

ALIGNMENT AND ADJACENCY

IN

OPTIMALITY THEORY:

Evidence from Warlpiri and Arrernte

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ABBREVIATIONS

()/F	=	foot
[]/PW	=	prosodic word
σ	=	syllable
μ	=	mora
	=	stem edge
{	=	intonational phrase edge
*	=	constraint violation
!	=	fatal violation
◇	=	unparsed.
-	=	morpheme boundary (<i>Sometimes glosses are not given to individual morphemes. This is because some morphemes are considered to be bipartite eg =ma=lu 1peS. In addition, there are a number of frozen complex words, in which the morphemes are discernible but no glosses are assigned to them</i>)
=	=	clitic boundary

1/2/3 first/second/third person

S subject

NS non-subject

s singular

d dual

p plural

i inclusive

e exclusive

3DAT 3rd dative

ALL allative

BEN benefactive

CAUS causative

CHARAC characteristic

COMIT comitative

DAT dative

DENIZ denizen

ELAT relative

ERG ergative

FUT future

IDENT identified information

IMP imperative

IMPF past imperfect

INCEP inceptive verb formative

INCH inchoative

INF infinitive

IRR irrealis

LOC locative

NOMIC agentive

NPST non-past verb inflection

PART participle

PL plural number

PST past verb inflection

POSS possessive

PROP proprietive

PURP purposive complementiser

RECIP reciprocal

SERCOMP preceding event

SEQCOMP directional purposive

CHAPTER 1

OPTIMALITY THEORY

1.1 Introduction

The aim of this thesis is to assess and account for phonological and morphological data by providing explanations and revealing generalisations not previously noted or not sufficiently reflected in analyses. This is a departure from most theses written in Australia which focus on previously undescribed Australian languages or particular grammatical aspects of Australian languages. These theses often bring to light data which challenges current theoretical models. Within the domain of phonology, this thesis attempts to take the next step and show how a broad selection of data can be incorporated into theoretical models of phonology, and what changes to the theory are needed to make this possible. Optimality Theory (McCarthy & Prince 1993a; Prince & Smolensky 1993) seems well suited to this enterprise since it allows for fluid interaction between phonological and morphological entities, not adequately captured in other or previous theories, and such interaction is particularly evident in Australian languages. The benefit to be gained is a better understanding of the interaction, the patterns of interaction, as well as improved theoretical models with greater empirical coverage which contain clearer and more relevant representations, and more constrained analyses.

In general, phonological descriptions of Australian languages use a version of Chomsky and Halle's (1968) generative phonology. The problem with such generative models and earlier item-and-process accounts is that two kinds of rules are required: phonological rules and morpheme structure constraints. The main role of phonological rules was to account for alternations such as that seen in vowel harmony, where the alternants are related to each other via underlying representations. Morpheme structure constraints are generalisations such as those defined on a language's segment inventory, combinations of features and phonotactic constraints on sequences of sounds.

The early generative model is a linear one which conceives of phonemes as a string of positions not grouped into any higher order constituents. Problems with this conception were revealed in processes which required reference to syllable structure and in accounts of stress. With reference to stress, Chomsky and Halle (1968) used a binary [+/- stress] distinction to show that the distribution of stress in a word could be predicted by simple rules. The binary distinction faced much the same problem that the structuralists (Trager & Smith 1951, Newman 1946, among others) encountered with their interpretation of stress as four stress phonemes. The problem is that stress is very different from segmental phonemes because stress has no invariant phonetic cues, has long distance effects, can be realised only in certain positions in a word, and can be lexical.

To better capture the qualities of stress, a metrical grid was introduced which represented different levels of prominence, and syllables were associated with positions on the grid (Liberman 1975). Thus a syllable would have primary stress by virtue of the fact that it was associated to a grid position which had the highest level of grid marks. Stress alternations, for instance, where a stress moves when adjacent to another, could be easily accounted for by moving grid marks that are adjacent on some level.

It became evident that the grid could be used to establish parameters. These parameters are based on whether at a word edge there was a stressed (peak) or unstressed syllable (trough) and on the direction for stress assignment, eg peak first right-to-left, trough first right-to-left. Among some proponents of the theory, there was no characterisation of metrical grouping. However, an alternative was to do just this, that is, group stressed and unstressed syllables into metrical units known as feet. A grouping which contains an initial stressed syllable is a trochaic foot, and one where a stressed syllable is final is an iambic foot. This led to a move away from purely linear representations to hierarchical structures in phonology.

Because syllables could be grouped into feet some interesting patterns were discovered relating to syllable weight. For instance, Hayes (1985) found that an asymmetry existed in stress patterns, which is that quantity insensitive systems (no distinctions in syllable weight) tend to be trochaic while iambic parses do not permit a heavy syllable to be in an unstressed position preceding a stressed light syllable, eg (HL'). The motivation for the asymmetry comes from human perception of rhythmic groupings. In experimental psychology it was found that when quantity distinctions are to be made an iambic grouping is favoured, but a trochaic grouping is favoured when distinctions of intensity are made (Bell 1977). The grouping principle is evident when English speakers demonstrate the difference between iambic and trochaic verse, eg iambic grouping is shown as: ta taa ta taa ta taa; while the trochaic grouping is TA ta TA ta TA ta.

Given that grouping syllables into feet revealed previously unnoticed patterns, a number of metrical theorists came to accept a hierarchy of phonological or prosodic constituents.¹ Such groupings were useful to account for a number of processes. In early linear models, morphophonological processes such as reduplication or infixation were accounted for with unconstrained rules potentially producing operations that did not occur. For instance, a phonological representation consisted of a string of phonemes, where there were no points or units that could be referred to. With the notion of prosodic constituents, eg syllable, foot and prosodic word, phonological and morphological operations could refer to such groupings.

Since it has been acknowledged that particular groupings exist, it has been possible to show what similarities exist across very diverse languages, revealing that little variation exists in certain properties. This moves in the direction of finding what common elements are shared amongst languages and thus what is part of Universal Grammar. The differences in languages then occur because of different choices of settings/parameters/options/constraint orderings.

Despite the variability evidenced across languages in stress patterns and reduplication, it was found that a small set of constituents could account for these processes. What undermined this benefit was how the patterns were derived and once derived whether any further changes were required. Rules derived outputs, but often morpheme structure constraints or wellformedness conditions, and not rules, determined the form of an output. Furthermore, wellformedness conditions could be overridden at various points during a derivation, for instance, certain elements may be assigned monosyllabic feet (σ) during a derivation, even though such feet do not occur in outputs. In addition, some wellformedness conditions were more important than others, but there was no systematic way to encode this.

¹ Note that the use of 'prosodic' differs from the term used by the Firthian school of phonology named after J R Firth (see Sommerstein 1977). The main thrust of this theory was that a speech stream could not suitably be analysed into discrete units. In an analysis of vowel harmony, features involved in the harmony like rounding and fronting are represented as 'prosodies' of a word which can affect intervening consonants. The harmonising vowels do not have any markings but take on a prosody. For instance, in Turkish **ulusum** 'my arm' would have the following representation /^wVIVsVm/. Prosodies are written as superscript symbols.

Essentially, the problem, known as the Duplication Problem as discussed by Kenstowicz and Kisseberth (1977), is that two separate mechanisms, the morpheme structure constraints and phonological rules, are required to account for the phonological generalisations of a language.

To avoid this disadvantage, the aim is to develop ways to account for processes which do not require unmotivated constituents, to develop a system of priorities leading to a much more constrained theory, to enhance our understanding of the various phenomena and to have better representations. Optimality Theory has made much ground in this direction. Here rules and constraints are both characterised in terms of constraints contained in a single grammar and these constraints interact just once, simultaneously, when evaluating the well-formedness of an output. The emphasis is on the output and constraints that ensure the well-formedness of an output.

In this thesis I examine the processes of stress, reduplication and vowel harmony in a number of Australian languages. The analysis of these processes is carried out within the theoretical framework of Optimality Theory (OT), incorporating the theory of Prosodic Morphology (McCarthy and Prince 1986, et seq), which is a theory of the interaction between prosodic constituents and morphological processes. OT builds on this theory, introducing a system of constraints based on well-formedness conditions which determine the well-formedness of surface forms. This chapter outlines the operation and principles of OT.

As will be shown in the thesis, one of the benefits of OT is a straightforward account of operations occurring at the interface between phonology and morphology. This contrasts with rule-based analyses which are restricted in providing explanatory accounts for such operations, often invoking un insightful mechanisms. As I show in Chapter 2, accounting for the behaviour of monosyllabic morphemes under stress requires that the morpheme structure of the word and the size of individual morphemes within this word are ‘known’ in order to derive optimal outputs. The failing with rule-based analyses is that they cannot know and are forced to introduce purely mechanical devices which are often subsequently obliterated before an output is finally generated.

The value then in accounting for processes in OT is to reveal patterns and phenomena previously obscured by the constructs of a rule-based analysis and to do so in a constrained fashion. The contribution this thesis makes in this regard is an explicit characterisation, for the first time, of the interaction between morphology and rhythm in both isolated words and casual speech, allowing for binary and ternary rhythm which is constrained by binary feet. This is achieved by aligning feet to an edge (the range of edges is expanded here), by requiring adjacency of feet, by ruling out sequences of unfooted syllables, and by allowing constraint relaxation in some contexts (the latter features independently introduced here). Support for adjacency is found in vowel harmony where adjacency accounts, in contrast with other analyses, for harmony and blocking without needing unusual feature specifications and representations and the consequence is finding three main characteristics in harmony processes. Finally, I introduce a theory to account for onset sensitivity in various phenomena which is based on syllable prominence, thereby enhancing our concept of prominence and rhythm. The overall finding is that prosodic constraints dominate constraints on the interaction between phonology and morphology.

The structure of this chapter is as follows. Section 1.2 discusses stress patterns of a few languages and shows how and why OT is preferred in accounting for these patterns. In 1.3 the concept of alignment is introduced and in 1.4 the notion of adjacency is discussed. As much of the data examined in this thesis is of Warlpiri, a brief outline of the grammatical structure of Warlpiri is presented in 1.5. The organisation of the remainder of the thesis is given in 1.6.

1.2 Theoretical Introduction

In this section, some basic stress patterns are presented and I show how these can be accounted for in OT. This is followed by discussion of the principles governing OT.

1.2.1 Stress patterns

In many languages, stress alternates on syllables across a word. A rhythmic pattern is created by the alternation of stressed and unstressed syllables. This is illustrated in Pintupi (Hansen and Hansen 1969,1978) where stress falls on the word-initial syllable and every other odd-numbered syllable. Odd-numbered syllables in word-final position are not stressed.

(1)	tjúrtaya	'many'
	márlawàna	'through from behind'
	púrlingkàlatju	'we (sat) on the hill'
	tjámulìmpatjùngku	'our relation'
	rtúrlirdìngulàmpatju	'the fire for our benefit flared up'
	yúrdanjùlulìmpatjùrra	'because of mother-in-law' ²

The alternation of stress is due to the assignment of feet across a word. Two syllables are grouped into a foot and one of these syllables receives stress, as in (márla)(wàna) 'through from behind', where "()" indicates a foot. Feet must consist of two syllables in Pintupi. Foot size accounts for the fact that adjacent syllables are not stressed, *(má)(rlàwa)na 'through from behind', and for the fact that word-final odd-numbered syllables are not stressed, *(tjúrta)(yà) 'many'.

In general feet are binary ($\sigma\sigma$); monosyllabic (σ) and ternary feet ($\sigma\sigma\sigma$) are not well-attested crosslinguistically. Some languages allow for monosyllabic feet in some contexts, but there is very little support for ternary feet. Languages with ternary alternation (eg Estonian and Warlpiri discussed in Chapter 4), where stress occurs on every third stress bearing unit, can be accounted for with binary feet.

The presence of an odd number of syllables in a word suggests that foot assignment is directional; that feet are parsed commencing from one edge of a word and moving to the other edge. In Pintupi, word-final odd-numbered syllables are unstressed indicating that feet are assigned from the left edge of the word.

In contrast to Pintupi, feet in Warao (Osborn 1966) are assigned from the right edge of the word, as is evident in (2a), where the initial odd-numbered syllable is unfooted:

(2)	a. e.(nà.ho.)(rò.a.)(hà.ku.)(tá.i)
	'the one who caused him to eat'
	b. (nà.ho.)(rò.a.)(hà.ku.)(tá.i)
	'the one who ate'

The location of feet indicates that the alternation of feet is oriented with respect to word edges. In previous accounts within metrical phonology (including Liberman and Prince 1977; Hayes 1981; Prince 1983; Hammond 1984; Selkirk 1984; Halle and Vergnaud 1987; Kager 1989)

² No morpheme-by-morpheme glosses are given.

such directional effects are derived by constructing feet from either the left or right edge of a word. This gives the following patterns in (3). σ =syllable

- | | | |
|-----|--|--|
| (3) | Left-to-right (Pintupi) | Right-to-left (Warao) |
| | $(\sigma\sigma)(\sigma\sigma)\sigma$ | $\sigma(\sigma\sigma)(\sigma\sigma)$ |
| | $(\sigma\sigma)(\sigma\sigma)(\sigma\sigma)$ | $(\sigma\sigma)(\sigma\sigma)(\sigma\sigma)$ |

The fact that a syllable is unfooted at the right edge in Pintupi indicates that feet are oriented to the left word edge, while in Warao the unfooted syllable word-initially shows feet are oriented to the right.

In languages with alternating stress, as many syllables as possible are parsed into feet. This is interpreted as exhaustive parsing³. However, when there are an odd number of syllables, one syllable is not incorporated into a foot, as exhibited by Pintupi and Warao. This means that exhaustive parsing is not satisfied. On the other hand, if exhaustive parsing was satisfied, all syllables would be parsed into feet, thus giving rise to a foot consisting of a single syllable: $(\sigma\sigma)(\sigma\sigma)(\sigma)$ ⁴, or a ternary foot: $(\sigma\sigma)(\sigma\sigma\sigma)$. A foot with a single syllable or monosyllabic foot would not satisfy the foot binarity requirement. This conflict between the two requirements can be resolved by a statement such as 'syllables are parsed into feet except final odd numbered syllables'. A better solution is to say that one requirement has priority over another. This is the solution offered by OT.

In Pintupi and Warao, foot binarity has priority over exhaustive parsing which means that satisfying foot binarity is more important than satisfying exhaustive parsing. In some languages the reverse is true; exhaustive parsing has priority over foot binarity. This is shown in Ono (Phinmore 1985, Hayes 1991):

- | | | |
|-----|--------------|----------------|
| (4) | (déne) | 'my eye' |
| | (ári)(lè) | 'I went' |
| | (lólót)(nè) | 'many' |
| | (mési)(kène) | 'you will sit' |

Word-final odd numbered syllables in Ono are parsed into feet, which is contrary to the requirement on foot size, but satisfactory for the requirement on exhaustive parsing. These requirements or conditions on parsing are expressed in OT as constraints. Where there are conflicts between constraints one of these constraints is given priority over the other. Priority is characterised in terms of ranking. If one constraint is ranked over the other the higher ranked constraint must be satisfied. Ranking is discussed in 1.2.2. The requirements on foot size and exhaustive parsing are expressed in the following constraints (McCarthy & Prince 1993a, henceforth M&P):

- (5) **FOOT BINARITY (FtBin):** Feet are binary at a syllable or moraic analysis.
- (6) **PARSE σ :** syllables must be parsed into feet.

³ This could also be interpreted as iterative footing – an unfooted syllable at the edge of a word is left stray.

⁴ In some analyses, an odd-numbered syllable at the end of a word is regarded as extraprosodic or invisible to feet.

In Pintupi and Warao, FtBin is ranked above (or is dominant over) PARSE σ which ensures that syllables can only be parsed into binary, and not monosyllabic, feet. The form $(\sigma\sigma)(\sigma\sigma)\sigma$ is well-formed by FtBin. In Ono, PARSE σ is ranked above FtBin which ensures that all syllables are parsed into feet, binary or monosyllabic. The form $(\sigma\sigma)(\sigma\sigma)(\sigma)$ is well-formed by PARSE σ .

In OT, the directionality in foot parsing is captured in a constraint requiring all feet to be as close as possible to the edge of a word. This is Align Foot (AlignFt) (M&P 1993b; Kirchner 1993):

- (7) **AlignFt:** A foot is aligned to the left/right edge of a prosodic word.

The location of feet with respect to the edge of a word is specified for each language. Thus, for Pintupi, it is AlignFt-Left, and for Warao, it is AlignFt-Right. As previously discussed, the evidence that feet are oriented to one edge comes from the location of unfooted syllables at the edge of a word. For instance, an unfooted syllable at the right edge can mean foot alignment is to the left edge.

Under AlignFt, every foot is assessed in relation to its distance from the edge of a prosodic word. For Pintupi, the location of feet is assessed in relation to the left edge of the word. To assess the distance from the left edge, the number of syllables are counted. In (8a), the second foot (F2) is two syllables from the left edge and satisfies AlignFt better than (8b,c) where the second foot is three syllables from the edge.

- (8) a. (púrling)(kála)tju F2: $\sigma\sigma$
 b. pu(rlíngka)(làtju) F1: σ ;F2: $\sigma\sigma\sigma$
 c. (púrling)ka(làtju) F2: $\sigma\sigma\sigma$

AlignFt ensures that the best output is where one foot is aligned to the edge of a word. Other feet in the word do not satisfy the requirement. When AlignFt has priority over PARSE σ , this will account for languages with one stress per word, as in French **amicalemént** 'friendly', or Turkish **adam-lar-á** 'to the men'.

To account for languages with alternating stress, PARSE σ must have priority over AlignFt. PARSE σ ensures that as many syllables as possible are parsed into feet. The form in (9a) satisfies this requirement better than (9b) because it has more syllables incorporated into feet.

- (9) a. $(\sigma\sigma)(\sigma\sigma)\sigma$ - satisfies PARSE σ but not AlignFt (1 foot is not aligned)
 b. $(\sigma\sigma)\sigma\sigma\sigma$ - satisfies AlignFt but not PARSE σ (3 syllables are unfooted)

The alignment of feet with prosodic word edges can account for the stress patterns of many languages. In previous metrical (or rule-based) accounts of stress, a stress rule, eg parse stress left-to-right, is stated along with well-formedness conditions, like FtBin. In many cases, the conditions on stress assignment determined the outcome of the rule, and some of these conditions had priority over others, for instance the priority of FtBin over PARSE σ for which a specific statement is required. This conflict between the rules for stress assignment and the conditions on stress assignment, as well as conflict between the conditions themselves, is given a straightforward account in OT. In OT, the motivation for the rule and the conditions on the rule are interpreted as constraints and ranked in a system giving priority to some constraints.

Constraints operate on inputs producing a surface form without the need for step-by-step derivations. In situations where rules are overridden by wellformedness conditions, the necessity for such rules diminishes and given that in many cases the structural description of a process, where A

becomes B, follows from general well-formedness constraints on the language, rules become redundant.

In rule-based accounts, rules are sometimes over-ridden by an 'except when' type of statement. This is the case for Pintupi, where the statement for parsing is: syllables are parsed into feet except when the final syllable is an odd-numbered one. Given that feet are universally binary, why would such a statement be necessary? The fact that feet are binary should account for unfooted syllables in Pintupi. However, since there are languages such as Ono, where feet can be monosyllabic word-finally, an 'except when' statement seems necessary. In Ono, an 'except when' statement is not required, but the condition that feet are binary has to be relaxed.

'Except when' statements are necessary to account for the inadequacies of rules which provide no reason for why rules are over-ridden. Nor is there an explanation in rule-based systems for why conditions can be relaxed in some instances. The existence of rules, well-formedness conditions or 'except when' statements obscure priorities exhibited by languages and the differences between languages.

In OT, well-formed outputs are a result of satisfying the constraints that have priority. This contrasts with similar theories where the output is the one that satisfies all constraints. Approaches that incorporate constraint satisfaction include Kisseberth (1970), Haiman (1972), Stampe (1973), Sommerstein (1974), Bird (1990), Bosch and Wiltshire (1993), Goldsmith (1991), Kaye, Lowenstamm and Vergnaud (1985, et seq.), Paradis (1988), Scobbie (1991), Singh (1987).

In OT, well-formedness constraints are ranked on a scale of most to least important. If higher ranked constraints cannot be obeyed, the next best thing is obeying the next condition down the scale. Violation of constraints is possible, but least violation will generate the most well-formed or optimal output.

Constraints that account for the stress patterns of a number of languages are AlignFt, PARSE σ and FtBin. A constraint on the type of foot, iambic ($\sigma\sigma'$) or trochaic ($\sigma'\sigma$), is also required. Differences in priority or ranking of these constraints account for the different patterns exhibited by the various languages. The notion of ranking is discussed below.

1.2.2 Ranking

In OT, constraints replace rules in determining the well-formedness of outputs in prosodic processes. Constraints are ranked on a language-particular basis and may be violated. This is in contrast to other constraint-based systems, which do not allow for constraint violation (Goldsmith 1990, 1991, among others). Candidates are evaluated in 'constraint tableau'. Following M&P (1993a) the following representations used in tableaux are adopted (with some modification):

% = optimal candidate (instead of a pointing hand in M&P).

* = violation of constraint.

! = fatal violation; the constraint that is responsible for the non-optimality of a candidate.

A blank box indicates that a constraint is satisfied. In the OT literature, a shaded box in a tableau indicates that a constraint is irrelevant to the fate of the candidate. Shading is not a crucial aspect in tableaux and is not included here.

In the constraint tableaux, constraints are ranked in descending order from left to right. The highest constraint is at the very left of the table, while the lowest is on the right. Ranking order is indicated as A >> B, which is interpreted as: A is ranked higher than B, or A is preferred over B. This is illustrated in the following tableau:

(10) candidate	A	B
% X1		*
X2	*!	

The optimal candidate is the one which does not violate the highest ranked constraint, in this case X1.

If both outputs violate constraint A, then the decision as to which is most optimal falls on B, as shown in (11).

(11) candidate	A	B
% Z1	*	
Z2	*	*!

When there is no violation of A, as in (12) below, B will make the decision on the optimal candidate.

(12) candidate	A	B
% P1		
P2		*!

In many cases, a candidate will violate more than one constraint. This is an instance where constraints conflict. If the conflict is between a specific constraint and a more general constraint, then the specific constraint must be ranked higher than the general one. This ranking is necessary if the specific constraint is to have some effect or seen to be active in the tableau. Prince and Smolensky (1993) term this ranking logic 'Panini's Theorem' (also known as the 'Elsewhere Condition'; see Kiparsky 1973 et seq).

The differences between the stress patterns of the languages discussed above are characterised by the following rankings.

- (13) Pintupi, Warao: FtBin >> PARSE σ >> AlignFt
 Ono: PARSE σ >> FtBin >> AlignFt
 French: FtBin >> AlignFt >> PARSE σ

The fact that monosyllabic feet occur in Ono is due to the ranking of PARSE σ over FtBin, and the fact that only one foot occurs in French is due to the ranking of AlignFt over PARSE σ . This ranking provides a way of explaining why some constraints but not others are violated and thus, the differences between languages in the realisation of outputs.

In rule-based accounts, no straightforward account of these differences is available, nor is there an explanation for why rules can be overridden by constraints. Constraints are turned on and off at particular points in a derivation without motivation for this apart from ensuring that the right output could be derived. Further, we find that some constraints are overridden during a derivation, but cannot be overridden in outputs. One consequence is the introduction of additional principles or rules which complicate the analysis and contribute no insights to the process. These deficiencies are detailed in Chapter 2.

Another advantage of constraints is that language typologies can be constructed and different languages can easily be compared. With the different rankings of the constraints in the languages in (13) we are able to see what gives rise to the differences in stress patterns.

Underlying the system of constraints are the Principles of OT discussed below.

1.2.3 Principles

There are five basic principles of Optimality Theory. These are listed below, followed by discussion of these principles.

(14) Principles of Optimality Theory

a. Universality

Universal Grammar provides a set CON of constraints that are universal and universally present in all grammars.

b. Violability

Constraints are violable; but violation is minimal.

c. Ranking

Constraints of CON are ranked on a language-particular basis; the notion of minimal violation is defined in terms of this ranking. A grammar is a ranking of the constraint set.

d. Inclusiveness

The constraint hierarchy evaluates a set of candidate analyses that are admitted by very general considerations of structural well-formedness. There are no specific rules or repair strategies.

e. Parallelism

Best-satisfaction of the constraint hierarchy is computed over the whole hierarchy and the whole candidate set. There is no serial derivation.

Constraints are said to be universal, such as the requirement for feet to be binary and for feet to align to the edge of a word, and these constraints are contained in the grammars of all languages. Violation of constraints is possible, and languages vary as to which constraints may be violated; for instance, violation of FtBin is allowed in Ono, but not in Pintupi. This variation reflects a difference in importance of some constraints and is expressed through constraint ranking.

As previously mentioned, there are no rules to derive surface forms. Surface forms are selected from a large number of forms on the basis as to how well they satisfy constraints. The constraints assess forms simultaneously which means that prosodic structure is not constructed gradually as in derivational analyses, but that this structure is constructed at the same time.

These principles enable a number of significant changes to the ways output forms are derived. The constraints together with their ranking determine wellformed outputs without the need for step-by-step derivation. In other words, evaluation by the constraints of various outputs is simultaneous.

According to the theory, a Universal grammar must provide the following:

CON.	The set of constraints out of which grammars are constructed.
GEN.	A function where an input string is associated with a potentially infinite set of outputs in line with that string.
EVAL.	A function that comparatively evaluates sets of forms with respect to a given constraint hierarchy, a ranking of CON.

The constraints that form the grammar of a particular language are given by CON. The set of constraints is specified by Universal Grammar and individual languages impose a different ranking on these constraints. There are three broad categories of constraint families which are discussed below. Variation between languages may result from the different ranking of the Universal constraints.

EVAL's role is to assess output candidates and sort them as to how best they satisfy the constraints of the language in question. The candidate that best satisfies the constraints is the one which minimally violates the constraints.

The tableau in (15) illustrates the generation of outputs from an input. From the input /tjurtaya/ 'many', from Pintupi, a number of outputs are produced which are assessed by constraints ranked as FtBin >> PARSE σ >> AlignFt. Many other outputs are possible, but would be ruled out by higher ranked constraints on parsing segments and syllable structure.

(15) /tjurtaya/	FtBin	PARSE σ	AlignFt
a. (tjúrta)(yà)	*!		F2: $\sigma\sigma$
b. tjurtaya		$\sigma\sigma!$	
c. tju(rtáya)		σ	F1: $\sigma!$
%d. (tjúrta)ya		σ	F1:#

In (15a) the higher ranked constraint FtBin is violated, and because of this violation to lower ranked constraints is irrelevant. PARSE σ rules out (15b) because it has more violations than (15c,d). The decision as to the optimal output is left to AlignFt. As the foot in (15d) is at the left edge of the word and is not in (c), (d) is the optimal candidate.

As shown in (15), EVAL determines the wellformedness of each member of the candidate set through the system of ranked constraints. A candidate is evaluated by how it best satisfies the constraint system. A candidate that least violates the constraints is the optimal candidate, as (15d).

Since constraints evaluate outputs, it is necessary to provide a large set of candidate outputs. GEN produces a set of outputs from a given input. This set is evaluated by the constraints in tableaux from which the best output is selected. Two features are incorporated into Gen: (1) representational primitives of linguistic form, for instance, features; (2) inviolable constraints on linguistic structure, such as the properties of feature geometry (eg root nodes dominate features) and prosodic structure (eg syllables dominate moras, feet dominate syllables etc). While Gen is constrained by these principles when it produces outputs from the input, it has some freedom to improvise for instance, with syllabification, features, deletion of structure, and ordering segments.

M&P (1995) introduce the Correspondence theory of faithfulness in OT which has different consequences for the interpretation of GEN compared to earlier work in OT (Prince & Smolensky 1993; M&P 1993a,b). The essential difference is that GEN is given a correspondence function where outputs are dependent on the input. Part of the motivation for this change came from reduplication where the reduplicant (the copy) is dependent on the base for its phonological

interpretation. Here there is a correspondence relation between the base in the output and the reduplicant, the reduplicant occurring only in outputs. In addition, there is the input-output relationship in phonology which looks at whether the identity of the output is the same as that in the input. In both kinds of relationship, a comparison between two forms is made. The formal statement for Correspondence is given as:

(16) Correspondence (McCarthy & Prince 1995)

Given two related strings S_1 and S_2 , Correspondence is a relation \mathfrak{R} from the elements of S_1 to those of S_2 . An element $\alpha \in S_1$ and any element $\beta \in S_2$ are referred to as *correspondents* of one another when $\alpha \mathfrak{R} \beta$.

The correspondence relation between S_1 and S_2 can vary, but the choice as to the optimal output is determined by the constraints which make up CON. The three main constraint families of CON are: markedness constraints, faithfulness constraints and alignment constraints. Markedness constraints look at how well-formed linguistic structures are, such as segments and syllables. For instance, syllables typically have onsets, and thus a markedness constraint would state that all syllables have onsets.

Faithfulness constraints look at the correspondence between two strings and any variations from the original string, such as reordering of segments, deletions and insertions of features and segments, are penalised. Three general constraint groups occur in the set of faithfulness constraints: MAX, DEP and IDENT. These are briefly described below (M&P 1995):

(17a) **The MAX Constraint family**

General Schema

Every segment of S_1 has a correspondent in S_2 .

Specific Instantiations

MAX-BR

Every segment of the base has a correspondent in the reduplicant.
(Reduplication is total)

MAX-IO

Every segment of the input has a correspondent in the output.
(No phonological deletion)

(b) **The DEP Constraint Family**

General Schema

Every segment of S_2 has a correspondent in S_1 .

(S_2 is 'dependent on' S_1)

Specific Instantiations

DEP-BR

Every segment of the reduplicant has a correspondent in the base.
(Prohibits fixed default segmentism in the reduplicant)

DEP-IO

Every segment of the output has a correspondent in the input.
(Prohibits phonological epenthesis)

(c) **The IDENT(F) Constraint Family**

General Schema

IDENT(F)

Let α be a segment in S_1 and β be any correspondent in S_2 .

If α is $[\gamma F]$, then β is $[\gamma F]$

(Correspondent segments are identical in feature F)

Specific Instantiations

IDENT-BR(F)

Reduplicant correspondents of a base $[\gamma F]$ segment are also $[\gamma F]$.

IDENT-IO(F)

Output correspondents of an input $[\gamma F]$ are also $[\gamma F]$

In sum, these constraints regulate the amount of deletion, insertion that occurs in an output string, as well as regulate the identity of features. In the next section the Alignment constraint family of CON is introduced.

1.3 Alignment

Prosodic processes, such as stress assignment discussed above, often make reference to an edge, morphological or syntactic. Theories of the syntax-phonology interface (including Chen 1987, Selkirk 1986) are primarily concerned with the edges of syntactic constituents. In these theories, the edges of syntactic constituents form the basis for constructing phonological representations. The edge of a lexical category may correspond to the edge of a phonological word or phrase.

M&P (1993b) propose to extend the theory to incorporate not only syntactic edges, but also morphological and prosodic edges. They claim that a theory which incorporates all such edges is better equipped to deal with the diverse range of prosodic processes exhibited by languages. Coincidence of the edges of prosodic constituents with other prosodic constituents and morphological ones is interpreted through alignment constraints, where the edge of one constituent is required to align/coincide with another. The relationship between edges is expressed in terms of alignment.

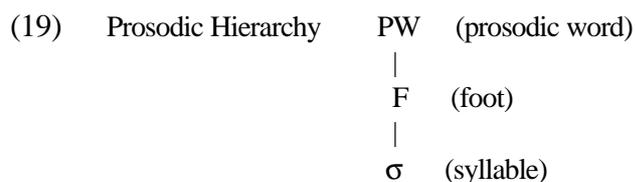
Alignment of prosodic and grammatical constituents is grouped under one family of well-formedness constraints known as Generalized Alignment (M&P 1993b). Coinciding edges may be of a PCat, prosodic category, or of a GCat, grammatical category. The range of alignments are PCat to Gcat, PCat to PCat, or GCat to PCat.

According to M&P, the technical interpretation of the term "edge" is relational, meaning something like "sharing an edge". When two categories share an edge they are aligned.

- (18) General Schema for ALIGN (M&P 1993a): In ALIGN(GCat, GEdge, PCat, PEdge), the GEdge of any GCat must coincide with PEdge of some PCat, where GCat = Grammatical Category, among which are the morphological categories, M_{Cat} = Root, Stem, Morphological Word, Prefix, Suffix etc, PCat = Prosodic Category = σ , Ft, PW, PhPhrase, etc, MEdge, PEdge = Left, Right.

Under this schema, the edges of grammatical constituents (morphological and syntactic) map onto or align with the edges of prosodic constituents, and the edges of prosodic constituents align with the edges of other prosodic constituents. The alignment of such edges can account for a wide range of processes, including affixation to prosodic constituents, alignment of stress to word edges and augmentation.

The prosodic constituents that are well established are the syllable, foot and prosodic word, shown in (19).



According to the hierarchy, syllables are incorporated into feet and feet are incorporated into prosodic words. Segments are not considered to be prosodic constituents and are therefore not included in the prosodic hierarchy, but they are grouped into syllables which are combined into feet and prosodic words. A prosodic word corresponds to a lexical or grammatical word.

Alignment accounts for the interaction of morphology and phonology at the edges of domains, such as the alignment of foot and prosodic word, or prosodic word and stem. Alignment between prosodic and morphological categories is referred to as 'interface' alignment. Alignment constraints are crucial in accounting for the stress patterns of the languages examined in this thesis, Warlpiri, Wambaya, Dyirbal, Diyari, and Martuthunira. I propose to extend the range to include the alignment of feet with word-internal morpheme edges (Chapter 2), specific morphemes or lexically marked morphemes (Chapter 3), and alignment to intonation phrases (Chapter 4).

In comparison to previous edge-based theories, alignment does not involve rules for constructing representations step-by-step. Instead, alignment operates within a system where prosodic structure is constructed simultaneously. Thus, syllables, feet and prosodic word constituents are all present for simultaneous assessment by constraints.

The benefit of alignment constraints is shown in Chapters 2 and 3, where the interaction of morphemes and feet can be directly accounted for. In previous analyses, this was difficult and was accomplished indirectly through a combination of rules and principles which could not always derive the correct forms and, as a consequence, additional mechanisms were required. Alignment provides an explanation for the stress patterns that is lacking in previous analyses.

1.4 Adjacency

In some of the data examined in this thesis, stress may be binary or ternary alternating, $(\sigma'\sigma)(\sigma'\sigma)(\sigma'\sigma)$ or $(\sigma'\sigma)\sigma(\sigma'\sigma)\sigma$. The ternary pattern referred to here is not dependent on ternary feet, but on a binary foot followed by an unfooted syllable. In the binary pattern, stress alternates on every second syllable, and in the ternary pattern, stress alternates on every third syllable. The ternary pattern is a variant on the binary one or arises from requirements of stress on initial syllables of word-internal morphemes; for instance, a string of trisyllabic morphemes with stress on the first syllable of each morpheme will generate a ternary alternating pattern $(\sigma'\sigma)\sigma-(\sigma'\sigma)\sigma$. Only a binary pattern best satisfies both *AlignFt* and *PARSE σ* .

AlignFt indirectly ensures that feet are adjacent within a word by requiring all feet to align to the edge of the prosodic word. Any foot not aligned to this edge will violate the constraint. However, outputs where all feet are as close as possible to the prosodic word edge, that is, where they are adjacent, will be preferred, eg $(\sigma\sigma)(\sigma\sigma)(\sigma\sigma)$.

In some cases, though, we want optimal outputs where feet are not adjacent. Feet are not adjacent in ternary alternating systems (except of course if feet are ternary) and they are not always adjacent in languages where word-internal morphology determines the placement of stress, eg $(\sigma\sigma)\sigma(\sigma\sigma)\sigma$, $(\sigma\sigma)\sigma-(\sigma\sigma)\sigma$.

This raises the issue of how feet can be non-adjacent. If feet can be non-adjacent what determines the distance between feet. I propose that this distance can be determined by notions of adjacency, where adjacency is based on the issue of locality.

It is generally acknowledged in generative grammar that featural processes are typically local. In other words, processes apply between segments or syllables that are adjacent. In theories such as prosodic phonology/morphology, it is believed that locality is a property governing all areas of phonology. This is based on observations that prosodic processes do not count more than two, which means a unit and an adjacent unit. Under this view, locality is used to constrain rules to apply within particular domains.

Processes that involve adjacent elements essentially involve two elements. This underlies the claim that phonological processes count up to two, or rather do not actually count but instead assess elements with regards to adjacency.

When parsing syllables into feet, one syllable is examined with respect to adjacency with another. In both representations in (20), there is one unfooted syllable. In (20a) this is the final syllable, and in (20b) this is the medial syllable. In (20b) the syllables incorporated into the foot are not adjacent. (20a,b) each incur one violation of $\text{PARSE}\sigma$. $\langle\sigma\rangle$ = unfooted syllable.

- (20) a. $(\sigma \sigma) \langle\sigma\rangle$ b. $(\sigma \langle\sigma\rangle \sigma)$
 | | | |
 X Y X Y

The syllables X and Y are adjacent in (a) but not in (b). Under notions of adjacency, structures like $(\sigma\langle\sigma\rangle\sigma)$ are not possible because the syllables in the foot are not adjacent. Such gapped configurations contradict linearity.

If the syllables parsed into a foot are not adjacent, this implies that the foot is not binary and any number of syllables could intervene between the two footed syllables. The result would be overlapping constituents.

I argue that the adjacency rather than alignment can better account for prosodic processes such as vowel harmony and for rhythmic patterns. I show that a constraint is necessary to align one foot to the edge of a word, but that the location of feet within words is dependent on other factors. In some cases, ternary rhythm is a result of requirements for feet to align with morpheme edges or specific syllables in a word. However, in other cases, ternary rhythm is due to a preference for such rhythm over a binary one. To account for ternary rhythm, I argue that some feet must be assessed with regards to adjacency. Under adjacency, feet are assessed as to whether they are adjacent or not.

Some featural phonology involving long distance processes, such as assimilation and dissimilation, are held to be best treated as local phenomena (Archangeli and Pulleyblank 1986, Clements 1985, Sagey 1990, Steriade 1987, among others). Following on from this view, vowel harmony in Warlpiri is analysed (in Chapter 5) as motivated by adjacency. When certain features are adjacent, vowel harmony applies.

Alignment generalises across a constituent, concerned completely with the edges of that constituent. This misses some details occurring within those edges (as discussed in Chapters 4 and 5). In such cases, one-to-one alignment, where one foot aligns to an edge, is preferred over many-to-one alignment, where all feet are required to align to an edge. I argue that one-to-one alignment constraints combined with adjacency constraints are more successful in dealing with some rhythmic phenomena.

In sum, this thesis shows that foot alignment is not just restricted to word edge and alternate syllables, but applies to word-internal morpheme boundaries and lexically specified

morphemes. In addition, the location of feet within a word can be governed by adjacency constraints, and such constraints are further supported by vowel harmony. An additional finding is that foot alignment can be affected by the absence of onsets or by the featural quality of onsets leading to an expanded theory of syllable prominence.

Much of the thesis is concerned with the interaction between morphology and phonology in Warlpiri, and for this reason, I briefly discuss some of the morphological features in Warlpiri in the following section.

1.5 Warlpiri

Warlpiri is a Pama-Nyungan language of the Ngumbin-Yapa language group spoken in Central Australia by over 3,000 people. There are four main dialect groups and all dialects are mutually comprehensible. The main distinguishing features of the dialects are pronunciation and vocabulary. Pama-Nyungan languages are commonly referred to as suffixing languages, due to the use of suffixes to mark verbal categories and nominal cases, although there are some exceptions to this general tendency. In contrast, a group of languages called the non-Pama-Nyungan languages tend to use prefixes as well as suffixes.

Warlpiri has an ergative-absolutive case-marking system. Predicate-argument relations are carried by the morphology rather than the syntax. Pragmatic considerations generally determine word order. Tense, case and person number information is carried by suffixes. Verb roots are required to be inflected, (with the exception of the first conjugation verbs where non-past may be indicated by zero or **-mi**) while nominal stems can occur uninflected.

To acquaint readers with the orthography used for Warlpiri an inventory is presented in (21). The corresponding IPA symbol is given in brackets.

(21)	bilabial	apico- alveolar	apico- domal	lamino- palatal	dorso- velar
stops	p (p)	t (t)	rt (𐐃)	j (c)	k (k)
nasals	m (m)	n (n)	rn (ɛ)	ny (ɟ)	ng (ŋ)
laterals		l (l)	rl (ɽ)	ly (ɻ)	
flaps		rr (r)	rd (ʀ)		
glides	w (w)		r (ɹ)	y (y)	

Vowels i, ii, u, uu, a, aa

The parts of speech categories in Warlpiri are nominals, verbs, preverbs, and particles. Nominals includes words which translate into English as adjectives or verbs (eg **want**, **know**). Preverbs are adverbial elements which combine with a verb forming a complex verb. 'Preverbs add meaning components such as manner, direction and result, quantification, means, or further specification of some property of the object or subject,' (Simpson 1991:34). Included as particles are propositional particles, sentential particles, interjections and conjunctions.

The following are the morphological categories required for word formation: nominal roots, verbal roots, preverb roots, clitics, particles, nominal and verbal suffixes. Clitics may attach to any morphological category without changing categories and, like suffixes, are phonologically subordinated to the word they are attached to. Another similarity to suffixes is that clitic boundaries are equal to suffix boundaries in stress assignment. For further details regarding the morphosyntax of Warlpiri I refer the reader to (Hale 1981,1982,1983), Laughren (1982), Nash (1986), Simpson (1991), Hale, Laughren & Simpson (1996) and references therein.

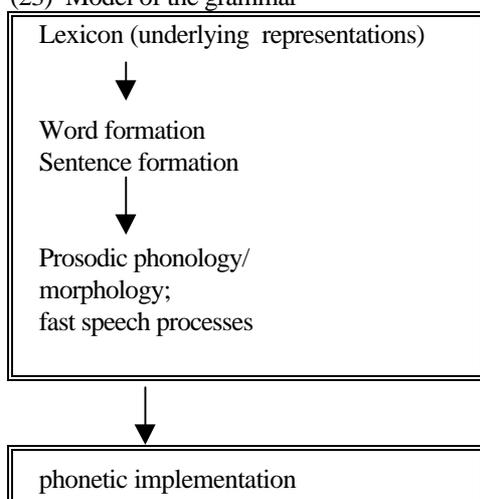
In Warlpiri, words must consist minimally of a foot and end in a vowel. Well-formedness conditions on the size of words can be stated and incorporated into the constraint system. Languages typically have grammatical requirements by which certain morphological units must correspond to certain prosodic constituents. A number of morphological categories in Warlpiri are required to correspond or align with prosodic words. The words in these categories may occur as phonologically independent words. The requirement for Warlpiri is given in the following constraint (M&P 1991a, 1993a):

(22) $MCat = PW$, where $MCat = \text{root, stem, preverb, particle}$.

By the Prosodic Hierarchy, in conjunction with FtBin, the minimal form of a prosodic word will be equivalent to a foot. The constraint ensures that roots, stems, preverbs and particles consist minimally of a foot. The constraint excludes other morphological categories, such as suffixes and clitics, which will not surface as prosodic words, as they are not required to correspond to prosodic words. The categories requiring correspondence will differ to some degree across languages.

There is no evidence from phonology for different levels of word-formation. I assume therefore, that after all word-formation occurs, words are subjected to prosodic phonology/morphology. Word-formation produces well-formed morphological and grammatical words. These serve as the inputs to the constraint tableaux where they are assessed by the constraints. In addition, I assume that sentence formation also occurs prior to the application of phonological processes. The model of the grammar is given in (23).

(23) Model of the grammar



Optimal outputs of the tableaux at the word level are submitted to a phonetic level. The outputs of the phonetic level are phonetic realisations.

1.6 Outline of Thesis

The remainder of this thesis is outlined as follows. Chapter 2 presents an analysis of the stress patterns of Warlpiri which is extended to account for the stress patterns of Wambaya, Diyari and Dyirbal. Polymorphemic words pose particular problems for the alignment of feet to word edges and for parsing syllables into feet. Alignment and adjacency constraints are introduced to account for the pattern of stress in these words. The adjacency constraint is a determining factor in the rhythmic organisation of words where both a binary and ternary pattern are evident. This constraint

is also active in phrasal stress. An interesting pattern in the relationship between feet and morphemes is found with variations across the languages investigated.

Chapter 3 examines variation in the stress patterns of specific morphemes in Warlpiri. I show that under the notion of alignment, the means to explain the variation is possible. The data contrasts with that from Martuthunira, which is dealt with through a difference in constraint ranking. I also examine how lexical stress can be interpreted in Optimality Theory.

Chapter 4 examines the nature of rhythmicity in casual speech contexts in Warlpiri. I argue that the alternation of stress within and across words is best accounted for by adjacency requirements on feet. I propose that the theory be modified to allow for one foot rather than all feet in a word to align to a word or intonational phrase edge which, firstly, enables a more straightforward assessment and, secondly, allows for binary and ternary rhythm. The analysis is extended to account for rhythmic alternation within words in Estonian. To account for differences in stress patterns between isolated words and those in phrases, as well as those that exhibit variation in canonical forms, I propose that constraints can be relaxed, thus introducing a novel conception of constraint ranking.

Vowel harmony in Warlpiri is analysed in Chapter 5. I argue that adjacency of features better captures the operation of vowel harmony than an alignment requirement. Requiring adjacency can explain why harmony occurs and why potential harmonising segments are not skipped over. In addition, constraints on identity of features are adopted which accounts for where harmony occurs, what blocks harmony and how. Constraints on identity throw a different light on harmony and can explicitly characterise the commonly observed factor that affixes and not roots undergo harmony. In addition, the constraints allow for a distinction between morphological and phonological harmony. The analysis reveals three main characteristics of harmony: motivation (does harmony require adjacency or not), feature dependency (what feature, if any, is the harmonising feature dependent on) and domain identity (does harmony apply to affixes and/or roots).

Warlpiri is typical of many languages where prosodic words align with feet on their left-edges. In Arrernte, a neighbouring language, misalignment of these prosodic constituents occurs when the word-initial syllable is onsetless. Alignment and adjacency requirements are unable to deal with the facts. I introduce a theory on left edge syllable prominence to account for onset sensitivity which is extended to other languages, enabling an analysis of stress in Arrernte, Spanish, Pirahã and Ngalakan, reduplication in Arrernte and Nunggubuyu, and patterns of allomorphy in Arrernte and Kayteye. The benefit of this theory is that a range of diverse prosodic phenomenon can be accounted for in this theory. An additional benefit is the discovery of another rhythmic dimension.