,seg) can be used. This leaves the sonority divisions between /a/, /ʌ/, and /ə/. SON(μ,/a/) distinguishes between /a/ and the other vowels, while SON(μ,/iu/) distinguishes between the peripheral vowels /a/ and /ʌ/ and the central vowel /ə/.

These constraints need to be ranked. If this were not so, mono-moraic syllables with a vowel of high sonority would incorrectly outrank bi-moraic syllables with a vowel of low sonority:

(97)

	NOT-MIN(σ,μ)	SON(μ,/a/)	SON(μ,/iu/)	EXIST(σ,seg)
əG			x	x
a	x			

To avoid this, NOT-MIN(σ,μ) must be ranked above the other constraints. In fact, further ranking is required: EXIST(σ,seg) must be ranked below the other constraints otherwise ʌGC would be ranked equally with aG:

(98)

	NOT-MIN(σ,μ)	SON(μ,/a/)	SON(μ,/iu/)	EXIST(σ,seg)
ʌGC		x		
aG				x

This results in the following tableau:

(99)

	NOT-MIN(σ,μ)	SON(μ,/a/)	SON(μ,/iu/)	EXIST(σ,seg)
aGC				
aG				x
ʌGC		x		
ʌG		x		x
əGC		x	x	
əG		x	x	x
aC	x			
a	x			x
ʌC	x	x		
ʌ	x	x		x
əC	x	x	x	
ə	x	x	x	x

As can be seen, the constraints hierarchy results in the correct grouping of syllable types. Wosera shows that there can be many distinctions of syllable weight – at least six, and possibly even twelve.

In a number of previous theories of syllable weight great attention has been paid to how many possible distinctions of weight can be predicted by the theory. This indicates that it is unwise to attempt to arbitrarily restrict the number of weight distinctions natural language may employ. The syllable weight system of Wosera shows that this should not be a major concern – any limit on the number of weights need not be stipulated by theory-internal restrictions but result from limits on computation.

3.2.4 MADIMADI: ALTERNATIVES TO FEATURE REFERENCE

Madimadi, an Australian language spoken in New South Wales, poses a challenge to the Prosodic Accessibility Hypothesis: its stress system seems to refer to the feature [coronal] (Hercus 1969, Davis 1988).[47]

Before stress is discussed, a note must be made regarding syllable structure. The Madimadi syllable is CV(C) in shape, with parentheses marking an optional coda consonant. An independent word can be composed of a CVC syllable alone, suggesting that CVC is bi-moraic (e.g. *gar* ‘edible grub’). CV_iV_j syllables are only possible in a stressed syllable (Hercus 1969:157, though there seem to be exceptions).

While primary stress always falls on the initial syllable in di-syllabic words, it is placed in a more complex fashion on longer words. One of the first two syllables must be stressed, depending on syllable type:

(100) H̀H́… e.g. dèl.gái.a.ðaŋ ‘good’
L̀H́… e.g. gà.nán.da ‘to steal’
H́L… e.g. wál.wa.ða ‘to burn’
C̀H́… e.g. dì.bár.gi.mà.ða ‘to adhere’
H̀Ć… e.g. mìn.dá.ra.ða ‘to be cold’[48]
L̀Ć… e.g. wì.rí.dab ‘whirlwind’
ĆL… e.g. dé.ma.ða ‘to hear’
C̀Ć… e.g. dʲì.ná.ŋu ‘a large spear’
ĹL… e.g. wí.ga.ðìn ‘dead’, bú.gu.ma.nà.ma ‘kangaroo’
(i) H = CVV/ CVC
(ii) L = CV, where C is a non-coronal consonant

---

[47] Addendum: Also see Gahl (1996). I was not aware of this paper when this thesis was written.

[48] Davis (1988) claims that the stress is actually H́C. However, Hercus makes the statement that “the accent on the second syllable was usual also when the [cluster] *nd* …[was] involved: *mìn.dá.ra.ða* ‘to be cold’” (p.153). Of Hercus’ list of permissible word-medial consonant clusters, only one has the second consonant as a coronal: *nd*. From this, it is evident that in $CVC_1.C_2V$ sequences if C_2 is a coronal then it must be /d/ and C_1 /n/. So, from Hercus’ claim the *second syllable* must be stressed; however, this does not explain Davis’ example [bún.di.là.ða] ‘to go on biting’.

(iii) c = cV, where c is a coronal consonant.

As it stands, the stress algorithm can be expressed as ‘Stress the heaviest syllable in a di-syllabic word-initial window; in the event of a tie, stress the peninitial.’ The obvious difficulty is in explaining why syllables with coronal onsets group with bi-moraic syllable for stress. This seems to require reference to the feature [coronal] – something deemed impossible by the PAH. However, it is possible that features do not have anything to do with the Madimadi weight pattern. Suppose that the constraint NOT-MIN(σ,μ) is used to distinguish bi-moraic CVC syllables from mono-moraic CV syllables. To distinguish coronal onset syllables from other types a constraint such as EXIST(onset, [coronal]) ‘an onset consonant must contain a [coronal] feature’ can be employed. This incorrectly gives a four-way ranking of syllable categories:

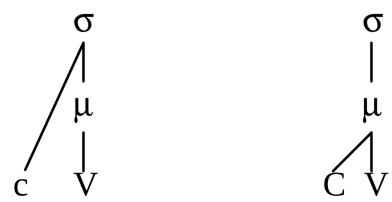
(101)

	EXIST(onset,[coronal])	NOT-MIN(σ,μ)
cVV		
CVC	x	
cV		x
CV	x	x

So bi-moraic syllables with coronal onsets (cVV) outrank CVV and cV syllables, with CV as the lightest type. Given the above stress algorithm, stress is attracted to the heaviest of two initial syllables. In the case of /del.gai.a.ðaŋ/, then, /del/ is heavier than /gai/ as /del/ has a coronal onset as well as being bi-moraic. However, this incorrectly means that /del/ should receive stress over /gai/, resulting in */dél.gai.a.ðaŋ/, not /dèl.gái.a.ðaŋ/. So, reference to the feature [coronal] results in too many weight distinctions.

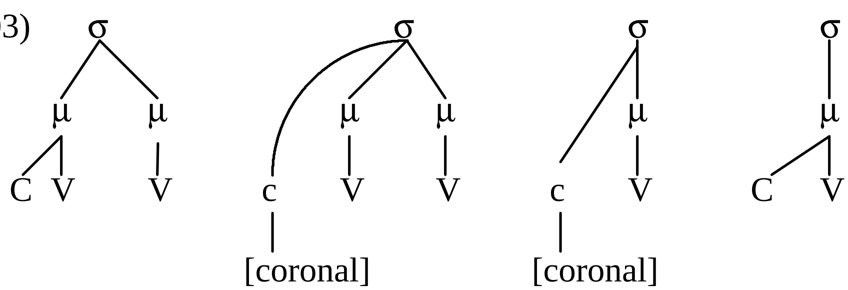
An alternative solution requires appealing to feature licensing and variable syllable structure. Madimadi syllable structure varies depending on the type of segment involved, as shown in the representations below:

(102)



This can be explained by appealing to feature licensing: only the σ node licenses the feature [coronal] for consonants, whereas μ licenses the other place features. Unfortunately, this claim is very difficult to prove or disprove. There are no other phonological processes that shed light on this issue.[49] Even so, it is a method of avoiding feature reference. It also has the advantage of resulting in only two categories of weight:

(103)



The only distinction that needs to be made is between the rightmost structure and the others. This is easily done by employing NOT-MIN(σ,*x*). CVV syllables satisfy this as there are two or three associations from the σ to other nodes. Even cV syllables satisfy it as the syllable node is associated to μ and c. The only syllable to fail it is CV as there is only one association from the σ node to a μ.

[49] Goldsmith (1990) argues that [coronal] is often the only place feature licensed in coda position. In present terms, this means that [coronal] is often the only feature licensed by the σ node. This is akin to the situation here.

This groups all non-CV syllables together, and correctly results in two distinctions of syllable weight. In sum, Madimadi is not necessarily evidence against the validity of the PAH. In fact, it serves to emphasise the significance variations in syllable structure can have in syllable weight categorisation.

3.2.5 Asheninca: The Significance of Syllable Structure

The Arawakan language Asheninca has a complex stress system, described and analysed by Payne (1990) (also see Hayes 1995:288-296). Asheninca is significant for the study of stress in a number of respects. Of immediate interest is its assignment of primary stress.

Primary stress must fall on one of the last three non-final syllables on a word. In addition, it may only fall on a syllable capable of being a foot head. For example, the word /hamanantakenero/ ‘he bought it for me’ is parsed into iambic feet from left to right: /(ha.ma^{+})(nan.ta^{+})(ke.ne^{+})ro/, where $^{+}$ marks a head syllable. Primary stress may fall on either /ta/ or /ne/ as both these are foot heads and both are in the last three non-final syllables in a word. Which of these syllables is stressed depends upon the following hierarchy:

(104) VV(N) > $\underline{V}$(N), iN > i > ɨ

(i) $\underline{V} \neq$ /i/, (i.e. $\underline{V} \in \{a, e, o\}$)

The above table only specifies the shape of the syllable rimes. Onsets are irrelevant to weight assignment; they consist of a single consonant followed by an optional palatal glide – /j/. The Asheninca rime contains at least one vowel, and maximally contains two vowels and a nasal consonant. In short, the syllable is of the type C(j)V(V)(N), where parentheses mark optional elements.

Two of the factors involved in the weight hierarchy are fairly obvious. The first is moraic content, distinguishing between syllables with two vowels, and those with one. This can be expressed by using the constraint NOT-MIN(σ,μ). The second difference is between Extra-Light syllables, which contain /ɨ/, and the others. Notably, this syllable type is the only one that contains a vowel of this quality – the others contain /a/, /e/, /o/, or /i/ (Payne 1990:196).[50] Since this difference is evidently one of sonority, the constraint SON(μ, /iu/) will adequately distinguish the Light and Extra-Light types.

This leaves the last difference, between syllables with a rime of /i/ alone, and syllables that contain either a vowel that is not /i/ or a rime that consists of /i/ and a nasal consonant. At first glance, there would seem to be a division between syllables with /i/ and those without. However, this would then require explaining why syllables containing /iN/ are heavier than those with /i/ alone.

Another approach, and one that has a more satisfactory result, is to appeal to a structural difference. From the hierarchy above, it is evident that syllables with a nucleus of /i/ are avoided in stress assignment. This dispreference signals a structural difference, of the following sort:

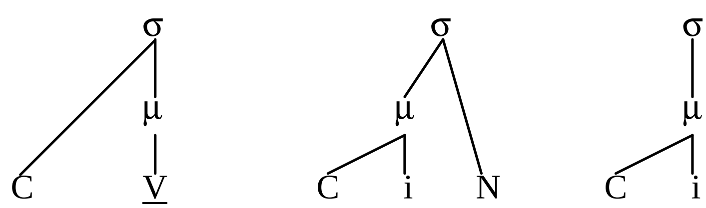
(105)

So, morae that dominate non-/i/ vowels (V̲) do not allow any other associations, whereas morae with /i/ must also dominate onset consonants. This means that the syllable in Asheninca has two different structures depending on the vowel. This allows a distinction to be made between Ci syllables and syllables of the type CV̲

[50] Extra-light syllables are of the form /s(j)ɨ/ or /ts(j)ɨ/. These are in complementary distribution to Light syllables, which are of the form /Ci/, where C is not /s/ or /ts/. Therefore, the vowel in light and extra-light syllables is underlyingly the same. Nevertheless, it is likely that they are featurally different as they

or CiN: Ci syllables are the only type which violate NOT-MIN(σ,*x*). This can be seen in the following representations:

(106)



For C$\underline{\text{V}}$ syllables there are two associations from the σ node: to the mora and to a segment. The same is true for CiN syllables: there is an association from σ to a mora, and from σ to the coda consonant's root node. In comparison, Ci has only *one* such association from σ – to a mora.

As the following tableau shows, this correctly divides the syllable types into the attested categories:

(107)

	NOT-MIN(σ,μ)	NOT-MIN(σ,*x*)	SON(μ, /iu/)
CVV(N)			
C$\underline{\text{V}}$ (N)	x		
CiN	x		
Ci	x	x	
Cɨ	x	x	x

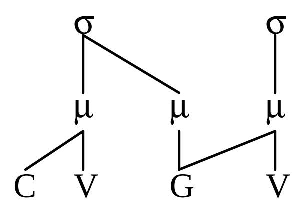
The Asheninca syllable weight system shows how differences in syllable structure can play a major role in weight effects. Asheninca's constraint system is almost identical to Southeastern Tepehuan's (§3.1.3), yet its structural differences result in a significantly different syllable weight hierarchy.

are treated differently with respect to other phonological processes (Payne p.195).

3.2.6 GEMINATES AND WEIGHT

The moraic theory of the syllable assumes that geminate consonants license a mora of their own. The resulting representation is shown below, with the leftmost syllable containing the first half of a geminate consonant (Hayes 1989):

(108)



(i) G is a geminate consonant.

Tranel (1991) observes that this has a number of implications for syllable weight.[51] In terms of moraic content, CVG syllables are equivalent to CVV syllables. Assuming a theory of syllable weight based on moraic content alone, this predicts that CVG syllables, like CVV syllables, are always heavy.

While there are languages that verify this prediction, there are a number for which it is not true. For example, stress falls on the leftmost heaviest syllable in Selkup, but only CVV syllables count as heavy; CVG and CVC are light:

(109)	CVV is heavy:	qu.mó:.qi ‘two human beings’
	CVC is light:	á.mir.na ‘eats’
	CVG is light:	ú:cɨk:ak [u.cɨk.kak] ‘I am working’
		[Data from Halle & Clements 1983]

A similar situation is found in Malayalam and Tübatulabal.[52] Tranel argues that these languages offer a serious challenge to a moraic theory of the syllable. In

[51] Also see Davis (1994), Sprouse (1995) and Hume, Muller, & Engelenhoven (forthcoming).

[52] Hayes (1995:299) suggests that the apparent gemination in Malayalam is really a featural difference.

contrast, I will argue that these examples do not put the moraic model of the syllable in question, but rather the assumptions made about syllable weight. Tranel was forced to the conclusion that the moraic model of the syllable was at fault because of his assumption that syllable weight is defined by moraic content alone. However, there are alternatives.

Let us reconsider Selkup. There are three types of syllable in this language: mono-moraic CVC, bi-moraic CVG, and bi-moraic CVV. Significantly, CVV syllables only contain *long vowels*: there are no diphthongs. So, the weight hierarchy of the language distinguishes between long vowels and other types. As shown in Maori and Kara, this can be implemented by using the constraint NOT-MIN(seg,μ).[53]

This same explanation can be used for Malayalam and Tübatulabal. Again, only long vowels are heavy; CVC and CVG count as light and there are no diphthongs. The Austronesian language Leti is another contender, treating CVG and CVC syllables as light (Elizabeth Hume – p.c.). Again, only CV: syllables are heavy – there are no diphthongs.

This is a welcome result: no change needs to be made to the moraic model of the syllable. Instead, alterations to conceptions of syllable weight that are necessary elsewhere can be invoked.

One further interesting case involving geminates remains. Tranel (1991) and Sprouse (1995) both claim that a stress system cannot exist in which CVC is heavy and CVG is light. In fact, there are two counter-examples to this claim.

[53] NOT-MIN(seg,μ) cannot be satisfied by geminates consonants even though a single consonant attaches to two morae. This is because in any relation all arguments must be accessible to the σ node in question. Notably, geminate consonants attach to a mora *outside* the syllable, making that an illicit relation in terms of syllabic categorisation.

3.2.6.1 Light Geminates

Based on the assumption that moraic content alone defines syllable weight, it is a necessary consequence that CVG syllables can never be light as they always contain two morae. Also impossible is a system in which CVC syllables are heavy and CVG syllables are light. In comparison, the proposals of this thesis do not ban such a possibility. In fact, such a situation is analogous to the case of Tiberian Hebrew, where bi-moraic CVV syllables are light but mono-moraic CVC syllables are heavy. So, an analysis identical to Tiberian Hebrew's can be employed in this situation. Such an explanation will be used in the analysis of Tashlhiyt Berber and Ngalakan.

3.2.6.1.1 Tashlhiyt Berber

In a common type of poem in Tashlhiyt Berber (TB), CVG syllables are treated as light for purposes of versification, while CVC are heavy (Dell –, p.c.). In fact, Dell (p.c.) describes four types of syllable in Poetic Berber:

(110) (i) CV, e.g. /za/, /br/

(ii) CVG, e.g. /<u>zag</u>.gd/, /<u>brg</u>.gd/

(i) G is shared between two syllables.

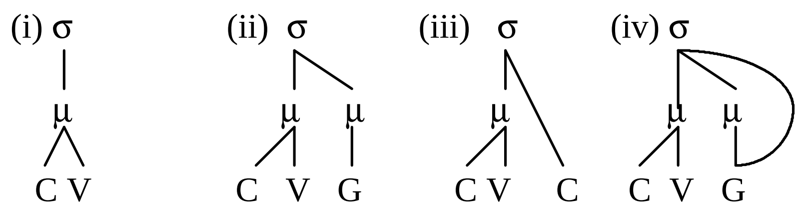
(iii) CVC, /<u>zan</u>.gd/, /<u>brn</u>.gd/

(iv) CVG:, /zan:.gd/, /brn:.gd/

(i) G: is contained within a single syllable.

I will take it that type (iii), CVC, is mono-moraic, while type (ii) CVG is bi-moraic. An interesting contrast is that between types (ii) and (iv). The only difference is that in (ii) the geminate is shared with the following syllable, while in (iv) it is contained within the same syllable. This suggests the following representations:

(111)



Type (i) and (ii) syllables (CV, CVG) count as light in poetic Berber, while types (iii) and (iv) count as heavy. From the representations above, the major difference in the syllable structures of CVC and CVG: syllables on the one hand and CV and CVG syllables on the other is the existence of an association between the σ node and a root node. Just as in Tiberian Hebrew, this can be used to good effect by the constraint EXIST(σ,seg). Only CVC and CVG: will satisfy this constraint, ranking them both above CV and CVG syllables.

3.2.6.1.2 NGALAKAN

Ngalakan is a non-Pama-Nyungan language of the Gunwinjguan family, spoken in Australia (Baker 1997a,b, p.c.). This section will focus on explaining primary stress alone.[54]

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[54] Many thanks to Brett Baker for discussing Ngalakan with me on several occasions. I note that the facts of this language with respect to stress are somewhat complicated, and deserve more attention than I give them here. The reader is referred to Baker (1997b) for further details.

There are five vowels phonemes in Ngalakan (/a e i o u/) and 23 non-vowel phonemes (see Baker 1997b for details). Of immediate interest is that five of these phonemes are geminates. These geminates have a restricted distribution, only appearing word-internally and only after non-nasal sonorants (vowels, glides, and liquids). In addition there is no vowel length distinction. Diphthongs are also prohibited, although vowel+glide sequences are permissible. While initial consonant clusters are banned, word-final consonant clusters are allowed. In the main, the only medial syllable-internal consonant clusters allowed are [CG], where G is the first half of a geminate.

Having established these facts, the primary stress rule can be stated as "Stress the leftmost heaviest syllable." Despite distinguishing only two syllable weights, Ngalakan is somewhat unique in the distinguishing factor it employs. Consider the following data:

(112) (i) pu.ṯól.koʔ 'brolga' (large bird sp.)[55]

(ii) ŋó.loŋ.koʔ 'eucalyptus sp.'

(iii) ká.mak.kun 'properly'

(iv) pí.cu.ṯu 'big wind'

Baker (1997b) shows that word-final consonants are extra-metrical, and do not count in the calculation of syllable weight.

It is not possible to simply state that CVC syllables are heavier than CV syllables, as shown by example (ii) where stress falls on the first CV syllable, and not on the second syllable: /loŋ/. Even CVG syllables are not heavier than CV syllables, as shown in (iii) where the syllable /mak/, containing the first half of a

[55] ṯ is a post-alveolar stop.

geminate /k/, does not receive stress over the CV syllable /ka/. On the other hand, the CVC syllable /t̠ol/ in (i) *does* attract stress over the other types.

From a number of similar examples, Baker concludes that a coda consonant is significant in defining a heavy syllable. However, the coda consonant of a heavy syllable must not have the same place of articulation as a following consonant. For example, /t̠ol/ in /pu.t̠ol.koʔ/ is heavy because it contains an apico-alveolar lateral /l/ and the following consonant has a different place of articulation (i.e. velar). In comparison, /loŋ/ in /ŋo.loŋ.koʔ/ has a final *velar* nasal and is followed by a *velar* consonant. Because of this, /loŋ/ is light. This argument is extended to geminates.

Baker's observation seems to require reference not only to place of articulation in characterising heavy syllables in this language, but to the fact that this place of articulation is *different* from that of a following consonant. However, there are other possibilities. Firstly, two types of CVC syllable are light: CVG syllables, and syllables of the type CVC, where C agrees in place with a following consonant. An interesting fact is that with these CVC syllables, the final consonant is *always a nasal stop* (Baker p.c.). This opens up an interesting possibility: the nasal in CVN syllables may not really be part of the syllable at all, but be part of a pre-nasalised stop. This means that /ŋóloŋkoʔ/ is actually syllabified as /ŋó.lo.ᵑkoʔ/.[56] So, there are no CVN syllables. CVN sequences are CV syllables followed by prenasalisation of a following stop. This effectively eliminates the class of CVC syllables with respect to syllable weight.

This means that the weight distinction is effectively between CVC syllables and CVG syllables. We have arrived at the same situation as in

[56] Baker (p.c.) notes that pre-nasalised stops are not permitted in word-initial position. While this suggests that they are non-phonemic, it is still possible that they are derived from underlying NC sequences.

Tashlhiyt Berber. Like Tashlhiyt Berber and Tiberian Hebrew, this weight distinction can again be attributed to the constraint EXIST(σ,seg).

3.3 CONCLUSION

The aim of this chapter was to provide empirical support for the proposals in chapter two. This has been done by showing that elements other than the mora can influence syllable weight distinctions (§3.1). In addition, the case studies have provided support for the contention that weight constraints are violable and can be ranked with respect to each other (§3.2). In addition, as many as four constraints were shown to be used in categorising syllable types, with a concomitantly large number of weight types (Kobon §3.1.7, Wosera §3.2.3).

A number of syllable weight hierarchies that seemed to pose problems for the suggestions in chapter 2 were also discussed. It was shown that appealing to different syllable structure for different types helped explain the disparity (Asheninca §3.2.5 and Madimadi §3.2.4). Indeed, the approach to syllable weight advocated in this thesis requires that a significant amount of attention be paid to syllable structure. Variations in structure can significantly affect the influence any constraint might have, as shown for Madimadi and Asheninca.

4 INTEGRATING SYLLABLE WEIGHT

Up to this point, this thesis has shown how the grammar distinguishes between different syllable categories by using the weight constraints NOT-MIN and EXIST. It is now possible to examine the role of weight constraints in the broader context of stress assignment. Accordingly, the aim of this chapter is to determine the place of weight constraints in an explanation of weight-sensitive stress systems. The framework in which this is set is Optimality Theory (OT).

There are two possible ways to integrate weight constraints into an OT analysis of stress. The first is to directly integrate these weight constraints into the constraint hierarchy in CON. The second approach is to form a separate constraint hierarchy for weight constraints, called *W*. *W* would co-exist with the main constraint hierarchy *CH* – the constraint hierarchy that identifies the most optimal candidate form. Constraints in *CH* would then refer to the weight constraint hierarchy *W* as a whole.

At this point, the first approach is by far the most desirable as it does not require any revision to the framework of OT. In fact, it is essentially the approach taken by Prince & Smolensky (1993:38-42) (hereafter P&S) in their discussion of Prominence-Driven stress systems, exemplified by Hindi.

In Hindi, primary stress falls on the heaviest syllable in a word. As discussed in §3.1.4.1, there are three syllable weights in this language: Superheavy (CV:C, CVCC), Heavy (CV:, CVC), and Light (CV). If there are two or more syllables of equal weight in a word, a non-final syllable is preferred over a final one:

(113) ró:z.ga:r ‘employment’
qís.mat ‘fortune’

ru.ká:.ya: ‘stopped (trans.)’

If there are two *non-final* syllables of the same weight, the rightmost is stressed:

(114) sa.mí.ti ‘committee’

ka:.rí:.ga.ri: ‘craftsmanship’

In sum, primary stress falls on the heaviest syllable in a word, regardless of its position (final or non-final). However, if there is more than one heaviest syllable, stress falls on the rightmost non-final one.

To require that the heaviest syllable in a word is stressed P&S use a constraint called PEAK-PROMINENCE (PKPROM). They define this in the following terms:

(115) “Peak(x) 〉 Peak(y) if $|x| > |y|$

By PKPROM, the element *x* is a better peak than *y* if the intrinsic prominence of *x* is greater than that of *y*.”

[P&S 1993:39]

For Hindi, the intrinsic prominence of syllable types is such that PKPROM is violated less by a stressed Superheavy syllable than by a stressed Heavy syllable. It is violated most by a stressed Light syllable. In short, the less intrinsically ‘prominent’ a category is, the more violations of PKPROM it will incur.[57] This effectively ensures that the heaviest syllable will be stressed.

57 P&S’s original interpretation of violations of PKPROM was somewhat different. The interpretation in this paper is the one adopted by more recent uses of PKPROM (e.g. Walker 1996). At this point, there may be some terminological confusion as ‘prominence’ has been used in several different ways throughout this thesis. There is Hayes’ (1995) ‘prominence’ which is a phonetic property that has relevance for the phonology (§1.3.2), Prince’s (1983) ‘intrinsic prominence’ refers to the ‘total sonority’ of a syllable (§2.1), the notion of ‘prominent element’ as used in §2.3.1, and the idea of ‘prominent syllable’ here, which is a primary stressed syllable. While the discussion here aims to avoid confusion

While the description of this constraint is characterised by the same nebulousness as Hayes' (1995) notion of prominence, for the moment it is enough to accept that it provides the correct ranking of syllable categories with respect to heaviness.[58]

Essentially following P&S's analysis, the following two constraints will be employed:

(116) (i) ALIGN(σ́, R, PrWd, R), where σ́ is the primary stressed syllable.[59]

(ii) NONFINALITY: 'The word-final syllable must not be stressed.'

Since the heaviest syllable in a word is stressed regardless of its position, PKPROM must outrank the other constraints. This way, it is more optimal for the heaviest syllable to be stressed than to be non-final, or aligned at the right edge of the word. For the other constraints, NONFINALITY must outrank ALIGN-σ́-R otherwise a final stressed syllable would be preferred over a final one. An example tableau is given below:

with respect to this term, it is noteworthy that 'prominence' is a term with many different meanings.

[58] The formulation of this constraint raises a number of questions. Most significantly, it does not explain what 'intrinsic prominence' is, a problem shared with Hayes' (1995) approach. In comparison, this thesis sees 'intrinsic prominence' as a function of the evaluation of the structural properties of syllables. The form of P&S's constraint will not be discussed further here as it is superseded by the weight constraints.

[59] See §1.2.1 for discussion of ALIGN constraints.

(117)

	PKPROM	NONFINALITY	ALIGN-σ́-R
☞ qís.mat	x		x
qis.mát	x	x!	
sá.mi.ti	x x		x x!
☞ sa.mí.ti	x x		x
sa.mi.tí	x x	x!	
ká:.ri:.ga.ri:	x		x x x!
☞ ka:.rí:.ga.ri:	x		x x
ka:.ri:.gá.ri:	x x!		x
ka:.ri:.ga.rí:	x	x!	

The proposals of this thesis with respect to syllable weight require slight alterations to the above (i.e. P&S's) analysis of Hindi. As argued in previous chapters, the weight of a syllable is not determined by reference to 'prominence' but by using weight constraints. In a straightforward implementation of this idea, the constraint PKPROM can be replaced by the relevant weight constraints.

For Hindi, it has already been determined in §3.1.4.1 that the relevant constraints are EXIST(σ,seg) and NOT-MIN(σ,μ). Since the primary stressed syllable must conform to these constraints, the constraints that appear in the constraint hierarchy are of the form EXIST(σ́,seg) and NOT-MIN(σ́,μ), where σ́ is a primary stressed syllable. As the tableau below shows, this achieves the correct results:

(118)

	NOT-MIN(σ́,μ)	EXIST(σ́,seg)	NONFINALITY	ALIGN-σ́-R
☞ qís.mat		x		x
qis.mát		x	x!	
sá.mi.ti	x	x		x x!
☞ sa.mí.ti	x	x		x
sa.mi.tí	x	x	x!	
ká:.ri:.ga.ri:		x		x x x!
☞ ka:.rí:.ga.ri:		x		x x
ka:.ri:.gá.ri:	x	x!		x
ka:.ri:.ga.rí:		x	x!	

The above tableau shows that weight constraints can be easily integrated into the analysis of Hindi stress.

This straightforward method of weight constraint integration can be used successfully in analysing a number of other languages. For example, in Maori the leftmost heaviest syllable is stressed, with a hierarchy of °CV: > CV_iV_k > CV° (§3.1.1). This hierarchy was explained by using the constraints NOT-MIN(σ,μ) and NOT-MIN(seg,μ).

A note on constraints is necessary here. While the form NOT-MIN(σ́,μ) is used above, this constraint is not expressed as explicitly as it should be. The problem is more evident when the form of the constraint NOT-MIN(seg,μ) is considered. As it stands, this constraint does not directly refer to the primary stressed syllable. To rectify this, the correct formulation of these constraints must be as follows: 'NOT-MIN(seg,μ), where μ is dominated by the primary stressed syllable'. This is abbreviated to 'σ́ = NOT-MIN(seg,μ)'.

Since the leftmost heaviest syllable is stressed in Maori, the constraint ALIGN(σ́, L, PrWd, L) can be invoked, requiring the primary stressed syllable to be aligned with the left edge of a PrWd. The following tableau suffices to show that the constraint hierarchy is adequate:

(119)

	σ́= NOT-MIN(σ,μ)	σ́= NOT-MIN(seg,μ)	ALIGN-σ́-L
☞tá.ŋa.ta[60]	x	x	
ta.ŋá.ta	x	x	x!
ta.ŋa.tá	x	x	x x!
má.rae	x!	x	
☞ma.ráe		x	x
kú.ri:	x!	x	
☞ ku.rí:			x
áu.a:		x!	
☞au.á:			x
☞tú:.i:			
tu:.í:			x!

4.1 AGAINST PKPROM

Proposing that weight constraints replace PKPROM is of more than just theoretical interest. Since a language can employ several different weight constraints, it is to be expected that other stress-related constraints such as ALIGN or NONFINALITY may interact with the weight constraints in some languages, producing observable effects. If this can be shown, it is an excellent demonstration of why a single unified weight constraint such as PKPROM should *not* be used in the analysis of weight-sensitive processes. Conveniently, such an example is found in Maori.

In some Maori dialects the stress algorithm differs slightly with respect to diphthongs. Whereas the leftmost long vowel in any position must be stressed, the leftmost diphthong is only stressed if it is *not* in word-final position (Biggs

[60] The glosses of the words are as follows: táŋata 'man', *maráe* 'meeting grounds', *kurí:* 'dog', *auá:* 'herring', *tú:í:* 'parson bird'.

1969:132, Bauer 1981:32, Bauer 1993:557).[61] For example, *marae* 'meeting grounds' will be stressed as /márae/, not /maráe/. This avoidance of final position requires the constraint NONFINALITY, which can be integrated into the constraint hierarchy as follows:

(120)

	σ́=NOT-MIN(seg,μ)	NONFINALITY	σ́=NOT-MIN(σ́,μ)	ALIGN-σ́-L
☞tá.ŋa.ta	x		x	
ta.ŋá.ta	x		x	x!
ta.ŋa.tá	x	x!	x	x x
☞má.rae	x		x	
ma.ráe	x	x!		x
áu.a:	x!			
☞au.á:		x		x
kú.ri:	x!		x	
☞ ku.rí:		x		x
☞tú:.i:				
tu:.í:		x!		x

This can be compared with an approach using PKPROM. For Maori, PKPROM would be violated twice by CV syllables, once by diphthongs, and not at all by CV: syllables. Analogous to the above constraint hierarchies, PKPROM would outrank ALIGN-σ́-Left. This easily accounts for dialects without the ban on stressed final diphthongs:

[61] A systematic survey to determine which dialects have this ban on final stressed diphthongs has not yet been undertaken. Bauer (1981) suggests that it is basically an East-West dialectal division, with Eastern dialects having the ban (Biggs 1969 cf Hohepa 1967).

(121)

	PKPROM	ALIGN-σ́-L
☞ tá.ŋa.ta	x x	
ta.ŋá.ta	x x	x!
ta.ŋa.tá	x x	x x!
má.rae	x x!	
☞ ma.ráe	x	x
☞ tú:.i:		
tu:.í:		x!

While this accounts for the dialects without the ban on word-final stressed diphthongs, this results in several problems in the dialects *with* the ban. As for Hindi, the constraint NONFINALITY is needed to ban final stressed diphthongs. However, no matter where it is ranked, a final stressed diphthong can never be avoided without also banning an attested form:

(122) (i) PKPROM » NONFINALITY

	PKPROM	NONFINALITY	ALIGN-σ́-L
má.rae	x x!		
* ☞ ma.ráe	x	x	x

(ii) NONFINALITY » PKPROM

	NONFINALITY	PKPROM	ALIGN-σ́-L
☞ má.rae		x x	
ma.ráe	x!	x	x
*☞ áu.a:		x	
au.á:	x!		x

(iii) PKPROM, NONFINALITY

	NONFINALITY	PKPROM	ALIGN-σ́-L
☞ má.rae		x x	
ma.ráe	x	x	x!
*☞ áu.a:		x	
au.á:	x		x!

The blame for the failure here can be placed squarely on PKPROM. It is because PKPROM is a single unified constraint that the correct result cannot be achieved.[62] In contrast, employing a number of syllable weight constraints does supply the necessary effects. In sum, PKPROM is empirically inadequate as a constraint.

4.2 SEPARATION OF HIERARCHIES

The success of the mode of weight constraint integration here is welcome as no new devices need to be added to the theoretical resources of OT. However, not all such integration is as straightforward. The situations that pose most problems are default-to-opposite stress systems.

A default-to-opposite stress system is one in which edge-alignment differs depending upon the weight of the syllable (see Käger 1995 for discussion). As an example, consider the stress system of Chuvash (Krueger 1961):

(123) Stress the rightmost heavy syllable,
Else the leftmost syllable.

The weight difference is based on sonority in this language: heavy syllables contain full vowels and light syllables contain reduced vowels.[63] The difficulty is in assigning stress to the correct *edge*. In Maori and Hindi it is enough to refer to the primary stressed syllable in a single ALIGN constraint. However, this is only because primary stressed syllables of all weights are preferred closer to the *same*

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[62] It is possible to suppose that there is a constraint NONFINALITY(diphthong), which bans non-final stressed diphthongs. However, I find this approach contrived and counter-intuitive.

[63] This distinction can be achieved by using the weight constraint SON(μ,full V). Some analyses treat full vowels as bi-moraic (Hayes 1995:296). This is neither necessary nor convincing for Chuvash as geminate-final syllables (with two morae) are not treated as heavy.

edge in these languages. In contrast, stressed heavy syllables in Chuvash are preferred closer to the *right* edge, while the default is the *left* edge.

This causes significant problems for the formulation of ALIGN constraints. If this differing edge-orientation is expressed by the two constraints ALIGN(σ́, L, PrWd, L) and ALIGN(σ́, R, PrWd, R), there is no ranking of these that will cause stressed heavy syllables to align right on the one hand and stressed reduced-vowel syllables to align left on the other. Whichever ALIGN constraint is ranked highest will obscure the effects of the other resulting in incorrect outputs:

(124)

(i) ALIGN-σ́-L » ALIGN-σ́-R

	σ́ = SON(μ, /eo/)	ALIGN-σ́-L	ALIGN-σ́-R
*☞ H́ H			x
H H́		x!	

(ii) ALIGN-σ́-R » ALIGN-σ́-L

	σ́ = SON(μ, /eo/)	ALIGN-σ́-R	ALIGN-σ́-L
Ĺ L		x!	
*☞ L Ĺ			x

This failure suggests that either ALIGN constraints cannot provide the necessary mechanism for explaining stress systems with differing edge-orientations, or that the ALIGN constraints are not formulated in a precise enough manner.

The first alternative means that there is some other mechanism which can account for default-to-opposite stress systems. Default-to-opposite stress systems are explained in derivational stress theories by setting different headedness parameters on different prosodic tiers.

In tree theory, Prince (1976) suggested that these systems had quantity-sensitive unbounded feet. If these feet were left-headed then the Word tree's associations were *right*-headed, and vice-versa. This was later translated into Grid Theory as setting End-Rules with different edges at different levels (Prince 1983). For example, a ‘Rightmost heavy, else leftmost’ system is explained by using End-Rule-Left at the foot level and End-Rule-Right at the Word level. End-Rule-Right requires the leftmost element in a level to project a grid mark to the next highest level, and vice-versa for End-Rule-Left:

```
(125)     (a)          *       (b)  *           ER-Right(PrWd)
              *    *   *            *           ER-Left(Ft)
              L L L H LH L          L L L L L
```

However, this requires *all* heavy syllables to be assigned a grid mark initially even if they are not actually realised as stressed. Halle & Vergnaud (1987) eliminated such incidentally stressed syllables by invoking a device called ‘line conflation’ which eliminated the lowest row of grid marks (the foot row), effectively eliminating unrealised secondary stresses while preserving the primary stress.

The difficulty in an OT approach to stress is that line conflation cannot be invoked as it is a two-step process; firstly, feet are built, the primary stress is located, *then* feet are deleted. This poses a problem to a phonological theory in which constraints apply only to output forms, not to intermediary forms in a derivation. This suggests that the ‘different edge settings at different levels’ approach cannot be directly emulated in OT.

This leads to the second possibility – modifying the ALIGN constraints in some way. In Chuvash’s ‘rightmost heavy syllable, else leftmost’ type, the best way of capturing the change in direction is to require *heavy* syllables to align with the right edge and *light* syllables to align with the left edge. This means that the ALIGN constraints need to refer not just to the primary stressed syllable but to the primary stressed syllable *of a certain category*:

(126) (I) ALIGN(σ́, R, PrWd, R), where σ́ is a primary stressed syllable, and this syllable does not violate SON(μ,full V).

(II) ALIGN(σ́, L, PrWd, L), where σ́ is a primary stressed syllable, and this violates SON(μ,full V).

These ALIGN constraints achieve the desired result, as the following tableau shows. V stands for 'full vowel', and ə for a reduced vowel here:

(127)

	σ́ = SON(μ,full V)	(I) ALIGN-v́-Right	(II) ALIGN-ə́-Left
Cə́.CV.Cə	x!		
☞ Cə.CV́.Cə		x	
Cə.CV.Cə́	x!		x x
CV́.CV.Cə		x x!	
☞ CV.CV́.Cə		x	
CV.CV.Cə́	x!		x x
☞ Cə́.Cə.Cə	x		
Cə.Cə́.Cə	x		x!
Cə.Cə.Cə́	x		x x!

The most significant characteristic of these ALIGN constraints is that they *contain* another constraint – SON(μ, Full V). While this is necessary it lends far greater expressive power to constraints. For example, if a language had a three-way weight distinction defined by the constraints NOT-MIN(σ,μ) and EXIST(σ,seg), its ALIGN constraints could take the following form (cf Hindi and Arabic §3.1.4.1):

(128) (i) ALIGN-σ́-Left/Right, where σ́ violates *neither* NOT-MIN(σ,μ) *nor* EXIST(σ,seg).

(ii) ALIGN-σ́-Left/Right, where σ́ *does not* violate NOT-MIN(σ,μ), but *does* violate EXIST(σ,seg).

(iii) ALIGN-σ́-Left/Right, where σ́ *does* violate NOT-MIN(σ,μ) but *not* EXIST(σ,seg)

(iv) ALIGN-σ́-Left/Right, where σ́ violates *both* NOT-MIN(σ,μ) *and* EXIST(σ,seg)

In effect, the above ALIGN constraints do not contain another constraint, but another *constraint hierarchy*. At this point, it is questionable whether these constraints are correctly formulated.

There is good reason to think that they are not. If weight constraints can be contained by ALIGN constraints there is no reason why the weight constraints should be *consistent*. In other words, one ALIGN constraint could refer to the constraint NOT-MIN(σ,μ) while another could refer to SON(μ,/eo/). There is nothing that forces these 'contained' constraints to be the same. This is obviously an undesirable situation. In all cases involving syllable weight, *all* the weights are defined with respect to the *same* constraints.

The best way to avoid this problem is to allow the weight constraints to form an entirely separate constraint hierarchy, termed *W*. Then, the ALIGN constraints can be expressed as 'ALIGN(σ́, L, PrWd, L), σ́ is of category *x*, and the category *x* is defined in *W*'. This way, all syllable weights are distinguished by the same constraints as there is only one weight constraint hierarchy, resolving the problem of consistency.

However, adopting such an approach raises many questions. Specifically, how does reference to *W* take place? Is a syllable categorised by referring to the *number* of constraints it violates, or by some other means? How are generalisations such as 'a lighter syllable never receives stress over a heavier one' accounted for?

To answer these questions, it is best to begin with an examination of the main premise: that syllable weight constraints form a separate constraint hierarchy in the grammar. To do so, it is necessary to consider Prominence Scales.

4.2.1 PROMINENCE SCALES

A 'Prominence scale' is a hierarchy of elements such as the phonetic sonority scale or the structural scale ‖Nucleus > Margin‖ (P&S 1993:67-82,129, Smolensky 1995:3).[64] Prominence scales are defined "on phonetic dimensions; these are … the analyses of phonetic space that are primitive from the viewpoint of linguistic theory." (P&S 1993:67). Prominence scales undergo a number of processes in order to be made available to the phonology in the form of constraints.

The first such process is 'Prominence Alignment' which amalgamates two Prominence scales into a single *Harmony* scale (Smolensky 1995:3). For example, the phonetic sonority scale and the structural scale ‖Nucleus > Margin‖ can be aligned to form the following Harmony scale:

(129) NUCHARMONY: {Nuc/a 〉 .. Nuc/l 〉 .. Nuc/n 〉 .. Nuc/t}

---

[64] All Prominence Scales are enclosed in double vertical lines, as here. Note that the *phonetic* sonority scale is not the same as the *phonological* sonority scale. The former is defined extra-linguistically, while the latter is a phonological construct. See below for further discussion. I am apprehensive about introducing yet another use of the term 'prominent' into this thesis. However, I retain this terminology following P&S (1993).

NUCHARMONY expresses a preference for certain types of segments in a syllable nucleus. 'Nuc/a $\rangle$ Nuc/t' means that a syllable nucleus that contains a segment with the sonority of /a/ is preferred over a nucleus containing a segment with the sonority of /t/. The above scale only represents fragments of the full hierarchy.

This Harmony scale is then converted into a set of ranked constraints by a process termed Harmony-Constraint Translation here:

(130) Nuc/a » Nuc/l » Nuc/n » Nuc/t

The constraints are of the form Nuc/α, requiring that a syllable nucleus contain a segment of sonority α. This process of Prominence Alignment followed by Harmony-Constraint Translation allows extra-phonological scales such as those motivated by phonetics or psychology to be accessible to the phonology.[65]

This leads to syllable weight. It has been an implicit belief in much recent work that constraints on syllable weight derive from a Harmony scale. It has been assumed by many that the extra-phonological factors contributing to syllable weight (such as phonetic amplitude, and so forth) form a Prominence scale.[66] Let us take the form of this Prominence scale to be $|\alpha > \beta > \gamma|$, where α,β,γ are degrees of some phonetic property, perhaps amplitude.[67] This Prominence scale is amalgamated with the scale $|$Peak > Non-Peak$|$, where Peak is a primary stressed syllable, to form the following Harmony scale:

(131) PEAKHARMONY: {Peak/α $\rangle$ Peak/β $\rangle$ … Peak/γ}

---

[65] The concept of a Prominence scale has not been greatly developed as yet. Even so, the intuition is clear: extra-grammatical scales can be translated into phonological terms (see Hayes 1996). By 'psychology' I refer to cognitive faculties other than the language faculty, such as the one that is responsible for the restrictions on the foot inventory (Hayes 1995).

[66] At this time it is not overly clear what the phonetic basis for such a scale would be (cf Gordon 1997, Appendix 3).

[67] Since this thesis claims that syllable weight is determined by phonological factors, not phonetic ones, the identity of these phonetic factors is of no interest here (cf Gordon 1997, Appendix 3).

It is believed that PEAKHARMONY is then translated into a single constraint: PKPROM. It has already been demonstrated that the use of this single unified constraint for syllable weight yields incorrect empirical results (§4.1). Even so, for the moment it is enough to recognise that constraints pertaining to syllable weight have been treated as being derived from a Harmony scale.

The proposal advanced in this thesis is quite different: syllable weight is not defined with respect to Prominence scales but by the interaction of phonological constraints that are not extra-phonologically motivated. In addition, it is claimed the variety of syllable weight systems observed in natural language is due to the variety of possible rankings.

Even so, it is fairly intuitive to speak of syllable weight hierarchies as 'Prominence scales'. This thesis claims that the significant characteristic of these 'syllable weight scales' is that they are not defined extra-grammatically, but by constraints internal to the grammar. Indeed, there are some similarities between Prominence scales and the syllable weight scale: both are conjectured to be independent from the main constraint hierarchy in some way, and both are treated as hierarchies of elements which are referenced by constraints in CH. So, it will be argued that Prominence scales and the syllable weight scale are realised in the same terms, phonologically speaking. The effect of Prominence Alignment and Harmony-Constraint Translation will be explained instead by conditions on constraint reference and consistency of ranking.

4.2.2 PROMINENCE TRANSLATION

To begin, consider P&S's procedure for converting Prominence scales into Harmony scales. In addition to the processes of Prominence Alignment and

Harmony-Constraint Translation, there is an additional restriction, namely Universal Domination Conditions. Consider the following Harmony scales:

(132) (i) NUCHARMONY: Nuc/a 〉 .. Nuc/t

(ii) MARHARMONY: Mar/t 〉 .. Mar/a

MARHARMONY is a Harmony scale incorporating the sonority scale and the Mar(gin) positions of a syllable (onset and coda). The interesting characteristic is that the rankings are reversed. P&S (p.127) explain this difference in ranking as the result of 'Universal Domination Conditions' which stipulate the ranking of elements in Harmony scales.

While there are a number of ways to conceive of these conditions, for the moment they can be regarded as restrictions that influence the algorithm of Harmony-Constraint Translation. If so, the process of translating Prominence scales into constraints can be represented diagrammatically as follows:

(133)

Prominence Scales → *Prominence Alignment* → Harmony Scale → *Harmony-Constraint Translation* → Phonological Constraints

↑

Universal Domination Conditions

P&S's approach identifies a number of phenomena that must be explained by any similar theory. Among these is the fact that Prominence scales influence the form of constraints, and that the ranking of certain types of constraints is fixed by extra-phonological conditions (implemented by P&S's Universal Domination Conditions). However, P&S's approach is not the only method of achieving the necessary results.

The alternative proposed here begins with the assumption that extra-phonological Prominence scales do exist. From here, there is a process, termed Prominence Translation, which converts Prominence scales into phonological terms. I do not mean to imply that the mechanisms of this translation are understood perfectly, or even in a rudimentary manner. However, they are not of concern at present – it is the *result* of this translation that is of interest here.

The result of this translation process is defined in terms of phonological constructs. For example, the Prominence scale for sonority ranks certain phonetic properties over others. This is then translated into the *phonological* sonority scale which ranks elements defined in phonological terms, such as /a/ and /t/. Of major importance is how the *points* on the Prominence scale and the relation of *ranking* between these points are encoded phonologically.

One approach is to see the translation of points on a Prominence scale into phonological terms as being a translation of phonetically defined elements into pre-determined phonological counterparts. For example, the element at the top of the sonority Prominence scale (i.e. /a/) is translated into the phonological features [+back], [+low], and so forth. Again, the exact workings of this process is not of present concern, only its results. In addition, there is no need to assume a 'perfect fit' of elements. From this, the element at the top of the sonority scale may not be perfectly definable in phonological terms. This would lead to incongruities between the phonological representation of Prominence scales and the Prominence scales themselves. Given this, it would be no surprise if, for example, the *phonological* sonority scale is slightly different than the *phonetic* sonority scale (see Clements 1990:291 for discussion).

The next step in this approach is to translate the relation of *ranking* between points in the Prominence scale into a similar relation in the phonology. However, it is at this point where difficulties emerge. While elements can be translated into features, it is not immediately evident which phonological relation is equivalent to that of the ranking relation between points on a Prominence Scale. Without adding another relation to the phonological system, there is only one relation that is remotely suitable: that used for constraint ranking.

This leads to the proposal of this thesis that *Prominence scales are translated into constraint hierarchies*. In this conception, the process of translating Prominence scales into phonological terms requires specifying a set of constraints, and ranking them. Elements in prominence hierarchies are then *not* specified as features, but as *configurations of constraint violations*.

An example will clarify this proposal. Consider again the Prominence scale for sonority. The proposal here requires all points on the scale to be considered. Then, a set of *constraints* can be determined, along with their rankings. For sonority, these constraints will be taken to be ‘seg = [+vocalic]’, ‘seg = [+approximant]’, and ‘seg = [+sonorant]’, for argument’s sake. These constraints are equally ranked. Now, given these constraints, a number of different configurations of violations are possible:[68]

(134) *The Sonority Constraint Hierarchy* – S

	seg=[+vocalic]	seg=[+approx.]	seg=[+son]
vowel			
liquid	x		
nasal	x	x	
obstruent	x	x	x

The labels ‘vowel’, ‘liquid’, ‘nasal’, and ‘obstruent’ are *not* candidate forms, but *labels* for each *constraint violation configuration*. So, elements on a prominence hierarchy are identified as sets of constraint violations, *not* as sets of features.[69]

---

[68] Not all possible violation configurations are listed below. Some possible configurations will never be matched in natural language, such as a violation of [+approximant] alone, and so forth.

[69] Given a rich enough set of constraints, any constraint violation configuration should identify one and only one phonological structure. This is not to say that lexical entries should be encoded as constraint violation configurations, but their near equivalence can be used to some effect (cf Golston 1995).

So, every Prominence scale that is converted into phonological terms, or 'phonologized', is translated into a set of ranked constraints, forming a constraint hierarchy.[70] However, this constraint hierarchy is *not* integrated into the main constraint hierarchy CH, but exists independently. Independent constraint hierarchies will be fully discussed below.

It remains to be seen what *use* this phonologized Prominence scale is. Firstly, take a phonological constraint in CH such as 'Nuc/vowel' which requires a segment in a syllable nucleus to have the same sonority as vowels. In present terms, this constraint requires that the Nucleus of the candidate under evaluation be input into the sonority hierarchy *S*, represented in the tableau above. This will return a set of constraint violations, call it *K*. Now, the actual form of the constraint 'Nuc/vowel' is significant: the term *vowel* does not refer to a set of features, but to a set of *constraint violations*. So, *K* is compared to the violation configuration denoted by *vowel*. If they are not identical the constraint 'Nuc/vowel' is violated.

For example, consider the candidate form /tń/. The nucleus is /n/, so /n/ is input into the sonority constraint system:

(135)

	seg=[+vocalic]	seg=[+approx.]	seg=[+son]
/n/	x	x	

The process that inputs /n/ into the sonority constraint hierarchy *S* returns the violation configuration *K* = {x, x}, as shown in the tableau above. Now, the constraint under consideration is 'Nuc/vowel', where *vowel* denotes the following set of constraint violations: { } in *S*. So, the set of violations denoted by *K* is compared to the set of violations denoted by *vowel*. Since {x x} and { } are not identical, the constraint 'Nuc/vowel' is violated.

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[70] I use the term 'phonologized' following Hayes (1996). See §1.3.1.

At this point it is timely to consider the mechanism used to compare sets of constraint violations. This is easily identified: it is the same process of constraint elimination that is used in computing optimality (§1.2). So, if there is a violation mark in one violation configuration set and an equally-ranked mark in the other set, those two marks will be eliminated. Let us call this process ‘C-Elimination’. If C-Elimination of *K* and *vowel* results in an empty set, the constraint ‘Nuc/vowel’ is not violated. In the case of /tn/ and ‘Nuc/vowel’ the set returned is {x, x}, and *vowel* = { }. This means that the output of C-Elimination is *not* an empty set, therefore violating ‘Nuc/vowel’.

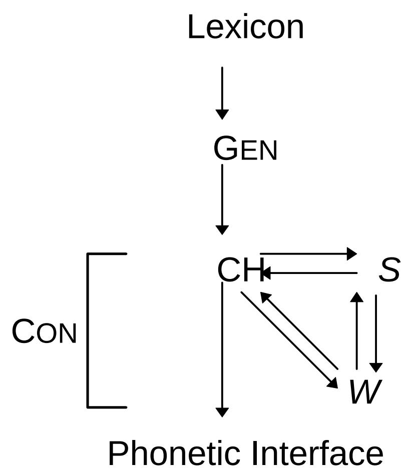
In comparison, consider how the input /tń/ fares with respect to the constraint ‘Nuc/nasal’, which requires that the nucleus of a syllable have the sonority of a nasal consonant. The violation configuration *nasal* denotes a set of constraint violations {x, x}. This set is identical to that returned by /n/, as shown in the tableau representing *S* above. So, C-Elimination will result in an empty set, meaning that ‘Nuc/nasal’ is not violated.

In sum, a constraint in CH such as ‘Nuc/vowel’ specifies an input to an independent hierarchy (in this case the sonority hierarchy). For ‘Nuc/vowel’ this input is the nucleus segment (Nuc). It further specifies a constraint violation configuration – ‘vowel’. The constraint requires that the violation configuration *K*, returned by the process that inputs Nuc to *S*, be identical to that denoted by *vowel* – in other words, that the process of C-Elimination applied to *K* and *vowel* will result in an empty set.

4.2.3 Structure of the Constraint System

Constraint hierarchies such as the sonority hierarchy *S* are not part of the main constraint hierarchy *CH*. Instead, they constitute independent constraint hierarchies in the constraint component CON. The following presents this diagrammatically, with arrows representing input-output flows:

(136)



The lexicon supplies GEN with an input. GEN in turn outputs a number of candidate forms to the main constraint hierarchy CH. CH then filters out all forms except the most optimal, sending this to the Phonetic component. Of interest is the constraint hierarchy *S* (for sonority). GEN does not feed *S* with candidates, nor does *S* output forms to the Phonetic Interface. If *S* did output forms to the Phonetic Interface there would be two different outputs (including the output from *CH*) that would need to be simultaneously realised – an impossibility. Instead, *S* receives its input from CH, and outputs to CH. *S* does not have a *direct* effect on which form is output – its interaction is limited by the nature of the reference from CH (i.e. the form of CH's constraint). In addition, *S* can receive its input from constraint hierarchies other than CH. For example, if an independent hierarchy *W* contains a constraint that referred to sonority, *W* would input the relevant candidate to *S*, as shown in the diagram above. *S* is not the only independent constraint hierarchy – there are as many as there are Prominence scales.

This finally returns to syllable weight hierarchies. It was noted above that weight constraints need to be contained in an *independent* constraint hierarchy. The discussion of phonologized prominence hierarchies above has shown how such independent hierarchies can be integrated into an OT grammar. So, in terms of form, the weight constraint hierarchy is identical to phonologized prominence hierarchies. The difference lies in their source: the structure of prominence hierarchies is determined outside the grammar, while weight hierarchies are internally motivated.

To explain further, consider a constraint in CH such as 'σ́ = Heavy'. This constraint requires that the primary stressed syllable be of the type *Heavy*. The term *Heavy* is actually the label for a set of constraint violations defined in the weight constraint hierarchy *W*. The primary stressed syllable of a candidate form is input to *W* and returns a set of violations, *K*. Thence, *K* is compared to *Heavy* by C-Elimination.

In sum, weight constraint hierarchies are independent hierarchies in the grammar. They are not alone in this regard as all phonologized Prominence scales are similar in form.

4.2.4 Consistency of Ranking

The preceding sections have discussed how Prominence scales are translated into phonological terms. However, there are a number of other issues that have not yet been resolved. P&S's conception of converting Harmony scales to constraints involves the process of Harmony-Constraint Translation, with Universal Domination Conditions playing a crucial role. The process of translating Prominence scales to constraint hierarchies proposed in the preceding section subsumes Prominence Alignment and Harmony-Constraint Translation.

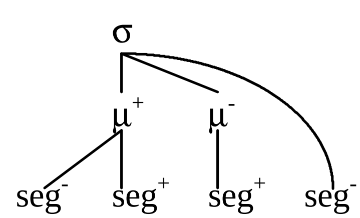
However, the issue of the combination of Prominence scales and the effect of Universal Domination Conditions has not yet been addressed.

These are by no means trivial issues. For example, consider the difference between the constraint sets |Nuc/a » Nuc/t| and |Mar/t » Mar/a|. For P&S, the difference in ranking is a result of Universal Domination Conditions. However, these conditions must now be seen in a very different light – they are not conditions on the ranking of Harmony scales, but on the ranking of constraints that refer to violation configurations in constraint hierarchies.

Consider the constraints ‘Nuc/a’ and ‘Nuc/t’. *a* and *t* denote violation configurations defined in *S* – the phonologized sonority hierarchy. *a* is more optimal than *t* in *S*, in terms of constraint violations. If this is carried further, the ranking |Nuc/a » Nuc/t| can be seen as a preservation of the ranking between *a* and *t* in *S*. In other words, if all else is equal, two constraints will preserve the ranking of their arguments. For example, ‘Nuc/a’ and ‘Nuc/t’ are identical in all respects except that the former refers to *a* and the latter to *t*. Since *a* outranks *t* in *S*, ‘Nuc/a’ outranks ‘Nuc/t’ in CH.

However, this process is not a simple preservation of ranking. The difference in ranking between |Nuc/a » Nuc/t| and |Mar/t » Mar/a| must be explained. The most obvious difference between ‘Nuc/α’ and ‘Mar/α’ is the syllable position they refer to. ‘Nuc/α’ refers to those elements in the syllable nucleus, while Mar/α refers to those in the onset and coda. In a moraic model of the syllable, the categories ‘nucleus’ and ‘margin’ do not have a corresponding constituent. However, the categories can be referred to:

(137)



As explained in §1.1, every category has a head. From the above representation, *head segments* correspond to the traditional category ‘nucleus’. Non-head segments, on the other hand, correspond to the Margin of the syllable. So, the constraint ‘Nuc/α’ can be recast as EXIST(μ,seg^{+}_{a}) ‘There is an autosegmental association from a mora to a head segment of category a’. ‘Category a’ refers to a violation configuration defined in the sonority constraint hierarchy. Mar/α can be similarly expressed, except that the segment in question is a non-head.

This suggests that the different ranking between ‘Nuc/α’ and ‘Mar/α’ is contingent on headedness: headed elements *preserve* the ranking of points defined on other hierarchies, while non-head elements *reverse* it. This is summarised in the following hypothesis:

(138)

<u>Hierarchy-Constraint Translation Hypothesis (HCTH)</u>

If: (i) C_1 and C_2 are constraints in a constraint hierarchy *H*,
and (ii) C_1 and C_2 are identical except for one argument:
α_β in C_1 and α_γ in C_2,
where β and γ denote constraint violation configurations in a constraint hierarchy *A*.

then:

- If $|\beta \gg \gamma|$ in *A* then $|C_1 \gg C_2|$
- If $|\gamma \gg \beta|$ in *A* then $|C_2 \gg C_1|$

– If α is a non-head, then reverse the ranking.

For example, take the two constraints ‘Nuc/a’ and ‘Nuc/t’. These can be more clearly expressed as EXIST(μ, seg^{+}_{a}) and EXIST(μ, seg^{+}_{t}) respectively. In this form, it is evident that these two constraints are almost identical. The only difference is that the seg^{+} arguments refer to different violation configurations – *a* and *t*. Now, in the sonority constraint hierarchy *S*, *a* outranks *t*. Because of this, EXIST(μ, seg^{+}_{a}) outranks EXIST(μ, seg^{+}_{t}). The only difference between ‘Nuc/α’ and

'Mar/α' is that 'Mar/α' employs a non-head segment. So, the ranking is reversed: $\left|\text{EXIST}(\mu, \text{seg}^{-}_{t}) \gg \text{EXIST}(\mu, \text{seg}^{-}_{a})\right|$.

At this point it may seem that all the above is an elaborate scheme simply to explain the ranking of two different constraint sets – 'Nuc/α' and 'Mar/α'. However, this is not so. In the first place, any theory needs to explain the difference in ranking between the two constraint sets. P&S do this by appealing to Universal Domination Conditions, whereas here it is done by the HCTH. The present approach only differs from P&S in making the domination conditions more general. It is this generality that is of use with respect to syllable weight, and serves to justify the above.

Significantly, the HCTH is essential with regard to syllable weight constraints. It was noted above that a syllable that violates fewer constraints is always heavier than one that violates more. There are no stress systems employing NOT-MIN(σ,μ) where CV is ranked over CVV. This fact follows from the HCTH.

Consider the form of the constraint that requires the primary stressed syllable to be of a certain weight: EXIST(Ft^{+}, σ^{+}_{A}) 'There is an autosegmental association between the head foot and a head syllable of type A'. For convenience, constraints of this type will be abbreviated to '$\acute{\sigma}$ = A'. In Maori, for example, there are three such constraints:

(139)

(i) '$\acute{\sigma}$ = Super-Heavy' 'The primary stressed syllable is of the type CV:'

(ii) '$\acute{\sigma}$ = Heavy' 'The primary stressed syllable is of the type CV_iV_k'

(iii) '$\acute{\sigma}$ = Light' 'The primary stressed syllable is of the type CV'

The only difference between these constraints is their reference to different violation configurations on the weight constraint hierarchy *W*. In *W*, Superheavy syllables outrank Heavy syllables, and Heavy syllables outrank Light syllables (see §3.1.1). By the HCTH, then, the constraints must preserve the ranking of the violation configurations. In addition, this involves a headed element: σ^{+}. This allows only one ranking: $|\acute{\sigma}$ = Superheavy » $\acute{\sigma}$ = Heavy » $\acute{\sigma}$ = Light$|$. So, the HCTH is the reason for the generalisation that a language prefers to stress more optimal syllables than less optimal ones. In addition, the HCTH takes the place of P&S's Universal Domination Conditions.

4.2.4.1 A NOTE ON POSITIVE CONSTRAINTS

The status of the sub-categorised element as a head or non-head affects the ranking of constraints according to the HCTH. In fact, there is one further factor that is relevant here: the formulation of constraints.

Something that has been implicit in many discussions of OT is that there are two types of constraint: positive and negative (P&S 1993:128). Positive constraints *require* a certain configuration in an input form, while negative constraints *ban* the configuration. For example, the positive constraint 'Nuc/a' is unviolated only if a syllable nucleus in the candidate form dominates a segment of sonority *a*. In comparison, the negative constraint *Nuc/a is unviolated only if a nucleus in the candidate *does not* dominate a segment of sonority *a*.

At first glance it may seem trivial whether a constraint is positively or negatively expressed.[71] However, their form does affect the HCTH, and necessitates the following emendation:

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[71] On the other hand, allowing positive constraints is not an insignificant matter (de Lacy 1997b). Even so, many analyses in OT have accepted the validity of positive constraints without question (e.g. see P&S 1993:128,129). This thesis will do the same.

(140) Addition to the HCTH: Positive *vs* Negative Formulation:

If C_1, C_2 are negatively formulated then reverse their ranking.

For example, the constraints ‘Nuc/a’ and ‘Nuc/t’ are positively formulated and so are ranked as such: |Nuc/a » Nuc/t|. However, the constraints *Nuc/a and *Nuc/t are negatively formulated, so their ranking is reversed: |*Nuc/t » *Nuc/a|.

In summary, the HCTH subsumes P&S’s Universal Domination Conditions. The HCTH is a universal and inviolable condition on constraint ranking that requires consistency of ranking across all constraint hierarchies in Con.

4.2.5 Learnability

If only one constraint hierarchy (i.e. CH) is permitted in Con the formation of any specific grammar only requires ranking the constraints supplied by UG. However, the preceding sections have suggested that there can be more than one constraint hierarchy. At first glance, this seems to complicate matters significantly: not only do language learners have to rank constraints, they must also *assign* constraints to different hierarchies.

This raises a number of issues. It is reasonable to ask whether all hierarchies contain the same constraints, just differently ranked. One would hope that the answer was in the negative, otherwise there would be a great deal of redundancy as many of the hierarchies would not utilise all the constraints. To avoid this redundancy, it could be proposed that independent hierarchies only contain those constraints they *need*. However, even this causes redundancy – CH will contain all constraints that the other hierarchies contain, as CH contains all constraints.

To avoid this, suppose that UG supplies a finite set of constraints and that a constraint may only appear once in CON. From here, it is a matter of assigning constraints to the relevant hierarchies, with CH being the default destination for constraints. So, all Harmony scales contain a finite number of constraints. This way, hierarchies such as *W* have only as many constraints as they need and there is no replication of weight constraints.

The requirement of assigning constraints to different hierarchies does not place a significantly greater load on the language learner. For the most part, independent hierarchies are formed from extra-phonological scales. So, the apportioning of constraints to these hierarchies is determined by whatever process translates extra-phonological Prominence scales into phonological ones. For independent hierarchies such as *W* the learning process does need to be more complex. However, independent hierarchies of *W*'s type are rare, an unsurprising fact if they require increased computational effort.

In addition, in some cases less learning effort is required – some ranking is determined by the HCTH. In fact, the amount of ranking determined by the HCTH is surprisingly large, including all constraints involving weight reference, sonority reference, feature reference, tonal reference, and any other scale that is determined extra-phonologically.

In summary, the extra requirement of assigning constraints to different hierarchies is offset by the HCTH and the working of Prominence scales. So, the proposals herein do not significantly complicate the learning process.

4.3 SON REVISITED

Having discussed how constraint ranking in CH is controlled by the HCTH, it is timely to reconsider the form of the SON constraint.

I have claimed that prosodic categorisation is relevant for every prosodic node (§2.3.2). This has been demonstrated to be true for the syllable in preceding chapters, and will be shown to be true for other nodes in the next chapter. This raises a question as to whether there are categories of segments. In fact, the answer is in the positive. However, categories of segments are defined not in terms of structure, but in terms of *sonority*.

With this in mind, the form of SON(α,β) may be reconsidered. SON(α,β) requires a node α to dominate a segment of greater than or equal sonority than β. As Prince & Smolensky (1993) have done with regard to the identical constraint HNUC, SON can be decomposed into a set of constraints of the form FINE-SON(α,β), which requires a node α to dominate a segment that *is* of β sonority. For example, FINE-SON(μ,/n/) is violated if a mora dominates a segment with sonority of anything but /n/. This is in fact, identical to the NUC/α and MAR/α constraints discussed above. As explained, the HCTH will ensure that these constraints are ranked correctly as follows: °FINE-SON(μ,/a/) » FINE-SON(μ,/eo/) » FINE-SON(μ,/iu/) » FINE-SON(μ,/ə/) » … FINE-SON(μ,/t/)°.

Considering the form of FINE-SON(α,β), it is evident that this can be stated in other terms. Compare FINE-SON with the constraint EXIST(Ft^+, σ^{Heavy}); this requires that a node Ft^+ dominate a syllable of category *Heavy*. Similarly, FINE-SON(α,β) requires that a node α dominate a segment of sonority category β. So, FINE-SON(α,β) can be restated as EXIST(α, seg^β). At this point, it is evident that constraints on sonority can be recast as EXIST constraints, thus reducing the constraints needed to four: ZERO(α,β), NOT-ZERO(α,β), EXIST(α,β), and NOT-MIN(α,β).

In addition, it explains why segmental sonority is only relevant for syllable categorisation. Since sonority is a property of segments, and categorisation of a node α that refers to sonority must be accessible to segments. The only elements for which this is true are σ and μ.

4.4 IMPLEMENTING SYLLABLE WEIGHT

The preceding sections have focussed on explaining the place of syllable weight constraints in the grammar. This section gives examples of their use in explaining natural language stress systems.

A stress system makes use of at least ALIGN constraints to locate primary stress. It may also employ weight-identity constraints. The latter type take the following form:

(141) EXIST(Ft^{+},$\acute{\sigma}^{X}$)

‘A head foot is associated to a head syllable of category X, where X is a set of violation configurations defined in the weight constraint hierarchy.’

- *Abbreviated to*: ‘$\acute{\sigma}$ = x’

Other stress-related constraints such as NONFINALITY can also play a part.

Firstly, let us consider default-to-same stress systems, such as Maori. Maori requires the leftmost heaviest syllable to be stressed, where heaviness is defined on the scale °CV: > CV_iV_k > CV°. Let us refer to the elements of this hierarchy as Super-Heavy, Heavy, and Light. This requires three constraints, so ranked: |σ́ = Super-Heavy » σ́ = Heavy » σ́ = Light|.[72] In addition, the constraint ALIGN(σ́, L, PrWd, L) is needed to account for the tendency for stressed syllables to align with the left edge of a word. This is ranked below the weight identity constraints:

(142)

	σ́ = super-heavy	σ́ = heavy	ALIGN-σ́-Left
kú.ri:	x!	x	
☞ ku.rí:		x	x

Ranking ALIGN-σ́-Left *above* the weight identity constraints would effectively render them inactive; the leftmost syllable would always be stressed:

(143)

	ALIGN-σ́-Left	σ́ = super-heavy	σ́ = heavy
*☞ kú.ri:		x	x
ku.rí:	x!		x

Similarly, if ALIGN was ranked above 'σ́ = heavy' but below 'σ́ = super-heavy' 'σ́ = heavy' would effectively be rendered inactive.

Default-to-same systems pose little difficulty in explanation. Of more interest are default-to-opposite systems.

[72] This ranking is determined by the HCTH, as discussed in the preceding section.

4.4.1 DEFAULT-TO-OPPOSITE SYSTEMS

The analysis of a default-to-opposite stress system requires ALIGN constraints with differing edge-orientations. In the case of a 'rightmost heavy, else leftmost' stress system such as in Chuvash, heavy syllables align right but the default alignment is left:

(144) (i) ALIGN($\acute{\sigma}^{\text{Heavy}}$, R, PrWd, R)

(ii) ALIGN($\acute{\sigma}$, L, PrWd, L)

These constraints alone will not cause the rightmost heavy syllable to be stressed. ALIGN-$\acute{\sigma}^{\text{Heavy}}$-R only requires that a primary stressed heavy syllable be aligned with the right edge of a word, not that a heavy syllable receive primary stress in the first place. To make sure that heavy syllables are stressed the constraint '$\acute{\sigma}$ = Heavy' is needed, requiring that all primary stressed syllables be heavy[73]:

(145)

	$\acute{\sigma}$ = Heavy	ALIGN-Heavy-R	ALIGN-$\acute{\sigma}$-L
H́ L H		x x!	
H Ĺ H	x!		x
☞ H L H́			x x
☞ Ĺ L L	x		
L Ĺ L	x		x!
L L Ĺ	x		x x!

Interesting effects result from re-ranking weight-identity constraints with ALIGN constraints. In the example above because '$\acute{\sigma}$ = Heavy' outranks ALIGN-Heavy-R,

[73] For purposes of clarity, the candidates used in the following tableaux will not be actual forms but

primary stress will always fall on the rightmost heavy syllable, even if that heavy syllable is not at the right edge of a word. The opposite ranking – with ALIGN-Heavy-R outranking 'σ́ = Heavy' – has a different result. In this case, the stress rule would be of the form: 'Assign stress to the rightmost syllable *if it is Heavy*, else to the leftmost syllable. This is because a stressed heavy syllable that is *not rightmost* will violate ALIGN-Heavy-Right, whereas a stressed light syllable will not, shown in the following tableau:

(146)

	ALIGN-Heavy-R	σ́ = Heavy	ALIGN-σ́-L
H́ L H	x x!		
H Ĺ H		x!	x
☞ H L H́			x x
☞ Ĺ H L		x	
L H́ L	x!		x
L H Ĺ		x	x x!

An example similar to the above is the stress system of Classical Cairene Arabic. This requires that a final superheavy syllable be stressed, else a heavy penultimate syllable, else the antepenult or penult (depending on factors discussed in §3.1.4.1). To explain this, the following constraints can be employed:

(147) (i) ALIGN-SuperHeavy-R » σ́ = Superheavy

(ii) NONFINALITY » ALIGN-Heavy-R » σ́ = Heavy

(iii) ALIGN-σ́-R

sequences of heavy (H) and light (L) symbols. For data, see the relevant sections in chapter 3.

Note that only a heavy penult will be stressed. A heavy syllable in any other position will not attract stress. So, let us consider the ranking with respect to Heavy syllables:

(148)

		NONFINALITY	ALIGN-H-R	ALIGN-σ́-R	σ́ = Heavy
	Ĺ H H			x x	x!
☞	L H́ H		x	x	
	L H H́	x!			
	H́ H H		x x	x x!	x
☞	H H́ H		x	x	x
	H H H́	x!			
	Ĺ L H			x x!	x
☞	L Ĺ H			x	x
	L L H́	x!			
	H́ L H		x x!	x x	
☞	H Ĺ H			x	x
	H L H́	x!			

A final stressed heavy syllable is banned by NONFINALITY. However, the constraint 'σ́ = Heavy' still makes it desirable for the primary stressed syllable to be heavy, despite its low ranking. This, combined with the requirement for a stressed syllable to be rightmost, values a stressed heavy penult. However, a heavy syllable in any other position is not so valued, as shown by the candidate H L H.

4.4.2 A CONSTRAINT TYPOLOGY

Two main constraint types have been identified in the preceding discussion: weight-identity constraints (‘$\acute{\sigma} = x$’) and align constraints that refer to syllable weight (of the form ALIGN(σ^x, Edge, PrWd, Edge)). Various rankings of these constraints produce different effects. These different rankings adequately account for the variety of stress systems found in natural language.

A stress system may be iterative with respect to heavy syllables, or non-iterative. An iterative stress system assigns primary stress to the heaviest syllable closest to a specified edge. In contrast, a non-iterative system assigns stress to a heavy syllable only if it is in a certain position – usually word-initial, word-final, or penultimate (Walker 1996). These two options are explained by differing constraint rankings:

(149) <u>Iterativity</u>:

1. $\acute{\sigma} = x$ » ALIGN($\acute{\sigma}^x$, L/R, PrWd, L/R): Iterative: Results in the leftmost or rightmost syllable (respectively) of category *x* being stressed.
2. ALIGN($\acute{\sigma}^x$, L/R, PrWd, L/R) » $\acute{\sigma} = x$: Non-iterative: Results in a syllable of category *x* being stressed *only if* it is on the left/right edge respectively.

Another constraint that is significant is ALIGN($\acute{\sigma}$, Edge, PrWd, Edge). This requires a primary stressed syllable to be near a certain Edge of a PrWd. This constraint is different from ALIGN($\acute{\sigma}^X$, Edge, PrWd, Edge) in that it does not refer to a weight category.

Languages differ as to whether they assign primary stress by referring to the weight of a syllable or not (for secondary stress see §5.1). For languages that do not refer to weight in assigning stress, the following ranking applies:

(150) ALIGN-σ́-Edge » σ́ = *x*

For languages which refer to syllable weight in assigning stress, σ́ = *x* outranks ALIGN(σ́, Edge, PrWd, Edge):

(151) (i) Default-to-Same side: σ́ = *x* » ALIGN-σ́-Edge

(ii) Default-to-Opposite: σ́ = *x* » ALIGN-$σ́^{X}$-$Edge_i$ » ALIGN-σ́-$Edge_j$

where $Edge_i \neq Edge_j$.

So, the above constraints can explain the basic types of stress system in natural language.[74]

4.5 ALTERNATIVES TO WEIGHT REFERENCE

The need for a separate weight constraint hierarchy is motivated by the claim that ALIGN constraints refer to syllables of different weights.[75] However, this is a contentious issue. Walker (1996) claims that ALIGN constraints do not need to refer to categories of syllable weight. Instead, she uses the following constraints:

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[74] In addition, other constraints can influence the assignment of stress, such as NONFINALITY. When this outranks all constraints, stress never falls on the final syllable. When it is ranked elsewhere, other effects occur (see Walker 1996, §4.1).

[75] Equally as valid evidence is if it can be shown that weights are referred to by other constraints. However, it is difficult to show whether constraints of the form 'σ́ = Heavy' are better than the type 'σ́ = NOT-MIN(σ,μ)'. While there should be observable empirical differences, the paucity of languages that use multiple syllable weight constraints and the variable interpretability of the data offers no clear cases. ALIGN constraints offer a better – a more observable – source for weight reference.

(152)(i) ALIGN ($\acute{\sigma}$, Edge, PrWd, Edge) ‘Align a primary stressed syllable at a certain edge’[76]

(ii) ALIGN ($\acute{\sigma}_{\mu}$, Edge, PrWd, Edge) ‘Align a primary stressed mono-moraic syllable at a certain edge’

The constraint ALIGN-$\acute{\sigma}_{\mu}$-Edge is motivated by Zoll’s (1995) claim that a stressed mono-moraic syllable is prosodically marked, and that such a structure must fall at a word edge.

The intended effect of these constraints is to distinguish between light and non-light syllables. For example, in a ‘rightmost heavy, else leftmost’ system, the above can be ranked as follows:

(153)

	PKPROM	ALIGN-$\acute{\sigma}_{\mu}$-L	ALIGN-$\acute{\sigma}$-R
Ĺ H L H	x!		x x x
L H́ L H			x x!
L H Ĺ H	x!	x x	x
☞ L H L H́			
☞ Ĺ L L L	x		x x x
L Ĺ L L	x	x!	x x
L L Ĺ L	x	x x!	x
L L L Ĺ	x	x x x!	

Even so, these constraints are not adequate for explaining all stress systems. The reason is this: ALIGN-$\acute{\sigma}_{\mu}$-Edge makes an invalid assumption about syllable weight

[76] Walker uses the term ‘Peak’ to stand for $\acute{\sigma}$; this difference is of no consequence (see Walker’s footnote 1).

– it assumes that the notion ‘light syllable’ is synonymous with ‘mono-moraic syllable’.

That this assumption is unfounded is evident in Kara (§3.2.1). Kara has the following weight hierarchy: °Ca: > Ca$\underline{V}$, CaC > Ca > C$\underline{VV}$, C$\underline{V}$C > C$\underline{V}$°. The rightmost non-C$\underline{V}$ syllable in a word is stressed, otherwise the leftmost C$\underline{V}$ syllable is stressed. Since this is a ‘rightmost heavy, else leftmost’ type of language, Walker’s constraints are ALIGN(σ́, R, PrWd, R) and ALIGN($σ́_μ$, L, PrWd, L) with the latter ranked over the former. This works for most cases, as shown below:[77]

(154)

	PKPROM	ALIGN-$σ́_μ$-L	ALIGN-σ́-R
ká.wa:.san	x x!		x x
☞ka.wá:.san			x
ka.wa:.sán	x!		
ϕá.ta:.pu.la:s	x x!		x x x
ϕa.tá:.pu.la:s			x x!
ϕa.ta:.pú.la:s	x x x x!	x x	x
☞ϕa.ta:.pu.lá:s			
☞p^hí.sə.ne	x x x x		x x
p^hi.sə́.ne	x x x x	x!	x
p^hi.sə.né	x x x x	x x!	

However, problems arise when Ca syllables are involved:

(155)

	PKPROM	ALIGN-$σ́_μ$-L	ALIGN-σ́-R
*☞ γá.γa.lu.ə.i.gə	x x		x x x x x
γa.γá.lu.ə.i.gə	x x	x!	x x x x
γa.γa.lú.ə.i.gə	x x x x!	x x	x x x

77 See Appendix 2.1 for glosses.

Here, the rightmost Ca syllable should be stressed: [γa.γá.lu.ə.i.gə] 'my image'. However, ALIGN-$\acute{\sigma}_{\mu}$-L requires Ca to be as close to the *left* edge of the word as possible since Ca is a mono-moraic syllable.

The source of the problem is evident: the division in edge-orientation is not between *mono-moraic* and other syllables in Kara, but between *lightest* syllables (i.e. mono-moraic syllables without an /a/) and other types. It is the mis-identification of the category 'light(est)' with mono-moraic syllables that gives the wrong results here.

So, ALIGN constraints must refer to syllable weight categories, not simply to 'stressed syllables', or 'mono-moraic syllables'. This supports the claim made herein that ALIGN constraints refer to syllable categories.

4.6 SUMMARY

This chapter has covered a number of topics, and suggested some significant revisions to the structure of the grammar. Firstly, it has been shown that a single constraint such as PKPROM cannot adequately account for syllable weight effects in natural language. In comparison, employing a number of weight constraints does supply the necessary distinctions, as shown for Maori (§4.1)

The second point stems from the question as to why syllables that violate the least weight constraints are heavier than others. This chapter considers two possible answers. The first assumes a straightforward method of integration whereby weight constraints are directly included in the main constraint hierarchy. The fact that more optimal syllable types are preferred follows from this direct integration – a heavier syllable violates less constraints than a lighter one, so a candidate with a stressed heavy syllable will violate less constraints than a candidate with a stressed light syllable.

The second answer argues for a more complex mode of integration, with weight constraints contained in a separate hierarchy. In this case, heavier stressed syllables are preferred over lighter ones because of the Hierarchy-Constraint Translation Hypothesis. The HCTH preserves the ranking of elements in other constraint hierarchies, explaining the ranking of various sets of constraints. This approach is argued to be superior to the former on the basis of default-to-opposite stress systems. However, such an approach requires a significant change in conception of the constraint component of the grammar – CON. CON is no longer seen as containing a single hierarchy of ranked constraints, but a number of interacting hierarchies. This has implications not only for prosodic categorisation, but for any processes and constraints that refer to points on Prominence Scales.

5 SYLLABLE WEIGHT IN OTHER CONTEXTS

The preceding chapters have considered syllable weight in the context of primary stress assignment. It is generally accepted that syllable weight also plays a role in locating secondary stress, in defining reduplicative templates and word minima, and in other phonological processes. This chapter considers syllable weight in these other contexts and examines the relevance of weight for prosodic elements other than the syllable.

5.1 SECONDARY STRESS

It has often been argued that the placement of secondary stress is dependent on syllable weight. However, examination of a number of languages suggests that weight with respect to secondary stress and weight with respect to primary stress are two independent concepts.

For example, in Tiberian Hebrew primary stress falls on the ultima if it is a CVC or CV:C syllable, else on the penult (§3.1.4, McCarthy 1979). This means that CV:C and CVC syllables are heavier than CV: and CV syllables for the purposes of primary stress. However, secondary stress works in an entirely different manner:

(156) " [Secondary stress] can fall on any *long vowel* separated by no less than one syllable and no more than one long vowel from the main stress or another [syllable bearing secondary stress]."

[McCarthy 1979:182, italics mine]

So, for purposes of secondary stress only syllables with a long vowel – i.e. CV:(C) syllables – count as heavy, while CVC syllables do not. In sum, the ranking of syllable types is entirely different depending on the level of stress: for primary stress the ranking is ⁰CV:C, CVC > CV:, CV⁰, while for secondary stress the ranking is ⁰CV:C, CV: > CVC, CV⁰. This disparity in weight types at different levels is not an isolated occurrence – Madimadi and Kara provide further examples.

In Madimadi primary stress falls on the second syllable in a word if it is heavy, otherwise on the initial syllable. In this case, a heavy syllable is one that is bi-moraic *or* is a mono-moraic syllable that contains a coronal onset consonant (§3.2.4). Secondary stress falls in two locations: on the initial syllable (if it does not bear primary stress), and on either the ultima or the penult. Which of these final two syllables receive stress depends on the type of syllable: secondary stress falls on the ultima if it is heavy, otherwise on the penult:

(157) wí.ga.ðìn ‘dead’ cf dì.bár.gi.mà.ða ‘to adhere’

A heavy syllable in terms of secondary stress is simply one that is bi-moraic. Significantly, syllables with coronal onsets are treated as light. For example, *gulinada* ‘(he is) angry’ is stressed as [gù.lí.na.da], whereas if syllables with coronal onsets were heavy for secondary stress it would be stressed as *[gù.lí.na.dà].[78] Again, this shows a disparity between what is heavy in terms of primary stress (i.e. bi-moraic and coronal onset syllables) and in the context of secondary stress (i.e. bi-moraic syllables alone).

The final example is Kara. As discussed in §3.2.1, Kara has five degrees of syllable weight for primary stress. However, for secondary stress the distinctions are far less fine-grained.

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[78] A non-initial secondary stress adjacent to the primary stressed syllable is deleted, explaining the lack

Secondary stress can fall in two places: on one of the first two syllables in a word, and on one of the final two. It falls on the peninitial syllable if it is bi-moraic (CVV, CVC), otherwise on the initial syllable:

(158) [ɸa.tàː.pu.láːs] 'keep on doing'

[ɣə̀.lə.pʰʊ́n] 'a swallow'

Similarly, it falls on the ultima if it is bi-moraic, else on the penult:

(159) [ɸáː.si.làk] 'nearly'

[ɸái.so.ɣə̀.ne] 'work it'

[sə́.ŋə.ɸì.lu] 'ten'[79]

Again, the only distinction needed for secondary stress is between bi-moraic and mono-moraic syllables, and again the categories of weight vary depending on the level.

These languages show that there is a disparity between syllable weight in the contexts of primary and secondary stress. In fact, there are a number of other observable differences between primary and secondary stress. Weight distinctions in secondary stress are far less richer than those in the context of primary stress. While there are a number of languages with more than two degrees of primary weight, there are none that have more than a two-way weight distinction for secondary stress. In addition, the factors that differentiate secondary weights are far fewer than those relevant for primary stress syllable

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of stress over /na/ in *gulinada*.

[79] Secondary stress cannot fall on a syllable adjacent to the primary stress. If it does, the secondary stress retracts to a word edge: e.g. gu.sáː.ŋa.nè (not *gu.sáː.ŋà.ne) 'shake it', nì.ŋaŋ.pʰáp (not *ni.ŋàŋ.pʰáp) 'stepmother'.

weight. Specifically, secondary weights are distinguished in terms of only one factor – moraic content.[80]

This can be seen in the stress systems above. In Tiberian Hebrew bi-moraic CV:(C) syllables are heavy with respect to secondary stress while mono-moraic CV(C) syllables are light. Similar generalisations can be made for Madimadi and Kara, both contrasting bi-moraic CVV and CVC syllables with mono-moraic CV syllables.

Recognising a disparity between primary and secondary weight is significant for the study of stress, but it raises the problem of providing an explanation for this difference. Fortunately, a fairly straightforward explanation can be provided. Notably, it involves demonstrating that syllable weight is not relevant for the assignment of secondary stress at all.

5.2 SYLLABLE-BASED STRESS *VS* FOOT-BASED STRESS

The difference between primary and secondary stress is that the former is located with reference to syllable structure while the latter is a side-effect of another process – footing.

In phonological terms, syllables that bear secondary stress are head syllables dominated by non-head feet. Previous studies in stress have argued that the headedness of syllables is determined by the characteristics of feet (Hayes 1981, 1995, Halle & Vergnaud 1987). For example, if a foot is left-headed, the leftmost syllable of those it dominates is marked as the head. In this sense, then, whether a syllable is a marked as a head is a 'by-product' of footing and of the characteristics of the foot's form.

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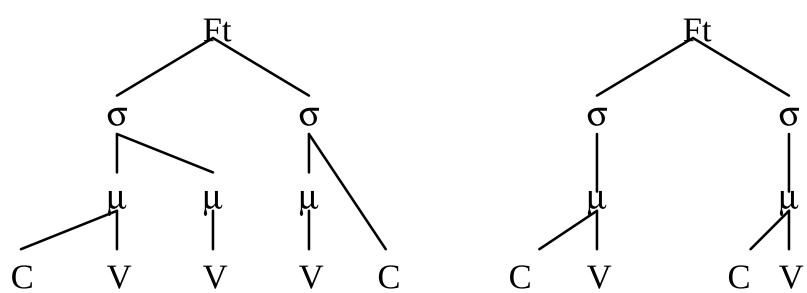
[80] This idea is also proposed in Hayes (1995:270ff).

In short, there is no need to invoke processes or constraints that locate secondary stress on syllables; it is enough to require that feet be constructed, and to specify the characteristics of those feet. This reduces the issue of how secondary stress is assigned to one of foot form. In terms of 'syllable weight', then, the issue for secondary stress is *not* how processes refer to the internal structure of *syllables* to assign secondary stress, but how *feet* distinguish between types of syllables and why they do not make any distinction other than between mono- and di-syllabicity and mono- and bi-moraicity.

This is answered by considering restrictions on foot form. In short, the reason that feet can only be defined in terms of syllables and morae is because these are the only elements that are *accessible*. Consider the following representations of feet:

(160)



Feet can be distinguished by two characteristics: syllable content and moraic content. Feet in quantity-insensitive languages can be of two types – bi-syllabic and mono-syllabic; moraic content is not significant (§1.1.2). The two feet above would be of the same type in this situation as both contain two syllables. So, feet can be distinguished by considering the associations between the foot and σ nodes. This distinction is permissible as the σ node is *accessible* to the foot – it conforms to the stipulations of the Prosodic Accessibility Hypothesis (§1.1.3). Specifically, σ is accessible to the foot as it is tier-adjacent to the foot tier.

For quantity-sensitive languages, moraic content is significant in distinguishing feet (§1.1.2). So, the two feet above are distinct as one contains a bi-moraic syllable while the other does not. In this case, differences in feet depend on relations between σ and μ nodes. Again, this is a licit relation by the Prosodic Accessibility Hypothesis: σ is tier-adjacent to the foot tier, and μ is tier-adjacent to the σ. As such, types – or templates – of feet can be licitly defined in terms of syllabic and moraic content.

Compare this with a hypothetical case where feet are defined by whether they contain a coda consonant. This requires reference to the association between a σ and a segment (seg). In terms of the PAH, *seg* is *not* accessible to Ft – it is neither tier-adjacent to the foot tier, nor adjacent to any node immediately adjacent to the foot tier. A similar argument against onset-sensitivity can be adduced.

In sum, feet can only be defined in terms of the number of syllables and morae they contain, and in no other terms. This effectively explains why syllable weight with respect to secondary stress can only be defined in terms of moraic content: secondary stress is a by-product of footing, and a foot can only distinguish between bi- and mono-moraic syllables.

Unlike secondary stress, primary stress is not simply the by-product of footing. The principal characteristic of a primary stressed syllable is that it is dominated by a head foot. So, the main aspect of assigning primary stress is in *locating* the head foot within the stress domain. All stress systems require reference to a word edge in determining the position of the head foot in a word, and in many languages this is the sole factor involved. An additional stipulation can involve referring to the elements the head foot dominates – by reference to the internal structure of the syllable. It is here that the evaluation of the internal structure of the syllable – the syllable's 'weight' – becomes significant. In effect, the weight of syllables acts as a marker for the location of the head foot. This distinguishes primary stress from secondary stress – while secondary stress is the by-product of footing, primary stress is located with direct reference to the internal structure of syllables.

In summary, syllable weight is not relevant to the assignment of secondary stress. Secondary stress is a side-effect of the characteristics of foot templates. In comparison, syllable weight is relevant to primary stress as it can be used as a marker for the location of a head foot in a stress domain.

5.3 DETERMINING MORAIC CONTENT

The conclusions of the preceding sections have a number of consequences for determining the structure of syllables in a language, especially with respect to moraic content. In fact, the findings of the preceding sections have the result that it is now more difficult to determine whether a syllable contains one or two morae.

For the view that syllable weight is an opposition between bi- and mono-moraic syllables, the fact that a syllable is heavy means that it is bi-moraic. However, this implication no longer stands. For example, consider a stress system which treats CVV and CVC syllables as heavy for primary stress, and CV syllables as light. While the traditional approach would conclude that both CVV and CVC are bi-moraic, this is no longer a necessary consequence. Certainly, one approach could suppose that CVV and CVC are bi-moraic and the constraint employed in this situation is NOT-MIN(σ,μ). However, there is an equally viable alternative: CVV is bi-moraic while CVC is mono-moraic. They can still be grouped together as 'heavy' by using the constraint NOT-MIN(σ,*x*) (see §3.1.3).

This approach also casts light on stress systems in which a heavy syllable contains a full vowel and a light syllable contains a reduced vowel. The traditional view that weight is entirely based on moraic content necessitated the analysis that syllables with full vowels are bi-moraic and those with reduced vowels are mono-moraic (Hayes 1981, 1995). However, with the proposals of this thesis, this is no longer necessary as the constraint SON(μ, full V) can be invoked.

In short, syllable weight is no longer a fool-proof method for determining moraic content in some contexts. While this is a necessary consequence of the proposals in this thesis it leaves the problem of finding another diagnostic for moraicity.

The solution to this lies in processes and devices that refer to moraic content. As discussed above, one such ‘process’ is secondary stress assignment: footing can be used as a diagnostic for moraicity. For example, in Tiberian Hebrew secondary stress falls on CV: syllables *alone*. This selective construction of feet marks only those types containing a bi-moraic syllable, indicating that CV: alone is bi-moraic (§5.4). If CVC syllables were bi-moraic as well then they would also be footed.

In addition to footing there are a variety of other processes that can aid in determining the moraic content of syllables. In many cases, it has been previously assumed that these processes refer to syllable weight. The following section will demonstrate that this assumption is incorrect.

5.3.1 ‘WEIGHT-BASED’ PROCESSES

A number of phonological processes, commonly termed ‘weight-based’ processes, have been claimed to refer to categories of syllable weight. Included among these are reduplication, tone-bearing status, and restrictions on word form. This section argues that this designation is incorrect: there processes do not refer to syllable weight at all.

McCarthy & Prince (1986) have identified a number of prosodic templates used in reduplication. The two that are of immediate interest are the 'light syllable' template σ_{μ}, and the 'heavy syllable' template $\sigma_{\mu\mu}$. From the terminology employed, one might believe that reduplication referred to syllable weight. However, these two templates are not defined by relative categories of 'heavy' and 'light', but in absolute terms – by *moraic-content*: the 'light syllable' template is a *mono-moraic* syllable, and the 'heavy syllable' template is a *bi-moraic* syllable. It has not been shown that reduplicative templates are characterised by anything approximating the richness of syllable weight. So, reduplicative templates are not defined in terms of the categories 'heavy' and 'light', but in terms of moraic content.[81]

The case of reduplicative templates clarifies the import of the observations on syllable weight made in this thesis: syllable weight can no longer be seen as being defined in an absolute manner. Instead, syllable weight is a *relative concept*. A syllable is not 'heavy' or 'light', but *heavier* or *lighter* – or more correctly *more* or *less optimal* in terms of weight constraints. In addition, categories of syllable weight are not absolute – they can vary cross-linguistically just as the ranking of weight constraints can be varied. The term 'weight-related process' was coined when it was believed that the terms 'heavy' and 'light' were synonymous with bi- and mono-moraic syllables. As this thesis has shown, this assumption is incorrect. Just like reduplication, many other so-called 'weight related processes' are not weight related at all – they are dependent upon *moraic content*.

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[81] The implications of this may be that reduplicative templates are types of feet – i.e. H or L feet. An alternative is to reject the idea that reduplicative templates are defined prosodically (McCarthy & Prince 1995).

As another example, consider tone-bearing units.[82] In many tone languages only a bi-moraic syllable can bear a contour tone. While this fact has been adduced as showing that only heavy syllables permit contour tones, it does nothing of the sort: it only shows that *bi-moraic* syllables permit contour tones, consistent with the notion that morae are tone-bearing elements.[83]

Another process claimed to be 'weight-related' is word-minimality. In many languages certain types of words (usually content words) must be of a certain phonological size. For example, in Polynesian languages words must contain at least two morae – i.e. either CVV or CVCV (de Lacy 1995). Again, there is no need to refer to 'weight' in invoking minimal words. The minimal word requirement seems to be almost entirely one of *moraic content* of the word. Certainly, minimal word requirements do not exhibit the variation of syllable weight requirements. In Gordon's (1997) study, the majority of languages required a CVV or CVC minimal word – one that can be easily tied to moraic content.[84]

In summary, so-called 'weight related processes' do not refer to the internal structure of syllables at all, but to *moraic content*. It is only due to the misdiagnosis of syllable weight as dependent on moraic content alone that they have been considered weight related at all. Fortunately, though, their moraic sensitivity is of use in determining the internal structure of syllables.

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[82] For more on tone-bearing units and their relation to syllable weight, see Gordon (1997).

[83] In fact, the status of contour tones as a diagnostic for moraicity is suspect. In some languages contour tones can dock with any type of syllable (Gordon 1997). Gordon's (1997) study of 42 languages in this respect found that tones always docked with vowels, but whether they docked with coda consonants depended upon the consonants' sonority. In some cases it seemed that tones could dock to a non-moraic coda consonant. While this requires further investigation, it indicates that the tone-bearing status does not imply moraicity.

[84] The most notable exception is Estonian, with a minimal word requirement of CVCCC or CVVV. It is unlikely that this restriction is tied to syllable weight, however, probably being dependent on foot-form (see Prince 1983). It is not clear whether minimal word requirements are reliable diagnostics for moraicity. It may be that some languages merely require that a σ node branch, thereby accepting a mono-moraic CVC syllable as a minimal word (see Gordon 1997).

5.3.2 DUAL CRITERIA OF WEIGHT

The identification of 'weight-based' processes as really being sensitive to moraic content has implications for situations where different processes require different distinctions of syllable weight. It has often been assumed that if a syllable type counts as heavy for one process in a language, it counts as heavy for all other processes (Hyman 1985). However, there are a number of counter-examples to this claim.

One of the most well known is Tübatulabal (Swadesh & Voegelin 1979, Crowhurst 1991, Steriade 1990, Hayes 1995). Stress distinguishes CV: syllables from others, therefore implying that only CV: syllables are heavy. However, one reduplicative template copies a CV: *or* CVC syllable, suggesting that CVC syllables are heavy as well (see Crowhurst 1991 for details). In addition, CVG syllables (G is a geminate) do not count as heavy in terms of stress.

Such examples have led researchers to conclude that the moraic model of the syllable is at fault (Hayes 1995:299ff. , Steriade 1990). However, this is no longer necessary. Instead, all that is needed is a rejection of the belief that syllable weight is defined in terms of moraic content alone. As previous chapters have shown, 'syllable weight' is not a unified concept. A heavy syllable for stress may not be the same as for reduplication. This helps explain the inconsistency of weight in Tübatulabal. In this language, CV: and CVC are both bi-moraic, counting as heavy for purposes of reduplication. However, a heavy syllable in terms of stress is defined by NOT-MIN(seg,μ). This correctly separates *long vowels* from all other syllable types, including CVG syllables.

Other examples of languages employing 'dual weight criteria' can be similarly analysed (see Hayes 1995:299, Steriade 1990). This makes the value of the proposals in this thesis evident: by altering conceptions of syllable weight, motivations for altering the moraic model of syllable structure are no longer compelling.

5.4 OTHER PROSODIC WEIGHTS

A large proportion of this thesis has been devoted to syllable weight. However, this does not imply that the syllable is the only prosodic element for which weight is a significant concept. After all, principles such as the PAH and HCTH do not apply solely to syllables, but to any prosodic category. This section shows that the proposals regarding syllable categorisation also apply to other prosodic elements.

Research into prosodic elements higher than the foot in the Prosodic Hierarchy has shown that there are a number of processes that can be analysed as involving weight phenomena. For example, Inkelas & Zec (1995:544) show that phonological constraints can refer to different categories or weights of Phonological Phrases.[85] A preferred phonological phrase in English is one that dominates two PrWds. Similarly, in Serbo-Croation a topic Noun Phrase must be dominated by a branching Phonological Phrase node (Zec & Inkelas 1990). These requirements can be stated as conditions on admissible categories of Phonological Phrase. Specifically, Phonological Phrases are permitted in these languages only if they satisfy NOT-MIN(Phonological Phrase, PrWd).

Even higher in the prosodic hierarchy, Zec & Inkelas (1990) argue that Heavy NP shift in English is only possible if the Noun Phrase involved is dominated by a branching Intonational Phrase. This identification of different prosodic categories shows that phonological processes refer to the weight of prosodic categories other than the syllable.

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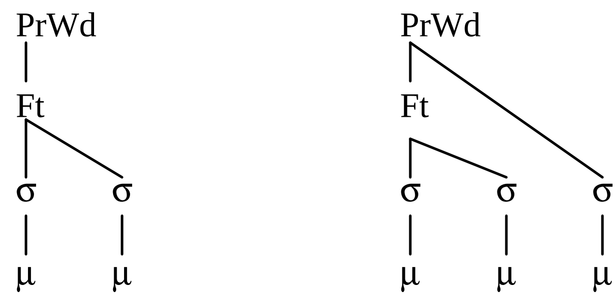
[85] A Phonological Phrase dominates a PrWd (Nespor & Vogel 1986, Zec & Inkelas 1990, Inkelas & Zec

In fact, weight effects can be observed much lower in the prosodic hierarchy: some phonological processes can be analysed as referring to the weight of PrWds. For example, the passive suffix in Maori takes different forms depending on the shape of the PrWd (Blevins 1994, Sanders 1991). It is +*tia* for PrWd's greater than two morae in size, and +*ia* for bi-moraic words. The difference between bi-moraic words and words of three morae or more can be made by reference to the structure of the PrWd:

(161)



The environment for the appearance of the allomorph +*tia* can be stated as following a 'heavy PrWd', where a heavy PrWd does not violate the constraint NOT-MIN(PrWd,*x*).[86]

Some phonological processes refer to the weight of *feet*. This reference to foot weight is most evident in the process of *selective footing*. For example, primary stress in Koya falls on the leftmost syllable and secondary stress falls on all bi-moraic (CVV, CVC) syllables (Tyler 1969, Halle & Vergnaud 1987). In this case, the directive to assign secondary stress is simply of the sort: 'Build (L)H feet'. In other words, only certain *types* of feet are built – selective footing.

Selective footing can be explained by appealing to *foot weight*. Like syllable weight, types of feet can be categorised by using weight constraints. For example, NOT-MIN(σ,μ) picks out all feet with a bi-moraic syllable. Unlike

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1995).

[86] Another distinction is that light and heavy PrWds are sometimes distinct domains for stress rules. A number of languages seem to have different rules for stressing bi-moraic or bi-syllabic words than for words of greater length (e.g. Alyawarra, Aranda §3.1.2, Madimadi §3.2.4, Wosera §3.2.3).

syllable weight, there are far fewer possible feet types to distinguish. In effect, only two constraints are of any use: NOT-MIN(Ft,σ) and NOT-MIN(σ,μ).

In the case where all bi-moraic syllables are stressed in a word, there are two foot-weight related constraints:

(162) (i) *HEAVY-FT 'There is no autosegmental association from PrWd to a heavy Foot'

(ii) *LIGHT-FT 'There is no association from PrWd to a light Ft'[87]

The types 'heavy' and 'light' are distinguished by the constraint NOT-MIN(σ,μ) 'There must be more than one association between a syllable and morae'.[88] A foot with a bi-moraic syllable (LH, H) will satisfy this constraint, while a foot with only mono-moraic syllables (LL, L) will violate it:

(163)

	NOT-MIN(σ,μ)
HL / LH	
LL	x
H	
L	x

The only other constraint needed is PARSE-σ 'All syllables must be parsed into feet'. These three constraints can be ranked in a number of ways. However, their ranking is somewhat restricted by the Hierarchy-Constraint Translation Hypothesis which requires *LIGHT-FT to outrank *HEAVY-FT.[89] This allows only three possible rankings:

[87] In other terms these are *R(PrWd, Ft^{Heavy}) and *R(PrWd, Ft^{Light}), where R is the autosegmental association relation.

[88] These constraints can be used to explain other tendencies in footing. For example, both NOT-MIN(σ,μ) and NOT-MIN(Ft,σ) can be used in the determination of foot weight. This achieves the ranking ° LH > H, LL > L ° (cf Prince 1991). Other combinations are possible, resulting in slightly different effects.

[89] For further explanation of this point, these constraints are of the form *R(PrWd, Ft^{Heavy}) and

(164) (i) PARSE-σ » *LIGHT-FT » *HEAVY-FT

(ii) *LIGHT-FT » PARSE-σ » *HEAVY-FT

(iii) *LIGHT-FT » *HEAVY-FT » PARSE-σ

In the first ranking, all syllables will be parsed into feet, optimally satisfying the highest ranked constraint – PARSE-σ. In the third ranking, it is better to avoid footing syllables at all, so satisfying the higher two constraints on foot form. The interesting case is ranking (2). Here, it is better *not* to form light feet – i.e. those without a bi-moraic syllable, keeping *LIGHT-FT unviolated. However, since PARSE-σ is ranked above *HEAVY-FT it is better to build heavy feet. This can be seen in the following tableau:

(165)

	*LIGHT-FT	PARSE-σ	*HEAVY-FT
☞ L L L L		x x x x	
(L L)(L L)	x x!		
L H L L		x x x x!	
(L H) (L L)	x!		x
☞ (L H) L L		x x	x

In conclusion, selective footing can be explained by appealing to varying rankings of constraints that refer to foot weight.

Foot weight can also be used to explain certain types of lengthening. For example, Hayes (1995:82ff.) discusses a number of cases of iambic lengthening. Here, underling /CVCV/ sequences become /CVCV:/ or /CV.CVC/. This can be explained as the imposition of an iambic LH template on these sequences. In

*R(PrWd, Ft^{Light}), where R is the autosegmental association relation. The only difference between them is the specification 'Heavy' and 'Light', which are violation configurations defined on a separate constraint hierarchy. Since Heavy outranks Light on that hierarchy, *R(PrWd, Ft^{Light}) must outrank *R(PrWd, Ft^{Heavy}), in the main constraint hierarchy (see §4.2.4).

present terms, this can be seen as the result of avoiding violations of the constraint *LIGHT-FT, where a light foot is one that violates NOT-MIN(σ,μ).

This concludes the demonstration that weight is a relevant concept for categories other than the syllable. It is notable that restrictions that apply to syllable weight such as the PAH and HCTH, also apply to other prosodic categories.

In summary, phonological processes may refer to different categories, or weights, of *any* prosodic node. However, these categories must be defined in terms of NOT-MIN(α,β) and EXIST(α,β). In addition, the arguments α,β must be *accessible* to the node in question, where accessibility is restricted by the PAH. Constraints that refer to categories of prosodic elements are also restricted in terms of their relative ranking by the HCTH.

Showing that prosodic categorisation is relevant for prosodic elements other than the syllable has important implications. Of even more significance is the claim that categories of *all* prosodic elements are defined in the same terms – by EXIST, NOT-MIN, and with arguments restricted by the PAH. The general applicability of this approach to prosodic categorisation lends attests to its validity. Syllable weight is not exceptional in the phonology; it is only a specific instance of prosodic categorisation.

5.5 SYLLABLE WEIGHT

The findings of this chapter have a number of implications for the study of stress. For one thing, it is now evident that the majority of natural languages do not refer to syllable weight. For example, consider a language in which stress falls on the ultima if it is a bi-moraic syllable, otherwise on the penult (e.g. Samoan – Churchward 1951, Mosel & Hovdhaugen 1993). It is a common claim that these languages make a distinction between light and heavy syllables. However, this is not correct. These languages only make a distinction between LL and H *feet*. Primary stress is then assigned to the rightmost foot. So, there is no reference to categories of syllable at all in the placement of primary stress, only to the location of Feet.

In fact, of all the phonological processes that have been assumed to be weight related, there is only one for which this can be maintained – the placement of primary stress. In addition, prosodic categories other than the syllable have been shown to have different weights. In most cases it is not syllable *weight* that is at issue but *moraic content*. It is the unfortunate mis-identification of moraic content with syllable weight that has resulted in bi-moraic syllables being called ‘heavy’ and mono-moraic syllables ‘light’.

6 CONCLUSIONS

> "Light syllables contain one mora, heavy syllables two."
> [McCarthy & Prince 1986:7]

> "This suggests that the heavy-light distinction is really one of sonority, not geometry."
> [Prince 1983:58]

At the present time, there are two competing views regarding syllable weight. Structural theories maintain that syllable categories are defined in terms of autosegmental relations (Halle & Vergnaud 1980, Hayes 1981, Hyman 1985, McCarthy and Prince 1986:7, Zec & Inkelas 1990:372, Blevins 1995). In comparison, functional theories distinguish syllable categories by referring to quasi-phonetic notions such as total sonority (Prince 1983:58), or entirely phonetic factors such as prominence (Hayes 1995, cf Gordon 1997, Appendix 3).

The functionalist method of explaining syllable weight is rejected in this thesis. Instead, it is asserted that categories of syllables are distinguished in terms of phonological structure and features alone, in agreement with structural theories. In addition, it is demonstrated herein that the grammar may refer to different categories of any prosodic element, not just to those of the syllable.

Like previous theories, the theory offered herein distinguishes between branching and non-branching structures, implemented by the constraint NOT-MIN(α,β) which is satisfied if there is more than one autosegmental association between a node α and nodes of type β. Despite this initial similarity, previous theories of syllable weight and prosodic categorisation are rejected as empirically inadequate.

Notably, the claim that a prosodic constituent is heavy if and only if it branches is rejected (cf Hayes 1981, Zec & Inkelas 1990, Zec 1988:246). It is shown that it is the *presence* of an element that causes a syllable to be identified as heavy in a number of languages (e.g. Tiberian Hebrew §3.1.4). This is expressed by the constraint EXIST(α,β), which is satisfied if there is one or more than one autosegmental associations between a node α and nodes of type β.

Another significant proposal is that prosodic categorisation is sensitive to properties of nodes. This includes sensitivity to the sonority of individual segments, and to the register (height) of tonal nodes.

Of particular significance are the proposals regarding the accessibility of nodes in prosodic categorisation. Many structural theories of prosodic categorisation adhere to the Strict Layer Hypothesis: categories of a node α can only be distinguished in terms of nodes that are immediately dominated by α (Selkirk 1984, Hyman 1985, McCarthy & Prince 1986:7, Inkelas & Zec 1990:372). The case studies herein show this to be overly restrictive in terms of empirical predictions. The Prosodic Accessibility Hypothesis (PAH) is advanced to take the place of the SLH. One clause of the PAH agrees with the SLH: nodes immediately adjacent to α may be used in identifying categories of α. However, the PAH also allows *minimally non-adjacent* elements to be relevant (cf Itô & Mester 1992). So, in the diagram below, both β and γ can be used in distinguishing categories of α: β is tier-adjacent to α, and γ is minimally non-adjacent:

(166)

$$\begin{array}{c} \alpha \\ | \\ \beta \\ | \\ \gamma \end{array}$$

At this point, it is important to note that none of the proposals require the addition of any new element to current phonological theory. The constraints EXIST and NOT-MIN are used for processes other than prosodic categorisation (§2.3).

Similarly, the PAH is necessary in constraining the form of prosodic structure, taking the place of the SLH. This means that the theory of prosodic categorisation proposed here is as parsimonious as possible: it makes use of elements that are necessary for independent reasons.

Even so, some proposals in this thesis do require significant modifications to the structure of the grammar, specifically within an Optimality Theoretic framework. From efforts to integrate weight-related constraints into the grammar, it is concluded that the constraint component CON contains multiple constraint hierarchies and that these hierarchies interact. Furthermore, it is shown that a principle of ranking consistency affects certain types of constraints – the Hierarchy-Constraint Translation Hypothesis (HCTH). Employing these modifications helps to explain a variety of stress systems that refer to syllable weight.

6.1 IMPLICATIONS

Having summarised the proposals of this thesis, it is timely to consider their implications for phonological theory. One of the most significant conclusions is that *hierarchical locality* in phonological representation must been redefined. This redefinition rejects the assumption that tier-adjacency is the limit of locality. Instead, the PAH allows minimally non-adjacent elements to be accessible. The implications of this are significant given the role of the SLH. The SLH was intended to restrict the formation of prosodic structure. With this rejected, it stands to reason that prosodic structure should be constrained by the PAH. In short, then, an autosegmental relation may only exist between elements that are mutually accessible. So, the PAH is not just relevant for prosodic categorisation, but for the formation of prosodic structure.

Another significant implication of the proposals herein is that 'weight' is relevant at every level of prosodic structure. In other words, the grammar can distinguish between categories of any prosodic element. However, because of the nature of the PAH and weight constraints, a category at one level may not be defined in the same terms as a category at another level. This causes disparity between syllable categories with respect to primary stress, secondary stress, reduplicative templates, minimal words, and other such phenomena (§5).

The proposals in this thesis also have significant implications for the model of the syllable in phonological theory. In fact, the findings of this thesis pose significant problems for the traditional model of the syllable:

(167) "The most robust evidence for the rhyme constituent is based on phenomena sensitive to syllable *weight*."

[Blevins 1995:214]

Syllable weight not only provides the most significant evidence for a rime constituent in the syllable, it is also the best evidence for the other sub-syllabic constituents. The existence of an onset is justified by the claim that the initial non-syllabic elements in a syllable do not contribute to the calculation of syllable weight. Constituents within the rime are also justified by reference to syllable weight. The division between nucleus and coda consonants is justified by the observation that in some languages only a portion of the non-onset elements in a syllable are significant with respect to weight. This is taken to be evidence for a constituent division between nucleus and coda (Halle & Vergnaud 1980, Blevins 1995). As this thesis has shown, there is no need to invoke such constituents in accounting for syllable weight. In all the languages discussed herein, there was never any need to invoke a more highly structured syllable model than the moraic one. In sum, the best evidence for the traditional syllable model has been eliminated.

While the conclusions of this thesis mean that there is no justification for the traditional constituents of the syllable, it also has implications for the *mora* – the only sub-syllabic prosodic element in the moraic model. Consider the following quote from Zec (1995:85):

(168) "The mora serves as a primitive subsyllabic constituent and as a measure of syllable weight".

While various authors have suggested other uses of the mora, these two are the most significant (Hyman 1985, cf Hayes 1989). However, the conclusions of this thesis cast doubt on the validity of the conception of the mora as a measure of syllable weight. The case studies plainly show that syllable weight is not calculated solely in terms of moraic content. In fact, in some languages the mora plays no role in determining syllable weight at all (e.g. Tiberian Hebrew, Tashlhiyt Berber). This means that the primary role of the mora is to serve as a "primitive sub-syllabic constituent". This is a striking contrast to other constituents such as the syllable and foot which serve as reduplicative templates, prosodic templates, and rule domains (McCarthy & Prince 1986). In fact, there are very few roles that can be claimed as being distinctly moraic. In any case, the role of the mora is not to encode syllable weight.

It is unclear where these implications lead. On the one hand, many analyses herein require reference to the mora in determining the weight of a syllable. However, it is surprising, to say the least, that the role of the mora is simply to act as a placeholder in phonological representation. This may mean that the mora is unnecessary as a prosodic constituent, or that it plays a far more restricted role than is currently believed.

A number of proposals in this thesis have significant implications for the structure of the grammar. It is argued that the constraint component CON contains many independent constraint hierarchies. The usefulness of this idea has been shown with regard to prosodic categorisation. However, multiple constraint hierarchies could conceivably be used for other purposes. Whatever these may be, it is clear that permitting multiple constraint hierarchies in CON is a significant change to the structure of the grammar, and one that deserves further investigation.

The End.

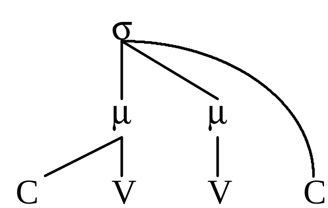
APPENDIX 1: FACTORIAL TYPOLOGY

While a number of languages have been discussed in this thesis, the issue of the predictive power of the present proposals has not been addressed in a systematic manner. Accordingly, this section identifies the empirical predictions of the proposals in this thesis.

For the purposes of the categorisation of prominent positions, only EXIST(α,β) and NOT-MIN(α,β) may be used. In the case of categorising the syllable (σ), the following arguments may be used: σ, μ, *seg* (root node), T(one), and an unspecified node *x*.

The discussion below assumes a syllable structure of $[[CV]_\mu[V]_\mu C]_\sigma$, with coda consonants dominated by the σ node and onset consonants dominated by the first mora:

(1)



A1.1 EXIST(α,β)

The following table lists the various possible EXIST constraints and their effect with respect to syllable weight:

Constraint	Characteristics	Examples
(σ,μ)	Vacuous (all syllables have this relation)	-
(σ,seg)	A syllable with a non-moraic coda consonant ranks above all others. (Esp. °CVC > CVV°, °CVC > CVG°).	Tiberian Hebrew, Ngalakan, Tashlhiyt Berber
(σ,*x*)	Vacuous	-
(μ,seg)	Vacuous	-
(μ,*x*)	Vacuous (identical to EXIST(μ,seg) or EXIST(μ,σ))	-
(μ,T)	All syllables with a (certain type of) tone rank above others.	Molinos Mixtec, Lithuanian, Golin, Serbo-Croatian.
(seg,*x*)	Vacuous (identical to EXIST(seg,μ))	-

The order of arguments is irrelevant for this constraint: if EXIST(α,β) is satisfied then EXIST(β,α) is satisfied and vice-versa. Because of this, a number of constraints can be eliminated (e.g. (seg,σ), (*x*,σ), (seg,μ), (*x*,μ), (Tone, μ), (*x*,seg)).

Of the remaining constraints most are termed 'vacuous'. This means that this constraint will be trivially satisfied since it is a well-formedness condition. For example, EXIST(σ,μ) will always be true because every syllable needs a mora (cf Asheninca). Similarly, EXIST(σ,x) will always be true because there is always a relation (σ,μ). This is also true for (μ,seg), (μ,*x*), and (seg,*x*).

This leaves only two constraints that are of any use: EXIST(σ,seg) and EXIST(σ,T). These constraints are used in a number of stress systems (e.g. Tiberian Hebrew and Lithuanian, resp.).

More than one EXIST constraint can be used in a constraint hierarchy. Molinos Mixtec has been shown to use two EXIST(μ,Tone) constraints. A system that it predicted to be possible by using EXIST(α,β) constraints is one in which weight is sensitive both to the presence of tone and to the presence of a non-moraic coda consonant (i.e. by using EXIST(σ,seg) and EXIST(μ,T) together). In this hypothetical language, a closed syllable with a certain tone would rank over an open syllable with a tone, and so forth. I do not know of such a language, but the existence of such a system does not seem implausible.

A1.2 NOT-MIN(α,β)

NOT-MIN(α,β) allows many distinctions to be made in syllable weight systems. Again, the relevant arguments are σ, μ, *seg*, *x*, and T(one). It should be noted that unlike EXIST, if NOT-MIN(α,β) is violated this does not imply that NOT-MIN(β,α) is violated. For example, a mora node might be branching with respect to segments – NOT-MIN(μ,seg) – but this does not imply that segments are branching with respect to morae: NOT-MIN(seg,μ).

Constraint	Characteristics	Examples
(σ,μ)	Bi-moraic syllables > mono-moraic syllables	Many
(σ,seg)	multiple non-moraic coda consonants > single/no non-moraic coda consonants (CVCC > CV(C))	?
(σ,*x*)	Bi-moraic syllables (CVV) and mono-moraic closed syllables (CVC) > CV syllables.	Southeastern Tepehuan
(μ,σ)	Vacuous (there may be no more than one association from a mora to a σ node)	–
(μ,seg)	Onset > Onsetless	Aranda, Alyawarra, Pirahã
(μ,*x*)	Vacuous (Always satisfied as there are always be two such relations – (μ,σ) and (μ,seg)	–
(μ,T)	Vacuous – There may be no more than one association from a given mora to tones.	–
(T,μ)	Bi-moraic level toned syllables > other types	?
(seg,σ)	Vacuous (see §3.2.7)	–
(seg,μ)	Long vowels > other syllables	Maori, Rarotongan
(seg,*x*)	≈ NOT-MIN(seg,μ)	
(*x*,σ)	Vacuous	–
(*x*,μ)	≈ NOT-MIN(σ,μ)[90]	See NOT-MIN(σ,μ)
(*x*,seg)	≈ NOT-MIN(σ,seg) *or* NOT-MIN(μ,seg): Syllables with onsets and syllables with complex codas *vs* others (i.e. CV, VCC > V(V)(C)).	?
(*x*,*x*)	V < All other types[91]	Aranda,

[90] This is equivalent as NOT-MIN(*x*,μ) is actuated as NOT-MIN(σ,μ) or NOT-MIN(seg,μ). Now, if NOT-MIN(seg,μ) is satisfied then NOT-MIN(σ,μ) must be satisfied, effectively rendering NOT-MIN(seg,μ) ineffectual here.

		Alyawarra

As the table shows, there are some gaps. The first is a stress system in which a syllable with more than one non-moraic coda consonant ranks over other types. It is unsurprising that such a case has not been documented given that the number of languages that allow complex codas is small, and many of these only allow complex codas at the edge of a word (Blevins 1995:219). Given the rarity of complex codas, it is unsurprising that a stress system has not been identified that utilises such a relation.

As for the other gaps, NOT-MIN(T,μ) has been discussed in §3.1.6. NOT-MIN(x,seg) ranks syllables with onsets or complex codas over others. Since onset-sensitivity is extremely rare and complex codas are also rare it is unsurprising that such a stress system has not been identified.

It could be claimed that these gaps are proof that the present proposals overpredict. However, for each unattested case above there are external factors, such as the paucity of languages with complex codas, that affect the likelihood of the stress system being attested in natural language.

A1.3 SON(α,β)

SON(α,β) refers to with the sonority of segments, with α being a node dominating the relevant segment and β being a point on the sonority hierarchy. α can be either σ or μ (§2.1.1). This leaves two possible constraints: SON(μ,β), which requires that an element dominated by μ be of a certain sonority, and SON(σ,β) which requires that a segment dominated by σ be of a certain sonority. Several

[91] (x,x) can be any NOT-MIN constraint. The only syllable that does not satisfy it is one that is minimally complex: [V].

examples of the former type of constraint have been given (§3.1.7) The latter constraint is satisfied if a non-moraic coda-consonant is of β sonority. An example of this type has been given (§2.1.1). Gordon (1997) identifies four other languages in which syllables with a sonorant coda consonant rank over syllables with a non-sonorant coda (Kwakw'ala, Lamang, Inga Quechua, Nootka, and perhaps Chickasaw). Again, SON(σ,β) can be used in these cases.

The final possibility, explored for Pirahã (§3.2.2.2), is that some positions might require a *reversal* of sonority. So, for onsets the constraint would effectively be *SON(α,β) – i.e. a syllable is more highly valued if it contains a segment which is *less* sonorous than point β on the sonority hierarchy. Since this is how the range of onset consonants is defined in most (perhaps all) languages, I see no problems with this solution *per se*.

It would be ideal to give examples of languages in which there is a division of heavy and light syllables at each point in the sonority hierarchy. However, mostly the divisions focus on the mora-licensing elements and so SON(α,β) only comes into play for the vocalic section of the sonority hierarchy. Even so, the languages discussed herein have employed SON constraints that make divisions between /a/, /e o/, /i u/, /ə/, liquids, and sonorant consonants (§3.1.7, 3.2.1, 3.2.3).

A1.4 WHAT CANNOT EXIST

This paper has accounted for a wide variety of weight systems. At this point, though, it is well to consider what the present proposals *cannot* account for, or in other words, what they predict *cannot* exist in a natural language weight system.

Firstly, as discussed in §1.1.3, the PAH prohibits weight categorisations from referring to features. So, a syllable cannot be heavy by virtue of containing a [nasal] segment, and so forth. Secondly, when sonority is concerned a syllable with an element of sonority α cannot be heavier than a syllable with an element of greater sonority than α. Thirdly, since the constraints NOT-MIN(α,β) and EXIST(α,β) are the only ones that can be used for calculating weight a syllable, *x* cannot be heavier than a syllable *y* if the cardinality of (α,β) in *x* is less than or equal to the cardinality of (α,β) in *y*. As an example, if the relation in question is (σ,μ) then a syllable with only one such relation (i.e. a mono-moraic syllable) cannot rank above a syllable with more than one such relation (i.e. a bi-moraic syllable). Similarly, if the relation (σ,seg) is at issue, a syllable without this association cannot outrank one that has this relation.

The final absolute prohibition relates to autosegmental relations. The only cardinality distinctions that can be made are between zero and greater than zero – EXIST(α,β), and one and greater than one NOT-MIN(α,β). No further distinctions can be made. So, there can be no weight system in which a tri-moraic syllable ranks above a bi-moraic syllable, or where a tri-consonantal coda ranks above a bi-consonantal coda.

In addition, there are some implicational restrictions. If a bi-moraic CVC or CV_iV_k syllable is treated as heavy, a CV: syllable will be heavy. If a language treats a CCV syllable as heavy, it will treat a CV syllable as heavy.

Notably, there are a number of changes to previous assumptions about implicata here. For example, it was previously assumed that if CVC is treated as heavy, CVV and CV: would be so treated (Jakobson 1962). This is not the case if CVC is mono-moraic and the constraint used is EXIST(σ,seg) (see §3.1.4, 3.2.6).

The final restriction relates to learnability and computational ability. In other words ‘Is there a limit on the number of syllable weight distinctions there can be in a language?’. In principle, given the structure of the system, there should be no restriction. In practice, there is an obvious tendency for languages to have two weight distinctions (heavy *vs* light). However, the existence of languages like Wosera, which has at least six and possibly twelve distinctions, and Pirahã and Kara (with five) shows that any limit must be quite high. On the other hand, one would be surprised to find a language that employed all the constraints above, valuing a bi-moraic syllable with an onset, complex coda, level high tone, non-sonorous onset, highly sonorous nucleus, and a sonorous coda consonant above other syllable types. Despite the complexity of some of the systems discussed, there was rarely need to employ three constraints, let alone four (perhaps in Wosera). I do not offer any reasons for this cross-linguistic fact, merely noting that it is probably of no theoretical interest.

APPENDIX 2: DATA

This appendix contains additional supporting data for the stress systems of two languages discussed herein – Kara and Maori.

In the case of Kara, additional data are supplied as most of the forms that substantiate the discussion of its stress system in §3.2.1 are from personal communication with Perry Schlie, as yet unpublished. It is important to provide this data as Kara's stress system is unique in the literature and lends empirical support to many theoretical points made in this thesis.

There have been a number of descriptions of Maori word-stress (Biggs 1961, 1969, Hohepa 1967, Bauer 1981, 1993, Schütz 1985, de Lacy 1995). However, none have presented the data in a systematic and comprehensive manner. Like Kara, the stress system of Maori has proven to be important, affecting a number of conclusions about syllable weight and stress throughout this thesis. As such, a systematic list of mono-morphemic forms is presented in Appendix 2.2.

A2.1 KARA DATA

Ca: >	(i) CaV	[ga.lá:k.mai] 'red parrot'
	(ii) CaC	[ka.wá:.san] 'ruin',
		[ϕá:.si.làk] 'sacrifice of abstinence'
		[ma.má:.lo.xàn] 'grief/pity'
	(iii) Ca	[la.pá:.na] 'under'
		[ϕà.pi.sa.xa.yá:n] 'the sixth'
		[ká:k.sa.xa] 'one leg'
	(iv) CVV	[nai.xá:m] 'greed'
	(v) CVC	[ma.má:.luϕ] 'forget'
		[ϕá:.gut] 'strong'
	(vi) CV	[ϕu.á:n] 'fat, grease'
		[ká:.li.u] 'around'
		[ne.má:m] 'we [excl.]'

CaV >	(i) CVC	[ɸái.sɔq] ‘work’[92]
	(ii) CV	[vo.váu] ‘spirit’
CaC >	(i) Ca	[q^{h}áq.sa.ɣə̀] ‘one-leg’ [SS]
		[ɸa.mà.ta.ka.sám] ‘cause to be quiet’
	(ii) CVC	[qə̀.nəm.sát] ‘saddened’ [SS]
Ca >	(i) CVV	[má.lui] ‘healthy’
	(ii) CVC	[ɸə.t^{h}á.pʊs] ‘quickly’ [SS]
		[ɸə.ɣá.ɾə.də̀q] ‘straighten’ [SS]
		[q^{h}á.p^{h}ɪs] ‘plant’ [SS]
	(iii) CV	[nɛ.t^{h}á.rə] ‘we’
		[já.mu] ‘axe’
		[mə.t^{h}á] ‘man’
CVC >	(i) CV	[ɣə̀.lə.p^{h}ʊ́ŋ] ‘a swallow’ [SS]
		[mɛ̀.lə.sʊ́ɸ] ‘meaning’ [SS]

Rightmost Non-CV:
[ɸa.tà:.pu.lá:s] ‘keep on doing’
[ɸa:.sá:l] ‘miss the target/mark’
[nì.ŋaŋ.p^{h}áp] ‘stepmother’ [SS]

Leftmost CV:
[p^{h}í.sə.nè] ‘tie it up’ [SS]
[mə́.t^{h}ə.ɸe.t^{h}ə̀.mə] ‘a family’ [SS]

The forms marked [SS] come from Schlie & Schlie (1993:109). All other forms are from Perry Schlie (p.c.).

A note on secondary stress: Secondary stress can be accounted for by building moraic trochees at either end of the word. For all but the primary stress, foot form must be respected. CVV and CVC count as bi-moraic and so can form an independent foot. Two adjacent stressed syllables are banned. In this case, two things can happen:

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[92] There are two counter examples to this, where CaV is outranked by other syllable types: *bi^{1}.lau* ‘intestines’ and *rəq^{1}.mai* ‘bird type’. I treat these as exceptions.

(1) Deletion: The secondary-stressed syllable loses its stress: [(xù)(t^{h}át)] → [xu.t^{h}át] ‘crayfish’.

(2) Stress Shift: The stress moves to a peripheral syllable: [(q^{h}áq).(sà.γə)] → [q^{h}áq.sa.γə̀] ‘one-leg’.

A2.2 DATA FROM MAORI

L = Long vowel, D = Diphthong, σ = syllable.
(!) indicates that the form is a loanword from English.

(i) σ́σ(σ)	pá.ke ‘obstinate’	kú.a.nu ‘cold’
(ii) Ĺσ(σ)	pá:.ke ‘adult’	kú:.ma.ra *ipomoea batata*
(iii) σĹ(σ)	ku.rí: ‘dog’	ke.ré:.me ‘claim’ (!)
(iv) σσĹ	we.hi.ké: ‘whiskey’ (!)	ta.ra.ki.tá: ‘tractor’ (!)
(v) .. Ĺ L ..	tú:.i: ‘type of bird’	kó:.ke:.i ‘distant, misplaced’
(vi) D́ σ	ái.a ‘retribution’	táu.ra ‘rope, cable, cord’
(vii) σD́(σ)[93]	ku.áu ‘beard’	tu.ái.na ‘twine’ (!)
(viii) D́ D	tái.tei ‘Thursday’ (!)	
(ix) Ĺ D(σ)	kó:.hao ‘hole’	tá:.mai.re ‘term for *kaka* parrot’
(x) DĹ	au.á: ‘herring’	tau.á: ‘ridge’

Words are taken from Williams (1971). Many thanks to Wharepapa Savage for providing native speaker intuitions regarding the stress placement on the above forms.

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[93] In some dialects a word-final diphthong is not stressed, e.g. /kú.au/, not /ku.áu/ (Biggs 1969, Bauer 1981).

APPENDIX 3: PHONETICALLY-DRIVEN APPROACHES TO WEIGHT

This section discusses the a phonetically-grounded theory of syllable weight proposed by Gordon (1997). Due to the fact that Gordon's work is very recent and still under revision at this time, I have refrained from discussing it in the body of the text. I have only chosen to comment on it here as Gordon's proposals are significant for the study of syllable weight and deny the validity of structural approaches, contrary to the claims of this present work.

This thesis has presented an approach to identifying prosodic categories by referring to properties of phonological representation alone. A very recent challenge to this way of approaching weight is Gordon's (1997) proposal that syllable weight distinctions are phonetically grounded. In other words, the designation of a syllable type as heavier than another is not dependent on the phonological structure but on phonetic factors. Gordon maintains that the phonology does play an active role in determining syllable weight distinctions. However, the phonology's role is limited to setting a parameter that designates which phonetic characteristic is relevant.

Gordon identifies two phonetic properties which the grammar can use to categorise syllables – duration and total energy. He argues that if the phonological system of a language chooses to use duration as its defining characteristic of syllable weight, it will (typically) treat (C)VV and (C)VC syllables as heavy and (C)V syllables as light. If, however, it refers to total energy then the language can distinguish between (C)VV and (C)VC syllables, and even between (C)VS and (C)VO syllables (S=sonorant, O = obstruent). He claims that other distinctions such as between low and high vowels and full and reduced vowels are also due to total energy (§5 of his paper).

There are two main issues that deserve close examination in Gordon's theory. Firstly, there is the question of what constitutes an adequate distinction between syllable weights. For example, in Telugu, CVV syllables are heavy and CVC syllables are light. Notably, there is a large discrepancy between total energies for these two syllable types: CVV generates about 205 energy units and CVC about 140-150 units (table 14). So, total energy seems relevant for stress in this language. In comparison, both CVV and CVC are treated as heavy in the poetic register of Telugu speech. This can be explained by examining the durations: CVV is about 140 ms in duration while CVC is about 135 ms (table 13). Gordon claims that this is not a large enough difference, so CVV and CVC syllables are placed in the same category. From this, it could be concluded that the relevant phonetic factor for Telugu poetics is *duration*, but for vernacular speech it is *total energy*.

Perhaps the most important issue relates to what constitutes a ‘significant phonetic difference’ between syllable types. Obviously 5 ms was not a significant distinction in Telugu poetics, but a difference of 55-65 energy units was for stress. Unfortunately, Gordon does not address this question in detail. Of course, this question has great significance with regard to languages with multiple weight distinctions. For example, in Wosera the differences between syllables with /a/, those with /ʌ/ and those with /ə/ must be quite marked (probably in terms of total energy) in order to allow the distinction (§3.2.3). Again, there must be a significant difference between long vowels, diphthongs, and short vowels in Maori and Rarotongan to warrant instantiating a phonological distinction (§3.1.1). This gets more complicated when considering languages with five distinctions (Kobon, Kara, Pirahã) and even six (Wosera).

Perhaps the most interesting questions arise when the predictions in this paper and those of Gordon diverge. In most part the constraints that prefer structural complexity (i.e. NOT-MIN(α,β), EXIST(α,β)) are analogous to increased duration since increased complexity implies more syllabic content. However, in some cases the predictions diverge. Gordon states that “CVC is never heavier than CVV because it never possesses substantially greater energy or duration than CVV." (§5). However, there is a counter-example to this claim: Tiberian Hebrew (§3.1.4).

Another interesting case is Kara. As noted /Ca/ syllables rank above CVC (V ≠ /a/) syllables. However, in Gordon's survey of ten languages low vowels are always significantly shorter in duration than VC rimes (between 40 and 80 ms), and for total energy low vowels can rank as far behind VC rimes as 80 energy units (for Finnish), or rank above VC rimes by a negligible amount (5-10 energy units). Such a ranking would suggest that /Ca/ could never outrank CVC, contrary to the empirical evidence.

As a final point, if syllable weight is motivated by an extra-phonological scale it is perhaps unique among Harmony scales in allowing variable ranking. For example, in some languages CVV ranks above CVC, while in Tiberian Hebrew CVC ranks above CVV. This is a significant fact. In no other phonetically-motivated scales (e.g. Tonal, sonority) is there variation. The phonologized sonority scale is universally fixed, as is the tonal scale. So, the syllable weight scale is unique if it is a phonetically-driven scale.

In conclusions, there is empirical evidence against some of the predictions made by Gordon's phonetically-driven theory of syllable weight. In contrast, the proposals in this thesis can account the attested systems, not by appealing to phonetics, but by evaluating phonological structure.

REFERENCES

Note: The *Rutgers Optimality Archive* is an electronic repository for works on Optimality Theory. It is currently located at the following internet site: *http://ruccs.rutgers.edu/roa.html*.

Archangeli, Diana and Douglas Pulleyblank (1994) *Grounded Phonology,* MIT Press, Cambridge, Massachusetts.

Bagemihl, Bruce (1989) "The Crossing Constraint and 'Backwards' Languages," *Natural Language and Linguistic Theory* 7, 481-549.

Baker, Brett (1997a) "Geminate Dissimilation as Alternation of Prominence in Ngalakan," Ms.., University of Massachusetts, Amherst.

Baker, Brett (1997b) "Edge-Crispness Effects in Moraic Structure," in *Proceedings of the Berkeley Linguistic Society (BLS*) 23.

Barbour, Julie R. (1995) "A Re-Analysis of Syllable Structure in Maori and Samoan," Master of Arts Research Paper, University of Auckland.

Bauer, Winifred (1981) "Hae.re *vs* Ha.e.re: A Note," *Te Reo* 24, 31-36.

Bauer, Winifred (1993) *Maori*, Routledge, New York.

Beckman, Jill (1995) "Shona Height Harmony: Markedness and Positional Identity," in *University of Massachusetts Occasional Papers* 18, Graduate Linguistic Student Association, Amherst, Massachusetts.

Beckman, Jill (1997) *Positional Faithfulness*, Doctoral Dissertation, University of Massachusetts, Amherst.

Biggs, Bruce (1961) "The Structure of New Zealand Maaori," *Anthropological Linguistics* 3, 1-54.

Biggs, Bruce (1969) *Let's Learn Maori*, A.H. & A.W.Reed, Wellington, New Zealand.

Blevins, Juliette (1994) "A Phonological and Morphological Reanalysis of the Maori Passive," *Te Reo* 37, 29-53.

Blevins, Juliette (1995) "Syllable in Phonological Theory," in John Goldsmith, ed., *The Handbook of Phonological Theory,* Blackwell, Cambridge, Massachusetts, pp. 206-245.

Breen, Gavan and Rob Pensalfini (1996) "Arrernte: A Language with No Syllable Onsets," Ms., Institute for Aboriginal Development and the Massacusetts Institute of Technology. [To appear in *Linguistic Inquiry*].

Broselow, Ellen (1992) "Parametric Variation in Arabic Dialect Phonology," in E.Broselow, M.Eid, and J.McCarthy, eds., *Perspectives on Arabic Linguistics,* vol.4., John Benjamins, Amsterdam.

Broselow, Ellen (1995) "Skeletal Positions and Moras," in John Goldsmith, ed., *The Handbook of Phonological Theory,* Blackwell, Cambridge, Massachusetts, pp. 175-205.

Bunn, Gordon and Ruth Bunn (1970) "Golin Phonology," *Pacific Linguistics A23*, Australian National University, Canberra, pp.1-7.

Chomsky, Noam (1986) *Barriers*, Linguistic Inquiry Monograph 13.

Chomsky, Noam and Morris Halle (1968) *The Sound Pattern of English*, Harper & Row, New York.

Chomsky, Noam and Howard Lasnik (1977) "Filters and Control," *Linguistic Inquiry* 8, 425-504.

Churchward, C. Maxwell (1951) *A Samoan Grammar*, Spectator Publishing Co., Melbourne.

Clements, G.N. (1985) "The Geometry of Phonological Features," *Phonology* 2, 225-252.

Clements, G.N. (1990) "The role of the sonority cycle in core syllabification," in J.Kingston & M.E.Beckman, eds., *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech*, Cambridge University Press, London.

Clements, G.N. and Elizabeth Hume (1995) "The Internal Organization of Speech Sounds," in John Goldsmith, ed., *The Handbook of Phonological Theory*, Blackwell, Cambridge, Massachusetts, pp. 245-306.

Clements, G.N. and Samuel J. Keyser (1983) *CV Phonology: A Generative Theory of the Syllable*, Linguistic Inquiry Monograph 9.

Coleman, John & John Local (1991) "The 'No crossing constraint' in Autosegmental Phonology," *Linguistics and Philosophy* 14, 295-338.

Crowhurst, Megan (1991) "Demorificaton in Tübatulabal: Evidence From Initial Reduplication and Stress," *Proceedings of the North-Eastern Linguistic Society (NELS)* 21, 49-63.

Davies, John (1981) *Kobon*, Linguistica Descriptiva Series vol.3., Amsterdam, North Holland.

Davis, Stuart (1982) "Rhyme, or Reason? A Look at Syllable-Internal Constituents," *Proceedings of the Berkeley Linguistic Society (BLS) 8*.

Davis, Stuart (1988) "Syllable onsets as a factor in stress rules," *Phonology* 5, 1-19.

Davis, Stuart (1989) "Stress, Syllable Weight Hierarchies, and Moraic Phonology," *East Coast Conference on Formal Linguistics (ESCOL)* 6, 84-92.

Davis, Stuart (1994) "Geminate Consonants in Moraic Phonology," *West Coast Conference in Formal Linguistics (WCCFL)* 13.

de Lacy, Paul (1995) "Polynesian and Fijian Stress Systems," Ms., University of Auckland.

de Lacy, Paul (1996a) "Circumscription Revisited: An Analysis of Maori Reduplication," *Rutgers Optimality Archive*, number 133.

de Lacy, Paul (1996b) "A Co-occurrence Restriction in Maori," Submitted for Publication.

de Lacy, Paul (1997a) "Rarotongan [Cook Islands Maori] Prosody," Ms., University of Auckland.

de Lacy, Paul (1997b) "Aspects of Phonological Representation," Ms., University of Auckland.

Dell, François and Mohamed Elmedlaoui (1985) "Syllabic Consonants and Syllabification in Imdlawn Tashlhiyt Berber," *Journal of African Languages and Linguistics* 7, 105-130.

Dell, François and Mohamed Elmedlaoui (1988) "Syllabic Consonants in Berber: Some New Evidence," *Journal of African Languages and Linguistics* 10, 1-17.

Dell, François and Mohamed Elmedlaoui (1992) "Quantitative Transfer in the Nonconcatenative Morphology of Imdlawn Tashlhiyt Berber," *Journal of Afro-Asiatic Languages* 3, 89-125.

Everett, Dan and Keren Everett (1984) "On the Relevance of Syllable Onsets to Stress Placement," *Linguistic Inquiry* 15, 705-711.

Everett, Daniel L. (1988) "On Metrical Constituent Structure in Pirahã Phonology," *Natural Language and Linguistic Theory* 6, 207-246.

Firth, J.R. (1957) *Papers in Linguistics*, Oxford University Press, London.

Frantz, C. and M.Frantz (1973) "Gadsup Phoneme and Toneme Units," in H.McKaughan, ed., *The Languages of the Eastern Family of the East New Guinea Highland Stock*, University of Washington Press, Seattle.

Fudge, Erik (1969) "Syllables," *Journal of Linguistics* 5, 253-287.

Fudge, Erik (1987) "Branching Structure Within the Syllable," *Journal of Linguistics* 23, 359-377.

Gahl, Susanne (1996) "Syllable Onsets as a Factor in Stress Rules: The case of Mathimathi revisited," *Phonology* 13.2, 329ff.

Goedemans, Rob (1994) "An Optimality Account of Onset Sensitivity in QI Languages [Preliminary Version]," *Rutgers Optimality Archive*, number 26.

Goldsmith, John (1976) *Autosegmental Phonology*, Doctoral Dissertation, Massachusetts Institute of Technology.

Goldsmith, John (1990) *Autosegmental and Metrical Phonology*, Blackwell, Cambridge, Massachusetts.

Golston, Chris (1995) "Direct OT: Representation as Constraint Violation," *Rutgers Optimality Archive*, number 71.

Gordon, Matt (1997) "Conflicted Weight Criteria and the Theory of Syllable Weight," Ms., University of California at Los Angeles [To appear in *UCLA Working Papers in Phonology 3*].

Grimes, Joseph (1981) "Synthesis and Feedback in Field Linguistics," Ms., *Presented at 101st Meeting of Acoustical Society of America*.

Halle, Morris and G.N.Clements (1983) *Problem Book in Phonology*, MIT Press, Cambridge, Massachusetts.

Halle, Morris and Paul Kiparsky (1981) “Review Article: *Histoire de l’accentuation slave* by Paul Garde,” *Language* 57, 150-81.

Halle, Morris and Jean-Roger Vergnaud (1980) “Three-Dimensional Phonology,” *Journal of Linguistic Research* 1, 83-105.

Halle, Morris and Jean-Roger Vergnaud (1987) *An Essay on Stress*, MIT Press, Cambridge, Massachusetts.

Hammond, Michael (1988) “On Deriving the Well-formedness Condition,” *Linguistic Inquiry* 19, 319-325.

Hansen, Kenneth C. and L.E.Hansen (1969) “Pintupi Phonology,” *Oceanic Linguistics* 8, 153-170.

Hansen, Kenneth C. and L.E.Hansen (1978) *The Core of Pintupi Grammar*, Institute for Aboriginal Development, Alice Springs, Australia.

Harris, J. (1990) “Segmental Complexity and Phonological Government,” *Phonology* 7, 255-300.

Harris, Zellig (1944) “Simultaneous Components in Phonology,” *Language* 20, 181-205.

Hayes, Bruce (1981) *A Metrical Theory of Stress Rules*, Indiana University Linguistics Club, Bloomington, Indianan [Originally Doctoral Dissertation, Massachusetts Institute of Technology, 1980].

Hayes, Bruce (1985) “Iambic and Trochaic Rhythm in Stress Rules,” in M.Niepokuj, M.Vanclay, V.Nikiforidou, and D.Jeder, eds., *Proceedings of BLS 11: Parasession on Poetics, Metrics, and Prosody.* pp. 429-446.

Hayes, Bruce (1989) “Compensatory Lengthening in Moraic Phonology,” *Linguistic Inquiry* 20, 253-306.

Hayes, Bruce (1995) *Metrical Stress Theory: Principles and Case Studies*, University of Chicago Press, Chicago.

Hayes, Bruce (1996) “Phonetically Driven Phonology: The Role of Optimality Theory and Inductive Grounding,” Ms., *Rutgers Optimality Archive*, number 158, [forthcoming in *Proceedings of the 1996 Milwaukee Conference on Formalism and Functionalism in Linguistics*.]

Hercus, Luise A. (1969) *The Languages of Victoria: A Late Survey Part I*, Australian Aboriginal Studies 17, Australian Institute of Aboriginal Studies, Canberra.

Hess, Thomas (1976) *Dictionary of Puget Salish*, University of Washington Press, Seattle.

Hockett, Charles (1947) “Componential Analysis of Sierra Popoluca,” *International Journal of American Linguistics* 13, 259-267.

Hohepa, Patrick (1967) *A Profile Generative Grammar of Maori*, Indiana University Press, Bloomington, Indiana.

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

Hulst, Harry van der and Norval Smith (1984) “The Variety of Pitch Accent Systems: Introduction” in Harry van der Hulst and Norval Smith (eds)

Autosegmental Studies on Pitch Accent. Dordrecht, Holland: Foris Publications, pp.ix-xxiv.

Hume, Elizabeth, Jennifer Mullen and Aone van Engelenhoven (1996) "Initial Geminates in Leti," *Mid-continental Workshop on Phonology* 2, University of Illinois.

Hunter, Georgia G. and Eunice V.Pike (1969) "The Phonology and Tone Sandhi of Molinos Mixtec," *Linguistics* 47, 24-40.

Hyman, Larry (1977) "On the Nature of Linguistic Stress," in Larry Hyman, ed., *Studies in Stress and Accent*, Southern California Occasional Papers in Linguistics 4, Department of Linguistics, University of Southern California, Los Angeles.

Hyman, Larry (1985) *A Theory of Phonological Weight*, Publications in Language Sciences 19, Foris Publications, Dordrecht.

Inkelas, Sharon and Draga Zec (1988) "Serbo-Croation Pitch Accent: The Interaction of Tone, Stress, and Intonation," *Language* 64, 227-48.

Inkelas, Sharon and Draga Zec (1995) "Syntax-Phonology Interface,' in in John Goldsmith, ed., *The Handbook of Phonological Theory,* Blackwell, Cambridge, Massachusetts, pp. 535-549.

Itkonen, Ergi (1955) "Ueber die Betonungsverhältnisse in den finnish-ugrischen Sprachen," *Acta Linguistics Academiae Scientarium Hungaricae* 5, 21-23.

Itô, Junko (1988) *Syllable Theory in Prosodic Phonology*, Garland Press, New York. [Originally Doctoral Dissertation, University of Massachusetts, Amherst, 1986].

Itô, Junko (1989) "A Prosodic Theory of Epenthesis Sites," *Natural Language and Linguistic Theory* 7, 217-259.

Itô, Junko and Armin Mester (1992) "Weak Layering and Word Binarity," Ms., University of California, Santa Cruz.

Jakobson, Roman (1962) *Selected Writings I:Phonological Studies*, Mouton, The Hague.

Käger, René (1993) "Alternatives to the Iambic-Trochaic Law," *Natural Language and Linguistic Theory* 11, 381-432.

Käger, René (1995) "The Metrical Theory of Word Stress," in in John Goldsmith, ed., *The Handbook of Phonological Theory,* Blackwell, Cambridge, Massachusetts, pp. 367-432.

Kahn, Daniel (1976) *Syllable-Based Generalizations in English Phonology*, Doctoral Dissertation, Massachusetts Institute of Technology.

Katada, Fusa (1990) "On the Representation of Moras: Evidence from a Language Game," *Linguistic Inquiry* 21, 641-46.

Kelkar, Ashok R. (1968) *Studies in Hindi-Urdu I: Introduction and Word Phonology*, Deccan College, Poona.

Kenstowicz, Michael (1996) "Quality-Sensitive Stress," Ms., Massachusetts Institute of Technology. [Previously "Sonority-Driven Stress" in *Rutgers Optimality Archive*, 1994, number 33; to appear in *Rivista di Linguistica*].

Kiparsky, Paul (1982) "Lexical Phonology and Morphology." in I.S.Yang, ed., *Linguistics in the Morning Calm*, vol.2, 3-91, Hanshin, Seoul.
Krauss, Michael (1975) "St.Lawrence Island Eskimo Phonology and Orthography," *Linguistics* 152, 39-72.
Krause, Scott (1979) *Topics in Chuckchee Phonology and Morphology*, Doctoral Dissertation, University of Illinois.
Krueger, John R. (1961) *Chuvash Manual*, Uralic and Altaic Series 7, Indiana University.
Ladefoged, Peter (1982) *A Course in Phonetics*, Harcourt Brace Jovanovich, New York.
Laycock, D.C. (1965) *The Ndu Language Family*, Linguistic Circle of Canberra, Series C No.1.
Levin, Juliette (1985) *A Metrical Theory of Syllabicity*, Doctoral Dissertation, Massachusetts Institute of Technology.
Levinsohn, Stephen H. (1976) *The Inga Language*, Janua Linguarum Series Practica No. 188, Walter de Gruyter.
Liberman, Mark and Alan Prince (1977) "On Stress and Linguistic Rhythm," *Linguistic Inquiry* 8, 249-336.
Lytkin, V.I. (1961) "Komi-iaz'vinskii dialekt," Izdatel'stvo Akademii Nauk SSR, Moscow.
McCarthy, John (1979) *Formal Problems in Semitic Phonology and Morphology*, Doctoral Dissertation, Massachusetts Institute of Technology.
McCarthy, John and Alan Prince (1986) *Prosodic Morphology*, Rutgers Technical Report Series, Number 32.
McCarthy, John and Alan Prince (1993a) *Prosodic Morphology I: Constraint Interaction & Satisfaction*, Rutgers Technical Report Series, number 3.
McCarthy, John and Alan Prince (1993b) *Generalised Alignment*, Rutgers Technical Report Series, number 7.
McCarthy, John and Alan Prince (1995) "Faithfulness and Reduplicative Identity," in Jill Beckman, Laura Walsh Dickey, & Suzanne Urbanczyk, eds., *University of Massachusetts Occasional Papers in Linguistics 18: Papers in Optimality Theory*, Graduate Linguistic Student Association, Amherst, Massachusetts, pp.249-384. [Also in René Kager, Harry van der Hulst, & Wim Zonneveld, eds., *The Prosody Morphology Interface*].
Mohanan, K.P. (1984) *Lexical Phonology*, Doctoral Dissertation, Massachusetts Institute of Technology.
Mohanan, K.P. (1986) *The Theory of Lexical Phonology*, Reidel, Dordrecht.
Mosel, Ulrike and Even Hovdhaugen (1993) *Samoan Reference Grammar*, Scandinavian University Press, Norway.
Nespor, Marina and Irene Vogel (1986) *Prosodic Phonology*, Foris Publications, Dordrecht, Holland.

Odden, David (1984) “An Accentual Approach to Accent in Kimatumbi.” in D.Goyvaerts (ed) *African Linguistics: Studies in Memory of M.W.K.Semikenke*. Amsterdam: John Benjamins, pp.345-419.

Odden, David (1995) “Tone: African Languages,” in John Goldsmith, ed., *The Handbook of Phonological Theory,* Blackwell, Cambridge, Massachusetts, pp. 444-475.

Ohala, John J. (1974) “Phonetic Explanation in Phonology,” in *Papers from the Chicago Linguistic Society Parasession on Natural Phonology*, pp. 251-274.

Ohala, John J. (1983) “The origin of sound patterns in vocal tract constraints,” in P.MacNeilage, ed., *The Production of Speech*, Springer, New York, pp. 189-216.

Ohala, John J. and Manjari Ohala (1993) “The phonetics of Nasal Phonology: Theorems and Data,” in Mariek Huffman and Rena A.Krakow, eds., *Nasals, Nasalisation, and the Velum*, Academic Press, San Diego.

Pankratz, L. & E.V.Pike (1967) “Phonology and Morphotonemics of Ayulta Mixtec.” *International Journal of American Linguistics* 33:287-299.

Payne, Judith (1990) “Asheninca Stress Patterns,” in Doris L.Payne, ed., *Amazonian Linguistics: Studies in Lowland South American Languages*, University of Texas Press, Austin, pp. 185- 212.

Pike, Kenneth and E.Pike (1947) “Immediate Constituents of Mazatec Syllables,” *International Journal of American Linguistics* 13, 78-91.

Prince, Alan (1976) “’Applying’ Stress,” Ms., University of Massachusetts, Amherst.

Prince, Alan (1983) “Relating to the Grid,” *Linguistic Inquiry* 14, 19-82.

Prince, Alan (1985) “Improving Tree Theory,” in M.Niepokuj, M.Vanclay, V.Nikiforidou, and D.Jeder, eds., *Proceedings of BLS 11: Parasession on Poetics, Metrics, and Prosody*, pp. 471-490.

Prince, Alan (1991) “Quantitative Consequences of Rhythmic Organisation,” in K.Deaton, M.Noske, and M.Ziolkowski, eds., *Proceedings of the Chicago Linguistic Society 26*, vol 2.

Prince, Alan and Paul Smolensky (1993) *Optimality Theory*, Rutgers Technical Report Series, number 2.

Rice, Keren (1992) “On Deriving Sonority: A Structural Account of Sonority Relationships,” *Phonology* 9, 61-99.

Sagey, Elisabeth (1986) *The Representation of Features and Relations in NonLinear Phonology*, PhD Dissertation, Massachusetts Institute of Technology [Published in 1991, Garland Press, New York].

Sagey, Elisabeth (1988) “On the Ill-formedness of Crossing Association Lines,” *Linguistic Inquiry* 19, 109-118.

Salisbury, Mary (1993) *A Grammar of Pukapukan*, Doctoral Dissertation, University of Auckland.

Sanders, G. (1991) "Levelling and Reanalysis in the History of Polynesian Passive Formations," *Journal of the Polynesian Society* 100, 71-90.

Schlie, Perry and Ginny Schlie (1993) "A Kara Phonology," in *Data Papers on Papua New Guinea Languages: Phonologies of Austronesian Languages 2*. SIL Academic Publications, Papua New Guinea, pp. 99-130.

Schütz, A. (1985) "Accent and Accent Units in Maori: The Evidence From English Borrowings," *Journal of the Polynesian Society* 94, 5-26.

Selkirk, Elisabeth (1980) "The Role of Prosodic Categories in English Word Stress," *Linguistic Inquiry* 11, 563-605.

Selkirk, Elisabeth (1982) "Syllables," in H. van der Hulst and N.Smith, eds., *The Structure of Phonological Representations*, vol.2, pp. 337-383, Foris Publications, Dordrecht, Holland.

Selkirk, Elisabeth (1984) "On the Major Class Features and Syllable Theory," in M.Aronoff & R.Oehrle, eds., *Language and Sound Structure*, MIT Press, Cambridge.

Skorik, P. (1961) *Grammatica čukotskogo jazyka*, Moscow.

Smolensky, Paul (1995) "On the Internal Structure of the Constraint Component *Con* of UG," *Rutgers Optimality Archive*, number 86.

Sprouse, Ronald (1995) "Vowels that borrow moras: Geminates and Weight in OT," *Proceedings of the North-Eastern Linguistic Society (NELS) 1995.*

Stampe, David (1973) *How I Spent My Summer Vacation (A Dissertation on Natural Phonology*, Doctoral Dissertation, University of Chicago.

Steriade, Donca (1988) "Review Article: Clements and Keyser: CV Phonology," *Language* 64, 118-129.

Steriade, Donca (1990) "Moras and Other Slots," *Proceedings of the First Conference of the Formal Linguistics Society of Mid-America (FLSM) 1.*

Stowell, Timothy (1979) "Stress Systems of the World, Unite!," *Massachusetts Institute of Technology Working Papers in Linguistics* 1, 51-76.

Strehlow, T.G.H. (1944) *Aranda Phonetics and Grammar*, Oceania Monographs 7, Sydney University Press.

Swadesh, Morris and Charles F. Voegelin (1939) "A Problem in Phonological Alternation," *Language* 15, 1-10.

Tanaka, Shin-ichi (1989) *Weight, Extrametricality, and Foot Typology in Prosodic Theory*, Master of Arts Thesis, University of Tsukuba.

Tranel, Bernard (1991) "CVC light syllables, geminates and moraic theory," *Phonology* 8, 291-302.

Tryon, Darrell T. (1967) *Ngenone Grammar*, Pacific Linguistics Series B, Australian National University, Canberra.

Tyler, S.A. (1969) *Koya: An Outline Grammar*, University of California Publications in Linguistics 54.

Walker, Rachel (1996) "Prominence-Driven Stress," *Rutgers Optimality Archive*, number 172.

Willett, Elizabeth (1982) "Reduplication and Accent in Southeastern Tepehuan," *International Journal of American Linguistics* 48, 168-184.

Williams, Herbert W. (1971) *A Dictionary of the Maori Language*, 7th edition. A.R.Shearer, Government Printer, Wellington, New Zealand [Originally Published in 1844].

Woodbury, Anthony (1985) "Graded Syllable Weight in Central Alaskan Yupik Eskimo (Hooper Bay-Chevak)," *International Journal of American Linguistics (IJAL)* 51, 620-623.

Woodbury, Anthony (1987) "Meaningful Phonological Processes: A Consideration of Central Alaskan Yupik Eskimo Prosody," *Language* 63, 685-740.

Yallop, Colin (1977) *Alyawarra: An Aboriginal Language of Central Australia*, Research and Regional Studies 10, Australian Institute of Aboriginal Studies, Canberra.

Zec, Draga (1988) *Sonority Constraints and Prosodic Structure,* Doctoral dissertation, Stanford.

Zec, Draga (1995) "Sonority Constraints on Syllable Structure," *Phonology* 12, 85-129.

Zec, Draga and Sharon Inkelas (1990) "Prosodically Constrained Syntax," in Sharon Inkelas and Draga Zec, eds., *The Phonology-Syntax Connection,* University of Chicago Press, Chicago, pp. 365-378.

Zoll, Cheryl (1995) "Licensing and Directionality," Ms., University of California, Berkeley.

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