

# The Domain of Phonological Processes\*

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## 1. Introduction

Optimality Theory, like Lexical Phonology before it, applies phonological constraints (or processes) to inputs which are of the phonological type 'word'. In example (1), I provide a schematic representation of an Optimality Theoretic 'tableau', the notational device used by the theory to evaluate relations between underlying and surface forms, and constraints applicable in a language. Here, the underlying form /x/ is evaluated with respect to two constraints A and B. The candidate surface forms differ in terms of their satisfaction of the two constraints shown. The fact that candidate (a) wins demonstrates that, though both candidates violate some constraint which is observably true of the language, it is more important (more highly-ranked) to satisfy Constraint A than Constraint B in this language.

### (1) Optimality Theory Tableau schema

/x/ #an underlying form#	CONSTRAINT A	CONSTRAINT B
☞ a. x' #the attested surface form#		*
b. x" #an unattested, but reasonable and potential surface form#	*!	

In (1), 'x' must necessarily be a word, not a morpheme nor a phrase. Here, I argue for a loosening up of this requirement, in particular, that 'x' can be any of the set of meaningful objects {morpheme, word, phrase}. I also propose some constraints on what kinds of morphemes in particular might be domains for phonological processes. I show that if we permit the input to evaluation to be a larger set than just 'word', we can unify the analyses of some common phonological processes, which would otherwise be problematic to explain under standard assumptions.

## 2. The problem: 'word-like' constituents of words

In many languages, we observe some complex words where some smaller part itself has the characteristics normally associated with free words. I present a range of examples here as illustration. In (2) for instance, we see the difference between the stress patterns found in morphologically complex words in Indonesian, and the stress patterns we would otherwise expect, given the pattern in morphologically simple words (Cohn 1989: *passim*).

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(2)	a. Stress in Prefixed Words	Expected stress pattern
	di-cát 'printed'	*dí-cat
	di-koréksi 'corrected'	*di-koréksi
	b. Stress in Compounds	
	hák-hák 'rights'	*hák-hak
	cáp-pós 'postmark'	*cáp-pos
	waníta-waníta 'women'	*wànità-waníta
	bòm-átom 'atom bomb'	*bom-átom

Example (3) shows similar examples from German, this time from syllabification phenomena. Again, the right-hand column presents the expected syllabification of these forms if they were morphologically simple (McCarthy & Prince 1993).

(3)	a. ver-[ʔ]irren	*ve.rirren	'to lose one's way'
	b. auf-[ʔ]essen	*au.fessen	'to eat up'
	c. Zoll-[ʔ]amt	*Zo.llamt	'customs-house'
	d. Rei[p]-[ʔ]eisen	*Rei.beisen	'grater'
	e. ber[k]-[ʔ]ab	*ber.gab	'downhill'

Many of these examples have been analysed in terms of the 'Cycle' (Chomsky & Halle 1968:26; henceforth 'SPE'). Phonological rules apply first to some domain (a stem), and then this structure is preserved even when more material is added on subsequent Cycles. In the German examples, on the first Cycle the rule inserting glottal stops before vowel-initial words applies. On the second Cycle, even though the reason for insertion of glottal stop has been lost, glottal stop nevertheless remains.

(4)	/irren/	'to go'
	[ʔirən]	Glottal insertion (Ø -> [ʔ] / #_V)
	ver-[ʔirən]	Affixation

Ordinarily, we might expect this word to be resyllabified, with the final /r/ of the prefix *ver-* becoming the onset of the following syllable of the stem. In SPE phonology, the reason that resyllabification is blocked is because of the abstract boundary element between the prefix and the stem. Rules such as resyllabification necessarily apply to strings containing no (internal) instances of such a symbol.

Although the Cycle can account for many of these patterns, there are various problems with it, many of which have been noted previously in the literature (see, for example, Spencer 1991, Carstairs-McCarthy 1992, Goldsmith 1993). In the first place, the Cycle is not particularly explanatory, since it is not directly a theory about word structure. Cyclic domains (in both SPE, and in modified form in Lexical Phonology) do not correspond directly to what might be thought of as productive morphological boundaries, except by accident. More problematically, the notion of the Cycle lacks psychological credibility (Goldsmith 1993:21). The idea that speakers churn representations through a series of phonological operations no longer has the appeal that it once might have. Thirdly, there is

no principled limit to the number of cycles and types of rules that may or may not apply at each step. Finally, and perhaps most seriously, analyses of this type rely on the representational device of the *boundary* in order to prevent the application of rules that would otherwise apply. There are well-known problems with positing boundary symbols in phonological rules (Pyle 1972).<sup>1</sup>

In OT, being a parallel theory of phonology, there is no step-wise derivation of words. Rather, words must be evaluated in entirety using one set of constraints. To get around the obvious problem presented by the kinds of patterns presented in (2)-(3), OT has invoked two kinds of strategies. The first is Alignment, defined in (5) (McCarthy and Prince 1993):<sup>2</sup>

- (5) Generalized Alignment  
 $\text{Align}(\text{Cat1}, \text{Edge1}, \text{Cat2}, \text{Edge2}) =_{\text{def}} \forall \text{Cat1} \exists \text{Cat2} \text{ such that Edge1 of Cat1 and Edge2 of Cat2 coincide.}$   
 Where  
 $\text{Cat1}, \text{Cat2} \in \text{PCat} \cup \text{GCat}$   
 $\text{Edge1}, \text{Edge2} \in \{\text{Right}, \text{Left}\}$   
 "For all forms of type Cat1 there is a Cat2 such that the Edge (left/right) of Cat1 and Cat2 coincide, where 'Cat1, Cat2' are elements of the set of (universal) prosodic (foot, prosodic word, etc) or grammatical categories (root, stem, word, affix)."

Alignment constraints demand coincidence of the edge of some category (e.g. a root) with the edge of another (e.g. a foot). I will demonstrate that Alignment constraints fail to account for some of the most common effects of the type referred to above, where morphologically-complex words do not conform to the phonological patterns found in simplex words.

The second kind of strategy invoked is Output-Output Correspondence (Benua 1997). OO-Correspondence is a species of Correspondence Theory, defined in (6) (McCarthy 1995). Correspondence constrains deviance from one-to-one relations between input and output segments standing in a corresponding position in the string. This standard type of correspondence is sometimes called 'Input-Output Correspondence'. By contrast, OO-Correspondence constrains the relation between corresponding segments in related words, such as the relation between a simple word (e.g. *consider*) and its derived complex forms (*consideration*).

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<sup>1</sup> For instance, unlike other phonemes, boundary symbols do not (consistently) correspond to any phonetic substance. Note that it is necessary here to distinguish the phonological effects of boundaries on *neighbouring* sounds, from the phonetic realisation of boundaries themselves. Final devoicing, glottalisation, and nasalisation are effects of this kind, which target phonemes at the edge of a domain. Pyle (1972) notes some more specific theoretical problems associated with positing boundary symbols as part of the symbolic inventory of a grammar. To wit, it should be possible to transform phonemes into boundary symbols (or vice versa) but no natural languages seem to do this. Thirdly, it should theoretically be possible to distinguish the phonological effects of multiple morphological boundaries from a single boundary at one site, but again, this never seems to be realised in natural language. There are many other potential problems. However, some of these problems may be artefacts of rule-based derivational models and may not apply equally to constraint-based nonderivational theories. I have not explored this possibility here.

<sup>2</sup> I ignore here the various proposals for 'stratal' OT, including McCarthy & Prince 1993. Allowing stratal evaluation seems to me like a negation of the enterprise of simultaneous evaluation.

In (7), we see two examples of OO-Correspondence. In the example on the left, we see a representation of the Correspondence relations on a reduplicated form [osampi-sampi]. There are two types: Base-Reduplicant (BR) Correspondence governs the relation between a reduplicant and its base. Standard Input-Output correspondence governs the relation between the input base and the output, and also between the abstract morpheme 'RED[uplicate]' and its output reduplicant. On the right, we see an example from English of Output-Output Correspondence between a name 'Larry' and a truncated form [læɹ].

- (6) Correspondence (McCarthy & Prince 1995)  
 Given two strings S1 and S2, correspondence is a relation  $R$  from the elements of S1 to those of S2. Segments  $\alpha$  (an element of S1) and  $\beta$  (an element of S2) are referred to as correspondents of one another when  $\alpha R \beta$ .

- |  |   |
|--|---|
| <p>(7) OO-Correspondence</p> <p>Reduplication</p> <p><i>BR-Identity</i></p> <p>[osampi ↔ sampi]</p> <p><i>IO-Faith</i> ↑      ↑</p> <p>/osampi -RED/</p> | <p>Truncation</p> <p><i>OO-Identity</i></p> <p>[læ.ri] → [læɹ]</p> <p><i>IO-Faith</i> ↑</p> <p>/læri/</p> |
|--|---|

Base-Reduplicant Correspondence and Output-Output Correspondence are related, in that they both constrain the alternation of one surface form with respect to another, related form. They differ in that BR-correspondence relates two parts of a single word, while OO-correspondence relates two separate output words.

In the following section, I discuss some very common phenomena, using examples from Australian languages, which are difficult to account for in these theories, before discussing in detail my alternative proposal based on the idea that phonological domains need not correspond to the word. I show that the major problem with all these theories, from the Cycle to Output-Output Correspondence, is that they are predicated on languages in which it can only be the stem which retains some kind of word-like status. None of these theories were tested on languages in which non-stem morphemes retain some kind of phonological independence. It's exactly these kinds of cases I examine in the next section.

### 3. Adjacent vs nested constituency in Australian languages

In many Australian languages, stress rules appear to apply to every suffix independently, before they are subjected to word-level phrasing. We have these kinds of stress patterns in Ngalakgan and many other Australian languages, such as Warlpiri (Nash 1986), Diyari (Austin 1981), Western Desert (Goddard 1985). The general pattern in these languages is that stress is regularly alternating from the first syllable (examples from Ngalakgan; Baker 1999):

- (8)
- |    |                 |                               |
|----|-----------------|-------------------------------|
| a. | pólo            | 'old person'                  |
| b. | kámala          | 'sky'                         |
| c. | káŋamùru        | '"long-nose" native honeybee' |
| d. | ká.ɽaŋkàŋaŋ̀ini | 'wallaby sp.'                 |

But morphological structure disturbs the regular stress alternation:

- (9)
- |    |                          |                  |
|----|--------------------------|------------------|
| a. | (tótóy?)-ki              | aunt-your        |
| b. | (tòtóy?)-(kí-kka?)       | aunt-your-LOC    |
| c. | (tòtóy?)-ki-p(púlu)      | aunt-your-PL     |
| d. | (tòtóy?)-ki-p(púlu-k)ka? | aunt-your-PL-LOC |

The generalisation to be drawn from these examples is in (10) (Baker 1999: 79; and cf. Nash 1986: 100 on Warlpiri stress):

- (10) Polysyllabic suffixes and clitics are *inherently* footed, but the footing of monosyllabic suffixes and clitics is *contingent* on their surrounding environment.

By 'inherently' I mean 'consistently'. Polysyllabic suffixes and clitics are always footed. In essence, it appears that polysyllabic suffixes and clitics are footed because of their inherent size, regardless of their position in the word.

This pattern is difficult to account for whether we derive it in Lexical Phonology (e.g. Poser 1986) or in Optimality Theory (using Alignment), since we cannot derive it by applying stress rules to incrementally larger domains which include the stem. (11) gives a representation of a derivation of the forms in (9) using Lexical Phonology (I ignore here the distinction between primary and secondary stresses).

(11)	Cycle	Morphology	Phonological rules (incl. stress)
	1	tótóy?	(tótóy?)
	2	[(tótóy?)]-ŋki	[(tótóy?)]-ki <b>(syllabification)</b>
	3	[(tótóy?)ki]-ppulu	[(tótóy?)(kí]ppu)lu <b>(wrong result)</b>
	4	[(tótóy?)(kíppu)lu]-kka?	[(tótóy?)(kíppu)(lú]-kka?
		aunt-your-PL-LOC	'to your aunts'

Where the disyllabic suffix is added on Cycle three, the stress rules should ignore the monosyllabic suffix that precedes it. But Lexical Phonology relies on building up morphology from the root outwards. There is no proviso in Lexical Phonology for the inherent size of affixes to affect the application of rules.

In an Optimality Theory analysis of Ngalakgan, we might propose the following constraints (well-used by many other analyses, cf. Crowhurst 1994, Pensalfini 2000):

- (12)
- |    |                  |   |
|----|------------------|---|
| a. | ALIGNL(M, FOOT): | 'Align the left edge of every morpheme to the left edge of some foot.'  |
| b. | PARSE(σ):        | 'All syllables must belong to some foot.'   |
| c. | FTBIN:           | 'Feet are binary at some level of analysis (σ, μ).'   |
| d. | FTFORM(TR):      | 'Feet are trochaic (left-headed)'   |
| d. | *LAPSE:          | 'Unstressed syllables must be separated by a foot boundary.'<br>(I.e. avoid sequences of more than two unstressed syllables.) |

For some forms, this kind of analysis works reasonably well:<sup>3</sup>

(13)

/t̥otoyʔ-ppulu-kkaʔ/ aunt-PL-LOC	FTBIN	ALIGNL (M, FT)	PARSE(σ)
☞ a. (t̥otoyʔ)(-púlu-k)kaʔ		*	*
b. (t̥otoyʔ)(-púlu-k)(kaʔ) <sup>4</sup>	*!		
c. (t̥otoyʔ)-pu(lú-kkaʔ)		**!	*

In this grammar, output forms where the maximum number of morphemes are associated with well-formed feet are preferred. However, blind left-edge morph-to-foot alignment cannot take account of morpheme size (and hence, *inherent footability*). So in the case of polymorphemic words with monosyllabic affixes interrupting the optimal foot structure (14), we get an unwanted result. Candidate (a) is the attested outcome, but it loses to the unattested candidate (b), the winning candidate here, because, although this candidate violates Align as much as candidate (a) does, it parses maximally.

(14)

/t̥otoyʔ-ŋki-ppulu-kkaʔ/ aunt-yours-PL-LOC	FTBIN	ALIGNL (M, FT)	PARSE(σ)
☞ a. (t̥ótoyʔ)-ki-p(púlu-k)kaʔ		**	**
☛ b. (t̥ótoyʔ)(-kí-ppu)(lú-kkaʔ)		**	
c. (t̥ótoyʔ)(-kí-ppu)lu-kkaʔ		**	**

The problem with Align constraints is that they are strictly local in their effects: all they 'see' is morpheme boundaries. But the stress rules (or constraints) in Ngalakgan need to know how big the domain is in order to apply properly. Align will not do this. The bigger problem however appears to lie with our assumptions about how words are built up, and how they are subjected to phonological processes. The usual assumption about word structure is that it is built up in layers from the root, like an onion. In phonology, rules are assumed to apply to domains which minimally include the root. They cannot apply to affixal domains without the root.

Within Optimality Theory, the other alternative for explaining patterns such as those in (2)-(3) is with Output-Output Correspondence. An Output-Output Correspondence model explanation of the Ngalakgan stress patterns runs into trouble because affixes are

<sup>3</sup> All stop-initial suffixes in Ngalakgan alternate between geminate and singleton realisations, depending on an interaction between syllabification constraints (as in (13)), prosodic structure, and the morphological analysis of the form (see Baker 1999: Chapter 4 for details). This alternation has no bearing on the point discussed here.

<sup>4</sup> We could regard such forms, where there is technical misalignment between the syllabification of the morpheme and the association of feet, as violating AlignL. Whether we do so or not has no consequences for the analysis. However, it is doubtful that such a technical enforcement of AlignL is warranted. It has been proposed that languages never contrast tautomorphemic forms in terms of syllabification (e.g. Blevins 1995: 221). Hence, the syllable affiliation of the initial part of the geminate in the suffix /-kkaʔ/ LOC could never affect the evaluation of alternative candidates that differed just in this feature.

never distributional words. It is therefore difficult to imagine how correspondence could become established. In addition, affixes differ in their behaviour depending on size. Disyllabic affixes are always inherently footable, as discussed above. Monosyllabic affixes vary in their prosodic behaviour depending on the surrounding morphology (their footing is contingent). We would have to stipulate that OO-CORR holds of disyllabic affixes, but not monosyllabic ones. This appears to be a restatement of the generalisation on the inherent footability of affixes depending on size.

The problem with Output-Output Correspondence is therefore two-fold. In the first place, it has nothing to say about correspondence between forms which can never be words, such as bound morphemes. In the second place, it causes some logical problems which are difficult to overcome. For instance, how do we decide (in a theory-neutral fashion) which is the form of the word that must be corresponded to? (Benua 1997) has no answer to this problem.

#### 4. An alternative model of the phonology-morphology interface

Here, I defend an alternative view of word structure: one based on adjacent, rather than nested, domains. In this model, outputs from the lexicon are independently subjected to rules of metrical stress assignment, as in (15). The domain of metrical stress is therefore not the (grammatical/distributional) word, but each productive morpheme within the word.<sup>5</sup>

(15)	PrWd		PrWd
	<sup>g</sup>		<sup>g</sup>
	Ft		Ft
	fh		fh
	$\sigma$ $\sigma$	$\sigma$	$\sigma$ $\sigma$ $\sigma$
	fg fgh	fgh	fg fgh fgh
	totoy?	-ŋki-p	pulu-k ka?
	aunt	=yours	-PL -LOC

(15) represents how this might be done in metrical phonology, by building metrical trees on each productive morpheme independently. In an OT analysis, I propose that we can achieve this by getting rid of the restriction on only allowing distributional words as inputs. Under this assumption, the analysis of complex words follows straightforwardly. We simply subject each morpheme to the well-known constraints deriving regular metrical patterns.

In (16)-(19), I have set out an array of tableaux representing the simultaneous analysis of several morphemes of a complex word for metrical structure. (16) and (18) are disyllabic morphemes which can be parsed as simple feet using constraints already introduced for this purpose. In (17) we see a monosyllabic clitic. This morpheme, like other monosyllabic

<sup>5</sup> This raises the issue of how we determine productivity in the lexicon. I have discussed this with respect to Australian languages elsewhere (Baker & Harvey 2003). For the purposes of this paper, we can regard productive morphemes as those morphemes which can be applied to any form of the appropriate morphosyntactic category ('N', 'V', etc), whereas unproductive or semiproductive morphemes can only be applied to forms belonging to a set which must be listed, as (the realisations of) {stem1, stem2, stem3...stem $n$ }. This is essentially the division followed by e.g. (Clahsen 1999) and (Jackendoff 2002).

suffixes and clitics, cannot be parsed as a disyllabic foot. It must be left unparsed, violating  $\text{PARSE}(\sigma)$ ; and hence FTBIN must be ranked above the former.<sup>6</sup>

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<sup>6</sup> A reviewer notes that any violations of ALIGNL due to lack of footing must entail a violation of  $\text{PARSE}(\sigma)$ . This observation is also made in (Cohn & McCarthy 1994), but the implications of this (partial) redundancy are not examined further in that work. I leave further examination of this question to future research. However, I note that eliminating  $\text{PARSE}(\sigma)$  from the grammar of Ngalakgan will make the evaluation of forms like that in (14) undecidable, under the analysis discussed there. Removing  $\text{PARSE}(\sigma)$  from my analysis in section 4 would seem to have no effects on the outcome.



(16) /totoy?-ŋki-ppulu-kkaʔ/

/totoy-/ 'aunt'	FTFORM	FTBIN	ALIGNL	PARSE(σ)
☞ a. (tótóyʔ)				
b. (tótóyʔ)	*!			
c. tótóyʔ			*!	**

(17)

/-ŋki/ 2sgDAT	FTFORM	FTBIN	ALIGNL	PARSE(σ)
☞ a. -ŋki				*
b. (-ŋki)			*!	

(18)

/-ppulu/ PL	FTFORM	FTBIN	ALIGNL	PARSE(σ)
☞ a. (-ppúlu)				
b. (-ppulú)	*!			
c. -ppulu			*!	**

(19)

/-kkaʔ/ LOC	FTFORM	FTBIN	ALIGNL	PARSE(σ)
☞ a. -kkaʔ			*	*
b. (-kkaʔ)		*!		

The line linking these tableaux together represents the idea that they are being simultaneously evaluated, as part of a distributional word. However, this is just a notational device and does not represent a theoretical claim about how the grammar is operating. Indeed, productive morphemes in Ngalakgan and related languages can on occasion be separated by pauses (deliberate or accidental), in which case their phonological representation *must* necessarily be evaluated independently of the root. In (20)-(21), there are two examples where speakers artificially slowed speech down (for the benefit of a certain hard-of-hearing linguist) into component morphemes, as shown on the right.

(20) /yiriŋ-pi-pak-wocma/ [yíriŋ]^[bi:]^[bak]^[wócma]  
 1pO-3p-APPL-get.PR 'they always steal from us' [2/7/96:2A]  
 normal speech: [yiriŋbibakwócma]

(21) /ŋur-ku-kamala-ŋan-ci/ [ŋur]^[gu:]^[gámala]^[nánji]  
 12pS-NEUT-sky-see.EVIT-FNEG 'we can't see the view' [2/7/96:2A]  
 normal speech: [ŋurgugàmalaŋánji]

I suggest that metrical and segmental processes can be applied to a different domain from that of syllabification and intonation. Some morphological or phonological device is responsible for ensuring that individual morphemes end up (usually) as a coherent string, part of the intonational phrasing of the utterance. But this is not necessarily the same

device that is responsible for the metrical and segmental phenomena that are part of that string.<sup>7</sup>

Syllabification must be applied to the whole form rather than the individual parts, since some affixes apparently begin in clusters. However, we need to allow for inter-word syllabification in any case because of the word sandhi and syllabification effects found cross-linguistically. One example of such a pattern applying to word-initial geminates has been described for Swiss German (Kraehenmann 2001). Similar patterns are found in Oceanic languages such as Leti (Hume, Muller & van Engelenhoven 1997), as shown in (22), where word-initial geminates and other clusters are parsed ambisyllabically in phrase-medial positions.

- (22) /spou/+/ttenan-ne/      [spout.ténan.ne]  
          boat    spine-his      'the keel of the boat/his keel'

We also need to allow phrasal syllabification for some phenomena in English, such as 't'-flapping in American English, and 'r'-insertion in Australian and other dialects of English:

- (23) Law[ɹən] Order  
          Pizza[ɹən] a garlic bread

Because phrasal syllabification is apparently needed in any case, we lose nothing in making it apply separately from stress assignment in Ngalakgan and other Australian languages.

I propose that speakers simultaneously evaluate forms at several levels: for different processes, applying to different domains. The domains applicable to distinct phonological processes are language-specific. I return to some examples of this below.

Tableau (26) represents the simultaneous evaluation of this same complex form for both syllabification and stress. The stress evaluation proceeds as schematised above in tableaux (16)-(19). At the same time, I propose, speakers evaluate the whole word for syllabification. The input then for syllabification corresponds in this case to the distributional word. Note that this is not a processual model, where the output of one level (the metrical system) constitutes the input to another (syllabification). Rather, both processes apply in parallel, but at different orders of magnitude.

The syllabification constraint at work here can be represented thus:

- (24) \*CCC: No triconsonantal clusters. (Blevins 2003:388)

'C' in this formulation applies to occlusives (nasal and oral obstruents including the glottal stop). This is a constraint that applies generally in Australian languages (Dixon 1980:159).

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<sup>7</sup> The idea that the input to phonological processes could be phrases as well as words was examined in earlier work on the prosody/syntax interface (Chen 1987, Selkirk 1986). This work directly contributed to the development of Alignment theory within Optimality, but therein was restricted to an application to domains *within* words. (I thank Caroline Jones for pointing this out.) Of course, as José Alvarez points out, in current OT models phrases can be the input to evaluation in 'OT syntax'.

In (26), it rules out an output involving a sequence of [ʔŋg].<sup>8</sup> This constraint conflicts with Correspondence constraints on the input: IDENT[SG] and IDENT[NASAL] (McCarthy & Prince 1995: 264):

- (25) IDENT[SG]: 'Corresponding segments are identical in feature [spread glottis]  
IDENT[NAS]: 'Corresponding segments are identical in feature [nasal]'

(26)

(16)-(19)	*CCC	IDENT[SG]	IDENT[NAS]
a. [dòdoigippúlukka]			*
b. [dòdoingippúluka]		*!	
c. [dòdoingippúlukka]	*!		

It is well-known that phonological processes apply at more than one level (see Kenstowicz & Kisseberth 1977: 83ff. for a review). The table in (27) provides a brief typology of some of those discussed so far. The only process which hasn't been mentioned is stress in French, which is typically analysed as having phrasal, rather than word-based stress (Di Cristo 1998, among others).

(27)

	stress	syllabification
<b>morpheme</b>	Ngalakgan	German compounds
<b>word</b>	English	English; Ngalakgan
<b>phrase</b>	French	Leti; English /t/-flapping, intrusive /r/

## 5. Word Minimality: size matters

A classic example of the importance of prosody for phonology comes from 'word minimality' effects (McCarthy & Prince 1986, 1993). These effects too have been reanalysed in OT terms using Alignment, but again, this analysis fails under certain morphological conditions where size matters.

(28) shows some examples of word minimality effects from Ngalakgan. We see that monosyllabic open roots must surface with long vowels, to satisfy the cross-linguistically common requirement that words be minimally bimoraic (McCarthy & Prince 1993). Monosyllabic closed roots surface with short vowels, demonstrating that codas in this

<sup>8</sup> In fact, the constraint at work here is more likely to refer to relative syllabic positions of the nasal and glottal stop, since sequences of [ŋʔg] are unproblematic in Ngalakgan and related languages (e.g. /gu-be[ŋʔ-gaʔ/ 'on the leaf'. But for present purposes it doesn't matter what the exact form of the constraint is.

environment are moraic. When open monosyllabic roots are affixed, they still must surface with a long vowel, even though at the surface the word is bimoraic (cf. Borowsky & Harvey 1999 for similar phenomena from other Australian languages). In Ngalakgan, this is the only environment where phonologically long vowels are found.<sup>9</sup>

- |      |    |         |             |         |         |
|------|----|---------|-------------|---------|---------|
| (28) | a. | /bo/    | 'river'     | [bo:]   | *[bo]   |
|      | b. | /bak/   | 'algae'     | [bək]   | *[ba:k] |
|      | c. | /bo-wi/ | 'river-LAT' | [bo:wi] | *[bowi] |

In my model, word minimality comes about because certain classes of morphemes (those that can occur as words) are required to be pronounceable as words in every environment, including that within complex words. The constraint proposed for this purpose in (Baker 1999:41) was the following, an adaptation of McCarthy & Prince's (1993) general 'MCAT  $\approx$  PCAT' constraint:

- (29) MWD  $\approx$  PRWD: Every Morphological Word corresponds to a Prosodic Word.

'Morphological Word' in this formulation refers to productive morphemes that are also 'lexical', or 'content', stems. (For a similar distinction between content and function words with respect to stress in English see Selkirk 1995.) Along with the requirement that Prosodic Words necessarily dominate some Foot, and the constraint FTBIN previously introduced, MWD  $\approx$  PRWD demands that Morphological Words be realised with a minimum of two moras.<sup>10</sup>

MWD  $\approx$  PRWD conflicts with Correspondence, the large 'family' of constraints resisting alternations between corresponding input and output segments. One suggestion for constraining alternations in moraicity is shown in (30) (Urbanczyk 1995, McCarthy 1995). WT-IDENT demands that there be no alternations in moraicity between corresponding input and output segments.

- (30) WT-IDENT  
 If  $\alpha \in \text{Domain}(f)$ ,  
     if  $\alpha$  is monomoraic, then  $f(\alpha)$  is monomoraic. (No lengthening.)  
     if  $\alpha$  is bimoraic, then  $f(\alpha)$  is bimoraic. (No shortening.)

WT-IDENT is highly ranked in Ngalakgan, leading to the distribution of long vowels that we observe: that these are only found where forced by word minimality.

Since productive stems, like productive morphemes, are assessed for prosodic structure independently of other material in the word, the presence of affixes is irrelevant to the evaluation of satisfaction of these constraints, in my model. For a complex form such as *bo-wi* 'river'-LATIVE, the stem *bo* is evaluated independently of the affix. There are only two options: either the form is realised with a long vowel or with a short vowel. Given a ranking of FTBIN and MWD  $\approx$  PRWD over WT-ID the result is inevitable, and will not be affected by affixation.

<sup>9</sup> (28)b implies that codas are moraic in CVC roots, and that syllables may not be trimoraic. This is covered by FtBin previously introduced.

<sup>10</sup> The requirement that Prosodic Words dominate some Foot is presumably not a violable constraint but rather a property of UG (McCarthy & Prince 1986, 1993).

(31)

/bo/ 'river'	FTBIN	MWD ≈ PRWD	WT-ID
a. (bo)	*!		
☞ b. (boo)			*

In an Alignment analysis, this result must be obtained by aligning both Left and Right edges of a Root to a Prosodic Word or Foot, since McCarthy & Prince (1993) specifically argue against the use of templatic formulas such as (29).

(32) AlignL(Rt, PrWd): Align the left edge of every root to the left edge of some Prosodic Word.

(33) AlignR(Rt, PrWd): Align the right edge of every root to the right edge of some Prosodic Word.

Although they do not directly conflict, ALIGNL presumably dominates WD-IDENT, since virtually every root begins in a foot (unless forced to move by a medial heavy syllable: Baker 1999 Ch 5). But WD-IDENT must in turn dominate ALIGNR, because it is not that case that every root ends in a foot (for example, in trisyllabic roots we do not find final vowels lengthening in order to satisfy ALIGNR).

Using these constraints, and those already introduced, we can derive the result that simple monosyllabic open roots have long vowels at the surface (34).

(34)

/bo/ 'river'	FTBIN	ALIGNL	WT-ID	ALIGNR
a. (bo)	*!			
☞ b. (boo)			*	

However, when monosyllabic open roots are affixed, as in (35), this grammar runs into problems. The unattested candidate (b) wins by virtue of not violating lower-ranked WT-ID, whereas the actual surface form (c) has an identical violation of AlignR but violates WT-ID in addition. The problem here is that, as with the multiply-affixed stems analysed in section 2, Alignment can't distinguish between distinct instances of an edge.

(35)

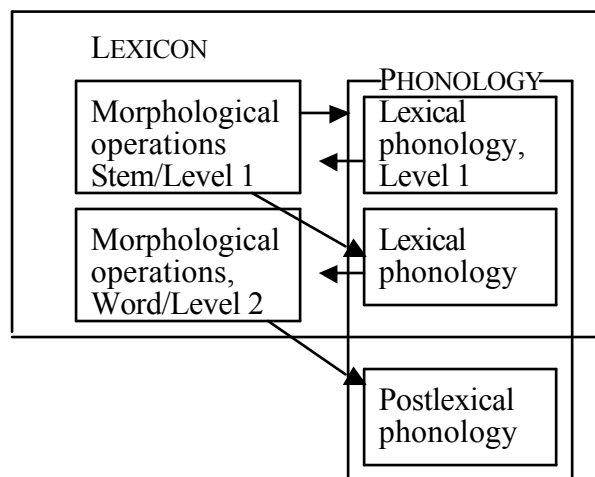
/bo-wi/ 'river'-LAT	FTBIN	ALIGNL	WT-ID	ALIGNR
a. (bo)-(wi)	*!*			
☛ b. (bo-wi)		*		*
☞ c. (boo)-wi		*	**	*

In McCarthy & Prince (1993), Alignment was proposed as a device to capture the common associations that we find between morphological and prosodic constituents. Examples like (35) however demonstrate a genuine problem with Alignment, that the previous Prosodic Templates approach of McCarthy & Prince (1986) did not face: Alignment constraints are satisfied by the coincidence of *any* morphological edge with any prosodic edge. There is no way to force a form, such as (35), to maintain alignment for both edges of the *same* morpheme in preference to edges of distinct morphemes. In the following section I discuss some earlier models in Lexical and Prosodic Phonology which did successfully capture the effects discussed here.

## 6. Adjacent domains in Borowsky's model of Lexical Phonology

In Lexical Phonology, the notion that phonological processes might apply to morphemes prior to concatenation was developed by Borowsky (1993: 200), who provides the following model:

(36)



Some examples of how this model might work are also provided by Borowsky, such as the famous problem of German [ç, x] alternation discussed by Bloomfield (1930). (37) shows that these two sounds appear to be in complementary distribution, with the palatal fricative found after front vowels and the velar fricative after back vowels. The rule suggested by Borowsky (following Bloomfield 1930) to explain this distribution is in (38).

German [ç, x] alternation (Borowsky 1993:205)

(37)	[ç]	[x]
	<i>ich</i> 'I'	<i>Buch</i> 'book'
	<i>höchlich</i> 'highly'	<i>hoch</i> 'high'
	<i>Küche</i> 'kitchen'	<i>Koch</i> 'cook' (n.)

(38) [ç] → [x] / [+back]\_\_

As shown by Bloomfield, the rule fails to apply across certain morpheme boundaries (but not others), so that within words, we end up with what looks like contrastive phonemes:<sup>11</sup>

- (39) Kuhchen [ku:çən] 'little cow'  
Pfauchen [pfaoçən] 'little peacock'  
Tauchen [taoçən] 'little rope'
- (40) Kuchen [ku:xən] 'cake'  
pfauchen [pfaoxən] 'to hiss'  
tauchen [taoxən] 'to dive'

Under Borowsky's analysis, the rule backing the palatal fricative applies on the 'Word cycle' before any Word-level affixation. Hence it affects *Kuchen* because this does not have a Word-level morphemic analysis, but not *Kuh-chen*, because this form is complex at the Word level. By the time the affix is attached, the rule can no longer apply:

- (41) Level 2: *Kuh* *Kuchen*  
Word cycle: — /ç/ → [x] Rule (38)  
Affixation: *Kuh+chen* —  
Output: [ku:çən] [ku:xən]

At the Word-level, affixes attach to items which are surface words of the language. There is no more phonology, after Word-level affixation, under Borowsky's analysis.

Under the current analysis, we might propose a constraint such as (42):

- (42) \*[back][pal]: 'Avoid dorso-palatal gestures after back vowels.'

This constraint applies within 'Words' in Borowsky's sense. We can understand 'Words' to correspond to elements which are listed in the lexicon, both simple morphemes and complex (but listed) forms. So \*[back][pal] applies to some forms which are complex at the Stem-level, such as *Kuchen* 'cake', because these are listed forms. In (43), \*[back][pal] conflicts with a constraint IDENT[PAL] demanding that underlying segments surface with the same specification for [palatal] as the input.

- (43) 'Lexical component'

<i>Kuchen</i> 'cake'	*[bk][pal]	IDENT[PAL]
a. [ku:çən]	*!	
☞ b. [ku:xən]		*

<sup>11</sup> The German data is less straightforward than the discussion here would suggest. Firstly, there is dialectal variation in the productivity of *-chen*. In Bavaria, this affix is no longer productive. Secondly, for some stems attachment of *-chen* requires fronting of back vowels in the stem: *Mutter*: *Mütterchen*, *Vater*: *Väterchen*. It is not clear to me whether this process is restricted to certain stems or certain speakers. If general, this process implies that for these speakers there is no [ç, x] contrast within words, even those which are productively derived. (Thanks to Andrea Schalley and Alex Borkowski for discussion of this data.)

The constraint \*[back][pal] also applies to affixes such as *-chen* DIMINUTIVE in (44), (trivially, since this form does not meet the structural description of the rule).<sup>12</sup>

(44) 'Lexical component'

<i>-chen</i> DIM	*[bk][pal]	IDENT[PAL]
☞ a. [çən]		
b. [xən]		*!

The reason then, that forms such as *Kuh[ç]en* 'cow'-DIM escape the constraint against palatal gestures after back vowels, is because this constraint applies only within word-level morphemes, and not between them. Thus, it can apply within *Ku[x]en* 'cake', because, at the Word level, this is a simple form with no internal analysis. The constraint does not apply to *Kuh[ç]en* 'cow'-DIM because this form is complex at the Word level: it consists of two Word-level morphemes. Neither of these Word-level morphemes violates the constraint.

Therefore, a central aspect of the current proposal can be seen as an Optimality Theoretic implementation of Borowsky's (1993) Lexical Phonology model. The other examples discussed by Borowsky (1993), as well as the general point that only postlexical phonology applies to words complex at the Word-level, also appear to transfer to the current model.

The major theories of generative phonology since SPE essentially followed the same view of word structure: that it was layered like an onion from the root outwards, encompassing larger domains with each additional morpheme. But one side-branch of phonology did investigate the possibility of domains external to the root: the theory of Prosodic Phonology developed by e.g. Selkirk (1982), Booij & Rubach (1984), Nespor & Vogel (1986). This theory was developed in part as an account of 'bracketing paradoxes', where the prosodic structure did not seem to reflect the morphological derivation of a word (see Spencer 1991 for a review). In words such as *ungrammaticality* for instance, the bracketing in (a) is demanded by the morphological subcategorisation of the affix *un-* which attaches to adjectives, so it can attach to *grammatical* but not to nouns such as *grammaticality*. The

<sup>12</sup> A reviewer raises the issue of 'Richness of the Base' here (McCarthy 2003). ROTB is a principle of OT designed to eliminate the need for morpheme structure constraints on the input. As McCarthy (2003:1) puts it: 'ROTB says that there are no language-particular restrictions on underlying representations'. ROTB interacts with another principle of OT known as 'Lexicon Optimisation' (Prince & Smolensky 1993). Lexicon Optimisation says that, presented with forms which do not alternate, learners will assume the simplest analysis of their UR: that the input corresponds to the output. In the case of the Diminutive affix *-chen* in German, there is no alternation. This is always realised as [çən]. Therefore, according to Lexicon Optimisation, the input will also be /çən/. ROTB has nothing to say here. ROTB does not license the learner to consider an input /xən/, given an output [çən], in cases where there is no alternation to suggest such a hypothesis. In the case of listed forms such as *Ku[x]en* and *Kü[ç]e*, we do observe an alternation. Here, Lexicon Optimisation cannot be straightforwardly applied. Let us say that ROTB operates in this case. If we allow a general Faithfulness constraint called IDENT to regulate the relation between input and output, then the outcome will be [x] in (43) regardless of whether the input is /ç/ or /x/. (Alternatively, we could have two constraints: IDENT[PAL] and IDENT[VEL], the result will be the same.) The reason that [x] will win in either case is because \*[back][pal] is ranked more highly than Faithfulness. *Within* lexical items (that is, listemes) then, we will never observe an output such that [ç] follows a back vowel.



suffix *-ity* however, is a Level 1 affix which attaches to adjectives and affects stress assignment, implying the bracketing in (b).

- (45) a. [[ungrammatical]ity]  
 b. [un[grammàticáality]]

Aronoff and Sridhar (1983) propose that there is no necessary isomorphism between morphological and prosodic structure. (45)a is the output from the morphology but the prosodic structure assigned to this form is as in (46), where both the prefix *un-* and the inflected stem *grammaticality* constitute Prosodic Words.

- (46) [[un]<sub>WD</sub>[grammàticáality]<sub>WD</sub>]<sub>WD</sub>

The Australian patterns are amenable to a Prosodic Phonology account. However, Prosodic Phonology is a declarative model — anything can be potentially declared to be a prosodic domain — and hence it over-generates patterns. The model argued for here makes a stronger and more constrained claim: only morphemes which, on independent grounds, can be shown to be elements of the lexicon may constitute a domain for phonological processes. I have discussed this idea elsewhere (Baker 1999, Baker & Harvey 2003), but in essence, it is productive morphemes which I assume can provide the input to evaluation in an Optimality Theoretic grammar. These correspond fairly closely with Word-level morphemes in (Selkirk 1982) and (Borowsky 1990), but these models make no necessary claim about the relationship between productivity and morphological status.

It might be claimed that by opening up OT to the possibility of multiple domains of analysis, I have made the model less, rather than more restrictive. This is certainly true in the broad sense, since under the proposed model, words can be evaluated for constraint satisfaction at several 'levels': (Word-level) morpheme, distributional word, and phrase. In addition, under this model constraints must be specified to apply to a certain level, and not at others, and languages are predicted to differ in exactly this respect.

These moves have been proposed in order to deal with some of the most recalcitrant and widespread of phonological patterns: what we might call word-internal phonological domains. While the model has become less restrictive, by allowing multiple domains of evaluation, it will presumably do away with the need for many language-particular constraints designed to account for just those word-internal domain effects which cannot be captured using more cross-linguistically well-founded constraints. One potential consequence is the ability to do away with Alignment (and other edge-based constraints) entirely. In this respect then, the model will result in a tightening of the set of potential phonological patterns predicted to exist under current OT models.

In the model proposed here, what is crucial to the determination of phonological domains is the productivity of morphology. Morphemes which are fully productive are listed in the lexicon, and are potentially subject to morpheme-level constraint evaluation. Morphemes which are unproductive or only semi-productive are not separately listed. Instead, words derived with such morphemes (at the 'Root-level') are simply listed in the lexicon (for similar views on the nature of morphology in the lexicon, see e.g. Jackendoff 1975, Selkirk 1982, Borowsky 1990, Clahsen 1999). My claim is that this is information which is necessary to the learner anyway, because it determines, for instance, the possibilities for

inflection and derivation of loanwords in a language. Only productive morphology will be available for this purpose (Clahsen 1999). Hence, the model relies on a lexical structure which already exists in the learner's grammar, and which will be language-particular to a large extent. Moving the locus of language-particularity out of the phonology and into the lexicon, I would argue, is a well-founded move. It enables us to restrict phonology to those patterns which are truly cross-linguistic and well-motivated, rather than forcing us to invent ad hoc constraints to solve language-particular peculiarities.

## Conclusion

I have argued for a model of phonology in which the inputs for phonological processes can be morphological elements of at least {(productive) morpheme, word, phrase}. By making such a move, we enable a unified analysis of phenomena such as syllabification, metrical structure, and segmental neutralisation without introducing boundary elements into the phonological representation itself. Instead, the input to phonology is controlled by the lexicon. The implication here is that the behaviour of the phonology should reflect in a rather direct fashion the structure of the lexicon. Languages in which words are built productively with a minimum of idiosyncratic morphophonemic rules should display phonological domains of the type discussed here. Indeed, this appears to be true of Australian languages in general, as well as other agglutinating Native American languages discussed in Cole & Coleman (1992), and Bantu languages discussed in, for example, Myers (1987). Part of the impetus for the research reported on here comes from the kind of word structure we see in these languages: not layered like an onion but instead built out of adjacent, non-overlapping domains. Until phonological models can deal with this kind of word structure they will fail to account for some of the most common phonological patterns, including those, such as compounding, found in better-known languages. In conclusion I note that, while making such a theoretical move seems to make the model less restrictive, it in fact allows us to eliminate a large number of language-particular constraints from CON, which is a desirable outcome. The additional specification required on constraints — to restrict their domain of application — is information which is already present on constraints in OT anyway. In addition, the model uses information which is already available to speakers in the distinction between freely productive morphology and morphology which is frozen to varying degrees. It therefore does not require any additional lexical annotation or structure than is already present in the grammar.

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