Chapter

Two

Prosodic Structure:

Theoretical Foundation

2.0. Introduction:

In this chapter, I lay out the fundamental theoretical foundations required for the analysis of the data in the following chapters. In particular, I compare the two theoretical frameworks of DT and OT, as far as the processes of syllabification and metrification in UHA are concerned. I survey the basic ideas suggested in the relevant primary literature, and relate individual rules to constraints or, where appropriate, to sets of constraints interacting to achieve a unified effect. This will highlight the areas of strength and weakness of both frameworks.

The chapter comprises two sections. The first section is about syllables. In this section, I examine issues of syllable structure and sonority to try to elicit the motivation behind theories of syllabification (Steriade (1982), Itô (1986), and the relevant OT literature). In section two, I present the main principles of metrification, paying particular attention to the issues of extrametricality and foot degeneracy (Halle and Vergnaud (1987), Idsardi (1992), and Hayes (1995)).

2.1. Syllables:

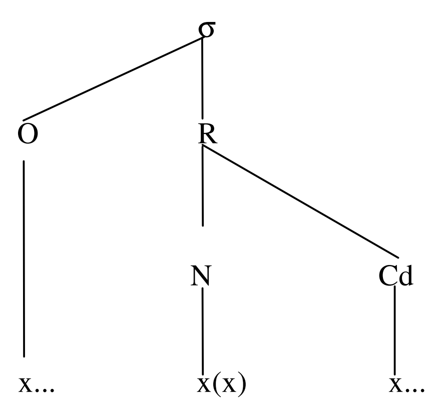
It did not take phonologists long to express their reservation about a theory denying the existence of the syllable as a distinct phonological constituent, as is the case in *SPE*. Among the earliest critics were Fudge (1969), Vennemann (1972), and Hooper (1972), who analysed several cross-linguistic phenomena demonstrating the need for the syllable for purposes of explanatoriness. In the late seventies and early eighties, work by Kahn (1976), McCarthy (1979a), Selkirk (1982), Clements and Keyser (1983), and others consolidated the role of the syllable. Three types of evidence have been put forward, in support of this stance. First, phonotactic constraints have the syllable as the natural domain. Second, rules of segmental phonology can only be adequately expressed and characterised with reference to the syllable. Third, supra-segmental phenomena like stress and tone make reference to the syllable, as they call for this intermediate level between the word or morpheme and the segments to express their assignment rules more adequately.

It is this prosodic domain this section sets out to investigate. Its internal structure and process of construction, i.e. syllabification, are of great importance for the description of further complexities in UHA. In addition to instances of segmental deletion and insertion, such complexities will be seen to involve higher prosodic domains, the foot in particular. However, before going into such matters, I will present the preliminary theoretical material required for the language-specific application in the next two chapters. Broad, yet essential, issues regarding the development of the syllable theory within the overall phonological theory are discussed. This will involve summarising the main contributions that are directly related to the objectives of this study.

2.1.1. Sonority and Syllable Structure:

In this subsection, I would like to establish the fundamental syllable structure that the syllabification theories sketched below are trying to achieve. This means highlighting the existence of subsyllabic constituency, which is motivated by different factors. Take, for example, weight-sensitive metrification, or requirements on the minimal-word. These must recognise subsyllabic constituency in order to draw a distinction between heavy and light syllables. This is because, in almost all cases, onsets do not count in syllable weight. On the other hand, vocalic and post-vocalic elements determine syllable weight. Such a cross-linguistically attested phenomenon motivates the binary hierarchical structure of syllables binding nuclei and codas under a subsyllabic constituent traditionally termed the rime, and distinguishing the onset as the other constituent.[1]

(1)



(O = onset, R = rime, N = nucleus, Cd = coda)

The most robust piece of evidence supporting the existence of subsyllabic constituency is the sonority requirement imposed on the segmental content of syllables.

[1] The moraic approach to syllable structure (section 2.2. below), advocated by researchers as Hyman (1985), McCarthy and Prince (1986), Hayes (1989), among others, stems form such a binary branching structure of an onset and a rime.

The rising sonority values from an onset towards a nucleus, and the decline from the latter towards a coda hints at some type of grouping holding between pre-vocalic consonants, on the one hand, and post-vocalic ones, on the other. Below, I will present a formalisation of this property of syllables demonstrating its effects on syllable structure.

Sonority is a property of sounds. In particular, it is the "sort of prominence associated with a segment by virtue of the way in which that segment is intrinsically articulated" (Trask 1996: 327). Therefore, basic sound classes may be ordered in a hierarchy showing their relative sonority values. More than one grading of sonority have been presented by different scholars, Hooper (1976), Kiparsky (1979), Broselow (1979, 1980), among others. The one that follows represents the mainstream.

(2) a. Stops
b. Fricatives
c. Nasals
d. Liquids
e. Glides
f. Vowels

This Sonority Hierarchy shows the two extremes of sonority, with vowels as the most sonorous and oral stops as the least. Crucially, however, we want to know the relation between this hierarchy and syllable structure. In other words, we want to find out how such a sequencing may contribute to subsyllabic constituency.

As mentioned above, it has always been claimed that the connection between sonority and syllable structure is rather perspicuous: Vennemann (1972), Selkirk (1982, 1984a), among others. In essence, a syllable is considered to be a mountain of sonority.

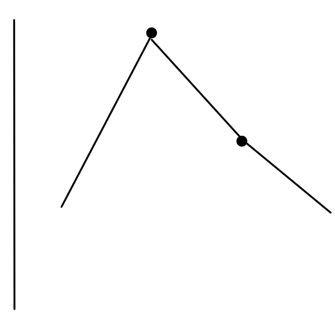
This mountain's peak is occupied by the syllable's most sonorous segment, which is usually a vowel. Also, the peak may be preceded and/or followed by margins that are crucially less in sonority. This configuration results in a mountain-like curve of sonority starting from the onset ascending towards the peak and then descending towards the coda. This is not everything, however. In well-behaved syllables, this order starts from and throughout the onset, if it is a complex one, and ends at the coda affecting it equally. The closer to the margin a segment is, the lower in sonority and vice versa. This property of the sonority curve exhibited in syllables may be formalised as follows (cf. Selkirk 1984a):

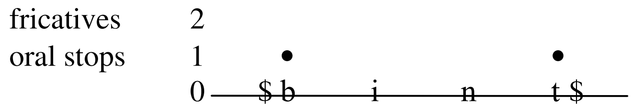
(3) Sonority Sequencing Principle (SSP)
The sonority profile of the syllable must slope outwards from the peak.
(Roca 1994: 153)

To see how this principle affects syllable structure, let us consider a concrete example. Take the UHA word [bint] 'girl or daughter' as an example of a monosyllabic word with the canonical shape CVCC. Such a syllable has a simple onset, as it is the case with all syllables in the language, but it has a complex coda. This makes it a potential example to demonstrate the sonority requirement imposed on syllabification by the SSP. Consider the following representation:

(4)

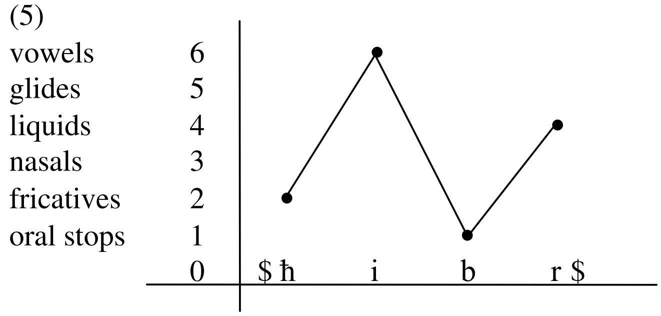
vowels	6
glides	5
liquids	4
nasals	3





Apparently, this syllable is well-behaved as far as the SSP is concerned. There is only one peak preceded and followed by a smoothly descending sonority curve towards the syllable boundaries. It starts with an obstruent onset segment /b/ ascending upwards to the peak that is occupied by a vowel. Then, it descends towards the other syllable boundary without experiencing any troughs. This is because the first consonant of the coda, closer to the peak, is more sonorous than the one closer to the margin; /n/ is higher in the sonority scale than /t/. This is not the case with all underlying strings, though. Consider the representation of a word like /ħibr/ ‘ink’:

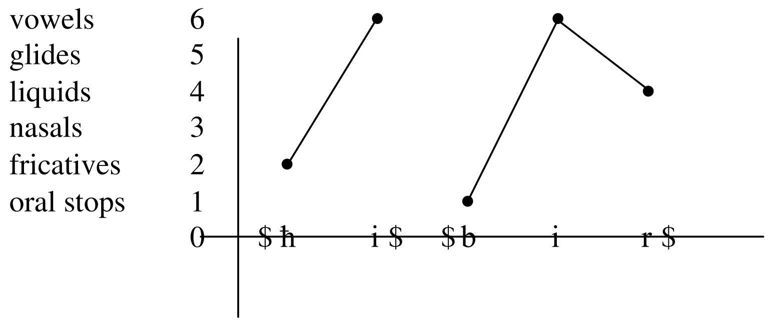
(5)



Such syllabification exhibits a violation of the SSP. The consonant closer to the syllable boundary is more sonorous than the one closer to the peak. Consequently, a sonority trough on /b/ is created. UHA, as we shall discuss thoroughly in the next two chapters, inserts an epenthetic vowel between the two coda consonants creating a new syllable and, consequently, a new sonority curve. This indicates that the subsyllabic constituency may not tolerate more than one sonority peak. To see the result of this

process graphically, consider the following representation :

(6)



These two examples demonstrate the role sonority plays in syllable structure and syllabification. In particular, the relation between syllable peaks and sonority peaks is clear in the second example (as we shall see in chapter three below, Clements 1997 introduces an OT constraint interpreting this relation). In the next chapter, I will address the matter again, considering a wider range of data and presenting a more substantial analysis.

Syllables are therefore not a haphazard grouping of underlying segments. There are well defined subsyllabic constituents, which impose constraints on syllabic segmental parsing. The question to address now is how this syllable structure is achieved. The following subsection tackles this issue presenting different approaches to syllabification.

2.1.2. Syllabification:

After establishing the existence of the syllable and recognising its role in phonological description, linguists aimed at syllabification. It was not a question of whether or not the syllable structure was predictable.[2] What has always stirred a great deal of discussion was the issue of achieving that structure. Within DT, a number of proposals were put forward endeavouring to formalise the syllabification process. Basically, these theories belonged to two distinct groups: one that views syllabification as a product of rule derivations (Kahn 1976, Steriade 1982, and Levin 1985) and another that achieves it through template-matching (Selkirk 1978, Halle & Vergnaud 1978, and Itô 1986). I will be mainly focusing on Steriade (1982) and Itô (1986) applying them to UHA in chapter four. These two theories fairly represent their respective frameworks. In what follows, I will present a summary of the main arguments, principles, parameters, etc. claimed by each theory. I will wind up this section with a note on syllabification in Optimality Theory, in an attempt to show how some of the main principles of syllabification are being interpreted as OT constraints.

2.1.2.1. Rule-based Syllabification:

Adopting Kahn's (1976) proposals of rule-based syllabification, Steriade (1982) proposed her theory that universalises the unmarked minimal syllable (C)V. She basically introduced a derivational syllabification procedure allowing for the incorporation of other processes. She recognised that some languages may require such an intermediate level of representation to achieve the environment of later

[2] Processes that are motivated by syllabification like epenthesis and syncope in UHA (cf. the next two chapters) point to the absence of syllable structure in underlying forms.

syllabification rules. In what follows, I will summarise her Core syllabification rules and two other main principles she proposed.

Steriade draws a clear line separating universal aspects from language-specific properties of syllabification. Crucially, she recognises the cross-linguistic tautosyllabicity of any CV sequence, and introduces a universal rule that interprets this phenomenon. Also, acknowledging the common, though language-specific, coda and onset cluster formation, she posits the coda and onset rules, respectively.

The first and foremost universal aspect of syllabification proposed by Steriade (1982, 1984) is the First Rule or Cv-rule. This rule creates the universally unmarked minimal syllable: CV.

```
(7)     (C)v    →        (C)  v
                          |   |
                          O   R
                           \  |
                             σ
```

(Steriade 1982: 78)

So, in any sequence of Cs and Vs, this rule will parse every V with a preceding C under a syllable node, literally translating the cross-linguistically attested CV tautosyllabicity, hence complying with what Roca (1994) terms the Minimal Onset Satisfaction Principle, given below:

(8) Minimal Onset Satisfaction Principle:
Onsetless syllables are disallowed (in the presence of suitable melodic material).

(Roca 1994: 145)

There are two important universal aspects of the Cv-rule, its order among other (language-specific) syllabification rules and the directionality of its application.

Steriade claims that the Cv-rule applies first in the derivation, and this may and will bleed other rules of syllabification. This is a predictable property of such a rule if it is to guarantee the Minimal Onset Satisfaction Principle. If, for example, a coda formation rule (to be discussed shortly) applies prior to the Cv-rule, to a VCV sequence, the highly marked *VC.V syllabification would result. This means that the order of this Cv-rule among other syllabification rules is universally set.

In addition, Steriade (1984) demonstrates that the Cv-rule must be universally set to apply from left-to-right. In almost all cases, applying the Cv-rule rightwards or leftwards makes no difference as we are grouping vowels with preceding consonants. However, building on the assumption that the high vowels /i, u/ are unspecified for the feature [syllabic], she claims that unless the Cv-rule applies in the set direction, an undesired syllabification of Latin words like *avia* [auia] 'grandmother' will arise. This claim is clarified in (9) below where segments that are unspecified for syllabicity are represented by Xs on the skeletal tier:

```
(9)a.  a u i a      >>   a u i a      >>   a u i a      >>   a u i a
       | | | |      | | | |      | | | |      | | | |
       v x x v           v x x v                v x x v             v   x
x  v
                         |                 | | |              | | | |
                         R                 R O R              R O R R
                         |                 | \ |              | \ | |
                         σ                 σ  σ               σ  σ  σ
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```
b.   *a u i a     <<    a u i a     <<    a u i a     <<    a u i a
      | | | |     | | | |           | | | |     | | | |
      v x x v           v x x v                 v x x v           v  x
x  v
      | | | |        | | |              |  |
      R R O R             R OR                   O R
      |  | \|              | \|             \ |
      σ σ  σ              σ  σ                σ
```

Therefore, only the left-to-right iteration of the Cv-rule achieves the surface true syllabification of /auia/ → [a.ui.a] rather than *[a.u.ia]. However, this also shows that the Cv-rule plus the two conditions on its application are insufficient to account for the syllabification of other intervocalic consonants. This means that other syllabification rules are in order.

Steriade thinks that the existence of other syllabification rules, their order and mode of application, and the environments they affect are the basic language-specific properties of the syllabification process. The Onset-rule and the Coda-rule are the other two members of the Core Syllabification Rules of Steriade's theory. It is a language-specific property whether or not either or both of these rules exist at all. Below is Steriade's universal configuration of these two rules:

```
(10)   a.    Onset-rule                b.    Coda-rule
             CCV   →    CCV                  VC    →    VC
              | |       \||                  |          |/
              OR         OR                  R          R
              \|         \|                  |          |
               σ          σ                  σ          σ
                                                (Steriade 1982: 78-9)
```

In languages where complex onsets are attested, some form of (10a) must be utilised. Similarly, (10b) creates codas.

If a language requires both rules, i.e. a language with attested optional codas and complex onsets, then the rules in (10) must be relatively ordered. Ideally, it is preferable to have a set universal order of application holding between these two rules, but linguistic facts may not be consistent with such an appealing objective. Languages like English tend to maximise onsets before creating codas, sometimes bleeding the realisation of the latter completely. On the other hand, languages like Klamath do the opposite (cf. Steriade 1982).

Another language-specific property that Steriade talks about is related to the mode of application of the onset and the coda rules. It has been established above that the Cv-rule operates in an iterative fashion exhausting all possible sequences matching its environment. This is not entirely the case with the Onset-rule and the Coda-rule, however. Their iterative mode may be parametrically set to create bounded or unbounded constituents.[3] This means that they may not be allowed to operate more than a certain number of application creating the maximum template of the language (Clements and Kayser 1983).

The last property that Steriade claims to be language-specific is manifested in the effects that the segmental content has on the application of the Onset-rule and the Coda-rule. Certain sonority distances, for example, play a decisive role in determining

[3] Steriade borrowed this term from metrical phonology, as she thinks that her syllabification rules are reminiscent of their metrical counterparts in their properties of iteration and boundedness.

the syllabic content. Acknowledging such constraints, language-specifically, may block the application or the iteration of either or both the Onset-rule or Coda-rule.

That is not the whole story, however. As stray segments are the underlying material on which syllabification rules apply, Steriade introduces two central principles governing their parsing: Stray Adjunction and Stray Erasure. Crucially though, the two principles identify a stray segment differently. The former applies prior to syllabification locating the segments to be parsed, and the latter applies after it deleting unparsed ones.

Steriade proposed this very general principle of syllabification, which I choose to term the Stray Adjunction Principle, given in (11) below:

(11) Core syllable rules apply to stray segments.

(Steriade 1982: 84)

Simply, this principle blocks the application of core syllabification rules if that would render a change in the syllabic configuration of a previous cycle. This means that such rules will only affect unsyllabified, stray, segments.

The other syllabification principle is hinted at quite frequently in such works as McCarthy (1979a), Harris (1983), and Cairns and Feinstein (1982). However, it is Steriade who first acknowledged the existence of what she termed, and is known since, as the Stray Erasure Convention. This principle will demand deleting segments that are not phonologically licensed..

(12) Stray Erasure Convention:
Erase segments and skeleton slots unless attached
to higher levels of structure.

(Steriade 1982: 89)

Therefore, the output of this convention must contain no unsyllabified segments, as it applies at the end of the cyclic and the phrasal component.

To summarise, Steriade proposes a set of syllabification rules. She universalises the existence and the conditions imposed on the application of one, namely the Cv-rule. However, she leaves the other two to be determined language-specifically. The Cv-rule must apply first and in an iterative left-to-right fashion. The Onset-rule and the Coda-rule, on the other hand, are parametrically set to either exist or not and, if they do, iterate or not. Also, languages choose different orders holding between these two rules and impose phonotactic constraints on their application. This means that we can, in principle, interrupt the syllabification process. In other words, since there is more than one rule involved in the construction of a single syllable, other rules that are external to syllabification may be fed by or feed the onset or the coda rule, for example. But, the cross-linguistic motivation for this explanatory power is not that strong, and, more crucially, the generalisations we miss by adopting this approach to syllabification, are quite substantial. These are the type of questions addressed in the following section, where an alternative approach is provided.

2.1.2.2 Template-based Syllabification:

Building on ideas basically proposed by Selkirk (1978), Halle & Vergnaud (1978), and McCarthy (1979a), Itô (1986) argues for a theory interpreting

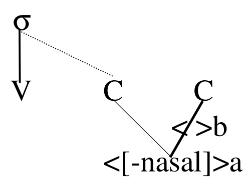
syllabification as a process of uninterrupted template-matching that is regulated by wellformedness conditions (both universal and language-specific) and directionality. She thinks that the very principles of Prosodic Phonology favour her framework over any other rule-based analysis, founded on stipulative extrinsic rule orderings. In what follows, I will summarise her main arguments in this respect and clarify her viewpoint about two other essential principles, viz. Structure Preservation and Extraprosodicity.

The principles of prosodic phonology Itô talks about may also be presented as arguments for her proposed framework. For purposes of syllabification, she basically advocates two principles and a parameter: Prosodic Licensing, Locality, and the parameter on directionality.

Prosodic Licensing is a universal principle that requires parsing all phonological constituents into higher respective levels. Therefore, all segments must be syllabified, all syllables must be metrified, all feet must be parsed into phonological words, and so on. Accordingly, the universality of such a principle and its cross-linguistic adequacy may not be ignored. Nevertheless, Itô thinks that this is what a rule-based theory of syllabification would dictate. She thinks that Prosodic Licensing is made redundant by the structure-building phonological rules like Steriade's core syllabification rules. Whenever their environments are met, such rules will independently apply associating segments with syllabic positions without any need to refer to Prosodic Licensing, or other principles of the sort, questioning its existence in phonological theory.

The other principle of prosodic phonology promoted by Itô is Locality. This principle requires that the wellformedness of prosodic constituents be interpreted only within the constituent concerned. Itô claims that phonological rules, employed by any rule-based theory of syllabification, will not always adhere to Locality. Her example of the Japanese coda supports her claim. In Japanese, no segment is licensed in the coda position unless it is a nasal or a geminate, therefore also associates with the onset of the following syllable. A rule-based theory, cannot offer anything better than (13) to account for this condition.

(13)

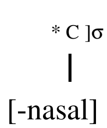


[if a, then b]

(Itô 1986: 31)

Even if we accept the complexity of (13) and its use of the notorious angled brackets notation, we may not overcome the violation of Locality brought about by stipulatively referring to the following syllable. A wellformedness condition, operating within a theory of template-matching as in (14) below, can convey the same information and adhere to Locality at the same time.

(14) Japanese Coda Condition:



(Itô 1986: 26)

What this condition is saying is that you may not have a *singly* linked non-nasal coda, while allowing a nasal and *doubly* linked coda consonants.[4]

Finally, Itô demonstrated that the parameter on directionality can account for some aspects of syllabification that will need to be extrinsically analysed in a rule-based approach. For example, mapping syllable templates in a language-specific directionality can predict the asymmetric sites of epenthetic vowels, introduced to syllabify the second consonant of a tri-consonantal intervocalic cluster in Iraqi and Cairene:

(15)	a.	ʔult-lu →	ʔul.ti̱.lu	(left-to-right mapping)
		gilt-la →	gi.li̱t.la	(right-to-left mapping)

(cf. Itô 1986: 193)

Therefore, we can say that, as far as these principles of prosodic phonology are concerned, Itô could argue for the superiority of her proposal somewhat convincingly. This is not the only reason why I will be adopting this approach to syllabification. It is the nature of her proposal (precisely the principles of Structure Preservation and Extrametricality) that is quite germane to the facts of UHA, if compared with Steriade's or any rule-based approach. In particular, I will demonstrate, in chapter 4 below, that Itô's interpretation of extrametricality as a lexical licensing mechanism plays a decisive role in syllabifying final consonants to superheavy syllables.

Itô summarises her theory of syllabification in two fundamental assumptions, given in (16) below:

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[4] In an OT framework, similar wellformedness conditions may be interpreted as constraints.

(16) i. Language-specific syllabification conditions are stated in terms of wellformedness conditions.

ii. Syllabification is not performed by a set of language-specific rules but by the universal association mechanism (which includes initial association as well as reassociation and dissociation).

(Itô 1986: 49)

Considering these two assumptions plus other remarks scattered throughout Itô (1986), we can say that syllabic parsing in this theory proceeds in a language-specific directionality maximally associating a language-specific syllabic template before introducing the next one. This mapping is *blocked* if the resulting syllabic configuration violates either a universal or a language-specific wellformedness condition.[5] The only universal wellformedness condition acknowledged by Itô is the Core Syllable Condition, which is a mere translation of Steriade's Cv-rule, and hence equivalent to Roca's Minimal Onset Satisfaction Principle.[6]

(17) Universal Core Syllable Condition:

IF C V

THEN σ

(Itô 1986: 5)

Itô appealed to Structure Preservation to maintain this proposal. Kiparsky (1983) introduced Structure Preservation as a convention maintaining the satisfaction of wellformedness conditions at the level of lexical phonology. So, a syllabic

[5] Blocking the process of template matching to maintain a wellformedness condition like the Universal Core Syllable may not be attained unless the proposed theory is equipped with a device anticipating the configuration of the next template matching. This means that an intervocalic consonant is not associated to a coda position to avoid creating a following onsetless syllable. This ability to look ahead is too powerful. Alternatively, Itô (1989) suggests that a process of moraification should precede and consequently feed syllabification. In this proposal, melodic elements are parsed into moras and then into syllables. In chapter four, I will apply this proposal to UHA demonstrating that it is the only feasible solution to a fundamental shortcoming of Itô's earlier proposed method of template matching.

[6] This condition, which strictly guarantees the tautosyllabicity of any CV sequence, is translated into OT constraints as we shall see below.

configuration that violates any wellformedness condition is subject to dissociation and/or reassociation (resyllabification) motivated by Structure Preservation. As I mentioned above, this principle is only operative at the level of lexical phonology**,** so structures not adhering to a wellformedness condition may be tolerated postlexically. When we talk about extraprosodicity, we will see how we can relate this to UHA.

Finally, the way in which Itô views extrametricality (extraprosodicity) provides a more plausible account of our data, as we shall see in chapter four. Capitalising on the claim that extraprosodicity is another mechanism of licensing, along with syllabification, Itô proposes universalising its application throughout the lexical level, but not postlexically. This means that peripheral segments that cannot be syllabified, as a result of maintaining a wellformedness condition, may be licensed extraprosodically, thereby, escaping Stray Erasure. However, they must be properly licensed by a syllable node postlexically. This is motivated by both the existence of Stray Erasure and the absence of Structure Preservation and extraprosodicity postlexically. In chapter four, we will adopt this assumption, and dwell more on its consequences, to account for the final consonant of superheavy syllables in UHA.

To sum up, I have presented Itô's main arguments concerning the principles of prosodic phonology that favour a template-matching approach over a rule-approach to syllabification. Prosodic Licensing, Locality, and the parameter on directionality point at some sort of superiority of Itô's theory. We have seen the proposed interaction of Structure Preservation and extraprosodicity, on the one hand, and Stray Erasure, on the other, allowing for different syllabic configurations lexically and postlexically. In

chapter four, I will apply this framework to the facts of UHA, providing a clearer idea of the advantages and disadvantages of this theory as compared to Steriade's approach.

2.1.2.3. Syllabification in OT:

The fundamental issue discussed in this section is the formalisation of primary constraints that convey the principles of syllabification, sketched above. In an effort to achieve this objective, Prince and Smolensky (1993) translate Jakobson's syllabic typology into a set of universal constraints aiming at the universal core syllable CV. In what follows, I will summarise their main ideas.[7]

According to Clements and Keyser (1983), the primary set of core syllable types, cross-linguistically, contains the following sequences:

(18)
a. CV
b. V
c. CVC
d. VC

(Clements and Keyser 1983: 28)

In particular, they cited a claim made earlier by Jakobson (1962) that languages neither forbid onsets nor require codas. This means that all languages have onsetful syllables, open ones, and some may allow nothing else. It also means that languages may have optional consonant-initial syllables but never ban them, and optional consonant-final ones but never require them. So, if we consider the inventory in (18) above along with Jakobson's claim, we will find that (18 a and d), i.e. CV and VC, occupy the two

[7] Blevins (1995) provides a thorough typological analysis of syllables.

extremes of markedness. Cross-linguistically, the former is the least marked syllable type, and the latter is the most highly marked one. To summarise, consider the following CV syllable structure typology:

(19)

		Onsets	
		Required	Optional
Codas	Forbidden	ΣCV	Σ(C)V
	Optional	ΣCV(C)	Σ(C)V(C)

(Prince and Smolensky 1993: 85)

According to Clements are Keyser (1983), there are two operations involved in deriving the three marked core syllables from the least marked one CV. The first involves deleting the initial consonant of the CV syllable type to have V. The second one involves adding a final consonant to the CV syllable type to have CVC. However, we need both operations to create VC from CV. This means that the process of basic syllabification can involve deletion and/or insertion. As the discussion progresses in the following chapters, I will be referring to these two operations as "underparsing" and "overparsing" respectively. So, how can Optimality Theory achieve this typology? This question is addressed below.

2.1.2.3.1. Basic Syllable Structure Constraints:

In this section, I shall focus on the set of constraints employed to determine the set of possible core syllables, presented above. Following Prince & Smolensky (1993), I will present these constraints as members of two families: Structural constraints and Faithfulness constraints. We will also find that some of these constraints are put in a

superordinate position, while others may be relatively ranked to meet language-particular requirements.

These two sets of constraints will aim at the least marked core syllable, CV, since it is at the very positive extreme of markedness. Such constraints, specially the structural ones, will be telling us that every syllable ought to be a CV (cf. Steriade's Cv-rule). Of course, this is not always the case. Here comes one of the main principles of Optimality Theory, Violability. We are not aiming to achieve the ideal or the perfect, e.g., "every syllable must be of the type CV". We are only trying to attain the optimal that may always minimally violate some constraints.

Based on this, let us now try to figure out the structural constraints that optimise CV. If we consider this syllable type, we will notice some specific structural properties. First, it has an onset and a nucleus, but it does not have a coda. Another thing is the lack of complexity in the association lines between the structural tier and the CV tier: only one C or V is associated to a given syllable position node:

(20)

```
   σ
  /|
 O R
 | |
 | N
 | |
 C V
```

The third trait we notice is that the nucleus is occupied by a vowel and the onset is occupied by a consonant. Out of observations like these, Prince & Smolensky postulated the following structural constraints:[8]

(21) a. NUC: Syllables must have nuclei

b. * COMPLEX: No more than one C or V may associate to any syllable position node.

c. * M/V: V may not associate to margin nodes (onsets and codas)

d. * P/C: C may not associate to peak nodes (nuclei)[9]

e. ONS: Syllables must have onsets

f. -COD: Syllables must not have codas[10]

(Prince and Smolensky (1993))

Obviously, this set of structural constraints interpret two essential principles of syllabification. Firstly, the constraints NUC, ONS, and -CODA conspire to attain the same effect as the Cv-rule (cf. Itô's Universal Core Syllable Condition and Roca's Minimal Onset Satisfaction). Secondly, *M/V and *P/C maintain the sonority requirement governing the syllable's internal structure. Keeping margins as consonantal and peaks as vocalic relates to subsyllabic constituency, discussed above.

In addition to this family of constraints, there are the Faithfulness constraints, PARSE and FILL. These constraints aim at restricting surface structures to those that exhibit a one-to-one correspondence with input segments (Prince and Smolensky

---

[8] These basic syllable structure constraints conspire to achieve the effect of the Cv-rule.

[9] The two constraints *M/V and *P/C maintain the sonority requirement imposed on syllable structure. In particular, the subsyllabic constituency where peaks are distinguished form margins is clearly emphasised in these constraints.

[10] McCarthy and Prince (1993) used ONSET and NoCODA for ONS and -COD respectively.

1993). In other words, this family of constraints considers the perfect syllable structure to be the one that can occupy all and only those segments of an input. This means that insertion or deletion are not preferred. These Faithfulness constraints are stated as follows:[11]

(22) a. PARSE: Underlying segments must be parsed into syllable structure

b. FILL: Syllable positions must be filled with underlying segments.

(Prince and Smolensky 1993: 85)

According to Prince & Smolensky (1993), of the constraints mentioned so far, only these two Faithfulness constraints along with the two structural ones, ONS and -COD, may be relatively ranked in an order of dominance to satisfy language-particular requirements. The remaining structural constraints, NUC, *COMPLEX, *M/V, and *P/V ought to be "fixed in superordinate position" (Prince and Smolensky, 1993: 88). Thus, the question to address now is how language-particular ranking of the basic syllable structure constraints may help optimise true phonological outputs.

2.1.2.3.2. Ranking and Language-particular Satisfaction:

To see how we may rank syllable structure constraints to serve our language-particular purposes, we must know that there are two angles from which we should view this ranking. First, the relative ranking of structural constraints, on the one hand, and Faithfulness ones, on the other, will determine whether onsets are required and/or whether codas are forbidden. Secondly, the relative ranking holding between the

[11] As we shall see in chapter three, this pair is substituted by the correspondence pair MAX and DEP.

Faithfulness pair will reveal how the onset requirement and/or the coda banning are enforced.

Let us start with onsets focusing on ONS, PARSE, and FILL. I will basically try to demonstrate that ranking ONS with respect to the Faithfulness pair will determine if onsets are required or not. On the other hand, ranking PARSE and FILL with respect to each other will show how this onset requirement is enforced. To do so, let us take the simple input /V/ and evaluate a set of three candidate analyses, each exhibiting a single violation of one of the three constraints in question.

(23)	a.	V	violates	ONS
	b.	<V>	"	PARSE
	c.	V	"	FILL

If we want to optimise the candidate .V., we would have to rank the constraint it violates, i.e. ONS, lower than the other two. Consider the following tableau:

(24) Onset Not Required:

/V/	FILL	PARSE	ONS
a. ☞ V			*
b. <V>		*!	
c. V	*!		

(Note that the relative ranking of FILL and PARSE is not decisive, and this is indicated by the dotted line separating them).

We conclude from this that a language optimising a candidate violating ONS like (24 a) is one that does not require onsets, that is, is a language in which onsets are optional. As demonstrated in tableau (24), this is achieved by ranking ONS lower than the Faithfulness pair. On the other hand, consider the following tableaux:

(25) Onset Required:

(i) Enforcement of the Requirement by Underparsing:

/V/	ONS	FILL	PARSE
a. V	*!		
b. ☞<V>			*
c. V		*!	

(ii) Enforcement of the requirement by Overparsing

/V/	PARSE	ONS	FILL
a. V		*!	
b. <V>	*!		
c. ☞ V			*

These two tableaux are indicative of two main points. First, both show that onsets are required, in languages that apply these two rankings, since .V. is never optimised as a result of ranking ONS higher than, at least, one of the Faithfulness constraints. Again, the relative ranking of a structural constraint like ONS and the Faithfulness pair proves decisive as to whether onsets are required or not. The other thing that is revealed by the tableaux in (25) above is the relation between the relative ranking of PARSE and FILL and the manner in which the onset requirement is enforced. By ranking FILL higher than PARSE in (25 i), the onset requirement in the optimal output is enforced by deletion, violating the lower ranked constraint. That candidate vacuously satisfies ONS by having no structure at all. Also, by ranking PARSE higher than FILL in (25 ii), the onset requirement in the optimal analysis is enforced by epenthesis, i.e. by creating an empty position that can later be filled by an onset to satisfy ONS.

As for codas, the same line of argument may be pursued. I will show that the relative ranking of -COD and Faithfulness determines whether or not codas are banned. Also, I will demonstrate that the relative ranking of FILL and PARSE decides how

exactly such a banning is enforced. To do that, I will consider some candidate analyses of the input /CVC/ such as:

(26)	a.	CVC	violates	-COD
	b.	CV<C>	"	PARSE
	c.	CV.C	"	FILL

We will reach the inevitable conclusion that when PARSE and FILL dominate -COD, in any language-particular ranking of constraints, codas will be considered optional. Consider the tableau below:

(27) Coda not Banned:

/CVC/	PARSE	FILL	-COD
a. ☞ CVC			*
b. CV<C>	*!		
c. CV.C		*!	

Similar to what we have seen with ONS, if -COD dominates either PARSE or FILL, codas will be forbidden. This banning will be enforced by either deletion or epenthesis. This is a function of the relative ranking holding between the pair.

(28) Coda Banning:

(i) Enforcement of the Banning by Underparsing:

/CVC/	FILL	-COD	PARSE
a. CVC		*!	
b. ☞ CV<C>			*
c. CV.C	*!		

(ii) Enforcement of the Banning by Overparsing:

/CVC/	-COD	PARSE	FILL
a. CVC	*!		
b. CV<C>		*!	
c. ☞ CV.C			*

Both tableaux in (28) show that codas are forbidden by virtue of ranking -COD higher than one of our pair of constraints on Faithfulness. They also show that compliance with -COD can be enforced by deletion of the final C, as in (28 i), or by epenthesis introducing an empty position, eventually filled by a vowel. This will create a new syllable, the onset of which is the final C of the input as in (28 ii).

Therefore, we saw that the process of ranking the basic syllable structure constraints involves two major steps that are decided differently to suit different languages. We first need to decide whether onsets are required and/or whether codas are forbidden by considering the syllable types of the language. This will allow us to determine the ranking of the structural constraints with respect to their Faithfulness counterparts. Then, we will have to decide the way in which requirement of onsets, if they are required, is enforced, and the way in which banning of codas, if they are forbidden, is enforced. This will help us determine the relative ranking of PARSE and FILL. This is the goal I shall aim to achieve in chapter three where I talk about syllabification in UHA employing OT.

By this I conclude the discussion of syllables after summarising the main proposals that are to be applied to UHA in the following two chapters. I introduced the two basic DT syllabification approaches and demonstrated how their basic ideas could be translated into OT. I also talked about the important issue of Sonority demonstrating how central it is to the internal structure of the syllable. In the remainder of this chapter, I will present the theoretical foundations for the other central issue discussed in the study, namely footing and stress assignment.

2.2. Footing and Stress Assignment:

The process of footing, the driving force behind stress assignment, involves a great deal of cross-linguistic variation. Stressologists, however, aim at a limited set of principles that are just capable of explaining the considerable diversity in attested stress patterns (cf. Liberman and Prince (1977), Hayes (1981, 1995), Prince (1983), Halle and Vergnaud (1987), Idsardi (1992), Kager (1993), Halle and Idsardi (1995), etc.). For example, Halle & Idsardi (1995) think that a formal account of cross-linguistic stress patterns calls for three basic devices: (1) a device that distinguishes stress-bearing elements, (2) one that distinguishes the limits or boundaries of the constituents made up of these elements, and (3) another that distinguishes the prominent elements of these constituents. To these, one may add a device to distinguish the direction of footing, i.e. boundary location

The approaches suggested within the derivational framework interpret the fundamental principles of stress assignment as rules and parameters. In OT, the same effect is achieved through constraints and constraint interactions. In this section, I present three distinct derivational approaches to metrification, namely Halle & Vergnaud (1987), Idsardi (1992), and Hayes (1995). Each of these approaches aims at achieving the same fundamental stress principles employing a different set of rules or parameters. I will also present the basic OT constraints enforcing footing and stress assignment, laying out the foundation for chapters five and six, where I apply these theories to UHA, in an attempt to determine which provides a more plausible account of the language's stress pattern.

2.2.1. Parametric Footing:

Halle and Vergnaud (1987) introduced an approach to metrification in which the shape of the foot is parametrically determined. As we shall see below, the foot's internal structure and prominence are determined utilising a very limited list of parameters. This is obviously motivated by the need to establish simple and perspicuous principles governing stress assignment, cross-linguistically. In addition, they demonstrated that stress alternation in words with multiple stresses is, by default, the product of a mere iteration of rhythmic footing. However, it can be motivated by phonetically or lexically marked syllables, or a combination of both (Halle & Vergnaud 1987). Before going into that, however, I will present the basic representational device employed in the theory, and basically in more recent metrical literature, namely the grid.

Building on earlier studies, namely Liberman (1975), Liberman and Prince (1977), Hayes (1981), and Prince (1983), Halle and Vergnaud treat stress as an entity occupying an autonomous tier analogous to tone. In this autosegmental plane, where stress is computed, each stress-bearing element is projected onto what will be called *line 0* and is represented by an asterisk. Above this line comes *line 1* where only stressed (or accented) elements are represented by asterisks, establishing their prominence, as (29) illustrates.

```
(29)    *   . *   . * .    line 1
        *   * *   * * *    line 0
        A p a l a c h i c o l a
```

(Halle & Vergnaud 1987: 6)

This representation conveys the idea that each prominent element on line 1 is a representative of some type of domain or constituency on line 0. Therefore, boundaries, indicated by parentheses, are introduced to designate each constituent as a unit, the head of which is the prominent element marked on line 1.

```
(30)     *   .   *     .   *   .   line 1
        (*   *)(*     *) (*   *)  line 0
         A p a l a c h i c o l a
```

(Halle & Vergnaud 1987: 9)

As Halle & Vergnaud claim, the considerably variable stress patterns attested in different languages may be accounted for using the metrical constituent structure summarised above. This might mean composing an enormous list of extremely varying metrical constituent configurations. On the contrary, setting only three, and in some cases four, binary parameters will generate a limited list of constituents that is capable of accounting for such a diversity. Head-terminality and Boundedness are the two basic parameters:

(31) (i) Head-terminality [+/- HT]
whether or not the head of the constituent is adjacent to the constituent boundaries.

(ii) Boundedness [+/- BND]
whether or not the head of the constituent is separated from its constituent boundaries by no more than one intervening element.

(Halle & Vergnaud 1987: 9-10)

To determine whether or not a certain head is [+HT], we must check whether or not that head and its dependent(s) are adjacent to each other. Also, to determine whether or not any constituent is [+BND], we have to decide whether or not the relation between

the head and either of the edges is well defined. This means that there are four [+HT] constituents as shown in (32).

(32)

[-BND]	[+BND]	[-BND]	[+BND]
x	x	x	x
a. (x x x...)	b. (x x)	c. (...x x x)	d. (x x)

As we can see, some of these are left-headed (32 a, b) and some are right-headed (32 c, d), which calls for introducing a third parameter to determine constituent Headedness.[12]

(33) Headedness

$$\text{[+HT] constituents are } \begin{Bmatrix} \text{left} \\ \text{right} \end{Bmatrix} \text{-headed.}$$

(Halle & Vergnaud 1987: 10)

On the other hand, the parameters of Head-terminality and Boundedness can only generate two [-HT] constituents, as clarified in (34) below.[13]

(34)

[-BND]	[+BND]
x	x
a.(x x x x x x x)	b.(x x x)

The fact that there are no reported languages with attested constituents like (34 a) draws our attention to the possibility of there being an independent condition to which heads and boundaries of metrical constituency are subjected. This is called the Recoverability Condition.

(35) *Recoverability Condition*
Given the direction of government of the constituent heads in the grammar, the location of the metrical constituent boundaries must be unambiguously

[12] In the interest of terminological transparency, Roca (1994) proposes the labels Adjacency and Flank, respectively substituting Boundedness and Headedness.
[13] Recent development in derivational metrical theory, Halle and Idsardi (1995) in particular, deny the existence of [-HT] feet. Constituent heads are only projected from an element occupying one of the constituent's edges. Obviously, this will render the Head-terminality parameter redundant.

> recoverable from the location of the heads, and conversely the location of the heads must be recoverable from that of the boundaries.
>
> (Halle & Vergnaud 1987: 10)

Simply, what this condition is saying is that if we know the directional relation between heads and dependents, determining either the location of a constituent's head or that of its boundaries follow from knowing the location of the other.

Although somewhat detailed in their description of a foot, the basic parameters introduced so far are not capable of really constructing constituents (feet). In a derivational framework, this may only be achieved by formalising a rule. Such a rule will help materialise the abstract settings of the parameters discussed above, (31 i and ii) in particular. The application of this rule, nonetheless, is subject to some conditions, as we shall see below. Consider the rule below:

(36) Construct constituent boundaries on line L.

However, when such a rule is applied to an odd numbered sequence of elements, it will yield different results. As clarified below, this is a consequence of the difference in the directionality of applying rule (36).

(37) a.(**)(**)(*)
b.(*)(**)(**)

When (36) applies from left-to-right, (37 a) results, and (37 b) is what we get if we proceed leftwards. This means that (36) needs to be parameterised as in (38) below.

(38) Construct constituent boundaries $<\left\{\begin{array}{c}\text{left to right}\\ \text{right to left}\end{array}\right\}>$ on line L.

(Halle & Vergnaud 1987: 11)

This longer version of (36) is only needed if the constituents constructed are [+BND]. However, such a rule will only build the constituent. It achieves no stress placement. Therefore, a rule that locates heads on a level higher than the constituents' is in order.

(39) Locate the heads of the line L metrical constituents on line L+1.

(Halle & Vergnaud 1987: 12)

The constituents that result from applying rule (38) are called *constructed* constituents. They should be distinguished from their *obligatory* counterparts that are the product of a different principle. This principle indicates that certain elements in the string are necessarily heads because they are inherently stressed. This may be due to their phonetic or lexical identity. They are called the *accented elements*. Such a principle will be enforced by a rule like (40).

(40) Assign a line 1 asterisk to the heads of *certain syllables*.

I conclude this summary of Halle & Vergnaud (1987) by presenting three conditions that govern the application of the two rules of constituent construction and head location, (38) and (39) above. First, the rule of constituent construction is subject to the *Exhaustivity Condition*.

(41) *Exhaustivity Condition*
The rules of constituent boundary construction apply exhaustively subject to the Recoverability Condition.

(Halle & Vergnaud 1987: 15)

This means that after the application of (38), every element in a given line must be included within the boundaries of a constituent even if that creates degenerate feet. Nevertheless, this could be naively satisfied by constructing minimal constituents that include their heads only. Avoiding this gives rise to the *Maximality Condition*.

(42) *Maximality Condition*
Each constituent constructed by a rule of boundary construction must incorporate the maximal substring, provided that other requirements on constituent structure are satisfied.
(Halle & Vergnaud 1987: 15)

Finally, the *Faithfulness Condition* is in order stressing the inseparability of heads and constituent boundaries.

(43) *Faithfulness Condition*
The output metrical structure respects the distribution of heads (accented elements), in the sense that each head is associated with constituent boundaries in the output structure and that these are located at the appropriate positions in the sequence. Constituent boundaries are erased in the output when none of the elements enclosed by the boundaries is marked as a head.
(Halle & Vergnaud 1987: 15-16)

This condition formalises the dependency relationship between heads and boundaries. Thus, we can only have boundaries and consequently metrical constituents if we have constituent heads, and vice versa.

The essential contribution of Halle and Vergnaud's approach is its parametric organisation of the process of foot construction, which is regulated by a number of conditions. Hayes (1995) puts forward another proposal that views footing, in

particular rhythmic bounded footing, as a process of template-matching. In other words, he thinks that due to the limited number of attested foot types, we do not need rules like (38) to construct feet. Instead, syllables are grouped into a pre-set foot inventory of mould-like feet (parsing feet (Kager 1993)), similar to Itô's (1986 and 1989) syllable templates. In the following subsection, I will present the basics of this proposal.

2.2.2. Universal Foot Inventory:

A key contribution of Hayes (1995) is his foot inventory (cf. Hayes 1985, 1987 and McCarthy and Prince 1986). Hayes claims that this highly restricted list of the legitimate bounded feet, with only three members, is capable of accounting for the various stress patterns cross-linguistically. I will be mostly capitalising on this inventory, that comprises Syllabic Trochaic, Iambic, and Moraic Trochaic feet. These foot types will be discussed individually below employing real languages.

2.2.2.1. Syllabic Trochees:

To introduce this foot type, I will follow Hayes (1995) and consider Pintupi, an Australian language. In this language, odd-numbered syllables counting from the left get stressed, but not the final in forms with an odd number of syllables. Main stress is on the initial syllable. To account for this pattern, Hayes proposed what he called the syllabic trochee, in (44).

(44) Syllabic Trochee (x .)

σ σ

This means that a well-formed syllabic trochee contains two syllables, whatever their internal structures. For the particular case of Pintupi, Hayes suggested constructing these left-headed feet going rightwards.[14] However, this would obtain the iterative stresses but not the main. So, in order to achieve the difference between primary and secondary stresses in this language and basically in all languages, Hayes mentioned the need for a further line of metrical structure, the "word layer" (cf. Line 2 in Halle and Vergnaud 1987). This word layer makes use of a parametric rule that would build an unbounded constituent over the "existing structure" and specifies the prominent flank of that constituent. Hayes calls it the End Rule, which is just a manifestation of Prince' (1983):[15]

(45) End Rule (Left/Right)
a. Create a new metrical constituent of maximal size at the top of the existing structure.
b. Place the grid mark forming the head of this constituent in the (left-most/right-most) available position.
(Hayes 1995: 61)

The phrase "available position" in (45 b) is motivated by a constraint on the well-formedness of metrical structure, to wit the Continuous Column Constraint.

(46) Continuous Column Constraint
A grid containing a column with a mark on layer $n + 1$ and no mark on layer n is ill-formed. Phonological rules are blocked when they would create such a configuration.
(Hayes 1995: 34)

---

[14] The syllabic trochee encapsulates three parameter settings of Halle and Vergnaud: [+HT, +BND, and left-headed].
[15] No similar rule is necessary in Halle and Vergnaud's approach. The very same parameters employed to describe the shape of the foot suffice to determine the shape of higher constituents. Pintupi line 1 parameter settings are [+HT, -BND, left-headed].

Therefore, Hayes claims that the rules achieving the desired Pintupi stress pattern are as follows:

(47)	a. Foot Construction	Parse words into syllabic trochees, going from left to right.
	b. Word Layer Construction	End Rule Left

The following example [málawàna] 'through from behind' demonstrates how these rules work.

(48)

```
(x   .)  (x   .)      Foot
 σ   σ    σ   σ       Construction
m a l a w a n a

(x            )       Word Layer
(x   .)  (x   .)      Construction
 σ   σ    σ   σ
m a l a w a n a
```

2.2.2.2. Iambs:

As I did with the syllabic trochees, I shall follow the footsteps of Hayes and use Seminole/Creek as an example to introduce the iamb as a foot type. This language, whose syllables are either light (CV) or heavy (CVC, CV:, or longer), has a rather complex stress system. Stress falls either on the final or the penult, whichever is heavy. If both are heavy, the ultima is stressed. Yet, if both are light the one that is separated from the first preceding heavy syllable or (if there is none) from the beginning of the form by an odd number of syllables is stressed. Hayes suggests the iamb, given in (49) below, as the foot type most suitable for this stress pattern.

(49) Iamb $\overset{(.\quad x)}{\cup\ \sigma}$ /otherwise, $\overset{(x)}{—}$ ($\cup$ = light, — = heavy)

This means that if iambs are made up of two syllables, the left is necessarily light. Alternatively, an iambic foot may be erected over a single heavy syllable. This leads us to the issue of syllable weight. There have been different proposals to formalise syllable internal structure relating it to weight units. I intentionally chose to postpone discussing this issue until now, to highlight its interaction with the process of stress assignment. Therefore, before attempting any analysis of Seminole/Creek, or any weight-sensitive, stress pattern, we need to know the factors involved in determining syllable weight.

The interpretation of syllable weight on a multi-tiered syllabic representation originated in Hyman (1985). He suggested the conceptual substitution of the x-tier by another tier representing phonological weight. The x-slots on such a tier correspond to *weight units*, WU. He prevents an onset from being linked to a WU through a universal Onset Creation Rule OCR, as in (50):

(50)
$$\begin{array}{ccc} X & & x \\ | & & | \\ [+cons] & & [-cons] \end{array}$$

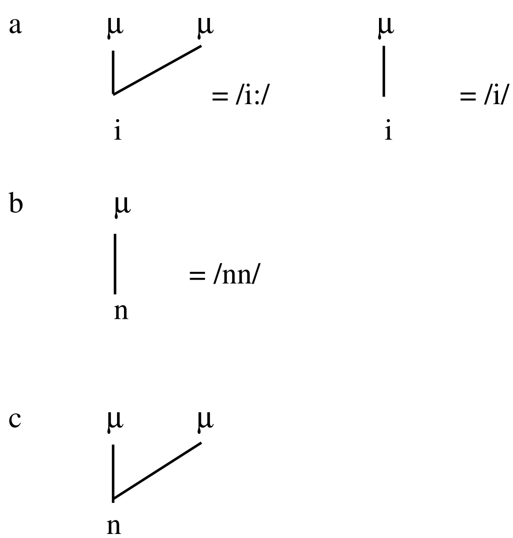
(the circled x symbolises deletion)

(Hyman 1985: 15)

Such a rule links any pre-vocalic consonantal segment to the following vowel's x-slot, achieving two objectives: lack of weight in the onset and its minimal satisfaction.

Hayes (1989) went one step further and eradicated the whole x-tier advocating a mora tier that characterises syllables as bimoraic or monomoraic, heavy or light respectively. Hayes proposed that moras fall in two groups underlying or derivational. He demonstrated that only vowels, geminates, and, very rarely, long syllabic nasals in Kimatuumbi are moraic.

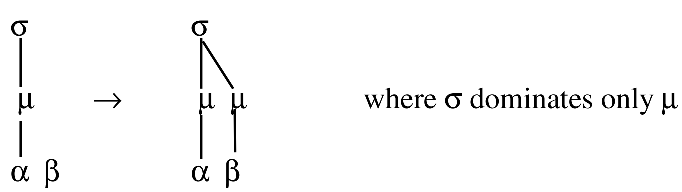
(51)



(Hayes 1989: 256-7)

To assign weight to coda consonants in languages that treat closed syllables as heavy, Hayes introduced the rule of Weight-by-Position, that is activated language-specifically.

(52)



(Hayes 1989: 258)

Accordingly, Hayes proposed the following metrical structure rules for Seminole/Creek:

(53) a. Foot Construction — Parse the word into iambs going from left to right.
b. Word Layer Construction — End Rule Right

Deriving the stress of the word [ta:shokíta] 'to jump *dual subj.*', demonstrates the effects of these rules.

(54)

```
          ( x )      ( .      x ) Foot
           —           ∪      ∪      ∪   Construction
        t  a:  s   h   o   k   i   t   a

         (                    x        )  Word Layer
         ( x )      ( .      x ) Construction
          —           ∪      ∪      ∪
        t  a:  s   h   o   k   i   t   a
```

The crucial point here is that syllables can be left unmetrified. The final light syllable cannot form an iambic foot on its own. This is because such a syllable may not support the word layer grid mark as a consequence of the Continuous Column Constraint (cf (46) above). In Halle & Vergnaud (1987), this is not allowed, as the maximality condition needs to be enforced across-the-board.

2.2.2.3. Moraic Trochees:

Cairene Arabic, a language that exhibits a distinctively complex stress pattern, is the example that Hayes analysed to introduce the third foot type, the moraic trochee. The stress algorithm of this language is given below.[16]

[16] The stress pattern of this dialect of Arabic is rather similar to UHA, though not identical. In the latter, syllable weight attracts stress to the antepenult. This seemingly minor detail affects the analysis quite considerably, as clarified in chapters five and six.

(55) a. Stress a final syllable if it is superheavy.
b. Otherwise, stress a heavy penult.
c. Otherwise, stress the penult or the antepenult, whichever is separated by an even number of syllables from the closest preceding heavy syllable or (if there is none) from the beginning of the word.

Basically, what this stress algorithm reveals is the common two binary syllable weight distinctions of light vs. other syllables word-internally and superheavy vs. other syllables word-finally. To maintain this asymmetry, Hayes suggested adopting some sort of final segment extrametricality. Before going into that, however, I will introduce extrametricality.

The device of extrametricality was developed in Hayes (1981) as a way of simplifying and rationalising the foot inventory, and was then extended into other areas of phonology (cf. Pulleyblank (1986) on tone). A rule of extrametricality renders a particular prosodic entity invisible to the rules of stress computation. Graphically, such an element is marked with angled brackets < >. Nevertheless, in order to control the rules of extrametricality as much as possible, Hayes suggests the following restrictions:

(56) a. Constituency
Only constituents (segment,[17] syllable, foot, phonological word, affix) may be marked as extrametrical.
b. Peripherality
A constituent may be extrametrical only if it is at a designated edge (left or right) of its domain.
c. Edge Markedness
The unmarked edge for extrametricality is the right edge.
d. Nonexhaustivity
An extrametricality rule is blocked if it would render the entire domain of the stress rules extrametrical.

(Hayes 1995: 57-8)

[17] Can segments be marked extrametrical? In other words, do individual segments participate in the process of metrification or footing? Questions like these will be central to the discussion in chapter six below.

In addition to these constraints on the application of extrametricality rules, Halle & Vergnaud think that "only a single entity may be marked extrametrical, which specially prevents us from treating the forms with antepenultimate stress by exceptionally marking their last two syllables extrametrical."(Halle & Vergnaud 1987: 58).[18]

For Cairene, Hayes suggested final consonant extrametricality to account for the attested facts. This will render CVCs light, hence stressless, while maintaining the heaviness of final CVVCs, and CVCCs and consequently having them stressed. As for the opposition between even and odd numbered sequences of light syllables that intervene between the antepenult or the penult and the first preceding heavy syllable or the beginning of the form, Hayes proposed parsing syllables into moraic trochees proceeding rightwards from the beginning of the word. This foot type is given below:

		(x .)		(x)
(57)	Moraic Trochee	∪ ∪	or	—

This foot type contains two moras, and only two, contributed either by two light syllables or by a single heavy syllable. So, to account for the stress pattern of Cairene, Hayes employed the following set of rules.

(58)	a. Consonant Extrametricality	$C \rightarrow < C > /$ --- #
	b. Foot Construction	Parse the word from left to right into moraic trochees.
	c. Word Layer Construction	End Rule Right

The examples below show how these rules derive stress in Cairene.

[18] Hayes (1995) formalised this idea as a condition imposed on the application of the device of extrametricality. Such a condition, that is operative throughout the metrification domain, disfavours chaining extrametricality.

```
(59)  a. (    x   )             b. (     x      )
            (x)                        (x)
        ∪   —                     ∪    —    ∪
       k a . t a b < t >        m u . d a r . r i < s >

      c. (          x     )     d. (           x          )
          (x    .)  (x    .)        (x     .)  (x    .)
          ∪    ∪    ∪    ∪          ∪     ∪    ∪    ∪    ∪
         k a . t a . b i . t u     ʃ a . d͡ʒ a . r a . t u . h u
```

Again, we notice that final light syllables, whether underlyingly motivated or resulting from extrametricality, cannot support a degenerate foot because they are monomoraic. However, the question that arises is whether or not these *degenerate* feet are disallowed across the board. I will not engage in such a matter for the time being, with an intention of discussing it in more detail in chapter six, where I apply Hayes' model to UHA. What we ought to know, however, is that Hayes proposes three levels of prohibition on degenerate feet: Strong prohibition where degenerate feet are absolutely disallowed, Weak prohibition where they are only allowed if metrically strong, i.e. dominated by an upper level grid mark, or Non-prohibition at all.

To sum up, we saw how Hayes introduced this limited foot inventory as an attempt to determine the very primitives of the process of iterative bounded footing. Indeed, this simplifies the overall process of stress assignment. Having a pre-set foot shape that serves as a mould matching the output of syllabification into feet removes almost all the burden of construction considerably reducing the number of parameters involved. However, Kager (1993) notices the asymmetry in Hayes' foot inventory. In particular, the fact that we have two types of trochaic foot vs. only one iamb prompted Kager to introduce a sub-theory of anti-lapse to explain this asymmetry. This filter that governs the process of footing is given below:

(60) Anti-Lapse Filter (domain: foot)
No lapse is allowed within the foot.
(Lapse: two adjacent stressless elements, σ or μ)

(Kager 1993: 394)

This will facilitate accommodating a symmetric foot inventory that comprises two trochees and two iambs, one syllabic and one moraic. Assuming the Anti-Lapse Filter, we do not need to indicate that iambs may include (σ_{μ} $\sigma_{\acute{\mu}\mu}$) while trochees may not include ($\sigma_{\acute{\mu}\mu}$ σ_{μ}). Obviously, the latter contains two adjacent stressless moras violating the Anti-Lapse condition while the former does not.[19]

By this, I conclude discussing Hayes' metrical approach and move to Idsardi (1992). There we will encounter a theory that commits itself more to universality. Interestingly, however, the application, though not the description, of some rule is constrained, which means employing both rules and constraints. In what remains of this subsection, I will summarise the fundamental claims of that approach in order to apply it to UHA in chapter six.

2.2.3. Parametric Boundary Location and Headedness:

[19] This filter ruling out lapse is interpreted as an OT constraint in Kager (1994), Green (1995), and Green and Kenstowicz (1995). In chapter five, I will show that adopting this constraint is essential in accounting for UHA stress pattern.

Idsardi (1992) and Halle & Idsardi (1992, 1995) put forward a theory of metrical computation where a number of parametric rules serve the purpose of projecting asterisks onto higher levels and inserting parentheses into any one level. In other words, constituent boundary location and head projection are, crucially, the only elements of the process of metrification. There is no need to describe the shape of the foot or to have a pre-set inventory of universal foot types. They aimed at universalising the content and the order of application of this set of rules.

2.2.3.1. Universal Principles:

To interpret the fundamentals of metrification, Halle and Idsardi (1995) introduced three primitive universal principles, viewed as parameters. These principles are: *Projection*, *Edge-Marking*, and *Head Location*. To introduce them, I will follow Halle & Idsardi's steps and use the Koya language as a practical experience of a simple unbounded stress system. In this language, stress falls on the head of every closed or long syllable as well as on the initial syllable. Main stress is on the initial syllable (Halle & Idsardi 1995: 406).

To lay the foundation of the metrical structure, i.e. the grid, where all stress computations take place, Halle and Idsardi firstly needed to distinguish the elements that are potential participants, usually syllable heads, from others in the string of phonemes. This interface between the metrical grid and the segmental tier is realised by what they call *projection*. This device will create an autonomous line, line 0, which is basically a reflection of syllable heads. This may be partially achieved by utilising the universal principle in (61).

(61) *Line 0 mark projection*
Project a line 0 element for each *syllable head*.
(Halle & Idsardi 1995: 407)

In some languages, quantity sensitive in particular, certain syllables are distinguished from others. Unlike Halle and Vergnaud (1987) where the accenting is achieved by projecting a grid mark on line 1, in this theory projecting the boundaries of certain syllables indicates their ability to attract stress. The parameter in (62) implements this.

(62) *Syllable Boundary Projection parameter*
Project the {left / right} boundary of *certain syllables* onto line 0.
(Halle & Idsardi 1995: 407)

Although all languages with attested stress patterns have to activate some form of (61), quantity-insensitive languages may not have a setting for (62). Another thing that attracts our attention when examining (62) is the use of a single boundary rather than both metrical boundaries. In this theory, a right parenthesis means that the elements to its left up to the next parenthesis or the end of the word are members of the same constituent, and equivalently for the elements to the right of a left parenthesis.

Thus, for Koya, a grid mark is projected for each syllable head. (62) is set to project the left boundary of any long vowelled or closed syllable, in order to account for stress on heavy syllables. However, this is not enough to account for initial stress. More generally, something else is needed to project a boundary in unbounded quantity-insensitive systems, where no form of syllable boundary projection is usually invoked.

Consequently, Halle & Idsardi proposed another universal principle that delimits the stress domain. They called it Edge-Marking, as in (63).

(63) *Edge-Marking parameter*

Place a $\left\{\begin{array}{c}\text{left}\\ \text{right}\end{array}\right\}$ parenthesis to the $\left\{\begin{array}{c}\text{left}\\ \text{right}\end{array}\right\}$ of the $\left\{\begin{array}{c}\text{left}\\ \text{right}\end{array}\right\}$-most element in the string.

(Halle & Idsardi 1995: 408)

This means that setting this parameter for a certain language boils down to a mere choice of one of the following possible rules.[20]

(64)

a. Edge: LLL = $\varnothing \rightarrow$ (/ # --- x	e. Edge: RRR = $\varnothing \rightarrow$) / x --- #
b. Edge: LRL = $\varnothing \rightarrow$ (/ # x ---	f. Edge: RLR = $\varnothing \rightarrow$) / --- x #
c. Edge: LLR = $\varnothing \rightarrow$ (/ --- x #	g. Edge: RRL = $\varnothing \rightarrow$) / # x ---
d. Edge: LRR = $\varnothing \rightarrow$ (/ x --- #	h. Edge: RLL = $\varnothing \rightarrow$) / # --- x

(Idsardi 1992: 4)

For Koya, (64 a) is activated to account for initial stress. Nevertheless, this edge marking would not apply if the Syllable Boundary Projection has provided the initial syllable in a certain Koya word with a left boundary. Also, this principle is obviously capable of achieving the effects of extrametricality (64 b or d).

We now have well-defined constituents on line 0, whose heads are to be projected onto line 1. In this theory, this is achieved by the Head Location parameter in (65).

(65) *Head Location parameter*

left

[20] I cannot see what (64 d and h) will mark.

Project the {   }-most element of each constituent onto the next line of the
right
grid.

(Halle & Idsardi 1995: 408)

For Koya, this parameter will be set to project the left-most element of each constituent.

Therefore, we can say that each heavy syllable in Koya is appointed head of its constituent by virtue of Project: L and Head Location. On the other hand, the representation of the initial syllable on line 1 is the making of both Edge-Marking and Head Location. This, however, would not obtain initial main stress, which will also require setting both parameters to apply on line 1 to construct a left-headed "unbounded" constituent. All these parameter settings are summarised in (66).

(66)	Line 0	Project: L	Edge: LLL	Head: L
	Line 1		Edge: LLL	Head: L

To see how these rules derive stress in Koya, Halle and Idsardi apply them to a hypothetical example that comprises light (L) and heavy (H) syllables. Each parametrically set rule applies as a step in the overall derivation as shown in (67).

(67)

Line 0	Project: L	x x x (x x x (x x x x x L L L H L L H L L L L
	Edge: LLL	(x x x (x x x (x x x x x L L L H L L H L L L L
	Head: L	x x x (x x x (x x x (x x x x x L L L H L L H L L L L

Line 1 Edge: LLL	(x x x (x x x (x x x (x x x x x L L L H L L H L L L L
Head: L	x (x x x (x x x (x x x (x x x x x L L L H L L H L L L L

The settings in (66) are not the only possible ones to derive Koya stress. We could, for example, have left edge-marking on line 0 and right one on line 1 and still attain the desired stress pattern, for Koya. Nonetheless, morphological processes like reduplication or even phonological ones like vowel syncope, that are affected or have an effect on stress, may be indicative of the active settings in a given language. However, we may not have access to similar indications. Halle & Idsardi (1995) claim that there is a universal tendency towards preferring homogeneous settings rather than heterogeneous ones. However, they stress the fact that some languages require heterogeneous settings, as we will see with UHA in chapter six.

2.2.3.2. Iterative Constituent Construction:

So far, I have introduced the basic “universal principles” and showed how this theory could account for them. This is by suggesting a number of parametric rules that serve the purpose of projecting asterisks onto higher levels and inserting parentheses into any one level. Koya, a language with a basic unbounded stress system, manifested these parameters in action. But, as we know, languages are not limited to having unbounded stress patterns that place stress on or near an edge of the form or on special (e.g. heavy) syllables. Languages can have iterative stress patterns where every other syllable, counting from the right or left, is stressed resulting in some kind of bounded

(binary) constituents. One such language is Warao, a South American language, where "stress falls on even-numbered syllables counting from the end of the word (and placing) main stress on the penultimate syllable." (Halle & Idsardi 1995: 418). To be able to serve this iterative occurrence of stresses and consequently metrical constituents, Halle & Idsardi introduce yet another universal parametric rule, as shown in (68).

(68) *Iterative Constituent Construction parameter*

$$\text{Insert a } \left\{ \begin{array}{c} \text{left} \\ \\ \text{right} \end{array} \right\} \text{ boundary for each pair of elements.}$$

(Halle & Idsardi 1995: 418)

Having a setting for this parameter in a certain language means that we aim to construct bounded (binary in particular) constituents. We will be inserting a parenthesis after every pair of grid marks. Another thing that the Iterative Constituent Construction governs is the direction of footing, interpreted as parentheses location. If we are inserting *left* boundaries, we will be proceeding from right to left and *vice versa* if the parentheses inserted are *right* ones. This means that we have two rules to choose from.

(69) a. ICC: L = ∅ → (/ --- xx (right to left)
b. ICC: R = ∅ →) / xx --- (left to right)

(Halle & Idsardi 1995: 419)

Before applying this to Warao, we should know that neither of these two rules could apply if the grid marks left are less than two. This means that the element on the far edge in an odd numbered string is usually left unmetrified, at least by the ICC (cf. Hayes 1995 for a similar, though more general, requirement banning degenerate feet altogether). This contradicts Halle & Vergnaud's (1987) Exhaustivity Condition.

For Warao, Halle & Idsardi suggest the parameter settings in (70), taking in consideration that the direction of footing should begin from the end of the word going leftwards.

(70)	Line 0	Project	Edge: RRR	ICC: L	Head: L
	Line 1		Edge: RRR		Head: R

(cf. Halle & Idsardi 1995)

To illustrate the derivational effects of these settings, (71) below applies them to two Warao words, one with an even number of syllables and one with an odd number of syllables.

(71)

Line 0	Edge: RRR	x x x x x x x x) y a p u r u k i t a n e h a s e	x x x x x) y i w a r a n a e
	ICC: L	(x x (x x (x x (x x) y a p u r u k i t a n e h a s e	x (x x (x x) y i w a r a n a e
	Head: L	x x x x (x x (x x (x x (x x) y a p u r u k i t a n e h a s e	x x x (x x (x x) y i w a r a n a e
Line 1	Edge: RRR	x x x x) (x x (x x (x x (x x) y a p u r u k i t a n e h a s e	x x) x (x x (x x) y i w a r a n a e
	Head: R	x x x x x) (x x (x x (x x (x x) y a p u r u k i t a n e h a s e	x x x) x (x x (x x) y i w a r a n a e

2.2.3.3. Avoidance Constraints:

Languages, sometimes, are not totally well behaved. They may show some irregularities for which a certain theoretical discipline is unable to account. For this purpose, Idsardi (1992) and Halle & Idsardi (1995) proposed what they called Avoidance Constraints. These will prevent an undesired metrical configuration from

being created. These constraints will apply to the relevant level in the derivation that would otherwise create the disfavoured metrical configuration.

The stress system of Garawa demonstrates the need for such constraints. In this language stress alternates by falling on even-numbered syllables starting from the end of the word. Main stress is on the first syllable, but the second syllable is never stressed. Halle & Idsardi (1995) set the parameters to account for these facts as follows:

(72)	Line 0	Project	Edge: LLL	ICC: L	Head: L
	Line 1		Edge: LLL		Head: L

(cf. Halle & Idsardi 1995)

Obviously, these settings may not lead to satisfaction of the restriction against stressing the second syllable. Its left boundary will be projected onto line 0 by virtue of ICC: L, if the word under consideration contains an odd number of syllables. To solve this problem, Halle & Idsardi introduce the constraint in (73) to apply simultaneously with ICC: L, in the Garawa case.

(73) Avoid (x (

(Halle & Idsardi 1995: 422)

This avoidance constraint, as illustrated below, helps us assign the true stress pattern in Garawa. (74) gives the derivations of two abstract words.

(74)

Line 0	Edge: LLL	(x x x x x x x x x ..V..V..V..V..V..V..V..V..V..	(x x x x ..V..V..V..V..
	ICC: L Avoid (x (	(x x x (x x (x x (x x ..V..V..V..V..V..V..V..V..V..	(x x (x x ..V..V..V..V..

	Head: L	x x x x (x x x (x x (x x (x x ..V..V..V..V..V..V..V..V..V..	x x (x x (x x ..V..V..V..V..
Line 1	Edge: LLL	(x x x x (x x x (x x (x x (x x ..V..V..V..V..V..V..V..V..V..	x x (x x (x x ..V..V..V..V..
	Head: L	x (x x x x (x x x (x x (x x (x x ..V..V..V..V..V..V..V..V..V..	x (x x (x x (x x ..V..V..V..V..

This completes the presentation of the basic principles of this theoretical framework. In chapter six, I attempt an application to UHA.

It is obvious that the different derivational frameworks of footing and stress assignment highlight and maintain the same fundamental principles. Take Boundedness for example. Halle and Vergnaud (1987) introduce a parameter, while Hayes (1995) builds that in his foot inventory. On the other hand, Halle and Idsardi (1995) utilise a parametric rule that also determines directionality. As for Weight-sensitivity, both Halle & Vergnaud and Halle & Idsardi distinguish heavy syllables, grid marks and boundary projection, respectively. Hayes achieves this by allocating the suitable foot type for a given language. Another interesting point is Exhaustivity. It is only enforced in Halle and Vergnaud where degenerate feet may always be created to maintain this principle. On the other extreme is Hayes, where non-binary feet can be absolutely banned. In Halle and Idsardi's approach, Exhaustivity is not enforced. However, degenerate constituents may result from the combined application of two rules like Edge-Marking and Iterative Constituent Construction. Variations like these will be seen to determine the adequacy of a given approach when I start analysing the UHA stress pattern. In what remains of this chapter, I will demonstrate how these particular principles are interpreted as OT constraints and/or constraint rankings.

2.2.4. Optimality Theory and Stress Assignment:

As we saw above, in the standard metrical theory, stress is derived by building feet, hence the finite and very limited list of parameters. These literally are set on a language particular basis to construct the desired foot form and/or content. Ultimately, they aim to account for three basic principles of footing, viz. Boundedness (Adjacency), Headedness (Flank), and Weight-sensitivity. The attested facts in any language determine whether feet are bounded (*binary* or in fewer and restricted number of cases *ternary*) or unbounded. They will also determine foot-content in foot construction, where in some systems this is affected by syllable weight. Thirdly, the stress pattern will reveal the dominance of a certain flank, either the left or right. Accordingly, the left or right-most element of a constituent, either on foot level or word level, is to be assigned headedness by suitably setting the right parameter.

In Optimality Theory, this is basically what we expect to achieve, as far as the final output is concerned. Nevertheless, it is done rather differently. It is not a matter of a step by step derivation, but rather of a constraint-regulated choice or optimisation of a certain candidate output. We do not need actually to perform footing, a task shifted to the dummy-like function of GEN, that provides us with all the possible logical candidate analyses of a certain input, all the possible footings in this case. Consequently, the focus is on determining the active constraints and their relative ranking enabling Eval to identify the optimal footing. So, in Optimality Theory, stress assignment is a mere testing of footing.

In what follows, I will dwell on the previously mentioned three basic principles of Boundedness, Headedness, and Weight-sensitivity, and summarise the relevant constraints suggested in the literature. I will also discuss the effects and the evaluation of extrametricality in Optimality Theory. Lastly, I will wind up the summary of the fundamental issues discussed in the literature with a small note on directionality in Optimality Theory.

2.2.4.1. Boundedness:

In different stress systems, feet are usually categorised into two main groups: bounded, where the distance between the constituent's head and boundaries is restricted to no more than one element, and unbounded, where no such a distance condition is imposed (Halle and Vergnaud 1987). To translate this into optimality, some constraints were presented in the primary literature (Prince & Smolensky (1993) and McCarthy & Prince (1993a, b)). The most important of these are Foot Binarity (FT-BIN), Parse (PARSE-SYL in particular), and ALIGN-FOOT.

2.2.4.1.1. Foot Binarity

The evidence for the need of binary feet cross-linguistically is overwhelming. As noted by Roca and Al-Ageli (1995), many segmental and suprasegmental processes may not be logically defined without reference to binarity in foot structure. Prince & Smolensky (1993), who basically introduced this principle within an OT framework to account for the minimality effect in Latin in particular, noted that "foot binarity is not itself a direct restriction on minimal foot size; it defines a general property of structure" (Prince & Smolensky 1993: 47), and they presented it as follows:

(75) Foot Binarity (FT-BIN)
Feet are binary at some level of analysis (μ, σ).
(Prince & Smolensky 1993: 47)

What this constraint says is that the internal structure of binary feet by definition comprises two elements, either syllables or moras. This means that in bounded systems, a legitimate foot can only be disyllabic or bimoraic, though never monomoraic or trisyllabic. In other words, this constraint strongly discriminates against degenerate (unary) feet. Interestingly, trisyllabic (ternary) feet are also disfavoured. To summarise this, here is the list of possible feet as seen by FT-BIN:

(76)	a.	Bimoraic	(H)	
	b.		(LL)	Bisyllabic
	c.		(LH)	
	d.		(HL)	
	e.		(HH)	

The two prosodic levels that define binarity clearly overlap on one of the five possible foot structures (76b). This particular foot structure is the perfect realisation of FT-BIN where binarity is met at both the syllabic and the moraic levels.

The point to consider now concerns the method by which this condition on foot structure is generalised throughout a given form of a sequence of syllables. FT-BIN does not say anything about parsing syllables into feet. What it says is that if there are feet, they must be binary. So, the theory has to incorporate a constraint that insures the parsing of all syllables into feet. Hence, PARSE-SYL was introduced.

2.2.4.1.2. PARSE:

This family of constraints that basically conveys Itô's (1986) Prosodic Licensing militates against unparsed elements whether feet, syllables, moras, etc. So, to satisfy it, every prosodic constituent must belong to a higher level of constituency. For our present purposes, I will concentrate on one member of this family, namely PARSE-SYL, in (77).

(77) PARSE-SYL
All σ must be parsed by feet.
(McCarthy & Prince 1993b: 11)

This constraint is essential to both bounded and unbounded systems. However, in these two types of systems, PARSE-SYL is ranked differently with respect to FT-BIN. In bounded systems, where foot binarity is required, dominance of FT-BIN over PARSE-SYL is inevitable to the extent that McCarthy & Prince (1993b) suggested that FT-BIN may be included in GEN, had this dominance been universal. This would guarantee that degenerate feet are not created, for the sake of satisfying PARSE-SYL. In unbounded systems, however, the tables are turned. Here, FT-BIN is low ranked, certainly lower than PARSE-SYL, as feet can be of any size in such systems.

Interestingly, in weight-insensitive unbounded stress systems like French or Latvian, as we will see more clearly when we discuss weight-sensitivity below, all syllables are usually grouped under one foot. This is to ensure the uniform word final or initial stress pattern. Depending on the two constraints introduced so far, such footing may not be achieved. Either a false output is optimised or more than one

possible candidate analysis of a given input are rendered equally harmonious. This is illustrated in tableau (78) that evaluates two hypothetical examples of an unbounded weight-insensitive stress pattern like French, where stress is invariably final.

(78)(i)

Candidates	PARSE-SYL	FT-BIN
a. ☞(σσ)(σσ)		
b. (σσσσ)		*!

(ii)

Candidates	PARSE-SYL	FT-BIN
a. (σσ)(σσ)σ	*!	
b. ☞(σσσσσ)		*
c. ☞(σσ)(σσ)(σ)		*

In (78 i) where the sequence of syllables is even-numbered, a false output is chosen. On the other hand, in odd-numbered sequences, two analyses like (78 ii b, c) are equally harmonious. Only one of these latter candidate analyses should be optimised. Clearly, the constraints PARSE-SYL and FT-BIN are incapable of determining that candidate. This is an indication that there is a need for an additional constraint that would be able to point (78 i b) and (78 ii b) as the most harmonious candidate analyses of their inputs.

2.2.4.1.3. Single Foot Prosodic Words:

In both cases in (78), the single foot analyses must be optimised to achieve the stress pattern of unbounded weight-insensitive systems, but the set of constraints available at hand failed to do that. The constraint that would achieve this objective is introduced by McCarthy & Prince (1993b) to account for a wholly different principle, directionality of footing. However, as is noted by Kenstowicz (1994c), the same

constraint may be used to discriminate against any candidate analysis that contains more than one foot.

(79) ALIGN-FOOT
Align (Ft, L/R, PrWd, L/R)
(McCarthy & Prince 1993b: 16)

A consequence of this is that the left or right edge of every foot must coincide with the left or right edge of some prosodic word.[21]

In unbounded weight-insensitive systems, this constraint must be ranked, along with PARSE-SYL, higher than FT-BIN. This will guarantee exhaustive parsing of all syllables into one foot. So, let us consider the same tableaux in (78), incorporating ALIGN-FOOT:

(80)(i)

Candidates	PARSE-SYL	ALIGN-FOOT	FT-BIN
a. (σσ)(σσ)		σ!σ	
b. ☞(σσσσ)			*

(ii)

Candidates	PARSE-SYL	ALIGN-FOOT	FT-BIN
a. (σσ)(σσ)σ	*!	σσ	
b. ☞(σσσσσ)			*
c. (σσ)(σσ)(σ)		σ!σσσ	*

(cf. Kenstowicz 1994c)

Obviously, ALIGN-FOOT, in this particular ranking, renders true footing most harmonious in similar languages.

[21] We need not specify a certain edge, for our present needs. What we must bear in mind is that the designated edge of both categories must be identical, both left or both right. This hints at the superiority of Prince & Smolensky's Edgemostness (1993), at least for this purpose, which crucially requires that both categories should share the same edge, a trait seen by McCarthy & Prince (1993b) as a shortcoming of the device if compared to their *Alignment*.

So, to summarise, we may say that FT-BIN is the most essential constraint for bounded systems. Its predominance is inevitable. In unbounded stress systems, FT-BIN is relatively low ranked, certainly lower than PARSE-SYL and ALIGN-FOOT. Kenstowicz summarises these relations as follows:

(81) a. FT-BIN >> PARSE-SYL >>ALIGN-FOOT (alternating stress)
b. ALIGN-FOOT, FT-BIN >> PARSE-SYL (disyllabic window)
c. ALIGN-FOOT, PARSE-SYL >>FT-BIN (unbounded foot)
(cf. Kenstowicz 1994c: 2-3)

2.2.4.2. Headedness:

We saw in the discussion above how a small set of constraints allows us to isolate true outputs. There, binary feet are constructed over as many syllables as possible, in accordance with FT-BIN for bounded systems. Also, we saw how violations of FT-BIN are tolerated, in unbounded systems, for the sake of aligning every foot at a designated edge. We saw how this amounts to a mere parsing of all syllables into a single foot per word. What we need at this point is to investigate the way in which constituent headedness is assigned or, to be more precise, optimal head location is promoted to true output level. In particular, I want to consider the constraints involved in determining headedness at both foot and word levels.

2.2.4.2.1. Foot Level:

As far as headedness is concerned, feet are basically of two types: left or right-headed. In the derivational metrical account, this is derived by parametric rules

assigning headedness to either the left-most or the right-most element in the foot. The need to employ this machinery in an OT environment is explicitly noted by Prince & Smolensky. They think that "there must be a constraint which set [*sic*] the rhythmic type at either iambic or trochaic; call this RhType = I/T." (Prince & Smolensky 1993: 53). This means that in languages where feet are empirically attested to be left-headed, the rhythm type constraint is set as RH-TYPE = T and RH-TYPE = I if the language promotes right-headedness on the foot level.

This constraint is usually ranked undominated.[22] For example, in Manam, as noted in Buckley (1994, 1995a), there are no right-headed feet. Prince & Smolensky (1993) also noted this fact about the rhythm type constraint by claiming that violating it is quite fatal, as a more suitable candidate that satisfies it will always be a potential alternative to any RH-TYPE violator.

Obviously, this constraint provides the needed barrier to stop any proposed output with undesired flank dominance on the foot level. But, its effects may not be elevated to maintain word prominence. We need something else to achieve this requirement.

2.2.4.2.2. Word Level:

As noted by McCarthy & Prince, in order "to complete the discussion of elementary stress-pattern theory, we observe that one foot must typically be picked out

[22] Some languages (like Yidiny, Axininca, Southern Paiute, etc.) are known to have opposing dominance on the foot level (Kager p.c.).

as the strongest, the head of the PrWd Ft´." (McCarthy & Prince 1993b: 17).The constraint they proposed is yet another member of the Alignment family: ALIGN-HEAD.[23]

(82) ALIGN-HEAD
Align (PrWd, Edge, H(PrWd), Edge)
(McCarthy & Prince 1993b: 18)

Simply, what this constraint says is that a certain edge of all prosodic words in a given language must be aligned with that of the word's head.

To show the effects of these two headedness constraints, viz. RH-TYPE and ALIGN-HEAD, I will apply them to Warao. As we saw above, main stress in this language is on the penult, with secondary stresses on every other syllable going leftwards. It is an iterative stress system (cf. (81 a) above). FT-BIN is predominantly ranked, along with RH-TYPE = T. This means that stresses are assigned to even-numbered syllables counting from the end of the word. This indicates that ALIGN-FOOT is set as: Align (Ft, R, PrWd, R) to ensure the right-to-left directionality of parsing. Last but not least, since the main stress is on the penult, ALIGN-HEAD will be set as: Align (PrWd, R, H(PrWd), R) to guarantee that the head foot is the right-most. Tableau (83) demonstrates all these points.

Evaluation of an input like /tapurukitanehase/ "verily to climb" (Halle & Idsardi: 1995) does not call for ALIGN-FOOT due to the fact that the form in question

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[23] Prince & Smolensky (1993) formalised a similar constraint: EDGEMOST (σ́, E). Clearly, the phonological category in this constraint is the head syllable rather than the head foot. Whose edge, if

contains an even number of monomoraic syllables that will be uniformly parsed into disyllabic/bimoraic feet. This means that the directionality of footing is of no consequence, at least for the present example, yet we must keep in mind that it is set as right-to-left.

(83)

Candidates	FT-BIN	RH-TYPE	ALIGN-HEAD	PARSE-SYL
a. ☞(σ̀σ)(σ̀σ)(σ̀σ)(σ́σ)				
b. (σσ̀)(σσ̀)(σσ̀)(σσ́)		*!***		
c. (σ́σ)(σ̀σ)(σ̀σ)(σ̀σ)			σ!σσσσσ	

2.2.4.3. Weight-sensitivity:

We saw above how Optimality Theory could impose the binarity effect on foot structure by implementing FT-BIN that applies on both levels, moraic and/or syllabic. I will now summarise the Optimality Theory machinery for distinguishing between weight-sensitive and weight-insensitive systems, where in the former binarity may be met at either the moraic or syllabic level, while in the latter it is only met at the syllabic level. First, I will present the constraints suggested in the primary literature for weight-sensitivity, namely WSP and RH-HARM, clarifying the relations between them. Then, I will present a constraint whose concept of content is proposed by both van der Hulst (1994) and Hung (1994) to promote weight-insensitive iterative parsing.

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either, ought to be regulated is an issue. More interestingly, however, this may bear some consequences on the evaluation of some candidate analyses as we shall see in chapter five below.

2.2.4.3.1. Weight-to-Stress Principle (WSP):

When FT-BIN was presented above, I listed the different foot configurations that are allowed by this constraint, regardless of the head location within each foot. Nonetheless, recognising headedness in all foot structures, in (76) above, will not create a list of cross-linguistically attested foot configurations. There is a certain degree of markedness consistent with some of them. McCarthy & Prince (1986 *et seq*) and Hayes (1987 *et seq*), interpreting Hayes (1985), think that such a list will surely incorporate some unacceptable feet. This is now clarified in the table in (84).

(84)

	(H)	**(LĹ)**	**(ĹL)**	**(LH́)**	**(ĹH)**	**(HĹ)**	**(H́L)**	**(HH́)**	**(H́H)**
FT-BIN	+	+	+	+	+	+	+	+	+
Unmarked	+	+	+	+	-	-	-	-	-

The constraints introduced so far are incapable of ruling out these five marked foot configurations. This means that a further constraint is needed to rule out these unattested FT-BIN satisfiers. Prince & Smolensky suggested this non-far fetched constraint of Prince (1990): Weight-to-Stress Principle given in (85) below.

(85) Weight-to-Stress Principle (WSP)
Heavy syllables are prominent in foot structure and on the grid.
(Prince & Smolensky 1993: 53)

Simply, as noted in Prince & Smolensky (1993), this constraint says that heavy syllables must be footed (prominent on foot structure), and they are always stressed (prominent on the grid).[24] Therefore, lack of stress indicates syllable lightness.

[24] What WSP does not predict, however, is the relation between primary stress and heavy syllables. As long as a heavy syllable is metrified and assigned headedness of its foot, it will not incur any violation of WSP, whatever the stress it carries is, primary, secondary or even tertiary.

Obviously this is a literal interpretation of the relation between weight and foot prominence, within an Optimality Theory framework.

The main task of this constraint is to rule out all the marked representations of prominence and weight relations in (84), where heavy syllables failed to be promoted: (ĹH) (HĹ) (HH́) (H́H). We are left with one problem, though. Neither WSP nor any constraint introduced so far could rule out the lawful but highly marked foot configuration (H́L), where the heavy syllable is stressed hence satisfying WSP and binarity is met syllabically. For this reason, Prince & Smolensky (1993) incorporated the constraint RH-HARM.

2.2.4.3.2. Rhythmic Harmony (RH-HARM):

In order to account for this loophole, Prince & Smolensky suggested a constraint "to ban these (feet) on grounds of *rhythmic* structure, which favours length at the end of constituents." (Prince & Smolensky 1993: 59).[25] They quite simplified its domain of application to only disfavour (H́L).

(86) RH-HARM:

*(H́L)

[25] In chapter five below, I will need to decompose FT-BIN (Hewitt 1994), for reasons discussed there. Such a decomposition will provide a set of constraints that will collectively disfavour any foot that is not strictly bimoraic. This will provide a more plausible alternative to RH-HARM.

Therefore, this constraint plus FT-BIN and WSP will rule out the list of highly marked foot types in (84) above.[26]

2.2.4.3.3. Syllabic Binarity:

We saw above how WSP could guarantee weight-sensitive moraic binary parsing, of at least Trochaic feet. And, more fundamentally, we saw how this constraint could ensure that heavy syllables are assigned foot headedness and consequently receive stress, whether primary or secondary. What I did not mention is the fact that WSP can deny the realisation of binary syllabic parsing of quantity-insensitive languages, if a sequence of two or more heavy syllables is involved. This means that incorporating WSP into a given hierarchy means that *uniform* weight-insensitive iterative bisyllabic footing is rendered less harmonious than bimoraic footing, regardless of FT-BIN's position in such a hierarchy.

(87)

	FT-BIN
$[[\mu\mu]_\sigma]_F$	√
$[[\mu]_\sigma[\mu]_\sigma]_F$	√

Van der Hulst (1994) noticed this limitation of this pair of constraints (WSP and FT-BIN) and introduced a constraint that will have to be relatively ranked with WSP to suit language particular requirements of parsing. He called it (Foot) Uniformity. This constraint imposes a restriction on parsing sanctioning only those feet that are uniformly syllabically binary, irrespective of any weight content. He also

[26] Peak-Prominence is another constraint suggested by Prince & Smolensky: (PK-PROM) = Peak (x) > Peak (y) if |x| > |y|. This means that stress results in heaviness which means that a light syllable is not

claims that the relative ranking of this constraint with respect to WSP would demonstrate whether or not a language is weight-sensitive.[27]

(88) a. FT-UNI >> WSP (weight-insensitive)
b. WSP >> FT-UNI (weight-sensitive)

Independently, Hung (1994) relies heavily on a constraint she argues for to account for some phenomena, the most important of which is extrametricality and stress clash. This particular constraint, Rhythm, is a potential alternative to the constraint in van der Hulst (1994). Hung's Rhythm is formalised as follows:

(89) Rhythm
Every grid mark x at level n + 1 (where n ≥ 1) must be followed by a beat of height n such that there is no beat of height greater than n which intervenes.
(Hung 1994: 15)

One of the implications of this constraint is a uniform binary syllablic footing, i.e. an interpretation of Hayes' syllabic trochaic footing.

So, we may claim that we have presented the basic constraints found in the literature that would constitute the primary machinery needed for realising McCarthy & Prince's foot typology:

(90) Foot Typology:

Iambic	Trochaic	Syllabic
LH	H, LL	σσ
LL, H		

(McCarthy & Prince 1993a: 43) (cf. Hayes 1995)

stressed. It is the mirror image of WSP when it comes to application (see Roca and Al-Ageli (1995) for a fruitful discussion).

[27] Uniform bisyllabic parsing may be attributed to the independently motivated constraint *CLASH (see chapter five below).

2.2.4.4. Non-final Stress:

Quite a few stress systems tend to keep stress off the ultima, or more generally off word final position. In a rule-based approach, this is accounted for by calling on extrametricality (Hayes (1981) *et seq*). This independent principle would provide us with language particular rules that apply before metrical rules to render the marked element (segment, syllable, foot) invisible (cf. chapter 6).

To yield this essential effect within Optimality Theory, Prince & Smolensky (1993) developed NONFINALITY. They introduced this constraint on three levels. It can affect one of two levels (syllable or foot) or both of them in a final position. Basically, their division is motivated by the facts of Latin stress, but could be extended to other languages.

First of all, they introduced NON-FIN to exclude final syllables from stress assignment and claim that this is the basic form of the "constraint":

(91) NON-FIN (1)
The prosodic head of the word does not fall on the word-final syllable.
(Prince & Smolensky 1993: 40)

Then, they introduced another level of application to help achieve the default antepenultimate stress in Latin, and similar languages. They wanted to ensure that the head foot is not final in the PrWd.

(92) NON-FIN (2)
The head *foot* of the PrWd must not be final.

(Prince & Smolensky 1993: 43)

This may render good results with almost all inputs in Latin. However, it will have undesired effects on bisyllabic words of the form (LH) and (LL) which are stressed on the initial syllable. In such forms, the head foot must be final, if FT-BIN is to be satisfied (cf. 93 c below). Obviously, this will incur a violation of NON-FIN(2) regardless of the position of stress within this particular foot (on the final syllable or not). This shifts the evaluation burden to WSP that will rule out (ĹH). The following tableau demonstrates the inability of NON-FIN(2) to resolve the conflict between (ĹH) and L(H́) in favour of the former, the true output.

(93)

/ LH /	FT-BIN	NON-FIN	WSP
a. ? (ĹH)		*	*!
b. ☞* L(H́)		*	
c. (Ĺ)H	*!		*

WSP, the low ranked constraint, evaluates the false output L(H́) as most harmonious. This motivated Prince & Smolensky to come up with the third and final version of NON-FIN to evaluate non-finality on both levels, syllables and feet.

(94) NON-FIN (3)
No head of PrWd is final in PrWd.

(Prince & Smolensky 1993: 52)

This constraint says that NON-FIN is violated when either the head foot or the head syllable is final. Forms where the head foot is a final iamb or erected over a heavy syllable incur two violations of NON-FIN.

(95)

/ LH /	FT-BIN	NON-FIN	WSP
a. ? (ĹH)		*!	*
b. L(H́)		*!*	
c. ☞*LH	vac.	vac.	*

This shows that (ĹH) is better than L(H́). Clearly, there remains one problem, however. The unparsed LH is a better candidate analysis, as it vacuously satisfies both FT-BIN and NON-FIN. Prince & Smolensky noted this shortcoming of the so far proposed hierarchy of constraints and suggested a constraint that they put in a wider perspective to rule out completely unparsed inputs.[28] Basically, this constraint was introduced to ensure that monosyllabic words are not extramericalised for the sake of satisfying NON-FIN, that is ranked lower. Prince & Smolensky formalised this constraint as follows.

(96) LX ≈ PR (*MCat*)
A member of the morphological category *MCat* correspond(S) to a PrWd.
(Prince & Smolensky 1993: 43)

To put it as simply as possible, this constraint says that lexical words must be phonologically (prosodically) realised. Obviously, this strongly motivates footing. Nevertheless, LX ≈ PR must be dominated by FT-BIN to block parsing sub-binary lexical categories into feet.

Putting all these constraints into action will attain the desired effect. Consider (97) where (95) is re-presented incorporating LX ≈ PR.

[28] One may argue for the use of the already existing constraint PARSE-SYL, that is violated twice by (95c). I would not favour this prospect because PARSE-SYL would have to be ranked lower than both FT-BIN and NON-FIN which means that violating it by (95c) is of no significance as far as the evaluation of the true output (ĹH) is concerned.

(97)

/ LH /	FT-BIN	LX ≈ PR	NON-FIN	WSP
a. ☞(ĹH)			*	*
b. L(H́)			**!	
c. LH	vac.	*!		*

By this, I conclude discussing NON-FIN and move to Directionality.

2.2.4.5. Directionality:

In standard metrical theory, directionality is accounted for, like almost everything else, by a rule explicitly indicating the direction in which footing proceeds. What I want to investigate below is whether or not this brute force is required to maintain directionality effects in OT.[29]

ALIGN-FOOT is introduced in McCarthy & Prince (1993b) to achieve the directionality requirement (cf. 2.2.4.1.3. though). It will determine directionality of footing, especially in odd-numbered syllable sequences, by scanning the candidates to see whose feet are closer to the designated edge. The distance is usually measured by syllables.

(98) a. Align (Ft, L, PrWd, L) left-to-right
b. Align (Ft, R, PrWd, R) right-to-left

(McCarthy & Prince 1993b: 16)

What these two constraints are saying is that the left or right edge of each and every foot, in a particular prosodic word, must be aligned with the same edge of that prosodic

[29] In Idsardi (1992) and Halle & Idsardi (1995), this may be achieved by a less explicit or wholly devoted parameter, i.e. Iterative Constituent Construction, that, for the sake of binarity as well, specifies the parenthesis iteratively inserted and consequently the direction of insertion (cf. § 6.3.).

word. As we saw above when we talked about single foot prosodic words, this will only be perfectly satisfied by a candidate containing a single foot aligned to the nominated edge. However, this is not always the case. Ranking FT-BIN over PARSE-SYL and having them dominate this alignment constraint to achieve binary bounded footing will inevitably incur violations of ALIGN-FOOT. This is not something adverse in OT. Candidates can violate some constraints and are still chosen to be optimal if the number and/or relative ranking of the violated constraint(S) is lower than in other alternatives (cf. Violability in chapter one). So, in our particular case, the lower the number of violations of ALIGN-FOOT a certain candidate incurs the higher its potentiality of being designated as the optimal true output - *ceteris paribus*. In other words, the shorter the distance separating each foot in a certain form from the desired edge, and consequently the fewer the number of syllables accumulating after evaluating every foot, the more optimal a candidate is.

Crowhurst and Hewitt (1994) take a slightly different position, however. They think that ALIGN-FOOT may not hold full responsibility for determining directional footing, which is basically decided by “its interaction with constraints requiring syllable-to-foot parsing and binary foot structure.” (Crowhurst and Hewitt 1994: 4). Therefore, they proposed three basic rankings for these three constraints, with different outcomes.

They suggested two different groups of rankings; one achieves iterative footing and the other does not. Firstly, they demonstrate that if ALIGN-FOOT dominates PARSE-SYL, no iterative footing will take place. The relative ranking of FT-BIN with respect to these two constraints will only determine whether or not all syllables are

parsed into a single unbounded multi-syllabic foot. This means that directionality is of no significance, assuming this particular ranking. On the other hand, ranking PARSE-SYL higher than ALIGN-FOOT will have wholly different consequences on iteration and more importantly (given the involvement of FT-BIN) on directionality. They summarise their claims as follows:

(99) a. Align >> Parse-σ : noniterative footing (independent of FtBin)

b. Parse-σ >> Align : iterative footing in α direction and *F(σ) if FtBin >> Parse-σ.
iterative footing in -α direction and F(σ) if Parse-σ >> FtBin.

(Crowhurst and Hewitt 1994:10)

This means that if PARSE-SYL dominates ALIGN-FOOT, directionality and the legitimacy of foot degeneracy are determined by FT-BIN and PARSE-SYL's relative rankings, as illustrated in the following tableaux.

(100) (i) FT-BIN >> PARSE-SYL >>ALIGN-FOOT (left)

Candidates	FT-BIN	PARSE-SYL	ALIGN-FOOT (L)
a. ☞(σσ)(σσ)σ		*	**
b. (σ)(σσ)(σσ)	*!		****
c. (σσ)(σσ)(σ)	*!		******

(ii) PARSE-SYL >> FT-BIN, ALIGN-FOOT (left)

Candidates	PARSE-SYL	FT-BIN	ALIGN-FOOT (L)
a. (σσ)(σσ)σ	*!		**
b. ☞(σ)(σσ)(σσ)		*	****
c. (σσ)(σσ)(σ)		*	*****!*

By this, I conclude discussing directionality, and I also conclude the summary of stress in Optimality Theory in general. In chapter five, as previously mentioned, I will analyse the stress pattern of UHA from an OT viewpoint, applying the constraints

discussed above. However, as we shall see there, these constraints will not be sufficient to account for a stress pattern that is both prominence-driven and rhythm-driven like UHA. The issues tackled in that chapter may not be as simple and straightforward as this. I will need to suggest further constraints and arguments to account for the attested facts of the language. Nonetheless, the challenge is to achieve this assuming universality.

Thus, I will conclude this subsection by presenting a comprehensive view of all the constraints discussed above and the broad principles they help to maintain or achieve.

(101)

Principle	Boundedness	Headedness	weightsensitivity	Extrametricality	Directionality	Exhaustivity
Constraints	FT-BIN	RH-TYPE RH-HARM ALIGN-HEAD	WSP	NON-FIN	ALIGN-FOOT	PARSE-SYL

2.3. Conclusion:

This chapter introduced the theoretical foundation required for my analysis of UHA data. I focused on the principles of syllabification and metrification in DT and OT. I aimed at the general issues in these fields postponing the more detailed analyses to subsequent chapters, as exemplified and mentioned in more than one place above. Therefore, in addition to providing an account for the processes of syllabification and metrification in UHA, the following chapters will evaluate the different frameworks summarised in this chapter. However, simplicity and plausibility are the determining factors in that evaluation.