

## **Distinguishing Prosodic Word and Phonological Word in Warlpiri: Prosodic Constituency in Morphologically Complex Words**

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### **1. Introduction**

This paper re-examines the criteria previously used to define the phonological word in Warlpiri and argues that the phonological word (PhonWd) and the prosodic word (PWd) are distinct phonological rule domains, which should be analysed as distinct phonological constituents as well. We base our hypothesis on the observation that there is not always a one-to-one correspondence between the stress domain and the domain of vowel harmony and case allomorphy rules in Warlpiri, although traditionally all these processes have been described as operating within a single domain known as the phonological word. As it is often the case that there is no surface difference between a PWd and a PhonWd (i.e., PWd=PhonWd), the question of a structural distinction between them only arises in cases where there seems to be a mismatch, or misalignment, of constituents that have previously been represented as a single element in phonological structure.

Our study combines experimental phonetic data based on the acoustic studies of stress and prosodic boundary marking described in Pentland (2004), and empirical data based on the traditional morphosyntactic analysis of Nash (1986), to develop a model of Warlpiri prosody. This model predicts that certain elements, which have been analysed previously in Warlpiri grammar as a single phonological word, are in fact phrasal constituents in prosodic structure. We therefore incorporate the phonological phrase (PPh) as a higher-level unit needed to account for prosodic constituency in morphologically complex words, and recognize both PWd and PhonWd as independent constituents in the phonological and prosodic organisation of Warlpiri.

### **1.1 Background**

#### **1.1.1 Prosodic theory**

The theoretical assumptions of prosodic theory are, first, that phonological units are organized in a hierarchical structure known as the prosodic hierarchy which is distinct from, though related to, syntactic structure; second, that these units represent bounded phonological rule domains; and third, that the mapping between prosodic structure and morphosyntactic structure is highly constrained (Nespor & Vogel 1986; Selkirk 1986; Hayes 1989). We base our analysis of Warlpiri prosody on the recent model of prosodic structure outlined in Selkirk (1995). This model is formulated in terms of alignment theory (cf. McCarthy & Prince 1993) and directly addresses the relationship of morphosyntactic structure and prosodic structure in terms of a formal mapping between syntax and prosody, as set out in (1).

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## (1) The Syntax-Prosody Interface (Selkirk 1995:444)

Right/Left edge of  $\alpha$  = = = > edge of  $\beta$   
 $\alpha$  is a syntactic category,  $\beta$  is a prosodic category

“The Right/Left edge of some syntactic category coincides with the Right/Left edge of some prosodic category.”

This edge-based model of grammatical structure thus predicts that prosodic cues (e.g., lengthening at word boundaries) should signal the edges of prosodic constituents (PWd/PPh) that are also the edges of morphosyntactic constituents (word/phrase).

**1.1.2 Prosody in Australian languages**

Aside from the phonetic studies referred to in Section 5, there have been few published or unpublished studies on prosody in Australian languages. It is therefore interesting to note that Baker (1999) has proposed a structural distinction between prosodic words and phonological words in Ngalakgan. Baker’s analysis is based on observations of distinct phonetic characteristics associated with single words and complex word+word compounds, indicating there are two levels of prosodic structure at the word level. In a further study of word structure in both Ngalakgan and Warlpiri, Baker & Harvey (2003) show that morphologically complex words display distinct phonological and morphological patterns related to their internal make-up as root-level (non-productive) or word-level (productive) structures. Overall, these studies point to the difficulty of establishing a prosodic model in Australian languages containing a single word-level constituent when prosodic and grammatical factors strongly suggest that morphologically complex constituents are prosodically complex as well.

The rest of the paper is organized as follows. Section 2 briefly outlines a framework for defining the phonological word. The criteria used by Nash (1986) to define the phonological word in Warlpiri are described in Section 3. This model is reviewed in Section 4. The acoustic framework is presented in Section 5. We set out our proposals for a model of word-level prosodic structure in Warlpiri based on these empirical and experimental data in Section 6 and we conclude the paper with a brief discussion of our findings in Section 7.

**2. Defining the phonological word**

In their recent typological survey and overview of the “word” in some of the world’s languages, Dixon and Aikhenvald (2002) note the difficulty of establishing criteria to define the phonological word with the observation that, “no single criterion can serve to define a unit ‘phonological word’ in every language” (Dixon & Aikhenvald 2002: 13). We suggest that the criteria needed to define the phonological word in Warlpiri fall into two distinct groups, which allow for a clear demarcation of rules and processes relating on the one hand to suprasegmental or prosodic features and, on the other hand, to segmental and articulatory features, as outlined in (2).

- (2) *Suprasegmental features* include prosodic organization; the phonetic reflexes of stress and rhythmic structure; word boundary marking (e.g., pause

phenomena, articulatory strengthening and weakening at word or phrase edges); word and phrase accent.

*Segmental/articulatory features* include the articulatory feature specification of individual segments including those involved in vowel harmony and case allomorphy rules.<sup>1</sup>

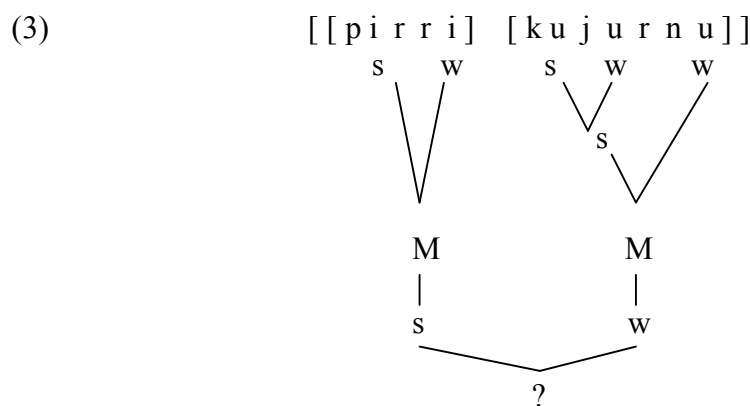
This demarcation suggests that, rather than being interchangeable, the terms prosodic word and phonological word refer to distinct domains governing quite distinct phonological processes: PWd is the stress domain and PhonWd is the domain of vowel harmony and case allomorphy.

### 3. The phonological word in Warlpiri

In the following sections we briefly discuss the three processes used by Nash (1986) as diagnostics of the phonological word in Warlpiri: stress, vowel harmony and case allomorphy.<sup>2</sup>

#### 3.1 Stress

In Nash's model, the phonological word is the stress domain. Morphologically complex words such as compounds and reduplications are analysed as phonological words containing two or more prosodic words (or domains). A metrical tree representation of the preverb-verb complex *pirri-kuju-rnu* 'scatter-throw-PAST', is set out in (3).<sup>3</sup> This model illustrates Nash's analysis of compound stress in Warlpiri (Nash 1986:100), which is based on the theoretical framework of early metrical theory (Liberman & Prince 1977; Hayes 1980).<sup>4</sup>



<sup>1</sup> Vowel harmony, nasalisation and retroflexion are categorized as 'prosodic features' by Dixon & Aikhenvald (2002: 13) in addition to the traditional prosodic features such as stress or tone assignment.

<sup>2</sup> Phonotactic constraints, which determine the shape and size of a word, and the permitted segment combinations within it, constitute another diagnostic of the phonological word. For example, a phonological word in Warlpiri must contain at least two moras (where 'mora' = V), and begin with a consonant and end with a vowel. The bimoraic requirement defines the 'minimal word' or 'prosodic word' in Warlpiri and in many of the world's languages (cf. McCarthy & Prince 1986/1996).

<sup>3</sup> The following abbreviations are used in this paper: 1 '1<sup>st</sup> person', S 'subject', AUX 'auxiliary', ERG 'ergative case' NONPAST 'non-past tense', PAST 'past tense', IMPERATIVE 'imperative', HITHER, 'directional'. The boundary symbols used are: - 'suffix' and = 'clitic'.

<sup>4</sup> The tree nodes are labelled as follows: s=strong; w=weak; M= 'mot', or prosodic word.

The structure in (3) represents each prosodic word as a separate domain grouped together within another word-level tree. The model predicts that the primary stress of the verb *kuju-rnu* is demoted to secondary stress in the compound structure, as shown in (4).

$$(4) \quad \begin{array}{ccc} [pírri- & [kúju-rnu] & \rightarrow & [pírri-kujurnu] \\ \text{PVB} & \text{V} & & \text{V} \end{array}$$

While Nash (1986) identifies the prosodic word as the stress domain, the prosodic status of complex words containing one or more prosodic words is unclear. Perhaps for this reason, the node marked with a ‘?’ in (3) is unlabelled in the original model.

### 3.2 Vowel harmony

Regressive assimilation of /i/ to /u/ is triggered by the [+back, +high] vowel of the PAST suffix, which in 4 conjugations has the form /Nu/. Regressive harmony in the 2<sup>nd</sup> conjugation verb *kijirni* ‘throw’ is illustrated in (5).

(5)	<i>kiji-rni</i>	‘throw-NONPAST’
	<i>kiji-ka</i>	‘throw-IMPERATIVE’
	<i>kuju-rnu</i>	‘throw-PAST’
	<i>pirri-kuju-rnu</i>	‘scatter-throw-PAST’

Harmony does not extend past the verb root into a preverb, hence \**purru-kuju-rnu* is unattested (Nash 1986: 85). The fact that harmony is blocked clearly indicates the presence of a boundary between the preverb (*pirri*) and the verb (*kuju-rnu*), and identifies the verb as the harmony domain. However, this poses problems for the analysis of the verbal compound as a single phonological word (i.e., a stress domain).<sup>5</sup>

### 3.3 Case allomorphy

The third diagnostic of the phonological word proposed by Nash (1986) is case allomorphy affecting the ergative (ERG) and locative case suffixes. There are two ergative allomorphs in Warlpiri: a lateral allomorph (-rIV) and a velar nasal+stop allomorph (-ngkV), where V represents a high vowel subject to vowel harmony, as shown in (6).<sup>6</sup>

(6)	<i>karnta-ngku</i>	‘woman-ERG’	<i>watiya-rlu</i>	‘tree-ERG’
	<i>wati-ngki</i>	‘man-ERG’	<i>tiripardu-rlu</i>	‘joey-ERG’
	<i>ngurrpa-ngku</i>	‘ignorant-ERG’	<i>ngurrpa-rlu</i>	‘throat-ERG’

The choice of allomorph is determined by the moraic structure of the stem: the -ngkV allomorph attaches to bimoraic stems and the -rIV allomorph attaches to polymoraic stems (and a few exceptional disyllabic roots). Allomorphy is sensitive to the structure of the entire stem, hence a distinction is made between compounds + ERG

<sup>5</sup> The authors note that Harvey & Baker (in press) give a different interpretation of this type of regressive harmony in Warlpiri; specifically, they argue that the past tense forms displaying /i/ to /u/ assimilation are lexically listed. It is beyond the scope of this paper to discuss the implications of their analysis with respect to our interpretation of prosodic constituency presented here.

<sup>6</sup> The locative allomorphs are -ngka and -rla.

case suffix and multi-word phrases + ERG case suffix. Examples of compounds and multi-word phrases with the ERG suffix are set out in (7) and (8).

(7) Word + word compounds:

<i>wati-wiri-rli</i>	‘big mob of men’	lit. man-big-ERG
<i>munga-wiri-rli</i>	‘all night long’	lit. night-big-ERG
<i>kuyu-pungu-rlu</i>	‘animal-killer’	lit. meat-killer-ERG

(8) Multi-word phrases:

<i>wati wiri-ngki</i>	‘big man’
<i>watiya wiri-ngki</i>	‘big tree’
<i>munga jinta-ngku</i>	‘one night’

Compounds are non-compositional and have idiosyncratic interpretations. For example, the compound structure [*wati-wiri*]-*rli* means ‘a big mob of men’, thus contrasting with the phrase *wati* [*wiri*]-*ngki*, which means ‘a big man’.

### 3.4 Summary

The different patterns of stress, vowel harmony and case allomorphy described in Sections 3.1-3.3 provide the empirical basis for our analysis of prosodic structure in morphologically complex words. The main thrust of our proposal is to acknowledge the close relationship between prosody and syntax and thus to allow for the possibility that morphologically complex structures are prosodically complex as well. In contrast, the criteria previously used to define the phonological word in Warlpiri by Nash (1986) do not explicitly allow for this. Hence the earlier model permits a phonological word to represent several distinct morphological and syntactic constituents. The examples in (9a-d) illustrate respectively: a monomorphemic noun (9a), an inflected verb stem (9b), a verbal compound (9c), and a case-marked nominal compound (9d).

(9)	a.	<i>wati</i>	N	‘man’
	b.	<i>kiji-rni</i>	V-NONPAST	‘throw’
	c.	<i>pirri-kuju-rnu</i>	PVB-V-PAST	‘scatter-throw-PAST’
	d.	<i>munga-wiri-rli</i>	N-N-ERG	‘all night long’

In Section 4 we argue that it is problematic to assume that the phonological word (as defined) corresponds in every case to a single element in prosodic structure (i.e., PWd=PhonWd) as not all phonological rules or processes select the same domain.

## 4. Theoretical framework

In the preceding Sections we have set out reasons for viewing the prosodic word and the phonological word in Warlpiri as distinct phonological rule domains (i.e., PWd≠PhonWd). In support of this view, we propose that the prosodic word should be defined only in terms of the suprasegmental or prosodic features identified in (2a), and the phonological word should be defined in terms of the segmental and articulatory features involved in vowel harmony and case allomorphy rules, identified

in (2b), i.e., PWd is the stress domain and PhonWd is the phonological rule domain. We illustrate these points with the examples in (9a-d), as follows.<sup>7</sup>

i. [[wati]<sub>PWd</sub>]<sub>PhonWd</sub>

The noun root *wati* (9a) is a minimal word and a stress domain: it is a PWd and (by default) a PhonWd.

ii. [[kiji-rni]<sub>PWd</sub>]<sub>PhonWd</sub>

The verb stem *kiji-rni* (9b) is a stress domain and a harmony domain: it is both a PWd and a PhonWd.

iii. [pirri]<sub>PWd</sub> [[kuju]<sub>PWd</sub>-rnu]<sub>PhonWd</sub>

The verbal compound *pirri-kuju-rnu* (9c) is a complex constituent that does not correspond to a single domain in phonological structure. We analyse *pirri* as a minimal word and stress domain, and *kuju-rnu* as a harmony domain. Unlike *wati* the preverb *pirri* does not qualify as a phonological word: it belongs to a class of ‘semi-productive’ preverbs that cannot occur alone, unattached to a verb (Nash 1982). This analysis predicts two levels of structure within the complex constituent.

iv. [[munga]<sub>PWd</sub>[wiri]<sub>PWd</sub>-rli]<sub>PhonWd</sub>

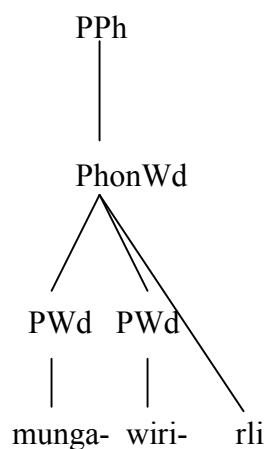
The nominal compound *munga-wiri-rli* is a complex constituent that is a single allomorphy domain. We analyse *munga* as a minimal word and stress domain and *wiri* as a minimal word and stress domain; the selection of the lateral allomorph *-rli* identifies the nominal compound as a single phonological word and allomorphy domain.

In keeping with Nash (1986), this framework defines phonological constituency in terms of rule domains. The crucial difference between Nash’s analysis and our own, is our proposal that two levels of structure within the word should be recognized, even when there is no distinction on the surface (e.g., *wati* is a PWd and a PhonWd). The structural distinction only becomes apparent when the structure of complex constituents such as nominal and verbal compounds is compared. For example, we analyse the nominal compound + ERG suffix *[munga-wiri]-rli*, illustrated in (10), as a phonological word (PhonWd) and the verbal compound *pirri-kujurnu*, illustrated in (11), as a phonological phrase (PPh). In the nominal compound, each element is a PWd incorporated within a single phonological word; however, in the verbal compound, the preverb *pirri* is not part of the harmony domain and must therefore be adjoined to the verb at the phrasal level in the prosodic hierarchy. The preverb *pirri* is analysed here as a PWd but not a PhonWd; in this regard it is assumed to pattern like

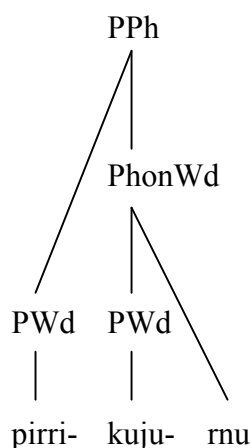
<sup>7</sup> For illustrative purposes we present our model as bracketed constituents corresponding to PWd, PhonWd, etc. It is important to note that the bracketing conventions we use do not necessarily mimic the bracketed model of morphology used by Nash (1986) (after Lieber 1980). We note in particular that preverbs like *pirri*, which belong to the class of semi-productive preverbs, do not emerge from the lexicon as well-formed words, i.e., they do not have a right bracket. A model of the morphosyntactic relationship of the preverb and verb (from Nash 1982: 166) is [preverb [root-inflexion]<sub>v</sub>]<sub>v</sub>.

consonant-final preverbs (e.g., *jaarl-* ‘in the way’), which are also prosodic words but not phonological words.<sup>8</sup>

(10) Nominal compound



(11) Verbal compound



## 5. Acoustic studies

In this Section we briefly review the experimental phonetic literature on Australian languages and discuss in greater detail the acoustic experiments on segment duration and prosodic boundary marking in Warlpiri described in Pentland (2004) that support the prosodic analysis outlined in this paper. We provide examples of segmental lengthening processes as cues to prosodic constituency in Figures 1-4.

<sup>8</sup> There are alternative constructions in which a preverb constitutes a phonological word, for example, when a vowel-final preverb hosts a Directional clitic (e.g., *pirri=rni* ‘scatter=HITHER’). These include consonant-final preverbs that are augmented by *pa* or *ki ~ ku* (e.g., *jaarlpa=rni* ‘in the way=HITHER’). As phonological words, these forms are not restricted to the immediate preverbal position (cf. Laughren 2002). (The CVVC and CVVC+*pa* or *ki ~ ku* alternants, which are respectively PWd and PhonWd, could be regarded as allomorphs.)

## 5.1 Background

Since the mid-1990s, a number of acoustic and instrumental studies of the segmental phonetics and connected speech of several Pama-Nyungan and non-Pama-Nyungan languages of Australia, including Warlpiri, have been carried out (see esp. Butcher 1995, 1996a,b; Tabain & Butcher 1999; Butcher & Tabain 2004). These studies point to major differences in the sound systems of Australian languages when compared with other languages. For example, their consonant systems are “long and flat”, having few manner contrasts but many place contrasts (Tabain & Butcher 1999: 335). Moreover, the proportion of sonorants and obstruents in these inventories is almost the direct opposite of the universal sound patterns observed by Lindblom & Maddieson (1988).<sup>9</sup>

In the light of these findings, it would perhaps not be surprising to find differences in the phonetic reflexes of prosodic structure in Australian languages as well. It is interesting to note, therefore, that recent acoustic and instrumental studies of Warlpiri are beginning to show that such differences do indeed exist. For example, an early study of word stress in Warlpiri by Harrington, Butcher & Palethorpe (2000) found that stressed initial syllables were actually shorter than unstressed medial and final syllables in 3-syllable words, in contrast to most stress languages in which stressed syllables are generally longer and louder than unstressed syllables. A similar finding to the Harrington *et al* study, based on a preliminary study of stress in verbs, was also reported in Pentland, Ingram & Laughren (1999).

A possible explanation for these results is that stress is not marked by vowel lengthening but by consonant lengthening. The idea that consonants, rather than vowels, carry the greater functional load in signalling prosodic prominence and boundaries has been investigated further in two recent studies examining the effects of focus and word/morpheme boundary distinctions on consonant duration and articulation (Butcher & Harrington 2003a,b). Evidence of consonant hyperarticulation (i.e., gestural strengthening) and increased duration was found at the boundary between two words in a phrase, e.g., the initial /p/ in the N+V sequence *kuyu pu-ngu* ‘animal meat kill-PAST’, but not at the boundary between two words in a compound, e.g., *kuyu-pungu* ‘game-killer’.<sup>10</sup>

Taken together, all these studies confirm the role of consonant lengthening as a prosodic cue. Lengthening occurs in two distinct environments, first, stops are lengthened following stressed syllables and, second, lengthening affects initial consonants at an utterance internal word boundary. The lengthening process associated with stress is sometimes called *post-tonic lengthening* and is notably different from stress marking in languages like English where stress is marked on the vowel. We interpret initial consonant lengthening in Warlpiri as a form of *domain-initial strengthening*, which is a recognized diagnostic of prosodic constituency in many languages.<sup>11</sup>

<sup>9</sup> A typical Australian consonant inventory may be 70% sonorants and only 30% obstruents (Tabain & Butcher 1999: 335).

<sup>10</sup> In the N+V sequence, each element constitutes a distinct syntactic phrase and potentially distinct phonological phrase.

<sup>11</sup> For studies of domain-initial strengthening as a prosodic cue in various languages see Fougeron & Keating (1997); Cho & Keating (2001); Fougeron (2001); Keating, Cho, Fougeron & Hsu (2003). For a recent theoretical overview see Keating & Shattuck-Hufnagel (2002) and Keating (2003).



## 5.2 The acoustic analysis of segment duration and connected speech in Warlpiri

Two recent studies of segment duration and connected speech processes by Pentland (2004) in part confirm these earlier findings (see also Pentland & Ingram 2003). It should however be noted that for several reasons these studies are not directly comparable with Butcher & Harrington (2003a,b) due to differences in methodology and data, thus it is not possible to generalise from them, especially with respect to the interpretation of consonantal lengthening as a prosodic boundary cue.<sup>12</sup> We suggest that initial lengthening occurs at a PwD boundary and therefore predict that lengthening may occur at the word boundary between the first and second element in both nominal compounds (e.g., *kuyu-pungu*) and verbal compounds (e.g., *pirri-kujurnu*), as we analyse each element as a PwD. (See Section 6 for further discussion.)

### 5.2.1 Segmental lengthening processes in Warlpiri

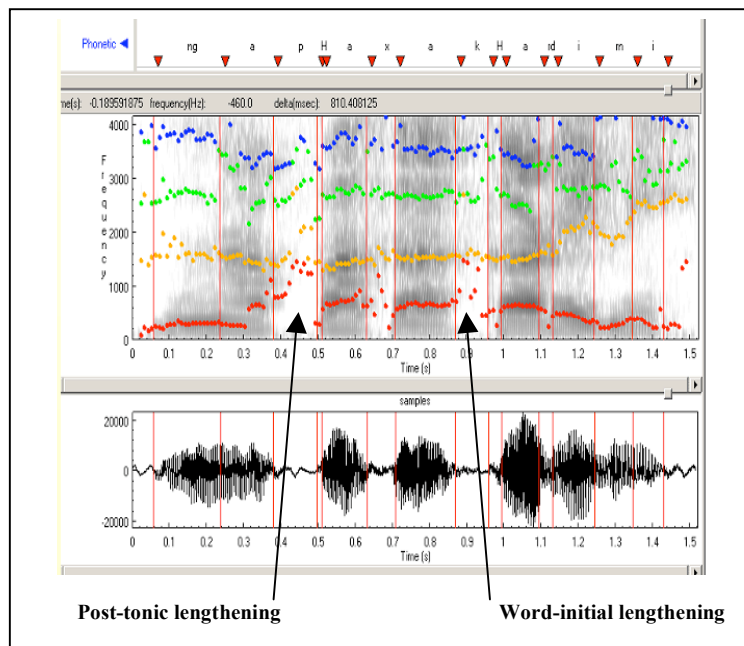
Our analysis of prosodic constituency in morphologically complex words is based on the statistically significant patterns of lengthening and strengthening that are described in detail in Pentland (2004). Overall, the studies provide fairly clear evidence that *post-tonic lengthening* (which only occurs in words at the left edge of the utterance) is a higher-level prosodic cue, marking prosodic prominence at the phrase or utterance level in the prosodic hierarchy, and that word-initial lengthening (which affects initial stops at the left edge of every word that is not utterance-initial) is a word or phrase boundary cue. Examples of *post-tonic lengthening* and word-initial lengthening in two- and three-word utterances are illustrated in the annotated spectrograms and waveforms in Figures 1-4.

The main features of the annotations are as follows:

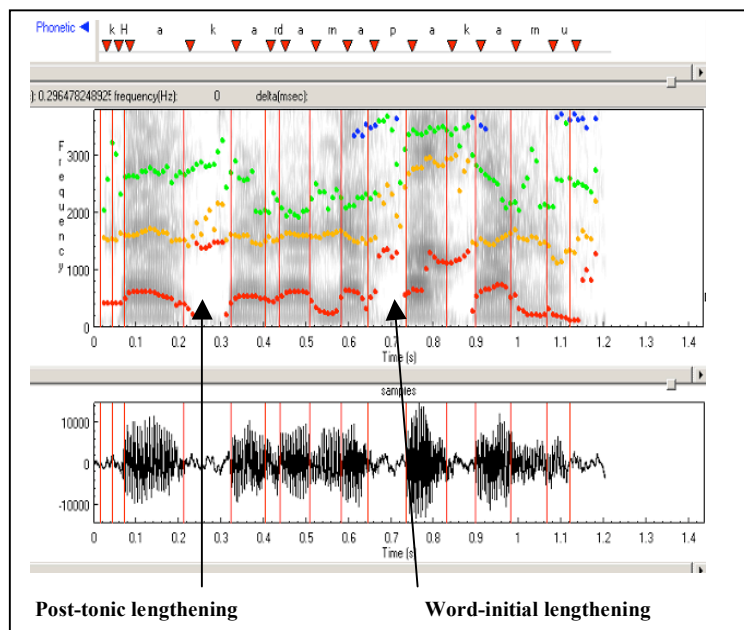
- i. Phonetic level segments are labelled above the spectrogram. Phonetic labels are not necessarily the same as the phonemic representation (cf.  $k > x$  in the 1<sup>st</sup> word in Figure 1 and  $rd > r$  in the 3<sup>rd</sup> word in Figure 3).
- ii. The vertical lines indicate segment boundaries. The wavy lines indicate vowel formants.
- iii. It is not possible to measure the acoustic duration of utterance initial stop closures. For annotation purposes, the closure duration of initial stops was arbitrarily estimated as being equal to the length of the release burst (cf. utterance initial  $[k][H]$  in Figures 2 and 3)

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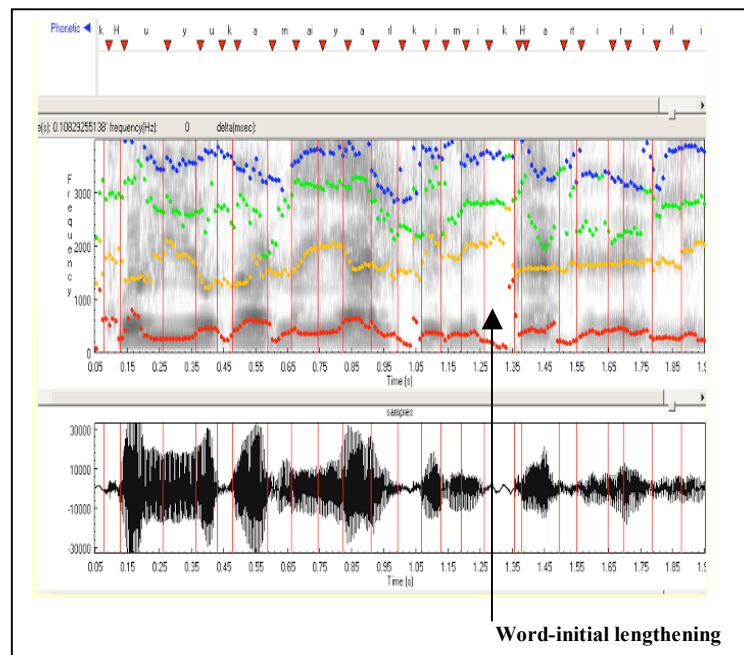
<sup>12</sup> The data used by Pentland (2004) were obtained from recordings of two female speakers of the Southern Warlpiri dialect made by Mary Laughren at The University of Queensland in 1999. The database comprised a selection of one-, two- and three-word utterances, 4-10 syllables long, representing a range of structures such as inflected verbs and verb-auxiliary sequences, nominal and verbal compounds, and short sentences.



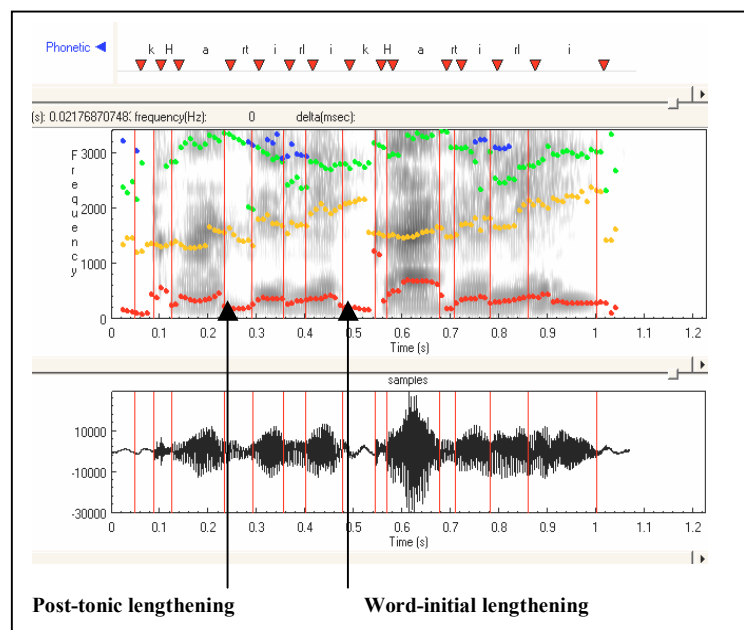
**Figure 1.** Annotated spectrogram and waveform of the Warlpiri utterance *ngapa=ka kardi-rni* ‘water=AUX scoop up-NPAST’ illustrating *post-tonic lengthening* affecting post-tonic /p/ in the 1<sup>st</sup> word (*ngapa=ka*) and word-initial lengthening affecting the initial /k/ in the 2<sup>nd</sup> word (*kardi-rni*).



**Figure 2.** Annotated spectrogram and waveform of the Warlpiri utterance *kakarda=rna paka-rnu* ‘back of head=1S hit-PAST’ illustrating *post-tonic lengthening* affecting post-tonic /k/ in the 1<sup>st</sup> word (*kakarda=rna*) and word-initial lengthening affecting the initial /p/ in the 2<sup>nd</sup> word (*paka-rnu*).



**Figure 3.** Annotated spectrogram and waveform of the Warlpiri utterance *kuyu=ka=rna yarlki-rni kartirdi-rli* ‘meat=AUX=1S bite-NONPAST tooth-ERG’ illustrating word-initial lengthening affecting the initial /k/ in the 3<sup>rd</sup> word (*k*artirdi- rli).



**Figure 4.** Annotated spectrogram and waveform of the nominal compound *kartirli-kartirli* ‘ant sp.’, illustrating *post-tonic lengthening* affecting post-tonic /rt/ in the 1<sup>st</sup> word (*kartirli*) and word-initial lengthening affecting initial /k/ in the 2<sup>nd</sup> word (*k*artirli), i.e., at the PWd boundary.<sup>13</sup>

<sup>13</sup> It is interesting to compare the closure duration of /rt/ in post-tonic and non-post-tonic positions - the post-tonic stop is much longer.

### 5.3 Segmental lengthening as a cue to prosodic structure

In the following sub-sections we describe the segmental lengthening processes illustrated in Figures 1-4 and their function as prosodic cues.

#### 5.3.1 Post-tonic lengthening

*Post-tonic lengthening* affects stops in syllable onset position following the primary stressed syllable in the first word of an utterance. In Figure 1, the duration (closure and release) of post-tonic /p/ is about 140ms, which is very long indeed, given that the average duration of bilabial stops across all positions reported by Pentland (2004) was 100ms. In Figure 2 the duration (closure and release) of post-tonic /k/ is nearly 110ms. This represents a very long closure for velar stops, which are generally shorter than bilabial stops.

As *post-tonic lengthening* only occurs in words that are also utterance initial (i.e., it does not occur after stressed syllables in the second or third word in a sentence of two or more words), we interpret this process as a higher-level prosodic cue, making a prosodic distinction between a word and some domain larger than a word.

#### 5.3.2 Word-initial lengthening

Initial lengthening affects word-initial stops in utterance-medial position (i.e., the second or third word in a two- or three-word utterance). Instances of word-initial lengthening can be observed if we compare the duration of the post-tonic stops /p/ and /k/ in Figures 1 and 2 with the duration of the corresponding word-initial stops, /k/ and /p/. Segments in all these positions are unusually long. Word-initial /k/ in Figure 3 is also very long (about 110ms), especially in view of its position as the initial segment in the third word, far removed from the start of the utterance.

We interpret initial consonant lengthening as a form of *domain-initial strengthening*; the relative strength of the cue is predicted to vary according to the strength of the prosodic boundary, e.g., U (or IP) > PPh > PWd.<sup>14</sup>

#### 5.3.3 Vowel length

There are some interesting examples of unusually long vowels with high amplitude occurring in the initial syllable of some words (cf. the initial vowels in each word in Figures 2 and 4, and in every word in Figure 3). In Pentland (2004) vowel length was not found to be statistically significant except for vowels that were both word-initial and utterance-initial and for this reason, vowel duration is not considered a word-level stress cue. The instances of initial vowel lengthening in Figure 3 are exceptional.

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<sup>14</sup> Based on the acoustic evidence we have so far, it does not appear that word-initial lengthening distinguishes prosodic word and phrase boundaries. For example, one might predict that the relative strength or length of initial /k/ in *kartirdirli* (the 3<sup>rd</sup> word in Fig. 3) would be greater than the initial /k/ in *kartirli* (the 2<sup>nd</sup> word in Fig 4), as *kartirdirli* 'tooth-ERG' is a phonological (and syntactic) phrase, whereas *kartirli*, being the second element in a nominal compound, is a PWd within a PhonWd. Further investigation of initial lengthening in connected speech - crucially when a PPh boundary is not also an Utterance boundary - is needed to determine how (or if) word and phrase boundaries are distinguished acoustically in Warlpiri.

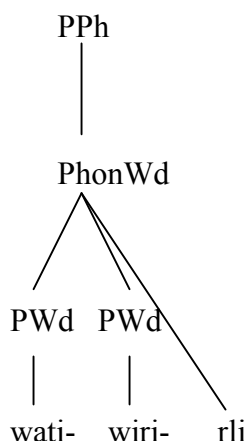
## 6. The prosodic structure of morphologically complex words

In the next sections we set out a model of Warlpiri prosody that incorporates PWd, PhonWd and PPh, in order to account for the structural differences we have noted. In Section 6.1 and 6.2 we describe the structure of a nominal and a verbal compound. In Section 6.3 we describe the structure of a complex phrase.

### 6.1 Nominal compound

A nominal compound is a phonological word (PhonWd): it constitutes a single domain for the application of the case allomorphy rule. N+N compounds select the lateral allomorph (-rIV), which attaches to polymoraic stems, e.g., [wati-wiri]-rli ‘man-big-ERG’, thus making a distinction between the compound and a multi-word phrase, e.g., wati [wiri]-ngki ‘man-big-ERG’, which selects the velar nasal+stop allomorph (-ngkV). The prosodic structure of the nominal compound *wati-wiri-rli* is illustrated in (12).

(12) Nominal compound (PhonWd)



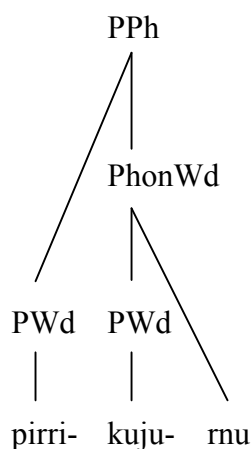
It is not possible to identify acoustically a clear boundary between words in a compound like *wati-wiri* because the second word is glide-initial. Hence our analysis of the nominal compound as a single phonological word containing two prosodic words is based primarily on the fact that it constitutes an allomorphy domain. As we noted in Section 5.3.2, the strong acoustic signals at the PWd boundary in the nominal compound *kartirli-kartirli* ‘ant sp.’ are somewhat difficult to interpret as an example of word-initial lengthening, although our theory predicts that initial lengthening will occur at prosodic word boundaries in both nominal and verbal compounds.

### 6.2 Verbal compound

We analyse a verbal compound - such as a preverb and inflected verb sequence - as a phonological phrase: each element of the compound is a prosodic word (i.e., a stress domain) but it is not necessarily the case that each element is also a phonological word (i.e., a harmony domain). For example, only the second element in the complex verb *pirri-kuju-rnu* ‘scatter-throw-PAST’ is a phonological word, due to the fact that harmony is blocked at the boundary between the preverb (*pirri*) and the verb (*kuju-rnu*). We propose that the preverb is adjoined to the verb at the phrasal level, as it is

not part of the harmony domain. The prosodic structure of the verbal compound *pirri-kuju-rnu* ‘scatter-throw-PAST’ is illustrated in (13).<sup>15</sup>

(13) Verbal compound (PPh)



### 6.3 Complex phrase

Though preverbs cannot host nominal or verbal grammatical inflections, they are the only class of words, apart from verbs, that are able to host a Directional clitic. There are four Directional clitics in Warlpiri (cf. Nash 1986: 62). These are listed in (14).<sup>16</sup>

(15) Warlpiri directional enclitics

<i>rni</i>	‘hither, towards speaker’	<i>rra</i>	‘thither, away from speaker’
<i>mpa</i>	‘past, by, across’	<i>yi</i>	‘continuative’

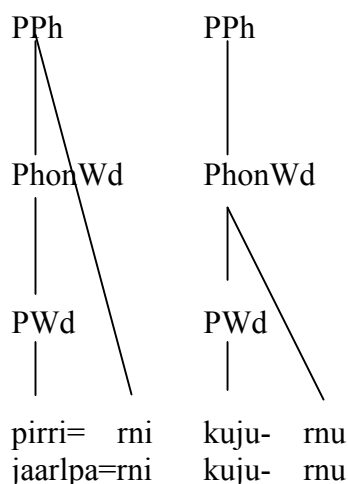
When a preverb hosts a Directional clitic we propose that the combined preverb plus directional enclitic constitutes a phonological phrase, and thus forms a complex phrasal structure when it combines with the following verb. In order to host an enclitic, consonant-final preverbs must be augmented with an extra syllable *pa* (or *ki* ~ *ku*), which converts them into a phonological word, thus licensing their ability to head an independent phonological phrase. We illustrate the prosodic structure of a preverb plus Directional enclitic and inflected verb sequence with the combinations *pirri=rni kuju-rnu* ‘scatter=HITHER throw-PAST’ and *jaarlpa=rni kuju-rnu* ‘in the way=HITHER throw-PAST’ (with the augmented preverb) in (15).<sup>17</sup>

<sup>15</sup> In fact, there are many types of preverb, and the class they belong to determines not only the relationship between preverb and verb but also its prosodic character (see ff. 8). Preverbs like *pirri* belong to a class of ‘semi-productive’ preverbs, which means they do not occur without a verb and they do not take any nominal or verbal inflections (Nash 1982). Semi-productive preverbs such as these qualify as prosodic words (i.e., they contain two moras), and in certain circumstances (cf. Section 6.3), they may constitute phonological words. However, within this group there is a subset of consonant-final preverbs (e.g., *jaarl* ‘in the way of’, *tuurl* ‘split’) that clearly do *not* satisfy the requirements of a phonological word since they end with a consonant, although they satisfy the bimoraic constraint on a possible stress domain (or PWd). The consonant-final preverbs pattern like (13).

<sup>16</sup> While the verb may host many types of enclitic morphemes, those in (14) may only be hosted by the verb or preverb.

<sup>17</sup> The bi-phrasal structure in (16) underlies the situation where the preverb is further separated from the verb by AUX (Laughren 2002). Enclitics such as the directional morphemes and pronominals attach to

(15) Complex phrase (PPh+PPh)



**7. Conclusion**

In this paper we have outlined our proposals for a model of the prosodic structure of morphologically complex words in Warlpiri that recognizes three distinct constituents: prosodic word, phonological word, and phonological phrase. The interpretation of a constituent as PWd, PhonWd or PPh depends on its morphosyntactic structure and its identity as a phonological domain for the application of stress or vowel harmony or suffixal allomorphy rules. We have illustrated our proposal with phonetic data providing evidence to suggest that consonantal lengthening functions as a prosodic cue in Warlpiri, although many details concerning the phonetic reflexes of prosodic structure remain unexplored at this stage.

Our model is based on the observation that the criteria used to define the phonological word in Warlpiri fall into two distinct categories that define separate phonological rule domains whose boundaries do not always coincide. We therefore propose that a model of Warlpiri prosody must recognize two word-level constituents: the prosodic word (PWd), which is the stress domain, and the phonological word (PhonWd), which is the domain of regressive vowel harmony and case allomorphy rules.<sup>18</sup>

In conclusion to this study we should point out that further studies of morphologically complex structures are clearly needed to test this model of prosodic structure in Warlpiri. Our acoustic data are limited to relative measures of consonant and vowel duration in stressed and unstressed syllables in a range of morphosyntactic and phonological environments. Studies exploring other types of phonetic data, such as relative pitch levels and formant transitions in V-C and C-V environments (i.e., to

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a phonological phrase, but this does not rule out the possibility that their internal structure may also consist of prosodic words, i.e. stress domains.

<sup>18</sup> Henderson (2002: 111) notes discrepancies between certain phonological processes and the stress rules affecting clitics in Eastern/Central Arrernte and suggests that a distinction between prosodic word and phonological word may usefully account for these facts. Elsewhere (p. 113) he proposes a recursive phonological word structure to account for compound stress and other phonological processes (e.g., prosodically conditioned allomorphy and Rabbit Talk) - all of which suggests that the Arrernte data might be amenable to an analysis similar to the one we have outlined here for Warlpiri.

investigate *hyperarticulation* of post-tonic consonants) could shed further light on the nature of prosodic and phonological constituency in Warlpiri.

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