Part II: Theoretical Aspects of Prosody in Ngalakgan

Part II of the thesis presents a discussion of the phonetic, phonological and prosodic bases of the geminate/singleton distinction, and alternations between the two, in Ngalakgan, and the basis of prosodic weight and prominence.

CHAPTER 4
Geminates as Boundary Signals

Until now I have assumed underlying and surface forms in Ngalakgan wherein there is a single series of stops, which can be either singletons or geminates. This chapter reviews this assumption critically, in the light of Merlan's (1983) analysis of Ngalakgan as a language with a fortis/lenis distinction. Heath, too, proposes a fortis/lenis analysis for the related language Ngandi (1978a).

I present a range of evidence from phonetics, vowel allophony, and syllable phonotactics which I will show accords better with a geminate/singleton analysis than a fortis/lenis one. The issue is important because, as we shall see in the second half of this chapter, geminate consonants alternate with singleton consonants in suffix-initial position. To understand this process we need to understand geminates. In Ch 5 I will discuss the nature of syllable weight in Ngalakgan. Both the geminate/singleton distinction, and the heavy syllable/light syllable distinction have been claimed to rest on a difference in mora count (e.g. Hayes 1989). Since I show that this is not true of Ngalakgan, it is necessary to show that Ngalakgan geminates really are geminates, and not single segments.

4.1 The contrast

I will briefly review the contrast here. Roots contrasting for singleton/geminate are presented in (1a) and (b), (2a) and (b), and (3a) and (b); (a) and (b) in each case are near-minimal contrastive pairs.

(1)	a.	/kacca/	[ɡácca]	'nothing'
	b.	/kacaʔ/	[ɡája̰ˀ]	'dog'
(2)	a.	/ŋappa/	[ŋáppa]	'better'
	b.	/ŋapak/	[ŋábak]	*E. grandifolia*
(3)	a.	/marcci/	[márcci]	'ghost; paleskinned person'
	b.	/maɹci/	[máɹji]	'hand'

The contrast between singleton and geminate stops is only possible between continuants, as discussed in §4.1.3.[1] In non-contrastive positions - before and after non-continuants, and word-peripherally - the geminate/singleton contrast is neutralised.

The same contrast between the (a) and (b) examples in each case is found in many languages of the Arnhem Land. This contrast has been interpreted in at least three ways:

(4)	a.	A voicing contrast	(e.g. Glasgow 1981)
	b.	A fortis/lenis contrast	(e.g. Heath 1978a; Merlan 1983)
	c.	A geminate/singleton contrast	(e.g. McKay 1975, 1980, 1984)
	d.	A long/short contrast	(e.g. Evans 1991; Green 1995)

The following sections show that the contrast must be interpreted as one of geminate vs singleton.

The chapter is organised as follows. The first half of the chapter discusses the surface characteristics of geminates and singletons in root-medial position. I show that surface geminates have both the phonetic and phonological characteristics of obstruent

[1]Throughout the thesis 'continuant' refers to vowels, liquids and glides. I will refer to nasals, glottal stop and supralaryngeal obstruents collectively as 'non-continuants'. This follows Australianist practice (e.g. Morphy 1983).

clusters, and not those of single fortis segments, indicating that geminates should be thought of as occupying two root nodes (or timing slots) associated to one place node (as proposed in e.g. Kenstowicz and Pyle 1973, Selkirk 1988[1990]).[2] The phonetic correlates of the contrast show that it is duration, not voicing, which is the primary cue to the contrast (4.1.1). The distribution of vowel allophones show that the geminates occupy both a coda and an onset position. They are not syllabified as single fortis segments in the onset (4.1.2). The distribution of geminates in syllables also classes them with phonological clusters, and not with single segments (4.1.1).

The second half of the chapter turns to the behaviour of geminates in suffixes. In §4.2 I show that geminates and glottal stops are associated with morpheme boundaries, and derive from historical gemination and laryngealisation in these positions. In these positions, geminates and glottal stops function as 'boundary signals' (Trubetzkoy 1939[1969]:275ff): overt phonological signals of morphological structure. Suffixes alternate predictably between geminate and singleton realisations (§4.3). Their realisation is conditioned by the phonological form of the preceding stem, and the location of pitch accent. I analyse these alternations as well-formedness conditions on the location of phonological boundaries in relation to intonation domains, and morphological and prosodic categories. As well as the allomorphy in suffixes, the analysis accounts for the morpheme structure constraints on geminates in Ngalakgan roots. The same constraints account for prosodically-conditioned distributions of geminate and glottal stops in the neighbouring, unrelated Ndjébbana and Yolngu languages respectively.

4.1.1 Phonetic correlates

In this section I show that at the surface, stops contrast in terms of length. The contrast in Ngalakgan is not a voicing contrast. The discussion closely follows that of

[2]Throughout this chapter, where I refer to geminates as 'clusters' I have this representation in mind.

Butcher (to appear): a survey of stop contrasts in central Arnhem Land, and Daly River area languages of the Northern Territory.

4.1.1.1 Duration

In roots, geminates are consistently longer than singletons at the same place of articulation in the same environment. In what follows I present measurements of singleton and geminate stops at all places of articulation which demonstrate this. Measurements of stops were taken from words in citation in most cases, in intervocalic environments following a primary stress.

Table (5) shows figures for singleton stops at all POAs except apico-alveolar, of which I have no citation examples in the relevant environment.[3] The average durations range from 48 ms for apico-postalveolars to 71 ms for labials. The average over all POAs is 62 ms.

[3]There are only four roots in the lexicon with the relevant environment: /karatata/ 'chest brace', /kolototok/ 'peaceful dove', /ciriʈiti/ 'bird sp. (possibly a fly-catcher)', and /ʈotoyʔ/ 'uncle'.

v́pv	v́tv	v́ʈv	v́cv	v́kv
97	no examples	34	76	76
87		50	48	65
93		60	79	68
46		59	54	52
69		63		46
56		52		69
46		57		
		35		
		35		
		50		
		50		
		56		
		48		
		75		
		68		
		55		
		33		
		41		
		56		
		25		
		26		
		43		
		40		
Av. (7) = 71		Av. (23) = 48	Av. (4) = 64	Av.(6) = 63

Table (5): Durations of post-tonic singletons

Table (6) below presents figures for durations of post-tonic geminates at all five places of articulation. The average durations range between 139 ms for apico-alveolar geminates, through to 226 and 228 ms for the apico-postalveolar and lamino-alveopalatal geminates, respectively.[4] The average of geminates over all POAs is 200 ms.

[4]Durations of geminates can be quite massive. One apico-postalveolar token, for the word [báʈʈiʔ] 'fly' was 392 ms. This token was omitted from the table.

v́pp	v́tt	v́ʈʈ	v́cc	v́kk
135	166	228	190	116
151	122	224	266	190
172	118			166
209	144			166
170	146			218
230				237
205				104
227				218
247				97
				221
				199
				215
				252
				146
				220
				230
				193
				172
				117
				247
				190
				266
				247
				310
				270
				249
				248
				232
				272
				170
				248
				268
				251
				231
				214
Av (9) = 194	Av. (5) = 139	Av. (2) = 226	Av. (2) = 228	Av. (35) = 211

Table (6): Durations of post-tonic geminates

Table (7) below presents average durations for post-tonic singletons and geminates ordered by place of articulation. The number of tokens is given in parentheses, followed by the average duration in miliseconds (ms). It can be seen that geminate stops at all places are at least twice the length of the corresponding singleton stop, with the exception of apico-alveolar singletons, for which there are no data. In the case of apico-postalveolar, the duration difference between geminates and singletons is 4:1. Similar ratios are presented by Butcher (to appear: 11) for six languages of central Arnhem Land.

	Labial	**Apico-alveolar**	**Apico-post-alv**	**Lamino-alv-pal**	**Velar**
Geminate	(9) = 194	(5) = 139	(2) = 226	(2) = 228	(35) = 211
Singleton	(7) = 71		(23) = 48	(4) = 64	(6) = 63

Table (7): Average durations of geminates and singletons

These duration ratios are consistent with those reported by researchers for length distinctions in other languages. For example, Lehiste (1960:53) reports ratios of between 1:2 and 1:3 for short vs long stops ('Quantity 1' vs 'Quantity 2') in Estonian.

Lehiste (1970:27) observes that 'the intrinsic duration of consonants is influenced both by their point of articulation and by the manner of articulation', citing evidence from English, Breton, Estonian, Norwegian and Swedish to back up the claim. Even taking into account these inherent durational differences, the values shown here are significant enough to suggest a systematic phonological difference between geminate and singleton stops.

The duration ratios of geminate/singleton in Ngalakgan are greater than those of voiceless and voiced stops in English and German (e.g. Fischer-Jørgensen 1972), which have also been analysed as having a fortis/lenis contrast. In these languages, voiceless stops are around 1.3 times as long as voiced ones. Phonetically, geminates in Ngalakgan are more like the geminates of languages such as Finnish, Italian, and Estonian, than they are like the 'fortis' voiceless stops of English and German.

4.1.1.2 Voicing

In this section I consider whether the geminate/singleton contrast at the surface can be described in terms of voicing, instead of or in addition to duration. I reject this proposal on the grounds that neither the presence during closure, nor the onset time of voicing at release is a consistent cue to the contrast (cf. Butcher, to appear:20). Firstly, I briefly discuss how voicing contrasts are implemented in languages. I then show that Ngalakgan stops do not implement a surface contrast in any of the ways that have been observed elsewhere.

I follow Lisker and Abramson (1964) in assuming that voicing contrasts are correlated with differences in 'voice onset time' (VOT): the time between the release of stricture in an obstruent and the onset of voicing in a following sonorant and, to a lesser extent, 'voice termination time' (VTT): the time between the onset of closure and the termination of voicing.[5] That is, voicing contrasts in stops are implemented by varying the timing between glottal abduction and adduction, and stricture formation. In *voiceless aspirated* stops, peak glottal opening is timed to co-occur with release of stricture. Voicing in the following vowel cannot begin immediately on release. These stops have a 'long lag' VOT. In *voiceless unaspirated* or *plain voiceless* stops, peak glottal opening occurs during articulatory closure. No voicing occurs during closure, but vocal folds can begin vibrating almost as soon as closure is released. In the case of *voiced* stops, Butcher (to appear:2) characterises them thus: 'the vocal folds are not actively abducted, and providing air is able to flow through the glottis, voicing can begin before the release of the articulatory closure. In the case of intervocalic stops this may well result in continuous glottal pulsing throughout the closure'.

If Ngalakgan were a language with a voicing contrast, we would expect to find a consistent difference between singletons and geminates in their implementation of VOT. None of the characterisations in the preceding paragraph describes the Ngalakgan facts.

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[5]VTT is also called 'voicing lead', and VOT 'voicing lag'.

The pages following this section display spectrograms and waveforms taken from recordings of Ngalakgan words in citation.[6] It is not the case that all intervocalic stops are fully voiced in Ngalakgan. Fig (1) shows an intervocalic singleton in the word /mu-wucur/ III-'flat grindstone' realised as a voiceless unaspirated lamino-alveo-palatal stop. So the opposition is not like that in French: with fully voiced stops, contrasted with voiceless unaspirated ones.

Nor is the opposition like that in English: where voiceless stops have long VOT, and contrast with short VOT voiced stops. It is not the case that every geminate in Ngalakgan has a long lag VOT. Most geminates have a VOT of around 20 ms. But Fig (2) shows two intervocalic geminates in the same word /yir-puyppuy+ɳe-ppiraʔ/; neither are aspirated. The intervocalic singleton in Fig (1) and the intervocalic geminates in Fig (2) both have zero VOT. VOT therefore does not consistently distinguish singletons and geminates in Ngalakgan.

Butcher (to appear:14, 19) found two consistent correlates of stop contrasts in languages of the area (Central Arnhem Land). The first of these was duration, as in Ngalakgan. The second consistent correlate of geminates was a higher degree, and a higher rate of rise in, intraoral pressure - the air pressure behind the oral stricture - in geminates as opposed to singletons.[7] Discussing Gunwinyguan and Burarran languages, Butcher (to appear: 20) observes that 'all speakers appear actively to abduct the vocal folds to avoid prolonging voicing into FORTIS [geminate] stop closures.'

Butcher proposes (to appear:23) that 'speakers consistently aim to achieve a different target peak pressure for each stop category [i.e. geminate vs. singleton], rather than maintaining a more or less constant subglottal pressure and leaving the peak intraoral pressure to be determined by the duration of the articulatory closure'. He bases this conclusion on the fact that, if the pressure differences were the automatic consequence of constriction duration differences, we would expect that duration and

[6]Recordings were digitised and analysed using the Signalyze program.
[7]These claims were based on volume velocity data recorded on a pneumotachograph.

pressure should show a regular mathematical relationship, and that the rate of rise should remain constant. But this is not the case, pressure in geminates rises at more than twice the rate in singletons, and in the case of the Daly languages (which have a stop contrast based on voicing), the duration differences between fortis and lenis stops are not great enough to explain the pressure differences, which are *greater* than those of the Maningrida group. Therefore, the intraoral pressure which correlates with geminates is not an automatic consequence of their duration, since the maximum reached and the rate of rise observed are both greater than that of plain stops.

We have seen that stops contrast consistently in terms of duration: plain stops are at least half, and down to a quarter of the duration of geminate stops. These ratios are consistent with duration differences between long/geminate and short/singleton stops in languages such as Estonian, Finnish and Italian (Lehiste 1960).

We have also seen that the contrast cannot be described as a voicing contrast. VOTs are not consistently long enough for the contrast to be characterised as one of voiceless aspirated vs plain voiceless or unaspirated stop. On the other hand, singleton stops are not consistently voiced throughout closure. So neither can the contrast be described as one of plain voiceless vs fully voiced stops. Butcher (to appear) has suggested that intraoral pressure differences between the two categories are also a consistent correlate.

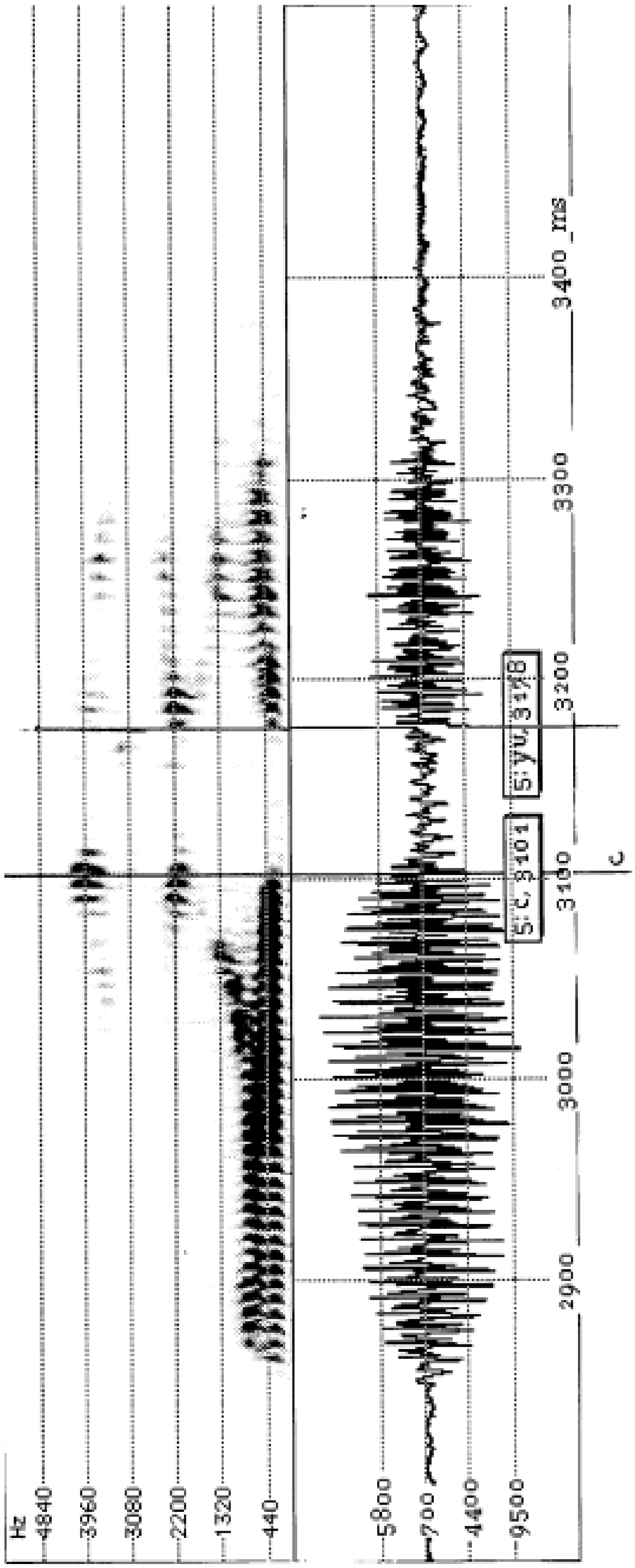

Figure (1) [muwúcur] /mu-wucur/ III-grindstone

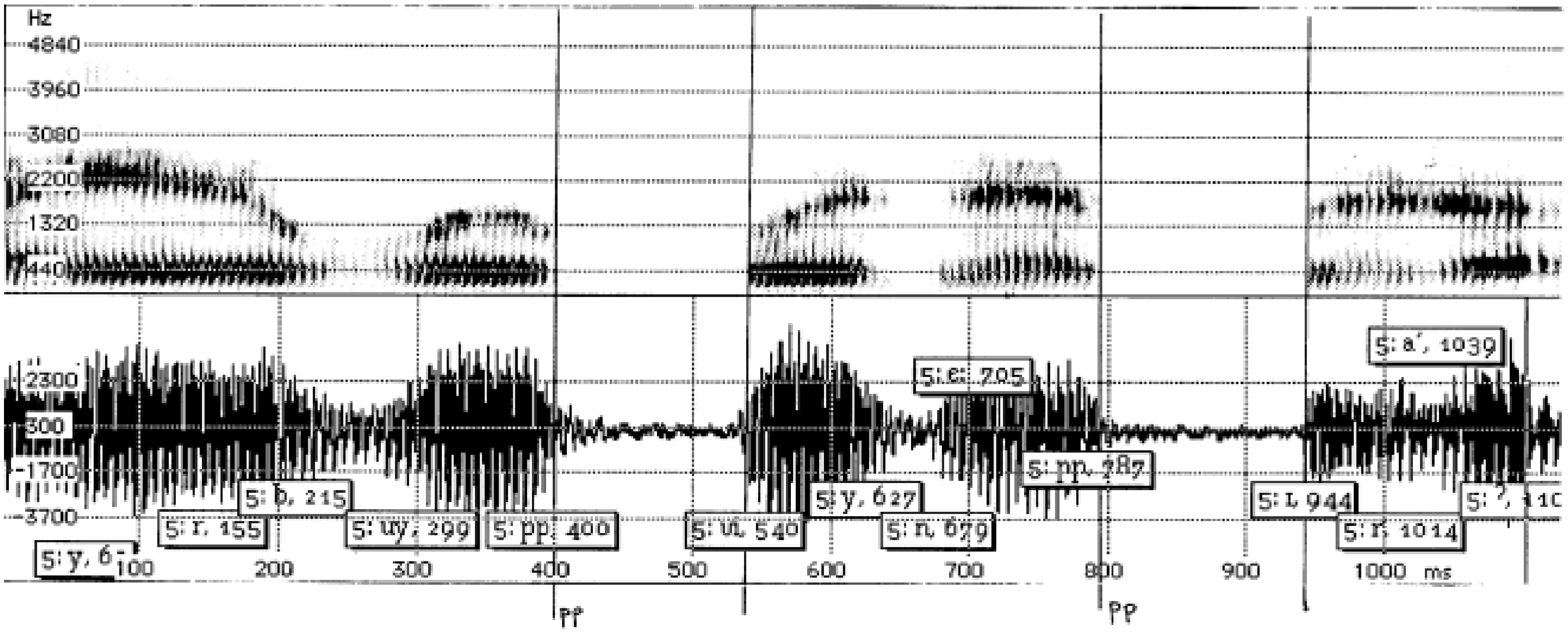

Figure (2) [yirbùippuyneppira]
/yir-puyppuy+ŋe-ppira?/
1aS-singe+[burn]PR-DU-grindstone

4.1.1.3 The phonological representation of geminates

In order to make concrete the phonetic description, I assume a representation of geminates and singletons as presented in (5). Underlying stops are symbolised with capitals here to indicate their status as stops unspecified for laryngeal features.

(5)	Geminate	Singleton	
Underlying	/PP/	/P/	
Representation	[RO] [RO]	[RO]	Root
	\\/	|	
	[lab]	[lab]	Place
	|	|	
	[]	[]	Laryngeal
Surface	[pp]	[b̥]	
Representation	[RO] [RO]	[RO]	Root
	\\/	|	
	[lab]	[lab]	Place
	|	|	
	[spread glottis]	[]	Laryngeal

'[RO]' stands for 'obstruent root node', that is, a root node specified as [+cons, -son] (McCarthy 1988, Selkirk 1988[1990]). Geminates differ from singletons in having two root nodes, rather than one. The two root nodes are associated to a single place node (Selkirk 1988[1990]).

There are laryngeal differences between the two. Underlyingly, neither geminates nor singletons have laryngeal specifications. At the surface, geminates are specified as 'spread glottis', while intervocalic singletons surface with no laryngeal specification. These phonological specifications adapt Butcher's phonetic characterisation of stop contrasts in Gunwinyguan and Burarran languages (to appear:24) as 'presence vs absence of vocal fold abduction reinforced by different articulatory constriction durations'.[8] The use of [spread glottis] as the surface specification of geminates is

[8]The feature label [spread glottis] was proposed in Halle and Stevens (1971), but I do not assume their classification for stop contrasts, and I am using 'spread glottis' to encode a different contrast to theirs. In Halle and Stevens (1971), 'spread glottis' entails aspiration, that is, maximal glottal abduction timed to

designed to encode the fact that geminates in the languages discussed by Butcher all had high intraoral pressure as a primary correlate, along with stricture duration. Spreading the glottis allows the maximum degree of pressure to be attained in the quickest time, as observed by Butcher (to appear:23ff).

The surface singleton stops are not phonologically specified for laryngeal features. This also accords with the phonetic facts. Butcher (to appear:20) notes that 'the inconsistent presence of glottal pulsing through lenis [singleton] stop constrictions provides a strong indication that active adduction of the vocal folds is not a prerequisite for these sounds'. Singleton stops require neither an abduction nor an adduction movement of the vocal cords.

Singleton stops in Ngalakgan do not have the same 'markedness value' as voiced stops in languages with a voicing contrast. Speakers do not actively seek to attain voicing throughout closure, or shorter VOT times, as we have seen in §4.1.1.2. Singleton stops are therefore not specified as [voice]. In Ngalakgan then, it is not the case that the surface 'voiced' stops are the marked members of the stop opposition, and the surface 'voiceless' stops are the unmarked members. If anything the opposite is true; the 'voiceless' [geminate] stops, require speakers to make an articulatory effort: to spread the glottis and maintain closure, while the 'voiced' [singleton] stops require less articulatory effort. The effortful nature of geminates, and relative effortlessness of singletons, is reflected in the fact that singletons are commonly approximated in Ngalakgan and the languages studied by Butcher (to appear). Geminates are never approximated in Ngalakgan.

The term 'lenis' is therefore appropriate as a characterisation of the phonetic and phonological characteristics of singletons, since they are articulatorily less effortful than geminates, and are unspecified for positive laryngeal features. I represent them

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co-occur with release of closure. Here, I mean that glottal abduction is part of the articulation of geminates, but is not *necessarily* timed so as to occur with release of closure. Butcher suggests the glottal spreading gesture in the Maningrida group is timed to co-occur *during* the closure, so as to maximise intra-oral pressure. In fact, the timing of glottal abduction in Ngalakgan geminates seems to vary, assuming that the duration of post-release VOT is an indication of this timing.

phonetically here with the IPA diacritic for voicelessness, but with a voiced symbol, to encode their lenis quality (Pullum and Ladusaw 1986[1996]). Elsewhere I simply represent them with the voiced symbol, though it should be kept in mind that singleton stops have a distinct place in the phonological system from voiced stops in systems of voicing contrasts, as I have observed.

Stops in Ngalakgan consistently contrast in duration; I have characterised the contrast as 'geminate' vs. 'singleton', but one might characterise it as 'long fortis stop' vs. 'short lenis stop' (e.g. Evans 1991 for Gundjeihmi or Green 1995 for Gurr-goni). This seems to be Merlan's (1983) proposal for Ngalakgan. Even though Merlan recognises that duration is the main phonetic correlate of fortis consonants, this does not alter the fact that she is setting up a phonological opposition of *segments*. In her analysis, a lenis syllable *onset* contrasts with a fortis syllable *onset*, not a fortis geminate, as she makes clear (1983:2): 'If...the stops represented by voiceless symbols are not taken to be geminate [but rather fortis], then (given restrictions on their distribution...) a single stop of this kind would always be the onset of a syllable frequently preceded by an open syllable, or sometimes by one with a non-nasal sonorant as the final segment.'

Characterising the contrast as fortis vs lenis implies that the surface contrast corresponds to an underlying segmental contrast between two series of stops. At this point in the argument, there is no evidence one way or the other for deciding whether the surface contrast implements an underlying segmental contrast, or whether it truly reflects geminate stop vs singleton. In the following sections, I provide phonological evidence that surface geminates are treated by the phonology of Ngalakgan in the same way as other stop sequences, and not as single segments.

4.1.1.4 Assignment of [spread glottis]

It might be thought that the fact that geminates and singletons contrast in terms of the [spread glottis] feature is grounds for treating geminates as a distinct series of fortis stops. In fact, as I show in this section, [spread glottis] is a characteristic of all obstruent clusters in the language, as well as geminates.[9]

The accompanying spectrograms (following this section) show that geminates (Figure 3), as well as two types of obstruent clusters - glottal+obstruent (Figure 4), and obstruent+obstruent (Figure 5) - are characterised by a long period in which full voicing ceases. (I use the term 'devoiced', rather than voiceless, to cover situations where full voicing is lacking, whether this is because of glottal abduction or glottal constriction.) In the geminate in Figure (3) /kamakkun/ 'properly', voicing ceases for 200 ms. In the glottal+obstruent cluster of Figure (4) /ɹay-ʔkan/ 'meat'-DAT, the devoiced period (creaky voice followed by voicelessness) lasts for 134 ms. In the obstruent+obstruent cluster of Figure (5) /cetpeʈe/ 'archer fish', voicelessness is maintained for 197 ms. The /ʈk/ cluster of Figure (6), /ŋuʈ-ka+na-ppiraʔ/ 'stop'-CAUS+FUT-DU has a duration of 245 ms. Note that in each of these clusters, C_2 /p/ of the cluster /tp/, and /k/ of /ʈk/ is aspirated at release, just like the geminate of Figure (3), indicating glottal spreading in heterorganic obstruent clusters. Figure (6) shows that the suffix-initial geminate /pp/ of /-ppiraʔ/ has the same characteristics as stem-internal geminates, with a duration of 225 ms and aspirated release.

A similar relationship between underlying and surface forms therefore holds of obstruent+obstruent, and glottal+obstruent clusters, as for geminates. Again, the underlying supralaryngeal stops are unspecified for laryngeal features, but are filled in with [spread glottis] at the surface. The glottal stop is underlyingly specified as [constricted glottis] ([cg]).

[9]McKay (1980) to my knowledge was the first to show that heterorganic and homorganic clusters of stops (in Rembarrnga) had similar acoustic characteristics. McKay originally proposed the analysis in (1975). The similarity had also been noted informally by Wood (1978), in the Yolngu language Gälpu.

(6)	CC cluster		ʔC cluster		
UR	/T/	/P/	/ʔ/	/K/	
	[alv]	[vel]	[]	[vel]	Place
	[]	[]	[cg]	[]	Laryngeal
SR	/t/	/p/	/ʔ/	/k/	
	[alv]	[vel]	[glot]	[vel]	Place
	[sg]	[sg]	[cg]	[sg]	Laryngeal

Geminates and obstruent clusters - obstruent+obstruent and glottal stop+obstruent - are characterised by a long devoiced period based on deliberate glottal abduction, or constriction and abduction gestures in the last case.

Since geminates and obstruent clusters are [spread glottis] at the surface, the fact that geminates are also [spread glottis] is not necessarily a reason for them to be considered a contrastive series of fortis stops.[10] The following section considers further evidence for geminates as clusters.

[10]The fact that geminates are [sg] cannot be considered to be positive evidence that they *are* clusters however, since obstruent clusters in Lithuanuan and many other languages agree in voicing also [Steriade 1997:18]. This does not mean that the voiceless stops in these languages are clusters.

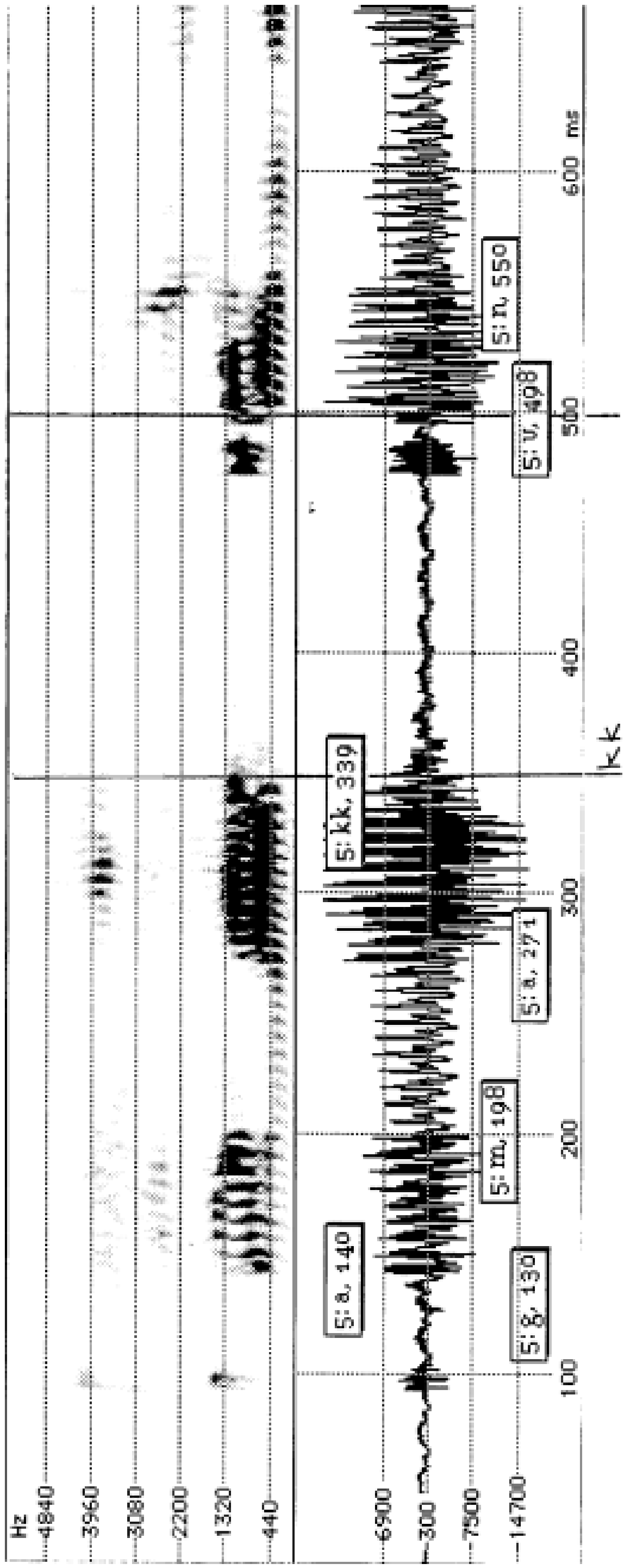

Figure (3) [kámakkun] /kamakkun/ 'properly'

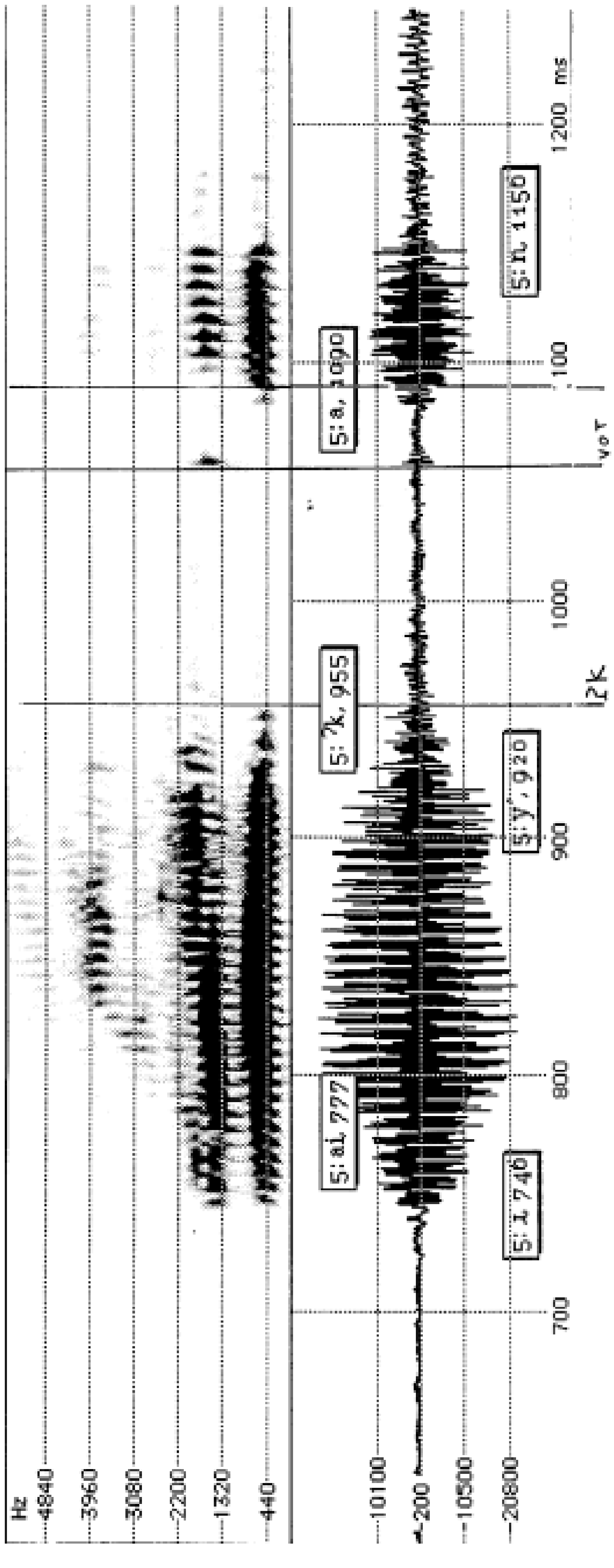

Figure (4) [ɹájʔkan] / ɹay-ʔkan / meat-DAT

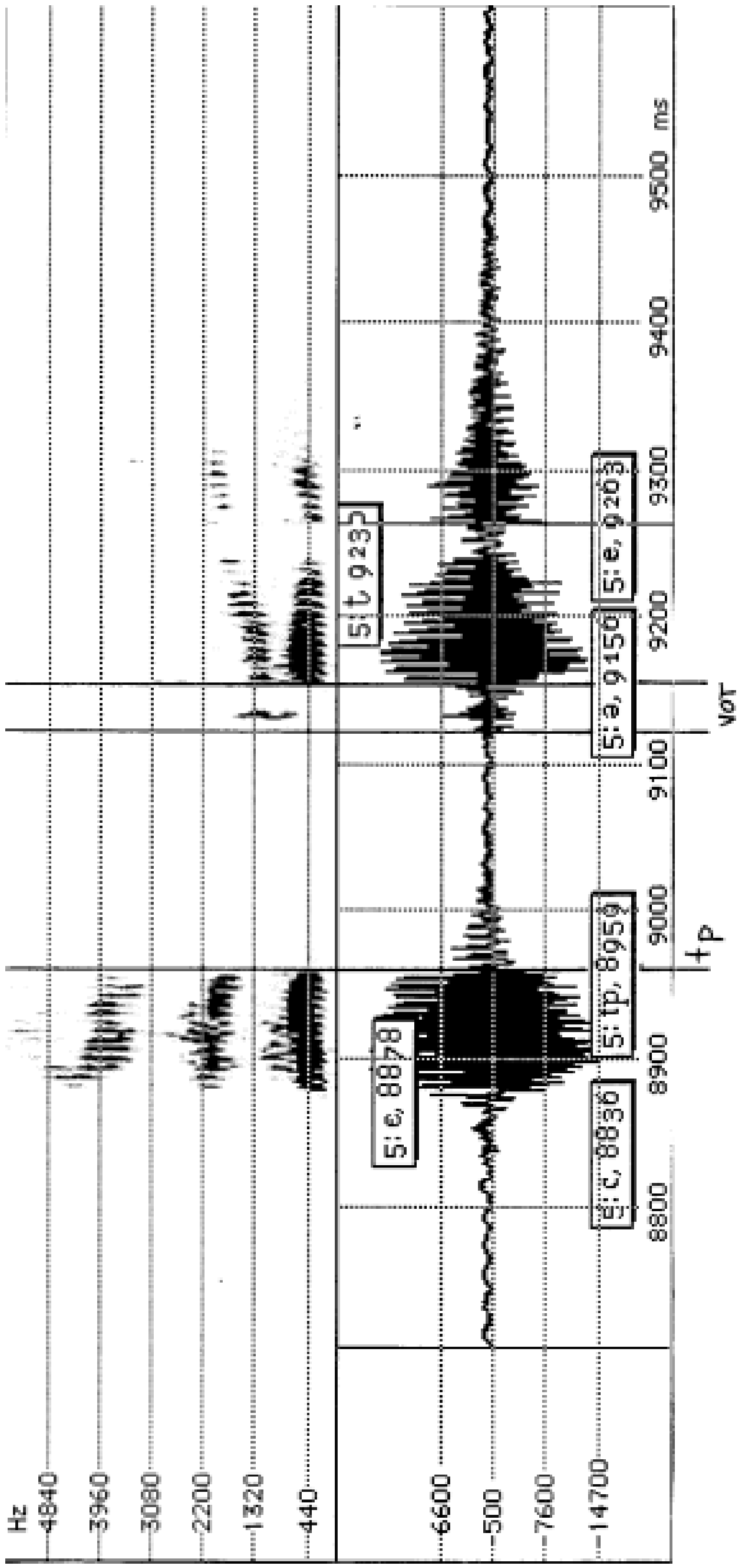

Figure (5) [jétpəḍe] /cetpeṭe/ 'archer fish'

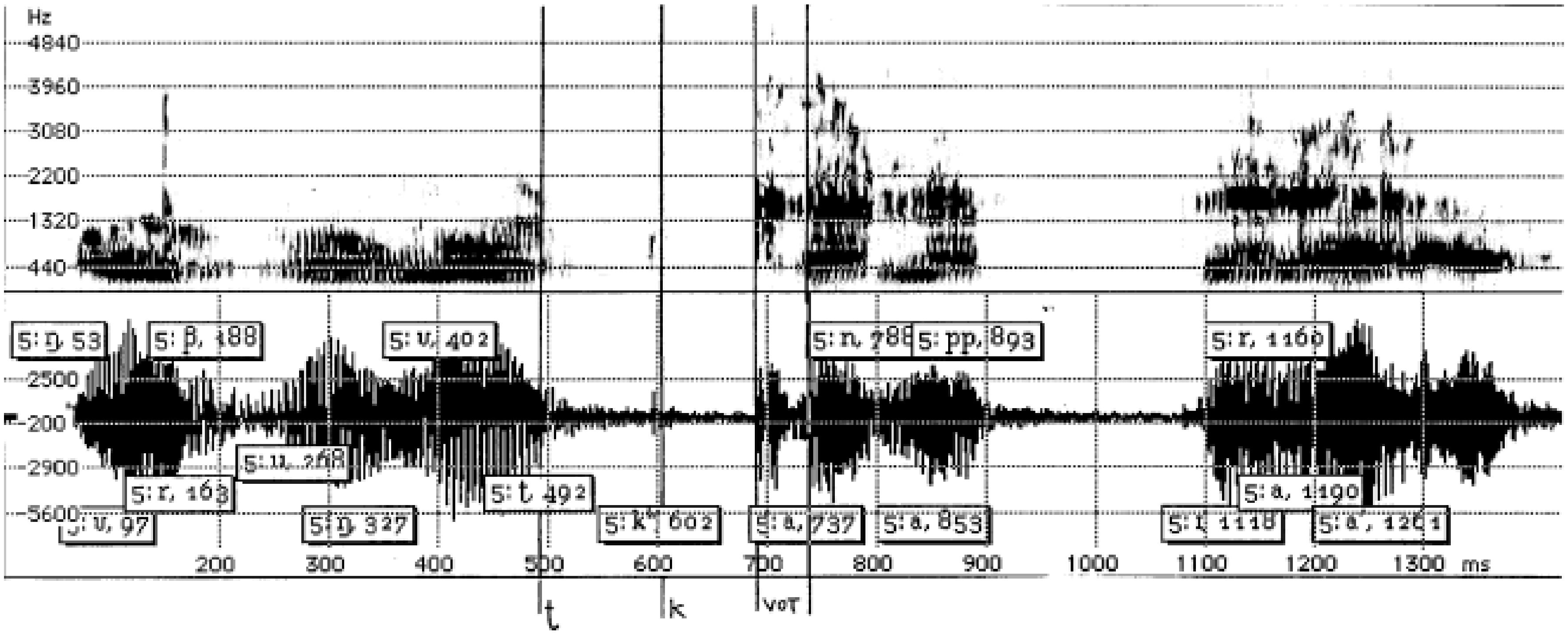

Figure (6) [ŋʊrβuŋòʈkanappiraʔ]
/ŋur-pu-ŋuʈ-ka+na-pira?/
12aS-3a-desist-CAUS+FUT-DU
'we have to stop those two'

4.1.2 Vowel allophony

All non-low vowels in Ngalakgan have two allophones, which I will call 'centralised' and 'peripheral'.[11] The realisation of vowel allophones is predictable based on syllable structure and stress. Centralised allophones occur in closed syllables, and peripheral allophones in open syllables if unstressed and/or final. If geminates were simple segments, we would expect to find the peripheral allophone preceding them, whereas if geminates are syllabified in both coda and onset, we expect to find them preceded by the centralised allophone. I will show that the latter is the case.

The full system of allophones is presented in table (8).

Table (8): Vowel inventory

	Front/unrounded		Back/rounded
	Peripheral ~ Centralised		Peripheral ~ Centralised
High	i ~ ɪ		u ~ ʊ
Mid	e ~ ɛ		o ~ ɔ
Low		a	

The environments for centralised allophones are presented in (8). Centralised allophones are found in all closed syllables, and in stressed, non-final open syllables.

(8) Centralised vowel allophone environments

a. Closed syllables — $cvc]_\sigma$

b. Stressed vowels preceding a consonant — $c\acute{v}]_\sigma c$...

Note that stress, as well as segmental context, determine vowel allophony. Non-final open but *stressed* syllables have the same vowel allophone as closed syllables; in a sense, stressed syllables sound like closed, 'checked' or short syllables, so both vowel

[11]The centralised allophone is lower and more open than the corresponding peripheral allophone, which is closer. The centralised allophones sound like the lax ('short') vowels in English, the peripheral allophones sound like the tense ('long') vowels. The two allophones could accordingly be called 'lax' and 'tense' or 'open' and 'close'. But since the peripheral/tense/close allophone occurs primarily in *open*, unstressed syllables, and the central/lax/open allophone occurs in *closed* syllables, the terms close/open could cause confusion.

allophones in the word in (9) are the same, even though the first is in an open, but stressed syllable, and the second in a closed syllable.

(9) ṭenek
[dɛ́nɛk]
'lower ribs'

The peripheral allophones are found elsewhere: that is, in open, unstressed syllables, and in open final syllables (whether stressed or unstressed). (The brevis diacritic 'v̆' indicates lack of stress here, not lack of duration.)

(10) <u>Peripheral vowel allophone environments</u>

a.	Final open syllables	$cv]_{WD}$
b.	Open unstressed syllables	$c\breve{v}]_{\sigma}$

In (11), the last two syllables both take the same allophone, because they are both in open *unstressed* syllables. These two allophones contrast with the allophone in the first syllable, because this is in a *stressed*, though open, syllable.

(11) komoḷo
[gɔ́moḷo]
'white crane'

The difference between allophones is clearest in the mid vowels. Examples of mid vowels in final, unstressed syllables are presented in (12). Centralised allophones occur in closed final syllables, on the left, and peripheral allophones in open final syllables, on the right.

(12) Unstressed final syllables

	Centralised V in CVC]$_{WD}$ syllable		Peripheral V in CV]$_{WD}$ syllable
a.	polkkoc [bɔ́lkkɔʲc] 'backbone'	a'.	pilppo [bílppo] 'wide'
b.	poɳʈok [bɔ́ɳɖɔk] 'flat woomera'	b'.	poɳo [bɔ́ɳo] 'another'
c.	kacet [gájɛt] 'stone knife'	c'.	kaɹe [káɹe] 'Eucaplyptus sp.'
d.	kolototok [gɔ́lodɔ̀dɔk] 'peaceful dove'	d'.	komoɭo [gɔ́moɭo] 'white crane'
e.	colok [jɔ́lɔk] 'sickness; cough; phlegm'	e'.	colo [jɔ́lo] 'meaty part'
f.	maŋaɭerek [máŋaɭɛ̀rɛk] 'beads'	f'.	moɹe [mɔ́ɹe] 'wounded'
g.	ŋoʈokoc [ŋɔ́ɖogɔʲc] 'ankle'	g'.	alakko [álakko] 'later'
h.	ʈenek [dɛ́nɛk] 'lower ribs'	h'.	coɳe [jɔ́ɳe] *'Terminalia canescens'*
i.	welec [wɛ́lɛʲc] 'red-collared lorikeet'	i'.	waɹŋmele [wáɹŋmɛ̀le] 'hip'
j.	womporoʈ [wɔ́mborɔʈ] 'big rock wallaby'	j'.	yiɳoro [yíŋoro] 'all around'
k.	yawok [yáwɔk] 'cheeky yam'	k'.	mako [mágo] 'No!'
l.	wulkkot [wúlkkɔt] 'shovel spear'	l'.	colkko [jɔ́lkko] 'earth'

(12) exemplifies the contrast using stop-final words, but words ending in other consonants also condition centralised allophones in preceding vowels, as shown in (13). In the examples on the left we see central vowels in final closed syllables. The examples have been constructed so that the same vowel+consonant sequence which is a word-final rhyme in the forms on the left, is a nucleus+onset sequence in the forms on the right.

(13)

	CVS]$_{WD}$ Centralised V		CVSV]$_{WD}$ Peripheral V
a.	kakkeŋ [gákkɛŋ] 'far'	a'.	weleŋe [wɛ́leŋe] 'girl; female'
b.	koloŋ [gɔ́lɔŋ] 'traditional doctor'	b'.	woroŋomoloʔ [wɔ́roŋomɔ̀lo̰] 'sedge grass sp.'
c.	campen [jámbɛn] 'snake' (generic)	c'.	ʈereneʔ [dɛ́renɛ̰] 'red bush-apple' (*Syzygium* sp.)
d.	yoɹom [yɔ́ɹɔm] 'soakage'	d'.	poromon [bɔ́romɔn] 'good'
e.	yoɭpor [yɔ́ɭbɔr] 'a quarter'	e'.	caworo [jáworo] 'patrilineal clan'
f.	woroɹ [wɔ́rɔɹ] 'rockhole'	f'.	woroɭoɭ [wɔ́roɭɔɭ] 'blowfly'

The pattern in these forms shows that vowel allophony depends on the syllabic affiliation of the following consonant. In the following section, I show that geminates are syllabified as two heterosyllabic consonants, based on the allophones they take in preceding vowels.

4.1.2.1 The effect of geminates on vowel allophony

We have seen that closed syllables condition centralised vowel allophones. Open syllables, unless stressed, condition peripheral vowel allophones. Therefore, if geminates are single fortis segments, they should condition peripheral allophones in preceding unstressed vowels because as such they can only occur in a syllable onset. If they simultaneously occupy onset and coda position, on the other hand, they should condition centralised allophones in preceding vowels. It is the latter generalisation which is true in Ngalakgan, as the examples in (14) show. On the left are vowels in unstressed syllables followed by geminates, and the vowels are realised with centralised allophones. On the right we see the same vowel in an unstressed syllable preceding a singleton, where peripheral allophones are observed.[12]

(14) Lax allophones in unstressed pre-geminate position

a.	moɭo̲ppoɭ [mɔ́ɭɔppɔɭ] 'shovelhead catfish'	a'.	poɹo̲korʔ [bɔ́ɹogɔr̰] 'whistling tree' (*Casuarina* sp.)
b.	were̲kka [wɛ́rɛkka] 'where'	b'.	mele̲ken [mɛ́legɛn] 'sleep on one's side' (+[yo+] 'sleep')
c.	meɭe̲ppeʔ [mɛ́ɭɛppɛ̰] 'shoulder blade'	c'.	caʈe̲ʈulʔ [jáɖeɖʊɭ̰] 'fire stick'
d.	moro̲ʈʈinʔ [mɔ́rɔʈʈɪn̰] 'bush banana'	d'.	kolo̲totok [gɔ̀lodɔ́dɔk] 'peaceful dove'

Vowel allophones preceding geminates in unstressed syllables are like the allophones found before clusters in unstressed syllables. They are not like the allophones found before single segments. At the surface therefore, geminates are hetero-syllabic strings of coda+onset. The first half of the geminate closes the preceding

[12]It is not possible to find exactly corresponding vowel+consonant pairs in every case.

syllable, conditioning centralised vowel allophones, and the second half (we assume) opens the following syllable.

There are only four tautomorphemic examples of this environment, which are shown in (14). Further illustration is provided by the heteromorphemic examples in (15) and (16). In (15a-b), (16a-b) a mid vowel in a final open syllable shows a peripheral allophone. The corresponding vowel shows a *centralised* allophone when the same stem is closed by a geminate-initial suffix |-kkaʔ| 'Locative' in (15c), and (16c).

Like other geminate-initial suffixes, /-kkaʔ/ alternates between geminate-initial and singleton-initial allomorphs. It has a singleton-initial realisation when affixed to a stem containing a geminate, and a geminate-initial realisation in the elsewhere case (see §4.3). In (15b, d), (16b, d) then, the final mid vowel of the stem has the same allophonic realisation in unaffixed (b) and affixed (d) forms: it is peripheral in both cases, because the following consonant is a single stop onset, there is no coda.

(15)	a.	/yele̲/ [yɛ́le] hole	b.	/yerkke̲/ [yɛ́rkke] below
	c.	/yele̲-kkaʔ/ [yɛ́lɛkka̰] hole-LOC	d.	/yerkke̲-kkaʔ/ [yɛ́rkkega̰] below-LOC
(16)	a.	/poɳo/ [bɔ́ɳo] another	b.	/colkko̲/ [jɔ́lkko] ground
	c.	/poɳo-kkaʔ/ [bɔ́ɳɔkka̰] another-LOC	d.	/colkko̲-kkaʔ/ [jɔ́lkkoga̰] ground-LOC

The heteromorphemic examples back up the claim made previously: geminates condition centralised allophones in preceding vowels, and are therefore syllabified in both coda and onset, like obstruent clusters, and unlike single segments. If geminates *were* single fortis segments, we would have no explanation for the distribution of vowel allophones in Ngalakgan syllables.

Geminates derived from heteromorphemic identical stops have the same characteristics as tautomorphemic geminates. In (17), below, two homorganic stops across a morpheme boundary condition a centralised allophone of the high back vowel /u/.

(17) a. /kuɳm**uk-ʔk**Vn/
[gʊ́ɳmʊkkʊn]
night.time-REL [5/9/97:1B]

b. /puru-wulup+wul**up-pp**iraʔ/
[wʊ́lʊppira̰]
3aS-DUR-bathe-DU [3/9/97:2A]

The fact that heteromorphemic geminates pattern like tautomorphemic ones is further evidence against a fortis analysis. In Merlan (1983:28), heteromorphemic geminate stops degeminate, such that the output contains a single fortis stop, as shown in the second line of (18), below. In this analysis, fortis stops are single segments, represented as voiceless stops. The output representations would predict a phonetic realisation of the preceding vowel with a peripheral allophone. This phonetic realisation is ill-formed however.

(18) Surface fortis/lenis analysis

a. /guɳmuk-ʔgVn/
/guɳm**u**kun/
*[gʊ́ɳmukʊn]

b. /buru-wulup+wulup-ppiraʔ/
/buruwulupwul**u**piraʔ/
*[wʊ́lupira̰]

Heteromorphemic geminates condition the same allophones as tautomorphemic geminates. Therefore, heteromorphemic geminates are not realised as singleton segments, any more than tautomorphemic geminates are. Both have the status of coda+onset strings. In itself, the fact that morpheme-internal geminates behave in the same way for vowel allophony as derived geminates is evidence that morpheme-internal geminates *are* geminates, and not some kind of single stop.

Further evidence for the claim that geminates are long heterosyllabic consonants comes from their distribution in syllables, examined in the following section.

4.1.3 Distribution of geminates in syllable structure

If geminates were single segments, we would expect them to have the same distribution in syllables as other single segments. If, on the other hand, geminates are heterosyllabic strings, they should have the same distribution in syllables as obstruent clusters. This section shows that the distribution of geminates follows if we treat them as heterosyllabic strings.

Segments contrast with each other for place of articulation in word-medial, -final and -initial position. (19) shows a three-way contrast between stops and the glottal stop in word-final position.[13]

(19) Segments contrast word-finally

a.	/ʈer**p**/	b.	/ʈer**k**/	c.	/ʈer**ʔ**/
	[dɛrp]		[dɛrk]		[dɛr̰]
	'tie'		'cut'		'hard'

Stops contrast for place in initial position also, as shown in (20), although in this position the contrast in apicals is neutralised, as described in Ch 2.

(20)

a.	/**ʈ**ac-ca/	b.	/**k**acca/	c.	/**p**acca/
	[dácca]		[gácca]		[bácca]
	'cut'-FUT		'nothing'		'hit'.PRES

Geminates do not have the same distribution in words as singletons. Geminates only contrast with singletons word-medially, as in (21). Clusters of [-cont] segments only contrast with single stops in word-medial position also, as shown in (22), (23).

[13]All stops contrast for place word-medially and finally, the examples in (19) demonstrate the contrast for three stops with a minimal triplet.

(21) Inter-continuant geminate vs singleton contrast

a. /marcci/ [marcci] 'white person'

b. /maɹci/ [maɹji] 'hand'

(22) Inter-continuant nasal-stop cluster vs single stop

a. /campuɹ/ [jambʊɹ] 'sand'

b. /capuɹ/ [jabʊɹ] 'great-grandparent'[14]

(23) Post-vocalic stop-stop cluster vs single stop

a. /caʈpa/ [jaʈpa] 'firstborn'

b. /caʈa/ [jaɖa] 'twirl firedrill'.PRES

Geminates and non-continuant clusters both contrast with singletons in the same position in words: medially, between continuants. Therefore, length in obstruents is phonemic.

Singleton stops do not contrast with geminates in word-final or -initial position. There are no words like that in (24a) below, ending in a contrastive geminate, nor are there any words ending in clusters of [-continuant] segments (24b-c).

(24) a. */ʈerpp/ b. */ʈetk/ c. */ʈent/

Similarly, there are no words like those in (25) in Ngalakgan, beginning in geminates, stop+stop or nasal+stop clusters.

(25) a. */tterp/ b. */tkerp/ c. */nterp/

[14]This term is glossed 'great-grandparent' in my notes, but it may be a borrowing from Rembarrnga, I have insufficient data on its application to kin in Ngalakgan. The Rembarrnga term /capuɹ/ 'wife's mother's brother' corresponds to Ngalakgan /copal/. The two terms are probably reflexes of the same proto-form, which makes the existence of /capuɹ/ in Ngalakgan doubtful.

With respect to their distribution in words, then, geminates are exactly like clusters, and unlike single segments, almost all of which contrast in both initial and final position, as we have seen.

Geminates behave like clusters in terms of heteromorphemic cluster-simplification also. Geminates, stop+stop and nasal+stop clusters arising at morpheme boundaries are realised faithfully if they follow a continuant, as in the (a) examples below. But if the underlying cluster follows a [-continuant], the underlying medial nasal or oral stop is deleted from the output, as shown in the (b) forms.[15]

		Post-continuant geminate		Post-obstruent geminate -> C
(26)	a.	/copa**l-kk**a?/	b.	/waṇca**t-kk**a?/
		[jobálkka̰]		[wáɲjatka̰]
		'mother-in-law's brother'-LOC		arm-LOC

		Post-continuant NC cluster		Post-obstruent NC cluster -> C
(27)	a.	copa**l=ŋk**i	b.	waṇca**t=ŋk**i
		[jobálŋgi]		[wáɲjatki]
		'mother-in-law's brother'=2mDAT		'arm'=2mDAT

		Post-continuant CC cluster
(28)	a.	ma**lk=p**ore
		[màlkpɔ́re]
		'subsection'=3aDAT

Underlying, heteromorphemic clusters of three [-cont] segments are simplified at the surface by deleting the middle segment. Geminates behave like an obstruent sequence or cluster for this syllabification process, and not like a segment.

The preceding two sections have shown that surface geminates behave like heterosyllabic clusters for two tests: vowel allophony and syllable phonotactics. Hence, the fortis/lenis analysis is inappropriate as a characterisation of the surface realisation of what are in fact geminate vs plain stops.

[15]There is no (b) form corresponding to (28a) because there are no morphemes beginning or ending in heterorganic obstruent clusters.

The following section shows that the analysis of geminates as heterosyllabic strings enables us to unify the description of morpheme boundary phenomena in Ngalakgan, which would not be possible under the fortis/lenis analysis.

4.2 Gemination and laryngealisation at morpheme boundaries

Geminates commonly occur at stem boundaries in complex words. Glottal stops appear in all of the same environments, suggesting that the two - glottal stop, and geminate - perform a similar function. If geminates are heterosyllabic strings, then it is possible to make a simple generalisation: the initial part of the geminate, and glottal stops, both close the preceding stem-final syllable. If on the other hand, geminates are regarded as fortis segments, this simple generalisation is lost: fortis stops are onsets, glottal stops can only be codas. There is no syllabic factor to connect the two.

4.2.1 The historical and synchronic sources

Geminates and glottal stops appear in suffixes, and between reduplicant and base; glottal stops appear between modifying prefixes and a stem. Geminates in these positions are derived from an original morpheme-initial simple stop. Glottals are derived in some cases from the initial position (in suffixes), and in others from a morpheme-final position (modifying prefixes, reduplicants, verb stems). I regard the two realisations as being two symptoms of the same syndrome.

The reason I regard laryngealisation and gemination as deriving from the same source is because of the form of suffixes. In WORD-level case suffixes, both geminate-initial and glottal-initial forms are found. A comparison of Gunwinyguan (GN) languages suggests that initial geminates in suffixes are innovations in Rembarrnga, Ngalakgan and Ngandi. [16] Suffix-initial glottal stops are found both in these three, and in other languages of the family also (dialects of Mayali, Dalabon). Ngalakgan, Rembarrnga and Ngandi reflexes of the Proto-GN suffix forms in other GN languages

[16] These are the same three languages in which geminate alternation, described in §4.3, is found. I will show that this is no coincidence.

do not necessarily show initial glottal stop or geminate, even if glottal stops or geminates are found in other suffixes in the same language. Nor do the geminates and glottal stops appear in the same positions in the cognate suffixes of Ngalakgan, Ngandi and Rembarrnga. This lack of correspondence can be shown by a comparison of two case suffixes in extent GN languages, given in table (29).

(29)

Proto-Gunwinyguan Dative	Ngalakgan GEN/DAT	Rembarrnga GEN/DAT	Ngandi GEN/DAT	Mayali[17] GEN
*-kun DAT	-ʔkVn	-kkan	-kku	-(ʔ)ken(ʔ)
*-kun REL[18]	-kVn		-ʔkuʔ	-(ʔ)ken(ʔ)
Proto-Ngalakgan-Rembarrnga Allative	Ngalakgan LOC/ALL	Rembarrnga ALL		Mayali GOAL
*-ka	-kkaʔ	-ʔkaʔ		-ka(ʔ)

For PGN Dative/Genitive *-kun, which is glottal-initial in Ngalakgan, both Ngandi and Rembarrnga have *geminate*-initial forms, while Mayali has a simple stop-initial form. A form of the Dative suffix became specialised as a verb subordinating or relativising suffix in Ngalakgan and Ngandi. Again, the suffixes are different in each language, and moreover, different to the related nominal suffix. The Ngalakgan REL suffix has a singleton-initial form, in Ngandi it is glottal stop-initial and final, where the suffix-initial glottal stop alternates with zero depending on the form of the stem (Heath 1978a:24). For Proto-Ngkn-Rmba Allative *-ka Ngalakgan has a geminate-initial form, while Rembarrnga has a glottal stop-initial form.[19] Despite the fact that Ngalakgan,

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[17]The form without final glottal stop is from the Gundjeihmi dialect of Mayali, the form with final glottal stop is from the Kunwinjku dialect (Evans 1991:77-78). Glottal-initial forms are also occasionally heard in Mayali, and more regularly in Dalabon. The suffix is also used as a Relative/Subordinator, though again, with more frequency in Dalabon (Evans p.c.).

[18]I regard the verb Relative/Subordinator suffix as deriving from the nominal Dative suffix. The evidence for this is that in both Ngalakgan and Ngandi, the two suffixes are the same, except for the differences in initial laryngealisation, and extend in the case of Ngalakgan to the fact that both suffixes undergo vowel-harmony with the preceding syllable. These are the only two morphemes in Ngalakgan which do so.

[19]The Proto-GN Dative/Genitive *-kun is ultimately from Proto-Australian *-ku which signalled Purposive as well as Genitive, Dative, and Allative functions (Dixon 1980:311). For the Proto-Ngkn-Rmba Allative *-ka, compare Ngandi -ki DAT. Rembarrnga and Mayali have a distinct suffix for LOC: -ca(m) ~ -cca(m), and -cam, respectively. The Proto-Australian Locative is reconstructed by Dixon as -ta ~ -la ~ -ŋka (1980:311), with prosodically-determined allomorphy in many Pama-Nyungan

Ngandi and Rembarrnga have both geminate- and glottal stop-initial suffixes, these realisations are distributed among the various suffix forms differently in each language.

The different distribution patterns in each language suggest two things. Firstly, each language applied both initial laryngealisation and gemination to suffixes independently, leading to the various realisations of what was the same suffix. Secondly, since both geminate-initial and glottal-initial suffixes are found in the same environment, I suggest that historical laryngealisation and gemination were variant realisations of the same impetus.

Stem-demarcation with gemination, laryngealisation and fortition/lenition alternations appears to be an areal feature of this region (see Harvey 1991 for a discussion and survey of glottal stop distribution in Top End languages).[20] Languages elsewhere show similar patterns. In Finnish for example, glottal stop and geminates both occur as word-boundary markers (Sulkala and Karjalainen 1992:369):

> 'There is a glottal stop in certain sandhi positions in Finnish, a phonetic marker of the word boundary which has no correspondence in the writing system. When the glottal stop is followed by a word-initial consonant it is realised as gemination of that consonant, e.g. [tulet tællep puolellek katuɑ] 'come to this side of the street' (written: <u>tule tälle puolelle katua</u>). When it is followed by a vowel, a true glottal stop may be pronounced [en hɑluɑʔ ʔollɑʔ ʔulkonɑ] 'I don't want to be outside' (written: <u>en halua olla ulkona</u>).

Synchronically in Ngalakgan, the stem-demarcation impetus derives the following morphological patterns at the WORD-level:

(30) a. Initial geminate alternation (but not glottal stop alternation) in WORD-suffixes
b. Final laryngealisation of thematic coverb stems
c. Final laryngealisation of Iterative WORD-reduplicants

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languages.

[20]This group includes GN languages Ngalakgan (Merlan 1983:6-8), Ngandi (Heath 1978a:9), Rembarrnga (McKay 1975:40), Gunwinjgu/Mayali (Carroll 1976:15-18; Evans 1991), Jawoyn (Merlan MS), Warray (Harvey MSb); possible GN languages Mangarrayi (Merlan 1982: 182-186), and Wagiman (Cook 1987:53-62); and the Pama-Nyungan Yolngu languages, e.g. Gälpu (Wood 1978), Djinang (Waters 1979), Djapu (Morphy 1983:20) and Djambarrpuyngu (Wilkinson 1991).

Geminate alternation in suffixes is described and analysed in the second half of this chapter, in §4.3, and laryngealisation in the Iterative reduplication pattern in Ch 5.

4.2.2 Reasons for boundary gemination and laryngealisation

Why is there such an association between edges and laryngeal activity? The link, I suggest, is cessation of normal glottal activity. Apart from the obstruent clusters examined here, glottal vibration is more or less continuous within Ngalakgan words. Intercontinuant plain stops do interrupt voicing sporadically, as we have seen; but by far the majority of intercontinuant plain stops are voiced throughout closure, and quite commonly fricated (cf. Butcher to appear:11). With respect to voicing, intercontinuant singletons are 'targetless' obstruents in the sense of Browman and Goldstein (1992): speakers make no concerted effort on the laryngeal tier with respect to singletons. They are specified neither for [-voice] nor for [+voice] in Ngalakgan. Speakers do not actively abduct vocal folds in their production, nor do they actively seek to maintain vocal fold vibration (Butcher to appear: 20).

Therefore, *apart from* word-internal geminates and glottal stops, the kind of targetted cessation of voicing found in these articulations is only otherwise typical of the boundaries of words in isolation. Word boundaries in Ngalakgan correlate, at least some of the time, with pause. Pause is acoustic silence. Therefore, we have the following two equivalences:

(31) a. Voice[On] = Word
b. Voice[Off] = Word edge '#'

I suggest that Voice[Off] with the interpretation of a word boundary, can be signalled either by cessation of phonation (pause), or by cessation of voicing in Ngalakgan, instigated by segments with [spread glottis] and [constricted glottis] specifications. That is, geminates, [sg] clusters, and glottal stop all signal 'word' boundaries, where 'word' corresponds at least to Prosodic Word, and also to other prominent prosodic positions.

Since both geminates and glottal stops are found at the boundaries of stems in Ngalakgan and other languages, learners might have posited a general association of the following kind:[21]

(32) Voice[Off] = # 'Contrastive cessation of voicing correlates with a MCat/PCat boundary.'

I will refer to the constraint which captures this association as 'No spurious devoicing'. The constraint demands that every *deliberate* break in the voicing profile of a word correspond to the boundary of some morphological or prosodic constituent. The constituents I include in this group are PrWd, strongest foot (Ft1), and tonic syllable.

If geminates surface with a privative [spread glottis] specification, in opposition to plain stops unspecified for laryngeal features, then the markedness of geminates and other obstruent clusters with respect to plain stops follows. The constraint licenses these clusters just if they occur at the boundary of a morphological or prosodic constituent.

By associating devoiced articulations with constituent boundaries, an acoustically highly-marked phenomenon in the language - acoustic silence - is put to the maximum use: signalling morphological boundaries. This has an obvious advantage for acquisition: wherever learners hear significant breaks in voicing they can be safe in assuming a constituent boundary, and conversely they will expect to hear voicelessness, otherwise they will posit no constituent boundary.[22] Properly interpreting morpheme boundaries becomes an important task in languages such as Ngalakgan, since as we have seen, words can be morphologically very complex.

There is a converse well-formedness condition, that every MCat or PCat constituent boundary should optimally correspond to a break in voicing. Consider the

[21] The statement in (32) is a preliminary one. A more careful definition is provided at (58).
[22] This kind of model will not work in languages with a voicing contrast, where [+voice] obstruents are argued to be the marked members of the opposition (Lombardi 1991[1994]).

following propositions. Many (perhaps all) languages mark off the edges of prosodic words in some perceivable way, for example by final obstruent devoicing rules as in German, Russian, Lithuanian and other languages (Steriade 1997). Probably, less languages mark off the edges of feet, and even fewer mark off the tonic syllables. I propose the following constraints to encode these propositions.

(33)	a.	#PRWD#	'The boundaries of the Prosodic Word are delimited by a '#' junctural element.'
	b.	#FT1#	'The boundaries of the strongest foot in a PrWd are delimited by a '#' junctural element.'
	c.	#σ́#	'The boundaries of the strongest syllable in a PrWd are delimited by a '#' junctural element.'

The three constraints in (33) are interface constraints, determining associations between prosodic structure and morphological strings. The junctural element '#' is defined in Ngalakgan by the constraint in (32) as a devoiced articulation: geminates and [spread glottis] obstruent clusters. Therefore, all three constraints determine that [sg] articulations should be found at the left and right edges of strong prosodic constituents, and are violated if this is not the case.

The general principle seems to be that the most important prosodic constituents should be delimited in this way before less important constituents. These constituents may therefore be ranked as separate constraints, in a 'meta-constraint hierarchy'.

(34) Constituent boundaries must be signalled ('No obscure boundaries')
#PRWD# >> #FT1# >> #σ́#

All of these constituents can be considered prosodic 'heads' of their respective superordinate constituents. The PrWd is the prosodic head of the Phonological Word, the strongest foot (Ft1) in a PrWd is its head, and the strongest syllable (tonic) is the head of the strongest foot (P&S 1993:52).[23] The constraints, when satisfied, have the

[23]It is perhaps for this reason that P-Wd does not figure in these constraints, since the domain of P-Wd

effect that each of these constituents stands out from its environment. Stress is one way of making constituents stand out and, I suggest, the distribution of obstruent clusters and glottal stops performs a similar function.

An example showing how the constraints work is given in (36). In this example, a stem is suffixed with the LOC suffix, which is underlyingly geminate-initial. Because this suffix is geminate-initial, it demarcates the boundary of the PrWd, which corresponds to the Morphological Word. To degeminate the suffix, as in (36b) is to leave the PrWd constituent unmarked: a violation of the principle 'No obscure boundaries.' Singletons by themselves do not interrupt voicing to a sufficient degree to constitute salient boundaries. Candidate (b), by degeminating the suffix, violates IO-MAX(Affix), preventing deletion of input material from affixes. The definition in (35) follows M&P (1995b:264), relativised to WORD-affixes.

(35) IO-MAX(AFFIX) Every segment of the input affix has a correspondent in the output affix. (No phonological deletion in affixes.)

The notation '#' is meant to suggest the voicing break instigated by obstruent clusters and geminates. The braces enclose material within which there are no [sg] or [cg] specifications: voicing is more or less continuous.

(36)

/yele-kkaʔ/ 'hole'-LOC	VOICE [OFF]=#	#PRWD#	#FT1#	#σ́#	IO-MAX (AFFIX)
☞ a. {yéle-k}#kaʔ				*	
b. {yéle-kaʔ}		*!	*	*	*

is the whole word, it is not a head position, it is the domain *within which* heads are defined. Some suffixes and many roots end in glottal stop, suggesting a P-Wd delimitation constraint. Glottal stops in these positions display no synchronic alternations, unlike the geminate behaviour discussed below, and I therefore omit consideration of #P-Wd#.

Geminate-initial suffixes are 'licensed by' constraints requiring that constituents be delimited. This is a synchronic aspect of Ngalakgan grammar, as demonstrated by the fact that suffixes alternate between geminate and singleton realisations. In the second half of the chapter, I describe these alternations, and propose an account using the characterisation suggested here: that geminates are associated with boundaries to prosodic and morphological domains.

4.3 Geminate alternation

Geminate-initial WORD-suffixes, such as /-kkaˀ/ LOC, /-kkoˀ/ DYAD, /-ppulu/ PL, have two allomorphs. One allomorph is geminate-initial: |-kkaˀ|, |-kkoˀ|, |-ppulu|. The other allomorph is singleton-initial, where the singleton is lenis |-g̊aˀ|, |-g̊oˀ|, |-b̥ulu|.

Both of these allomorphs are conditioned by the prosodic and phonological structure of the stem to which they attach. In the first place, allomorphs are conditioned by syllable structure. The surface realisations of the Locative suffix -kkaˀ ~ -kaˀ are exemplified in (37) below. The suffix is realised as -kkaˀ with initial geminate following continuant-final stems (37a). The geminate is degeminated following non-continuants (37b-c).

(37)	a.	/campuɹ-kkaˀ/	[jambʊ́ɹkka̰]	'on sandy ground'
	b.	/ʈaɹˀ-kkaˀ/	[ɖá̰ɹ̰ˀka̰]	'in a tree'
	c.	/ŋariɲ-kkaˀ/	[ŋáriɲga̰]	'in [my] hand'

The surface phonetic realisation of degeminated /-kkaˀ/ depends on the preceding environment: it is a [spread glottis] stop following obstruents including the glottal stop, and a lenis singleton stop following nasals.

Allomorphs are also conditioned by non-local factors. A suffix-initial geminate remains geminate at the surface if there are only voiced and singleton obstruent segments between the suffix and a preceding tonic syllable as in (38a-e). If there are any obstruent clusters between an underlying suffix-initial geminate and a preceding tonic syllable, as in (38f-j), the geminate is realised as a singleton at the surface (heterorganic obstruent clusters are exemplified below). I define 'tonic' as a stressed syllable associated with a pitch accent. In the following examples, '**triggers**' of the process are indicated with bolding, and 'targets' with double underlining.

(38)

a.	[bʊ́lugɪkka̰]			f.	[álakkoga̰]	
	/puluki-kkaˀ/	bullock-LOC			/ala**kk**o-kkaˀ/	later-LOC
b.	[ȷambʊ́ɹkka̰]			g.	[wácciga̰]	
	/campuɹ-kkaˀ/	sand-LOC			/wa**cc**i-kkaˀ/	sun-LOC
c.	[yɛ́lɛkka̰]			h.	[yɛ́rkkega̰]	
	/yele-kkaˀ/	hole-LOC			/yer**kk**e-kkaˀ/	bottom-LOC
d.	[láŋgakka̰]			i.	[ŋɔ́lkkoga̰]	
	/ɭaɳka-kkaˀ/	lagoon-LOC			/ɳol**kk**o-kkaˀ/	big-LOC
e.	[ȷítnɪkka̰]			j.	[bálkkuga̰]	
	/citni-kkaˀ/	Sydney-LOC (loan)			/pal**kk**u-kkaˀ/	string-LOC

Of course, stem-internal obstruent clusters do not correspond to a morphological boundary, so in the case of examples (38f-j), the stem does not constitute a domain in which voicing is uninterrupted. All stem-internal obstruent clusters *do* correspond to a prosodic boundary, either Ft1 or tonic syllable, and it is this fact which is sufficient to make them well-formed, as I will show in §4.3.2.

The conditioning environments for each allomorph are schematically represented in (39), and (40). (39) states that an alternating stop (the 'C' in bold) is realised as a geminate ($\mathbf{C}_{\boldsymbol{i}}\mathbf{C}_{\boldsymbol{i}}$) if the string between the stop and a preceding tonic syllable (σ́) is all [slack vocal cords] ('voiced') at the surface.

(39) [σ́...(CV)*...]$_{[slk]}$-$\mathbf{C}_{\boldsymbol{i}}\mathbf{C}_{\boldsymbol{i}}$[...VX*...]

(40) states that an alternating stop is realised as a singleton (**C*i***) if there is a [sg] cluster in the preceding string, intervening between the alternating stop and a preceding tonic syllable.

(40) [σ́...V$C_i C_{i/j [sg]}$V(CV)*...]$_{[slk]}$-**C*i***[...VX*...]

The process refers to the surface structure of words. Thus, [sg] clusters refers to the following kinds of clusters, whether tautomorphemic or heteromorphemic:

(41)
a. Geminates
b. Oral obstruent clusters
c. Glottal stop+obstruent clusters

As we have seen in §4.1.1, all three clusters are [spread glottis] at the surface, in contrast to singleton stops, which are unspecified, and most commonly voiced in both closure and release.

Examples of each of the types of triggers of geminate alternation are presented in (42). In (42a), a geminate-initial suffix is singleton-initial when it attaches to a stem which contains a geminate, such as /kappuci/ 'old person'. A geminate-initial suffix is also singleton-initial if the stem contains a glottal+obstruent cluster, as in (42b), or obstruent+obstruent cluster, as in (42c).

(42)
a. [gáppuɟ̆iji]
/ka**pp**uci-cci/
old.person-PRIV

b. [gʊ́n̪piriga̰]
/kunˀ**p**iri-kkaˀ/
that-LOC

c. [wɔ́cpɛlga̰]
/wo**cp**el-kkaˀ/
hospital-LOC

d. [mánacci]
/mana-cci/
mother-PRIV

e. [jáŋgʊkka̰]
/caŋku-kkaˀ/
meat-LOC

f. [dʊ́ɖʊkka̰]
/ʈuʈu-kkaˀ/
father's.father-LOC

So glottal+obstruent and obstruent+obstruent clusters behave in the same way as geminates for this process. The stems in (42d-f) do not contain any clusters of this type, so the suffix begins in a geminate. Note that nasal+stop clusters, as in (42e), do not condition singleton realisations of suffixes.

Singleton realisations triggered by preceding geminates appear to be entirely consistent for all speakers with whom I have worked. At this point, there is not enough information to tell whether types (41b) and (41c) are consistent triggers. There are only a few examples of singleton realisation triggered by type (b) and just one of (c). But while there is little positive evidence, there is no negative evidence to prove that they are not triggers.

The contribution of obstruent clusters to geminate alternation is difficult to check because they are rare morpheme-internally. They are reasonably common heteromorphemically at compound boundaries, but in compounds, stress is commonly associated with the second member (43a), or with a following disyllabic suffix, as in (43b-c).

(43) a. [ŋubuwɛ̀tbé:nappı̀ra̰]
/ŋu-pu-we**t**+**p**aya+na-<u>pp</u>ira?/
1mS-3a-sneak.up.on+[go.look]+FUT-DU
'I'll sneak up on those two.' [4/7/96]

b. [ŋubuɭàkpunappíra̰]
/ŋu-pu-ɭa**k**+**p**u+na-<u>pp</u>ira?/
1mS-3a-split.shell[+hit]+fut-du
'I'll split the shells of those two' [4/7/96]

c. [ŋubuŋʊ̀ʈkanappíra̰]
/ŋu-pu-ŋu**ʈ**-**k**a+na-<u>pp</u>ira?/
1mS-3a-stop-CAUS+FUT-DU
'I'll make those two quiet/stop them' [4/7/96]

These do not constitute counterexamples to a claim that obstruent clusters condition geminate alternation. In (43a), a pitch accent intervenes between the obstruent cluster /tp/ in the stem and the geminate in the suffix, hence the latter is well-formed. In (43b-c), the suffix itself is associated with a pitch accent, which also sanctions a geminate-initial realisation (see §4.3.1 below). I have no examples of suffixed nouns with medial obstruent clusters: these would provide better evidence.[24]

As with obstruent clusters, glottal stops are rare morpheme-internally, and hence the number of environments in which they would trigger singleton-realisations of suffixes is limited. I tentatively include both heterorganic obstruent clusters and glottal+obstruent clusters in the class of triggers, subject to further investigation. Comparative evidence (from Ngandi: Heath 1981, and Rembarrnga: McKay 1975) also suggests that all three clusters are triggers of the process.

It can be shown that some other kinds of clusters - nasal+stop - do not trigger singleton-initial realisations of suffixes, and NC clusters therefore differ from geminates in this respect. Some examples of this difference are presented in (44).

(44)	a.	[jáŋgʊkka̰] /caŋku-kka?/ meat-LOC	d.	[jɔ́lkkoga̰] /colkko-kka?/ ground-LOC
	b.	[láŋgakka̰] /ɭaŋka-kka?/ lagoon-LOC	e.	[nɔ́ccoga̰] /ɳocco-kka?/ grass-LOC
	c.	[jámbʊɹkka̰] /campuɹ-kka?/ sand-LOC	f.	[ŋáʸccalga̰] /ŋaccal-kka?/ spring-LOC

(44a-c) show that nasal+stop clusters do not condition singleton-initial realisations. Therefore, these kinds of clusters do not have the same effect that obstruent clusters and geminates do. For reasons discussed previously, it is not possible at this stage to show definitively that other kinds of clusters, e.g. glottal+sonorant, do not condition singleton-initial realisations of suffixes.

---

[24] I have recently confirmed a further example, given here.

[ŋiɲyábʊn	jáʈpaga̰]
/ŋiɲ-ɹapo+n	caʈpa-kka?/
2mS-go+PR	eldest-LOC

'you go to the eldest one'

This provides further evidence that heterorganic obstruent clusters do trigger degemination in Ngalakgan.

Note that the schematic representation of the alternation given in (39) violates the lenition [i.e. geminate alternation] rules provided by Merlan (1983:27) for Ngalakgan, and Heath (1978a:22) for Ngandi. Merlan's rule is reproduced here (Heath's rule 1978a:22 is similar).

(45) Stop -> [-fortis] / ... C_1VC_2V(C)-___V

(Either C_1 or C_2 is a fortis stop or ʔC; final C may be any consonant; '-' = morpheme boundary).

The rule states that stops must be lenis following a fortis stop or glottal+obstruent cluster in the preceding two syllables.[25] Heath's rule includes 'hard clusters' among the triggers for degemination (though curiously, only as C_2, not C_1 triggers). These are (a) glottal stop + oral obstruent, or (b) oral obstruent cluster.

Merlan's and Heath's rules make no mention of the effect of intervening accent on the realisation of geminates. Merlan (1983:6) denies any connection between the two: 'the presence of a fortis segment is not directly linked to placement of major word stress'. The following section shows that accent *does* affect the realisation of geminates and singletons in suffixes: following a tonic accent, geminates in suffixes are preferred.

There are therefore two conditioning 'trigger' factors: the presence of preceding obstruent cluster, and the location of tonic syllables. The alternation process only applies to the initial geminates of WORD-suffixes. Initial *glottal* clusters in WORD-suffixes are not affected consistently.[26] Initial obstruents and geminates in ROOT-suffixes and clitics do not alternate, nor do geminates in other positions: stem-initially or -medially.

This section has shown that certain clusters trigger the appearance of singletons initially in suffixes, while other kinds of clusters have no effect. In the following section I provide evidence that prosodic structure conditions geminate alternation.

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[25]I have interpreted the (1983) published version of Merlan's conditioning environment "C_1CV_2V(C)" as a typographical error.
[26]Glottal stops are sporadically deleted from surface forms under conditions similar to the geminate alternation process. See §4.3.2.1.

4.3.1 Geminate alternation is prosodically-conditioned

The location of tonic syllables alone can determine the realisation of a suffix, as shown by the contrasting pair in (46). (46a) and (b) both have underlying segmental strings /ˀpVLV-kkaˀ/, where 'L' is a liquid. Yet (46a) is realised with singleton-initial suffix [-g̊aˀ] and (46b) is realised with geminate-initial suffix [-kkaˀ]. The difference between the two conditioning environments is prosodic: in (46a), the tonic accent is before the trigger /ˀp/, while in (46b) the tonic accent occurs between the trigger /ˀp/ and the following target.

(46) a. [gúnˀpiriga̰] / b. [bɔ̀lɔ̰ˀpɔ́lɔkka̰]
/kunˀ**p**iri-kkaˀ/ / /poloˀ**p**olo-kkaˀ/
that-LOC / woman-LOC

A tonic syllable 'licenses' geminate-initial realisation of the following suffix.

Location of pitch accent can distinguish minimally contrastive strings. Consider (47a) and (b) below. In (47), we observe that the same stem+enclitic sequence /palak=ŋki/ 'wife's.mother'-2mDAT is followed by a geminate-initial suffix in (47a) but a singleton-initial suffix in (47b). The difference between the two lies in the location of pitch accents in each case. In (47a), a pitch accent occurs between the trigger and the target, so the latter is realised as a geminate. In (47b), the trigger occurs between preceding tonic and suffix-initial geminate, so the latter is realised as a singleton.

(47) a. [bàlakkíkka̰] / b. [bálakkibìra̰]
/pala**k=ŋk**i-kkaˀ/ / /pala**k=ŋk**i-ppiraˀ/
'wife's.mother'-2mDAT-LOC / 'wife's.mother'-2mDAT-DU

The observation that a tonic accent occurring between a trigger and target allows the target geminate to surface is one that holds generally within words, not just heteromorphemically. In (48a), the geminate in the stem is separated from the geminate-initial suffix |-cci| PRIV by a tonic accent, so the geminate is well-formed in the suffix. If there is no tonic accent separating the target and trigger, as in (48b), the initial-stop of the suffix must be a singleton.

(48)	a.	[màrkkarálacci] /mar**kk**arala-cci/ headband-PRIV 'no headbands'	b.	[yáppaji] /ya**pp**a-cci/ sister-PRIV 'no sisters'

Whether or not a geminate can be realised initially in suffixes is therefore determined by the location of tonic accents *as well as* preceding triggers.

Kinterm morphology provides rich ground for testing geminate alternation, since the Dative enclitics are associated with pitch accents (Ch 3) if stressed. Some examples of intervening accent 'defusing' the alternation are presented in (49).[27]

(49)	a.	[jiyàppaŋgíkka̰] /cu-ya**pp**a=ŋ̣ki-kkaʔ/ II-sister-2mDAT-LOC	[yáppaga̰] /ya**pp**a-kkaʔ/ sister-LOC
	b.	[ɳumɔ̀kkɔlŋgíkka̰] /ɳu-mo**kk**ol=ŋ̣ki-kkaʔ/ I-father-2mDAT-LOC	
	c.	[nugàkkaŋgíkka̰] /ɳu-ka**kk**a=ŋ̣ki-kkaʔ/ I-brother-2mDAT-LOC	
	d.	[jumàrkkɛŋgíkka̰] /cu-mar**kk**e=ŋ̣ki-kkaʔ/ II-father's.sister-2mDAT-LOC	[márkkego̰] /mar**kk**e-kkoʔ/ father's.sister-DYAD
	e.	[nubʊ̀yppʊŋgíkka̰] /ɳu-puy**pp**u=ŋ̣ki-kkaʔ/ I-brother-2mDAT-LOC	[bʊ́yppugo̰] /puy**pp**u-kkoʔ/ brother-DYAD

In (49a-e), a tonic accent is associated with the enclitic /=ŋ̣ki/ 'yours' when followed by a monosyllabic suffix, as it is here with /-kkaʔ/ Locative. The initial-stop

[27]It is difficult to compare minimally contrastive forms here. The Locative suffix /-kkaʔ/ normally requires a preceding Dative enclitic, so minimal contrasts such as that in example (a) are rare and difficult to obtain. The Dyadic suffix /-kkoʔ/ cannot co-occur with a preceding enclitic, so is used in lieu of /-kkaʔ/ in the other forms.

of the suffix is geminate, even though in all cases there is a preceding trigger. The tonic accent intervening between target and trigger allows the geminate in the suffix to be realised. The contrasting forms on the right hand side show that without the intervening tonic accent the following suffix /-kkoʔ/ or /-kkaʔ/ must be singleton-initial.

Further evidence for the proposal that geminate alternation is prosodically-conditioned comes from examples where the location of tonic accents co-varies with the realisation of geminates. In Ch 3 I observed that affixed words, and roots with two feet or more, showed variation in the location of tonic accents. Where primary stress precedes secondary stress(es), there is just one pitch accent (T*), located on the primary. Where secondary precedes primary, pitch accents are located on both primary and secondary. The two possibilities are represented schematically in (50).

```
              T*
              |
(50)   a.  [...σ́...σ̀...]
              T*  T*
              |   |
       b.  [...σ̀...σ́...]
```

Where a word allows both possibilities in (50), the realisation of suffixes differs accordingly. Example (51a) with initial primary stress has a single tonic accent and the suffix must be singleton-initial. Example (51b) shows that the same word but with a variant stress pattern. In this variant, main stress is on the penultimate of the stem, allowing the geminate realisation in the suffix. The examples in (c) and (d) contrast similarly. Example (c) is a fast-speech variant, where an unstressed vowel between peripheral stop and following liquid is elided. Examples such as these indicate that the alternation is a surface phenomenon, not an underlying, lexicalised one.

(51)

a.
T*
[bɔ́lɔ̰ˀpɔ̀lɔbɪ̀ra̰]
/polo**ˀp**olo-ppiraˀ/
woman-DU

b.
T* T*
[bɔ̀lɔ̰ˀpɔ́lɔppɪ̀ra̰]
/polo**ˀp**olo-ppiraˀ/
woman-DU

c.
T*
[**náɹakkɹàniga̰**]
/ɳaɹa**kk**aɹani-kkaˀ/
[place name]-LOC

d.
T* T*
[**nàɹakkaɹánɪkka̰**]
/ɳaɹa**kk**aɹani-kkaˀ/
[place name]-LOC

Example (52b) shows a second variant for the word in (52a), besides that in (51b) above. In (52b), a tonic accent is associated with the initial syllable of the suffix itself. This also allows a geminate realisation in the suffix (sporadically). Another example is given in (52d).

(52)

a.
T*
[bɔ́lɔ̰ˀpɔ̀lɔbɪ̀ra̰]
/polo**ˀp**olo-ppiraˀ/
woman-DU

b.
T* T* T*
[bɔ̀lɔ̰ˀpɔ̀lɔppíra̰]
/polo**ˀp**olo-ppiraˀ/
woman-DU

c.
T* T*
[gɔ̀rɛ̰ˀpɔ́rɛppɪ̀ra̰]
/koreˀ=**p**ore-ppiraˀ/
alone=3aDAT-DU

d.
T* T*
[gʊ̀n̰ˀpɪrɪppíra̰]
/ɳu-kun**ˀp**iri-ppiraˀ/
I-that-DU

Therefore, geminates in suffixes can be licensed in two ways. Either they can be the first [sg] cluster after a tonic, as in (52c), above. Or they can themselves be associated with tonic accent in the following syllable, as in (52b, d), in which case the initial geminate can sporadically be realised.[28] If neither of these two conditions holds, as in (52a), the suffix must be singleton-initial.

An explanation for these patterns is advanced in the following section.

[28]The sporadic failure of lenition in disyllabic suffixes was observed also by Merlan 1983:26 and Heath 1978a:23, though neither made a connection with stress.

4.3.2 Analysis

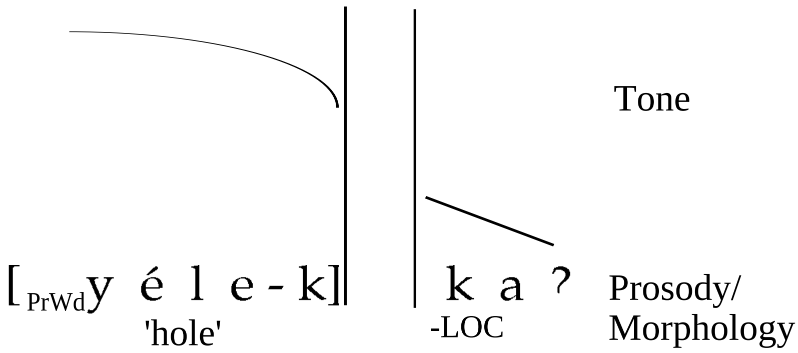
In §4.2 I proposed that [spread glottis] clusters constituted boundary signals in the grammar, to a range of prominent prosodic constituents: PrWd, strongest foot, and tonic. In this section, I develop the analysis further, to account for the geminate alternation patterns we observed in the preceding sections.

We have seen that obstruent clusters, which trigger singleton realisations in following suffixes, are characterised by a [spread glottis] gesture. These clusters break the voicing 'profile' of the word. One aspect of surface forms which depends on voicing is tone. Tone requires a minimum degree of voicing (Ohala 1978; Silverman 1997) and cannot be implemented simultaneously with [spread glottis]. These clusters therefore interrupt the *intonation* profile, as well as the voicing profile, of the word.

I have observed previously (§4.1.4.2) that [sg] segments and clusters are associated with morpheme boundaries in Ngalakgan, and other languages in the region. There is therefore a common association between stretches of intonation, broken by [sg] clusters, and constituents of prosody and morphology, such as Morphological Word/Prosodic Word. This association is schematised in (53) below.

The intonation contour (the wavy line) is associated to the word as a whole (the Phonological Word). The intonation contour is broken by the [spread glottis] gesture associated with the geminate (indicated by '||' which can be thought of as an iconic equivalent to '#'), which is in turn associated to the morpheme boundary. The salient portion of the intonation contour is associated to the salient portion of the word: the Morphological Word/Prosodic Word.

(53)



I suggest that it is this bilateral association - between the intonation contour, and prosodic and morphological constituents - which is manipulated by speakers in the process of geminate alternation. Geminates alternate to achieve the best, the optimal, match between constituents of morphology, prosody and intonation domains.

The general principles to be expanded on in this section are these:

- Every [spread glottis] gesture is interpreted as a 'domain' boundary.
- Every domain corresponds both to a stretch of intonation, and a constituent: Prosodic Word, strongest foot (of PrWd), or tonic syllable (of PrWd).
- Domains must not be 'broken' by an internal [sg] cluster.

[Sg] and [cg] clusters constitute boundaries to the spread of an intonation contour through the word, and I suggest that this is how they are interpreted by speakers: as boundaries of 'intonation domains'.[29] Every intonation domain extends from a pitch accent as far as it can rightwards through the word. It is blocked by any [spread glottis] clusters.

Optimally, the intonation domains defined by pitch accents on the one hand, and geminates on the other, are isomorphic to MCats and PCats. I translate this as a requirement that domains be properly headed.

(54) DOMAIN(HD) 'Every domain must be headed.'

[29]These do not necessarily correspond to Prosodic Words.

The proper head for an intonation domain is the tonic syllable. The idea is that intonation domains should not be spurious; they should draw attention to the same strong positions in the word that are optimally demarcated with boundaries: PrWd, strongest foot, tonic syllable. The intonational domain headed by the tonic, and the prosodic constituency, together identify the strong morphological positions in the word such as the Morphological Word (≈ Prosodic Word), initial foot or syllable of morpheme (≈ strongest foot and tonic).

I have claimed that clusters which are [spread glottis] interrupt intonation contours in words. The presence of [sg] clusters *within* words leads to an ill-formed domain for the feature [tone]: one which is interrupted in the middle by a [spread glottis] gesture. I follow Cole & Kisseberth (1994) in assuming a general constraint that feature domains should not be interrupted by elements which carry an opposite or antagonistic value for that feature.

(55)	$*[...[-F]...]_F$	Feature domains where [F] elements enclose a [-F] element are ill-formed.

In this case, the [F] feature is 'tone' and the domain is the intonation contour associated to the word. The [-F] feature is the class of elements which block the spread of intonation in the word: obstruent clusters, which are [spread glottis]. Using '#' as before, to represent [sg] clusters qua boundary signals, (56a) is an ill-formed domain configuration, (56b) is an acceptable parse of a string separated by a boundary element #. ('D' represents any domain, '#' represents any domain boundary.)

(56)	a. $*[...[\#]...]_D$	'No Broken Domains.'
	b. ✔$[...]_D\#[...]_D$	

Configurations (56a-b) are well-formedness conditions on surface forms. I will use (56a) as a constraint 'NOBROKENDOMAINS'.

I return to the example presented before, to illustrate the constraints. The extent of intonation domains is indicated with underlining and braces in the candidates; PrWd boundaries are indicated with square brackets in bold; # indicates the [sg] domain boundary. In (57a), the suffix is geminate-initial, and thereby the PrWd and the strongest foot boundaries are demarcated. The Morphological Word, which corresponds to the PrWd, stands out in the word by virtue of being associated to the tonic, and by being demarcated with the geminate in the suffix: the morphological boundary in the form is clear. Were the suffix-initial consonant *not* geminate, as in (57b), it would leave the PrWd constituent without a phonologically realised boundary, a violation of the 'No obscure boundaries' constraint: #PRWD# (introduced in 4.2.2). Recall that this constraint demands that the edges of PrWds be associated with [sg] articulations. To parse the intonation domain *beyond* the suffix-initial geminate, as in (57c), is to create an ill-formed domain structure, which is broken in the middle by a [sg] cluster.

(57)

/yele-kkaʔ/ hole-LOC	DOMAIN (HD)	NO BROKEN DOMAIN	#PRWD#	#FT1#	#σ́#	IO-MAX (AFFIX)
☞ a. **[**{yéle-k}**]**#kaʔ					*	
b. **[**{yéle-**]**kaʔ}			*!	*	*	*
c. **[**{yéle-k**]**#kaʔ}		*!	*	*	*	

The contrasting examples of suffix 'degemination' violate IO-MAX(AFX); an example is shown in tableau (59) below. The attested output, candidate (59a), is well-formed despite the fact that it fails to delimit the PrWd or Ft1 boundaries. It violates #PRWD# and #FT1# because neither of these positions is associated with a [sg] articulation at the edge. (59a) is nevertheless the most harmonic candidate because it is the only one which parses a single domain, which is properly headed (by the tonic) and unbroken. Every other candidate violates one of the constraints ranked higher than IO-

MAX. In the faithful candidates, (59b) and (c), the suffix-initial geminate fails to delimit an intonation domain headed by a tonic. Candidate (59b) parses the domain to the left, and candidate (59c) the domain to the right. Neither of these domains is properly headed by a tonic.[30] Therefore, these candidates both violate DOMAIN(HD): the suffix-initial geminate is unlicensed. Candidate (59d) is an interpretation where the suffix geminate delimits the domain of the PrWd: this creates an ill-formed domain structure, violating NOBROKENDOMAIN. Finally, candidate (e) parses no intonation domains beyond the initial syllable, but realises the suffix-initial geminate faithfully. This is a violation of VOICE[OFF] = # (which was introduced in §4.2.2), I provide a closer definition here.

(58) VOICE[OFF] = # Every [sg] articulation demarcates the boundary of a constituent which is both an intonation domain and a morphological/prosodic category.[31]

The geminate here does demarcate the PrWd and Ft1 boundaries, but it does so without associating them to a properly-headed intonation domain. The geminate is again unlicensed. Therefore, the constraints regulating the mapping of intonation domains to MCats and PCats dominate the constraints purely demanding [sg] boundaries to these constituents (#PRWD#, #FT1#, #σ́#).

[30]If the suffix was disyllabic, and therefore stressed and potentially accented, the suffix *would* constitute an acceptable domain for demarcation at its left boundary. Demarcating the left boundary of prosodic constituents is a possibility examined in (66).

[31] This definition is different from the characterisation given at (32). The former was not meant to be interpreted as a definition.

(59)

/yappa-kka?/ sister-LOC	DOMAIN (HD)	VOICE [OFF]=#	NO BROKEN DOMAIN	#PRWD#	#FT1#	#σ́#	IO-MAX (AFFIX)
☞ a. [{yáp}#pa]-ka?				*	*		*
b. [{yáp}#{pa-k}]#ka?	*!						
c. [{yáp}#pa-k]#{ka?}	*!						
d. [{yáp#pa-k}]#ka?			*!				
e. [{yáp}#pa-k]#ka?		*!					

I proposed in Ch 3 that long roots in Ngalakgan can be parsed into two PrWds, where the second PrWd domain is associated with primary stress. Since geminates are licensed by a preceding tonic syllable, if a word is parsed as two PrWds, there are two tonics and hence two geminates may be licensed.

This opens the way for other possible parses of /yappa-kka?/, examined in (62), but these are ill-formed for higher-ranked constraints. Candidate (62c) violates FTBIN (§2.1.1), the requirement that feet (and hence PrWds) be binary at the moraic or syllabic level. I repeat the definition here.

(60) Foot Binarity (FTBIN) Feet are binary at some level of analysis (mora μ, syllable σ)

Until now, we have only allowed vowels to be moraic in Ngalakgan.[32]

There is no better candidate than (62c) to be found in degeminating the stem-internal geminate, rather than the suffix-initial geminate. Candidate (b) violates high-ranking IO-MAX(MWD). Geminate alternation is a property of initial geminates in WORD-suffixes, it is not sanctioned in any other position (see further at §4.3.2.2).

[32] Ch 5 shows that consonants in Ngalakgan can be moraic, but not if they are part of a homorganic articulation such as a geminate or homorganic nasal+stop cluster.

(61) IO-MAX(MWD) Every segment of the input MWd has a correspondent in the output MWd. (No phonological deletion.)

(62)

/yappa-kkaʔ/ sister-LOC	FTBIN	IO-MAX (MWD)	DOMAIN (HD)	#PRWD#	#FT1#	#σ́#	IO-MAX (AFFIX)
☞ a. [{yáp}#pa]-kaʔ				*	*		*
b. [{yápa-k}]#kaʔ		*!				*	
c. [{yàp}]#[{pá-k}]#kaʔ	*!				*		

Tonics cannot be adjacent within PrWds because of the constraint *CLASH, which prevents adjacent stress accents within a PrWd domain.[33] Geminates are thereby banned from adjacent positions in PrWds. This leads to two predictions: if geminates are distant enough to fall in separate PrWd domains, each should be licensed, since each PrWd licenses a tonic. Conversely, if tonics belong to separate PrWds, regardless of adjacency, then each should license a geminate. Both predictions can be confirmed. Multiple PrWd parses are attested, and indeed preferred, in polypedal roots, as in example (a) below, repeated from (48). In these forms with two pitch peaks, we also find two geminates in the same word.

(48) a. [màrkkarálacci]
/markkarala-cci/
headband-PRIV
'no headbands'

b. [yáppaji]
/yappa-cci/
sister-PRIV
'no sisters'

Words like (48a) are associated with a secondary^primary stress pattern, which I described as having two pitch peaks. Words of this form contrast with those in which primary stress is initial: any following secondary stresses are not associated with a pitch peak. The difference between the two contours is repeated in (50).

[33] *CLASH is defined and exemplified at §5.3.1.

T*
|
(50) a. [...σ́...σ̀...]
T* T*
| |
b. [...σ̀...σ́...]

The general rule is this: a primary stress and any *preceding* secondaries are tonics (pitch accents); any secondaries *following* a primary are not tonics. The vowels of tonics will be bolded in what follows.

Recall from §2.2.4 that each of the pitch accents in a word starts a new Prosodic Word. Each of these PrWds contains a strongest foot, and a strongest (tonic) syllable. Therefore, each of multiple Prosodic Words in a form should show demarcation effects at the boundaries of these constituents, and each tonic should license a new geminate to perform this function.

(63) shows that the parsing of words into stress and pitch peaks, and the location of geminates in the structure, are two mutually reinforcing aspects of the same grammar. In the attested candidate - (a) - the association of the primary stress with pitch, and the presence of the geminate initially in the suffix, combine to give this stretch of syllables the characteristics of Prosodic Words in Ngalakgan. Prosodic Word boundaries are indicated, as in Chs 2 and 3, with square brackets, in bold.[34] Candidate (c) parses the word with primary stress in initial position. In this parse, the secondary stress cannot be associated with a pitch accent: there is only one tonic in this word, which is the initial syllable. Therefore the intonation domain bounded by the suffix-initial geminate lacks a pitch head.[35]

[34]I assume for convenience that every tonic syllable begins a new Prosodic Word domain, which extends as far as the next pre-tonic syllable, or the end of the MWd, whichever is appropriate. The location of PrWd right boundaries internal to MWds makes no difference to the outcome, because of high-ranking faithfulness to MWds no segmental changes can be made inside stems.
[35]All candidates shown in (63) satisfy #Ft1#, because the initial syllable of the word is a bimoraic foot; see Ch 5.

(63)

/markkarala-cci/ 'headdress'-PRIV	DOMAIN (HD)	#PRWD#	#FT1#	#σ́#	IO-MAX (AFFIX)
☞ a. [{màrk}#ka][{rála-c}]#ci		*		*(ɹá)	
b. [{màrk}#ka][{rála]-ci}		**!		*(ɹá)	*
c. [{márk}#{karàla-c}]#ci	*!				

A foot whose left edge is not aligned with a pitch accent is not an acceptable domain for delimitation; as in (63c). The intuition is that there is no head strong enough to support the domain delimited by the geminate here: a stressed, but accentless syllable, is not a strong head (Ch 2).[36] Failing to delimit the second PrWd domain, as in candidate (63b), again violates #PRWD#: a case of obscure boundaries.

A similar analysis obtains for other forms with medial tonics, such as the examples below, repeated from previous sections (4.3.1). The observation was that a tonic syllable licenses a following geminate. This is because each and every PrWd, strongest foot, and tonic syllable should ideally be delimited with a [spread glottis] gesture.

(49) a. [jiyàppaŋgíkka̰] /cu-yappa=ŋki-kka?/ II-sister-2mDAT-LOC b. [yáppaga̰] /yappa-kka?/ sister-LOC

In this case two PrWds are licensed not just because of the length of the form, but because of constraints demanding isomorphism between morphological and prosodic constituency, as discussed in the previous two chapters.

An analysis of (49a) is presented in (64). In (64), we see an instance where an enclitic /=ŋki-/ - licenses a domain delimited by the geminate in the following suffix.

[36]Words of this form are never parsed in this stress pattern, perhaps to reinforce the legitimacy of the suffix-initial geminate.

Since the enclitic is stressed here, it can and should be delimited by a tonic boundary. The other candidate fails to do this, and is less harmonic for that reason.

(64)

/cu-yappa=ŋki-kkaʔ/ II-sister-2mDAT-LOC	DOMAIN (HD)	#PRWD#	#FT1#	#σ́#	IO-MAX (AFFIX)
☞ a. cu-[{yàp}#pa=ŋ][{kɨ-k}#kaʔ]		*	*		
b. cu-[{yàp}#pa=ŋ][{kɨ́-kaʔ}]		*	*	*!	*

Finally, the most complex set of examples are those where three obstruent clusters are observed. These all have the structure shown in (65).

(65)	[MWd]PRWD	=enclitic	[-suffix]PRWD	-suffix
	[ʈòʈoyʔ	=ki	-ppúlu	-kkaʔ|
	uncle	=yours	-DUAL	-LOC

There are two PrWds, and two tonics. The second PrWd is bounded on both sides by a geminate, and it is because each geminate bounds a PrWd in this way that they are licensed.

The analysis of this form is presented in (66). In the optimal candidate (a), every internal instance of a PrWd boundary corresponds to a [spread glottis] articulation - a break in the intonation contour. Hence, this form maximally satisfies the top-ranked of the boundary demarcation constraints #PRWD#. The other candidates do not demarcate each PrWd to the same extent as candidate (a), and are less harmonic for that reason. The boundaries which they fail to demarcate in each case are spelled out in the appropriate cell in the tableau.

(66)

/ʈotoyʔ=ŋki-ppulu-kkaʔ/ uncle-2mDAT-PL-LOC	DOMAIN (HD)	#PRWD#	#FT1#	#σ́#	IO-MAX (AFFIX)
☞ a. [{ʈòtoyʔ}]#=ki-p#[{púlu-k}]#kaʔ				**	
b. [{ʈòtoyʔ}]#=ki-p#[{púlu}]-kaʔ		]*!	*)	**	*
c. [{ʈòtoyʔ}]#=ki-[{púlu-k}]#kaʔ		[*!	*(	**	*

The analysis predicts that geminates should be licensed at every PrWd boundary, left or right. This is the case; examples such as (52), repeated below, show that a PrWd (the suffix ⌊-ppíraʔ⌋ in this case) can be geminate-initial as well as geminate-final. Both constitute boundaries, and a domain which is bounded on both sides is well-formed.

(52) [bɔ̀lɔ̰ʔpɔ̀lɔppíra̰]
/poloʔpolo-ppiraʔ/
woman-DU

An analysis is presented in (67). In candidate (67a), every PrWd is clearly demarcated with a [spread glottis] gesture: each is a salient association of morphology, prosody, and acoustics.[37] The candidate with the singleton-initial suffix, (67b), is less harmonic than the candidate with the geminate-initial suffix, (67a).[38]

(67)

/poloʔpolo-ppiraʔ/ woman-DU	DOMAIN (HD)	#PRWD#	#FT1#	#σ́#	IO-MAX (AFFIX)
☞ a. [{pòloʔ}]#[{pòlo-p}]#[{píraʔ}]				***	
b. [{pòloʔ}]#[{pòlo}][{-píraʔ}]		*!		***	

[37]The stem itself is a relic of the same process. /poloʔpolo/ 'woman' is a frozen reduplicant (since the root /polo/ is a distinct root meaning 'old; old person', /poloʔpolo/ is not a WORD-level reduplication - see §5.5.4). The internal glottal stop in the stem serves the same function that the geminate in the suffix does.
[38]Both candidates violate the constraint #σ́# three times, once for each instance of an accented syllable which is not right-aligned with a [sg] articulation.

We have seen that the constraints against ill-formed intonation domains dominate one Faithfulness constraint on suffixes - IO-MAX(Affix), ruling out deletion - with the result that suffixes degeminate where they would otherwise demarcate the boundary of a prosodic non-constituent, as in /yappa-kkaˀ/ (59). In the following section, I show that higher-ranked Faithfulness constraints rule out alternations in glottal stop-initial suffixes, and in clitics and ROOT-suffixes.

4.3.2.1 Faithfulness to laryngeal features

Ngalakgan has both geminate-initial and glottal stop-initial suffixes. The geminate-initial suffixes alternate with a singleton-initial realisation, as we have seen. The glottal stop-initial suffixes do not alternate, at least not to the same degree of consistency. Merlan (1983:8) notes that there is a partial correlation between stems with internal geminates and 'delaryngealised' suffixes. She gives the following example (my transcriptions):

(68)
a. [wɛ̀rɛkkawála]
/werekka-ˀwala/
where-ABL

b. [gʊ̀ɳɖuɳʊ̀wḭʔwála]
/kuɳʈu=ɳowi-ˀwala/
country=3mDAT-ABL

Merlan notes however that [werekka-ˀwala] 'was found as a less frequent alternative' to [werekka-wala] (1983:8).[39] Merlan suggests that 'glottal stop has, over

[39]Heath (1978a:24) describes glottal alternation as regular in Ngandi, adducing examples such as the following (transcriptions are my own, based on Heath).

(92)
a. [ŋ̣ad̪akkuguˀ]
/ŋ̣a-t̪akku-kuˀ/
1mS-child-REL
'when I (was) small'

b. [ŋ̣awurˀwuruŋ̣uˀguˀ]
/ŋ̣a-wurˀwuruŋ̣u-ˀkuˀ/
1mS-old.person-REL
'when I (become) an old man'

a. [awaʈʈuwaɲ̣jiˀ]
/a-waʈʈu-ˀwaɲ̣ciˀ/
V-dog-LIKE
'like a dog'

b. [amanbaˀwaɲ̣jiˀ]
/a-manpa-ˀwaɲciˀ/
V-armband-LIKE
'like an armband'

the recent past, been in the process of becoming a fixed initial boundary of the suffix, by being generalised from fortis-free environments to those containing a fortis stop'.

I follow Merlan in assuming that speakers do not synchronically allow alternations in glottal-initial suffixes. In OT terms, this translates as underlying specification of affixes as [constricted glottis] initial, together with a high-ranking IO-MAX constraint relativised to segments bearing this feature.

(69) IO-MAX[cg] Every [cg] segment in the input string corresponds to some [cg] segment in the output string. ('No [cg] deletion')

IO-MAX[cg] rules out alternations in the form of glottal clusters. An example of a suffix with initial glottal+obstruent cluster is shown in (70) below.[40] In (70), we see a stem with internal geminate, followed by a suffix with underlying glottal stop. On the analogy of [yappa-kaʔ] 'sister'-LOC, we expect that the glottal should delete at the surface, leaving the intonation contour after the stem-internal geminate unbroken. But the attested candidate leaves the glottal intact, violating the constraint against headless domains: DOMAIN(HD). The IO-MAX constraint demanding no deletion of underlying [cg] material therefore dominates DOMAIN(HD).

(70)

/yappa-ʔkVn/ sister-DAT	IO-MAX [CG]	DOMAIN (HD)	#PRWD#	#FT1#	#σ́#
a. [{yáp}#pa-]kan	*!		*	*	
☞ b. [{yáp}#{pa-ʔ}]#kan		*			

The dominance of Faithfulness to glottal stops over the constraints deriving geminate alternation must be a fairly recent innovation in the grammar, judging by the sporadic effects observed by Merlan (1983), and the perhaps regular alternations of

[40] I have ignored the vowel harmony effects which derive [-ʔkan] from /-ʔkVn/ here.

glottal stops in Ngandi (Heath 1978a). In 4.3.3.1, I examine an instance of synchronic alternations involving glottal stop in the nearby, genetically distant Yolngu languages.

4.3.2.2 Faithfulness to Morphological Words

There are both singleton-initial and geminate-initial ROOT-level suffixes; but segments in neither of these positions alternate. Since ROOTs followed by ROOT-level suffixes together constitute a single MWd, ROOT-level suffixes are subject to the same Faithfulness constraint that roots are: IO-MAX(MWD), preventing any deletion of underlying segments (§4.3.2). This is shown in (71), square brackets in bold indicate **MWd** boundaries (these also correspond to the PrWd boundaries, by MWd ≈ PrWd: Ch 2). The MWd in this form is the whole inflected ROOT-compound. The attested form, in (a), is ill-formed from the point of view of DOMAIN(HD), since the string [+pu(+c)] is not headed by a tonic. Yet candidate (a) is faithful to the underlying Morphological Word. Being faithful to the MWd is the most important consideration, encoded by the high-ranking of IO-MAX(MWD) here. The other candidates (b) and (c) each violate MWd Faith in one way or another. Candidate (b) degeminates the RR affix /+cci+/, while candidate (c) deletes the glottal stop from the root /kuɭaʔ/.

(71)

/kuɭaʔ+pu+cci+n/ skin+[hit]+RR+PR 'shed one's skin'	IO-MAX (MWD)	DOMAIN (HD)	#PRWD#	#FT1#	#σ́#
☞ a. **[**{kúɭaʔ}#{+pu+c}#ci+n**]**$_{MWD}$		*	*		*
b. **[**{kúɭaʔ}#{+pu+ci+n}**]**$_{MWD}$	*!		*		*
c. **[**{kúɭa+pu+c}#ci+n**]**$_{MWD}$	*!		*	*	*

The fact that geminate alternation is a process restricted to the boundaries of WORD-level constituents should be no surprise. We have seen that it is the WORD-level, and not the ROOT-level which counts for compound stress (Ch 2) and affixal stress (Ch 3). The distribution of geminate alternation in words confirms the primacy of WORD-level constituents as the locus of phonological alternations. ROOT-complex forms are treated as units by the geminate alternation process, just as they are by prosodic structure.

That concludes the formal analysis of geminate alternation in Ngalakgan.[41] I have observed that certain segmental configurations are articulated with a [spread glottis] gesture. These clusters are highly salient, and are perceptually similar to word boundaries. I suggested that speakers have grammaticalised the association between [spread glottis] clusters and boundaries, and that prosodic and morphological constituents prefer to be demarcated, and that these clusters conversely are optimally associated with actual PCat and MCat boundaries, not spurious ones.

I further noted that [spread glottis] is incompatible with implementation of tone. This suggests that [spread glottis] clusters divide a word into stretches of intonation I have referred to as 'intonation domains'. Optimally, these intonation domains are associated with prominent morphological and prosodic constituents: PrWd, strongest foot, and tonic syllable. If an intonation domain is not associated with one of these constituents, it is ill-formed. The 'repair' of this ill-formed structure consists of degemination in suffixes at the surface.

If speakers can recognise, and manipulate, the associations between intonation domains, and prosodic and morphological structure, as I have suggested, then we should find similar associations elsewhere. This is the topic of the following sections.

[41]The analysis appears to generalise without change to Rembarrnga and Ngandi, however, since stress is not marked in the published accounts I cannot be sure that the relationship between prosody and geminate alternation is the same as in Ngalakgan.

4.3.3 Prosodic effects on margins in other languages

Aspects of the phenomena discussed here have been described for a number of other languages. They provide further evidence for the constraints proposed here: demanding boundary signals at the edges of prosodic and morphological domains. Dialects of the Yolngu dialect chain have a glottal stop alternation process which in many respects is similar to the geminate alternation process found in the three southern Arnhem languages; I discuss the process in the following section.[42] §4.3.3.2 describes and analyses the alternation of stem-initial segments in Ndjébbana, which McKay (1984) proposes is prosodically determined by a following tonic. Both processes can be accounted for with the same system of constraints that I have proposed for Ngalakgan. We might also expect that constraints of this form might find reflections in the structure of the lexicon. I show that this is the case for Ngalakgan.

4.3.3.1 Glottal stop alternations in Yolngu

Wood (1978:91) discusses a process of glottal stop alternation in the Yolngu dialect Gälpu. The same process is found in other dialects, such as Djapu (Morphy 1983:26), and Djambarrpuyngu (Wilkinson 1991).[43] The discussion of Djambarrpuyngu in Wilkinson (1991:85, 541) is the most extensive, and examples are taken from the latter work except where noted. I will use a phonemic representation, rather than the Yolngu orthography.

Wilkinson describes the distribution of glottal stop as follows (1991:85).[44]

[42]The Yolngu languages form a Pama-Nyungan island surrounded by Non-Pama-Nyungan languages such as Burarra, Rembarrnga, Ngandi, Nunggubuyu and (formerly) Warndarrang. Yolngu languages are genetically quite distinct from GN languages. There has been extensive diffusion of vocabulary, morphological patterns, and phonological patterns however, including a distinction between two stop series in some Yolngu dialects (Gupapuyngu), and the occurrence of glottal stops in many Yolngu dialects (see e.g. Wood 1978, Heath 1978b, Harvey 1991 for discussion).
[43]Wilkinson (1991) groups Djapu and Djambarrpuyngu dialects under the term 'Southern Yolngu', and I follow her usage here. Gälpu belongs to a different group 'Northern Yolngu'.
[44]To the version of Wilkinson's (1991) rule, I have added a second ellipsis before the final word boundary which is in closer accord with Wilkinson's description.

'[W]ith a single class of exceptions one glottal stop is permitted in a word. There is a rule of glottal stop deletion that removes any occurrences of glottal stop after the first in a word. This operates after morphological processes of suffixing and reduplication.

/ʔ/ -> Ø /#......../ʔ/............___..........#

The process prevents the realisation of glottal stops which would otherwise be introduced by suffixes and at the reduplicant-base boundary. Reduplication in Djambarrpuyngu, Djapu and Gälpu regularly introduces a glottal stop between reduplicant and stem, as shown in (72a-b). Reduplication is prefixal, as in Ngalakgan (glottal stop introduced by **reduplication** is in bold, and the reduplicant stem is underlined). Some verb stems end in a glottal stop underlyingly, as in (c-d) (the double underlined glottal stop). When *these* verbs are reduplicated, only the glottal stop at the reduplication boundary is realised, the glottal stop in the base corresponds to surface zero.[45]

(72)

a.	[n̪ínaʔn̪ìna] /n̪inaʔ-n̪ina/ RED-sit(intr)	c.	[ɳálʔɳàlyun] /ɳalʔ-ɳalʔ-yu+n/ RED-climb/rise-AUX+PR
b.	[yú:lɳuʔyùlɳu] /yu:lɳuʔ-yu:lɳu/ RED-person	d.	[yámanaʔyàmanayun] /yamanaʔ-yamanaʔ-yu+n/ RED-poke.out.tongue-AUX+PR

Note that stress in reduplicative forms is initial, as in words in general. The change in stress pattern is reflected in the loss of underlying vowel length in the base in (b), and its retention in the surface reduplicant. Long vowels only occur in initial, stressed syllables in Djambarrpuyngu (Wilkinson 1991:44), where they contrast with short vowels.

[45]The stress in the surface representations is derived from the descriptions and representations in Wilkinson (1991:62-3) and Wood (1978:85-87). I have glossed the verb inflection affix /-yu+/ as an 'auxiliary'. This element has a similar function to the auxiliary verb root /-mi+/ in Ngalakgan, or /-t̪u+/ in Ngandi. The latter is derived from the Yolngu auxiliary, according to Heath (1978b). The tense inflection of /-yu+n/ I have glossed as 'Present', which is one interpretation of the inflection (Wilkinson 1991:336).

Some suffixes introduce glottal stop also; examples in (73) show a similar contrast in realisation of glottal stop, depending on whether there is a stem-internal glottal stop. Of two underlying glottal stops in the words of (c) and (d), only the stem-internal glottal stop is realised at the surface.

(73)
a. [yápaʔm̀iriṇu]
/yapa-ʔmiriṇu/
'sister'-KIN.PROP

b. [yápaʔmàɲci]
/yapa-ʔmaɲci/
'sister'-DYAD

c. [máːɹiʔmum̀iriṇu]
/maːɹiʔmu-ʔ̳miriṇu/
father's.father-KIN.PROP

d. [máːɹiʔmumàɲci]
/maːɹiʔmu-ʔ̳maɲci/
father's.father-DYAD

In both the reduplication and suffixation cases, the generalisation is that of two underlying glottal stops, only that closest to the primary stress is realised at the surface, whether this glottal stop derives from the reduplication process (as in (72)) or is stem-internal, as in (73). Note that it is *not* the case that glottal stops belonging to stems are retained, at the expense of those belonging to affixes, since it is the *reduplicant*-final glottal stop which is retained in (72c-d), rather than the root-final one.

I regard these patterns as reflecting the interaction of the same set of constraints as were described above for Ngalakgan. In Djambarrpuyngu, Djapu and Gälpu, the only boundary signal element is glottal stop. These languages all lack a stop contrast morpheme-initially at the surface. Underlying morpheme-initial lenis stops are subject to extensive lenition processes when occurring between continuants, in all three languages.[46] At the surface between morphemes then, there is a single stop series and no contrastive tautomorphemic geminates.

[46]There is an underlying distinction between a 'fortis' stop series which does not alternate, and a 'lenis' stop series. Morpheme-initial lenis stops (e.g. in suffixes and verb roots) are realised either as stops or as homorganic continuants, depending on the preceding segment. Underlying lenis stops are realised as obstruents following [-cont] segments (Wood 1978:71). Gemination of post-tonic consonants is one common implementation of stress in at least some Yolngu languages (Djinang: Waters 1980, Gälpu: Wood 1978). These geminates are non-contrastive, predictable realisations. But since geminates cannot occur elsewhere in the word, I assume they cannot constitute PrWd boundaries effectively. Nor can fortis stops constitute effective boundary signals, since the only position in which they are contrastive is morpheme-internally between continuants. Stops in these positions cannot alternate because of high-ranking Root Faithfulness constraints, as in Ngalakgan.

Therefore, the only boundary element to which the No Obscure Boundaries constraints can refer in Djambarrpuyngu is glottal stop. As in Ngalakgan, the boundary closest to the tonic is realised at the surface, and all other boundaries are eliminated from the surface word due to lack of a proper head. It appears that Yolngu has the same Headedness requirement as Ngalakgan, repeated here.

(74) DOMAIN(HD): 'Domains must be headed by a tonic.'

Note that primary stress is initial in words in Yolngu, in all but a small class of exceptions. If Yolngu is anything like Ngalakgan, the pitch accent in an intonation contour docks to the first primary stress, and any preceding (but not following) secondary stresses. In both Yolngu and Ngalakgan, the only tonic syllable in a word with initial primary stress is the primary stressed syllable itself.

The typical domain delimited by glottal stop in Yolngu corresponds to WORD-level stem (MWd) or primary foot.[47] The characteristics of Prosodic Word in Yolngu languages are unclear to me, I will omit consideration of PrWd in what follows. In place of PrWd, I will refer to MWds as the domain which should be demarcated: #MWD#, and square brackets in bold represent MWd boundaries accordingly.

The DOMAIN(HD) constraint conflicts with the glottal stops introduced by reduplicants in Yolngu, (presumably this is due to the same constraint #MWD# or #PRWD#); for the sake of argument I will assume the glottal stop is present in the underlying form, like the initial geminates in Ngalakgan suffixes. I will assume further that reduplicants in Yolngu are MWds - WORD-level stems - as they are in Ngalakgan (§5.5.4). DOMAIN(HD) conflicts with the same constraint - IO-MAX[cg] - which was introduced in §4.3.2.1 above, as shown in (77). In the case of Yolngu, unlike Ngalakgan, IO-MAX[cg] is ranked below DOMAIN(HD), with the result that glottal stops alternate,

[47] I will simply assume that Yolngu has a similar level-ordered morphology to Ngalakgan. Like Ngalakgan, it has a number of irregular verb paradigms (like the finite ROOTs of Ngalakgan), which act as auxiliaries for coverbs, some of which are in an opaque semantic relationship (like ROOT-compounds in Ngalakgan).

according to their location with respect to intonation domains, just as geminates do in Ngalakgan.

In both Yolngu, and Ndjébbana (examined in §4.3.2.2), it is only segments at the *edges* of morphemes which alternate, rather than those internal to morphemes. Wilkinson (1991:85) notes explicitly that morpheme-medial glottal stops are never deleted. This is also true of geminate alternation in Ngalakgan, but so far we have not needed to make this distinction between segments at the edge and those which are internal.

M&P (1995b:371) propose two Faithfulness constraints which specifically refer to the internal structure of morphemes. Their definitions are presented in (75), (76).

(75) I-CONTIG(M) ('No skipping')
The portion of S_1 (a M) standing in correspondence forms a contiguous string.
Domain (ℜ) is a single contiguous string in S_1.

(76) O-CONTIG(M) ('No intrusion')
The portion of S_2 (a M) standing in correspondence forms a contiguous string.
Range (ℜ) is a single contiguous string in S_2.

M&P (1995b:371) characterise the constraints as follows:

> The constraint I-CONTIG rules out deletion of elements *internal* to the input string [S_1]. Thus, the map xyz -> xz violates I-Contig, because the Range of ℜ is {x, z}, and x, z, is not a contiguous string in the input. But the map xyz -> xy does not violate I-Contig, because xy is a contiguous string in the input. The constraint O-CONTIG rules out internal epenthesis: the map *xz* -> *xyz* violates O-CONTIG, but *xy* -> *xyz* does not'.[48]

An example of glottal alternation is presented in (77). Candidate (77a) has the only allowable association between morphological and prosodic category and the

[48]The symbol 'ℜ' stands for the Correspondence relation between two strings (e.g. input and output, base and reduplicant). The 'Domain' is (the portion of) the string mapped from, the 'Range' (the portion of) the string mapped to.

intonation domain which ends at the first glottal stop. This intonation domain is headed by the only tonic - the primary stress. This candidate demarcates *only* the primary foot.[49] Associating a boundary with the suffix, as in (77b), creates an intonation domain [mu-], which is much worse. This intonation domain is not headed by a tonic, violating DOMAIN(HD), and the glottal stop is ill-formed in this position. Candidate (c) deletes the underlying root-internal glottal stop, instead of the glottal stop in the suffix, thereby violating I-CONTIG(MWD). Candidate (d) adds a glottal stop, following the tonic, which is not present in the underlying form, violating O-CONTIG(MWD): root-internal epenthesis is ruled out in Yolngu.

(77)

/maːɹiˀmu-ˀmiriŋ̱u/ father's.father-KIN.PROP	NO SKIP	NO INTRSN	DOM (HD)	MAX [CG]	#MWD#	#FT1#	#σ́#
☞ a. [{máːɹiʔ}]#mu-mìriŋ̱u				*	*		*
b. [{maːɹiʔ}]#[{mu-ʔ}]#mìriŋ̱u			*!				*
c. [{maːɹimu-ʔ}]#mìriŋ̱u	*!			*		*	*
d. [{maːʔ}]#ɹimu-mìriŋ̱u		*!		*	*	*	

At this point, there is no argument for a ranking between the three top-ranked constraints shown in (77): NO INTRUSION and NO SKIPPING, and DOMAIN(HD).

In the reduplicated examples, such as (72c) shown below in (78), the reduplicant makes the best, most minimal domain: it is simultaneously a MWd, primary foot and primary syllable. Hence, candidate (78b) has a more harmonic association between boundaries and constituents than (78c). This is the case even though (78c) maintains the underlying glottal stop of the input stem, rather than that of the reduplicant. Both candidates (b) and (c) violate IO-MAX[cg]. The difference between them comes down to how well they demarcate the optimum constituents, and (b) is the winner here.

[49]It is worth noting that roots with internal glottal stops are quite rare in Yolngu languages, Wilkinson (1991:82-3) notes twenty such forms.

(78)

RED-/ŋalʔ-yu+n/ climb-AUX+PR	NO SKIP	NO INTRSN	DOM (HD)	IO-MAX [CG]	#MWD#	#FT1#	#σ́#
a. [{ŋálʔ-}]#[{ŋàlʔ}]#-yu+n			*!				
☞ b. [{ŋálʔ-}]#[ŋàl]-yu+n				*	*		
c. [{ŋál-][ŋàlʔ}]#-yu+n				*	*	*!	*

In the reduplicated examples with longer stems, the effects of O-CONTIG(M) (No Intrusion) become more visible. Candidate (79c), below, has a perfect association between the tonic syllable, and a following boundary signal, but it fatally violates O-CONTIG. The optimal candidate here is (79b), since it delimits the first boundary (MWd) (assuming reduplicants are WORD-level stems) without violating O-CONTIG. In other respects, the evaluation of (79) proceeds like that of (78).

(79)

RED-/yamanaʔ-yu+n/ poke.out.tongue-AUX+PR	NO SKIP	NO INTR'N	DOM (HD)	MAX [CG]	#MWD#	#FT1#	#σ́#
a. [{yámanaʔ}]#[{-yàmanaʔ}]#-yu+n			*!			*	*
☞ b. [{yámanaʔ}]#[- yàmana]-yu+n				*	*	*	*
c. [{yáʔ}#mana][- yàmana]-yu+n		*!		**	*	*	

The distribution of glottal stop in words in Southern Yolngu languages therefore parallels that of geminates in GN languages of southern central Arnhem Land (Ngalakgan, Ngandi, Rembarrnga) in a close way. In both cases, the PrWd, the strongest foot, or the tonic, in that order, are optimally demarcated by a boundary signal. Boundaries in Ngalakgan are signalled with either [spread glottis] or [constricted glottis] gestures, or both, while in Yolngu only [constricted glottis] gestures signal boundaries.

The difference in boundary signal realisations appears to be related to the contrasting presence vs absence of contrasting obstruent geminates in each language.

As with Ngalakgan, the boundary of a domain headed by the tonic in Yolngu words need not be immediately adjacent to the tonic, and need not correspond to a morpheme boundary. The fact that the Yolngu pattern can be accounted for with the same constraints which derive geminate alternation in Ngalakgan supports the approach taken here.

In the following section, I discuss the case of Ndjébbana, which McKay argues has geminate alternations determined by a *following* tonic. The Ndjébbana pattern can be regarded as another instance of the same series of constraints as proposed for Ngalakgan and Yolngu.

4.3.3.2 Pre-tonic gemination in Ndjébbana

Ndjébbana is a non-GN, Non-Pama-Nyungan language of the Arnhem Land coast to the north of Rembarrnga. Ndjébbana favours geminates in the initial position of stems following prefixes, but just if the initial syllable of the stem is stressed. Contrast examples (80a) and (b), (c) and (d) (from McKay 1984:110).[50] Alternating stops in corresponding positions of roots are underlined. In (80a), the verb /cúwe/ 'be sick, suffer, die' shows a geminate initial form when the initial syllable of the verb stem is stressed, otherwise the initial stop of the root is a singleton (and initial peripheral and laminal singletons of some verbs lenite intervocalically); other verbs behave similarly (80c-d).

(80)
a. ka-ccúwa 'he is sick'
b. ka-yawé+la 'he was sick/died'
c. ka-ppúceya 'he is shouting'
d. ka-pací+na 'he shouted'

[50] I have used phonemic representations, rather than McKay's orthographic ones. Only surface forms are shown. Vowels show prosodically- and morphologically-determined alternations which are not relevant here: McKay (1993:5) states that 'short/unstressed vowels are often reduced to /a/'. Morpheme boundary symbols have roughly their meanings in Ngalakgan, e.g. '+' signals a finite verb root+tense suffix boundary.

Similar examples are found among nominals. If stress is not root-initial, the root-initial stop is not geminate (McKay 1984:111-112); contrast (81a-b) with (81c-d). In (81a), stress is associated with the second syllable of the stem /parapara/ 'big'. In (81b), the Feminine prefix /ɲa-/, rather than the root, is stressed. In both cases, the initial stop of the stem is realised as a singleton stop.

(81)
a. ɲa-parápara
FEM-'big'
c. ɲa-ccícappa
FEM-'same'

b. ɲá-kaɹo
FEM-'fat'
d. ɲa-ppókka
FEM-'bad'

Geminates in Ndjébbana are subject to phonotactic constraints, as in Ngalakgan. Contrast (82a) with (b), (c) with (d) (from McKay 1984:111). In (82a), the initial stop of the stem /pokka/ 'bad' is geminate when the following syllable is stressed, and the stop follows a continuant. Following a nasal, as in (82b), the singleton/geminate contrast is neutralised. The same contrast is found in (82c) and (82d).

(82)
a. ɲa-ppókka
FEM-'bad'
b. n-pókka
MASC-'bad'

c. ɲa-ccícappa
FEM-'same'
d. n-cícappa
MASC-'same'

The same series of constraints that account for Ngalakgan can be used to derive the Ndjébbana pattern. Ndjébbana is analysed by McKay (1984) with a singleton/geminate opposition. McKay (1984) states that the opposition has the same phonetic basis as Rembarrnga, where geminates and other obstruent clusters are voiceless throughout closure and typically aspirated; I assume that as in Ngalakgan geminates are [spread glottis] at the surface.

McKay (1984:109) assumes that stems are underlyingly singleton-initial. The geminate-initial form is derived by rule. The Ndjébbana alternations fulfil the same criteria as the Ngalakgan and Yolngu alternations: the process triggers [spread glottis] (respectively, [cg]) clusters or segments at morpheme boundaries, and is conditioned by the location of the tonic syllable. In Ndjébbana, the stem-initial consonant geminates if and only if it demarcates the PrWd, the primary foot, and the tonic all at once. If one of the three constraints demanding these associations is not satisfied, stems are not geminate-initial, because they fail the same headedness requirement which was proposed previously: DOMAIN(HD).

It is significant that geminate alternations are only observed at stem-edges in Ndjébbana: the internal structure of stems does not change, as in Ngalakgan and Yolngu. Again I assume that stems in Ndjébbana are subject to Output-Contiguity ('No Intrusion'), following M&P (1995b:371).

I referred above to the fact that stem-initial obstruents lenite to the homorganic glide when the primary stress is not on the first syllable of the stem. I leave aside the question of what kind of condition should account for the lenition pattern, and simply represent the requirement in the following constraint.

(83) *VCV 'No intervocalic (plain) obstruents.'

Lenition does not apply to geminates, and does not apply exceptionlessly to plain stops in Ndjébbana (1984:109).[51]

Tableau (84) presents an analysis of an alternating verb form. In Ndjébbana, I propose, geminates demarcate intonation domains, as in Ngalakgan. I assume that a tonic starts a new PrWd in Ndjébbana as in Ngalakgan. Therefore candidate (84a) is optimal here, the stem-initial geminate simultaneously demarcates the Prosodic Word, the strongest foot, and the tonic.[52] The domain thus formed satisfies the headedness

[51]McKay notes that the stem-initial alternations between geminates, singletons, and glides is exceptionless for laminal-initial verbs, but has exceptions among peripheral initial verbs (1984:109). McKay does not mention the status of apical-initial verbs.

[52]I assume that unstressed prefixes in Ndjébbana are not associated with PrWd domains, and are not evaluated for the constraints on tone domains, as in Ngalakgan.

requirement, since it is a PrWd headed by a tonic syllable. These constraints dominate IO-DEP(MWd), since the stem has an extra root node in the output. The Faithful candidate (b), fails to demarcate any constituents, violating the principle of 'No Obscure Boundaries' (the #PCat# series). Candidate (c) fatally violates Contiguity: no changes to the internal structure of stems are permitted. I have represented the violations of candidates (b) and (c) to the #PCat# series with an asterisk and a left boundary marker for the appropriate constituent. This is to emphasise the fact that it is only the stem left edge which is significant in Ndjébbana, in contrast to what we have seen in Yolngu, and in contrast to the simple examples in Ngalakgan.

(84)

/ka-cuwa/ 3s-sick+is	DOM (HD)	NO INTRSN	#PRWD#	#FT1#	#σ́#	*VCV	IO-DEP (MWD)
☞ a. ka-c#[{cúwa}]							*
b. ka-[cúwa]			*[	*(	*[	*	
c. ka-[{cúp}#pa]		*!	*[	*(	*[	*	

In (85), I show an analysis for a 'leniting' Ndjébbana verb form. The optimal candidate in this case is one where no intonation domains are demarcated, because the MWd and PrWd constituents do not correspond. This is the problem with candidate (a), where the stem-initial segment is geminated. The following domain does not correspond to a PrWd, and therefore violates #PRWD#. Gemination is unlicensed in this case: the form violates DOMAIN(HD). The fact that this candidate demarcates MWd is unimportant. Candidate (d) does demarcate a PrWd, but the gemination is stem-internal, violating high-ranking Output-Contiguity ('No Intrusion'). The difference between the remaining two candidates (b) and (c) comes down to the lenition constraint *VCV. This constraint must dominate IO-IDENT[ROOT NODE](MWd) (not shown) - since the output segment [y] has different root node features to the input [c].[53]

(85)

/ka-cuwela/ 3s-sick+was	DOM (HD)	NO INTRSN	#PRWD#	#FT1#	#σ́#	*VCV	IO-DEP (MWD)
a. ka-c#{ca}[{wéla}]	*!						*
b. ka-ca[wéla]			*	*	*	*!	
☞ c. ka-ya[wéla]			*	*	*		
d. ka-yap#[{péla}]		*!					*

I assume that the set of constraints (or lexical specifications) determining stress in surface forms dominates - that is, takes priority over - the set of constraints determining alternations. The same is true of Ngalakgan and Yolngu: there can be no re-organisation of stress in order to better satisfy the realisation of geminates/glottal stop in a form.

In sum, historically and synchronically, Ngalakgan and neighbouring languages provide evidence for the importance of constituent boundaries in the languages, and for the demarcation of those boundaries with salient articulations. In Ndjébbana, geminates are the salient articulations, there is no glottal stop in the language. In Ngalakgan, Ngandi and Rembarrnga, both geminates and glottal stops are found as boundary-marking signals, with geminates being synchronically manipulated in all three to provide the best association between intonation and constituency. In Yolngu, with no contrastive geminates, glottal stop is the boundary marker, and is manipulated in a way reminiscent of Ngalakgan geminate alternations. It is noteworthy that demarcation of both the left and right edges of prominent constituents is found among these languages. This ambivalence about which edge should be demarcated is predicted by the constraints.

[53]I will not attempt to account for the vowel alternations in this form.

I have motivated a series of constraints demanding that constituents of morphology and prosody be demarcated by segments/clusters which have boundary signal interpretations. I justified the interpretations of obstruent clusters and glottal stops as boundary signals with reference to their acoustic characteristics: the fact that both obstruent clusters and glottal stops make a salient interruption to the voicing and hence the intonation contour of words. If the 'No Obscure Boundaries' series are constraints of universal grammar, we expect to find evidence of boundary signal phenomena in other languages. In addition, if geminates and glottal stops are salient in Ngalakgan because they are articulated with marked laryngeal gestures, then we should similarly observe associations between laryngeal markedness and boundary phenomena elsewhere. This is the topic of the next section.

4.3.3.3 Implications for other languages

The use of segments or allophones as boundary signals is well-known since Trubetzkoy (1969:275ff). I briefly note just a few instances of boundary signalling in other languages, to back up my contention that the alternations found in Ngalakgan, Yolngu and Ndjébbana are boundary signal effects on segments, licensed by prosodic and morphological constituents.

There is evidence that prosodic constituents require salient boundaries. In English, it is well known that obstruents preceding stressed vowels and some other positions are aspirated, but elsewhere are unaspirated (Kahn 1976; Hayes 1995:12ff). Selkirk (1996:451; citing Cooper 1991) claims that onsets to PrWd are also aspirated.[54] We can interpret this to mean that English evinces both constraints #σ́# and #PRWD#, with a left-edge bias, as in Ndjébbana.

Pre-tonic fortition is described for several dialects of the Koniag Aluutiq (Yupik) group (Leer 1985a:84ff). The Yupik facts are interesting, since Leer shows that fortition

[54]There is disagreement about the distribution of aspiration in English. Nespor and Vogel (1986:91) claim the correct generalisation is the initial obstruent in a foot. However, some of their proposed feet in English, such as the initial syllable of '[t^h]errain', would not meet with general agreement.

is conditioned by *foot* boundaries: the fortis consonant need not be in the onset of a stressed syllable. Voicing is non-contrastive in obstruents. Fortition is realised phonetically as voicelessness, 'tenseness' and lengthening in obstruents.[55] Lenis obstruents are short and at least partially voiced (Leer 1985a:84). Environments (a) and (b) in (86) both condition fortition (foot boundaries represented with parentheses; fortis consonants are underlined).[56]

(86) a. (c̲vxv́c)$_{FT}$
b. (c̲v́:c)$_{FT}$

Examples (from Leer 1985a:84) are presented in (87).

(87) a.	(naá)ma#(c̲íq)(:uá)	'where is her plate?'
b.	(naá)(m̲ací)(q̲uá)	'I will suffice'
c.	(naá)ma#(c̲iqúq)	'where is the plate?'
d.	(naá)ma(c̲iqúq)	'it will suffice'; or: 'it will continue to burn'

Leer observes that 'fortition of foot-initial consonants...set[s] apart the accented foot as a highly marked unit and impart[s] phonetic reality to the underlying prosodic structure of the word' (Leer 1985a:83). Thus the Aluutiq pattern satisfies #FT#.

In Ngalakgan, the realisation of boundary signals to tonics is derived from boundary signals occurring elsewhere in the language. Geminates, glottal stops and obstruent clusters all signal the boundaries to prosodic and morphological constituents. Likewise in Aluutiq, the fortis consonants which are boundary signals to feet act as general boundary signals also. Leer notes that 'systematically and phonetically, word-

[55]Leer does not describe the phonetic realisation of fortis sonorants. From Leer's description, fortis obstruents appear to be identical to geminates, and he notes that the fortis/lenis distinction is neutralised in geminates. He distinguishes the fortis from geminate obstruents on syllable structure possibilities: in a cluster C_1C_2, C_2 can be distinctively fortis, but not geminate. The phonetic difference between these two remains unclear to me.

[56]The orthography is that of the source, except that I have represented fortis consonants with underlining. Geminates, following Leer (1985a) are represented as C:, with syllable boundary and hence foot boundary separating C from following colon.

initial consonants are fortis', and hence that the effect of fortition is to make the left edge of a foot sound like the left edge of a word (1985a:83-84).

The Aluutiq pattern provides evidence that prosodic heads and prosodic domains, as well as morphological domains, can be associated with boundary signals. This is a pattern I have formalised as a series of constraints 'No Obscure Boundaries' which refer to prosodic and morphological constituents alike.

So far, in all the patterns discussed we find that segmental boundary signals have one or more of the characteristics of word edges. There was the correlation I noted between pause and [spread glottis] or [constricted glottis] gestures in Ngalakgan in §4.2. The same is true of Ndjébbana (with geminates) and Yolngu (with glottal stop). The correlation between word and foot-initial segments is specifically observed by Leer, as we have just seen. Aspiration in English is also a feature of both word-initial and tonic syllable-initial stops, according to Selkirk (1996).

Geminates and glottal stops are both common as boundary signals in many other languages (Firth 1966[1948]:178). In German, glottal stop precedes all vowel-initial stems, in both words and compounds (Booij 1995). In various Austronesian languages, for example Sundanese and Indonesian, glottal stop is found as a boundary signal either stem-initial or stem-final before or after vowels, respectively (Robins 1953, Cohn 1989). Geminates are found as boundary signals in Malayalam (Mohanan 1986), at the boundary between two stems in a compound. Dialects of Italian geminate word-initial stops following a stressed open syllable in the phenomenon called *raddoppiamento sintattico* (e.g. Chierchia 1982; Nespor and Vogel 1986). And in Finnish, geminates alternate with glottal stops, in a way reminiscent of Top End languages (Sulkala and Karjalainen 1992:369, cited previously.) All of these patterns may be regarded as satisfying #MWD# or #PRWD# or both.

Similar correspondences therefore exist in other languages, between geminates or fortis segments, glottal stop, and boundaries of morphological and prosodic constituents. I regard the constraints proposed here as justified, on the basis that their effects are observable in other languages. In the final section, I show that the constraints proposed also account for the asymmetric distribution of geminates in roots.

4.3.4 Geminates and morpheme structure constraints

The distribution of geminates in roots in Ngalakgan is consistent with the same constraints which drive geminate alternations in complex words. The geminates in roots are lexicalised: they do not alternate with singletons, and the extent to which they obey the synchronic constraints is subject to exceptions. Nevertheless the majority of root-internal geminates do obey the constraints, giving the historical lexicon and the synchronic grammar a degree of consistency.

Geminates in roots have a restricted distribution. There can be no more than one geminate per root (Merlan 1983:3). Thus, along with words like (88) below, there are no words like those in (89) in Ngalakgan:[57]

(88)	a.	capatta	[jábatta]	'long necked tortoise'
	b.	kappuci	[gáppuji]	'old person'

(89)	a.	*cappatta	*[jappatta]
	b.	*kappucci	*[gappucci]

In addition, the single geminate allowed in a root is not freely distributed. In 88% of these roots, the geminate is immediately post-tonic; some examples are presented in (90).

(90)	a.	palkkiɲ	[bálkkiɲ]	'salty, dangerous; constable'
	b.	kappuci	[gáppuji]	'old person'
	c.	maraŋkaɭppa	[màraŋgáɭppa]	'green tree snake'

In these cases, then, the geminate satisfies the constraint #σ́# 'tonics must be demarcated'.[58]

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[57]Ngandi and Rembarrnga both allow roots with more than one geminate, but only around 5% of roots have such a form. The Ngandi form of (88a) is recorded by Heath as /cappatta/.

[58]As we will see in the following chapter, syllables like the primary stressed syllables of examples

In the remaining 12% of 190 roots with geminates (i.e. c. 22 examples), the geminate is a coda to the second syllable. All of these examples are presented in (91).

(91)	a.	álakko	'later'
	b.	cápatta	'freshwater tortoise sp.'
	c.	cáruʈʈuʔ	'female agile wallaby'
	d.	kámakkun	'properly'
	e.	káracci	'spinifex wax'
	f.	kúruppiɭ	'freshwater tortoise sp.'
	g.	léricceI	'freshwater tortoise sp.'
	h.	màɭamáɭappa	'young girl'
	i.	mánappuɳ	'echidna'
	j.	méɭeppeʔ	'shoulder blade'
	k.	menikkaʔ	'unlike'
	l.	míricci	'barramundi'
	m.	míɳicca	'tree sp.'
	n.	móɭoppoɭ	'catfish sp.'
	o.	móroʈʈinʔ	'bush banana'
	p.	ŋámuccùlo	[subsection term]
	q.	ŋáɹakka	'bone'
	r.	pálukkun	SOURCE, ORIGIN [clitic]
	s.	wáɹaccàra	'floodwater'
	t.	wérekka	'where?'
	u.	wúlukkurʔ	'sibling-in-law'
	v.	yánippi	'whatsit?'
	w.	yárakka	'bandicoot sp.'

These examples satisfy #FT1#: 'Demarcate the strongest foot'.

Therefore, the structure of roots in Ngalakgan is compatible with the synchronic constraints on geminates in complex words. Given that the distribution respects the same constraint ranking which accounts for geminate alternation, there is no need for a separate 'morpheme structure constraint'. Only the WORD-level morphology is synchronically susceptible to alternation however, as we would expect given the other characteristics of WORD-level morphology described in preceding chapters.

Morpheme structure constraints in other languages have similar properties. In Copala Trique (an Otomanguean language), Hollenbach (1977:36) claims that the fortis series of obstruents (stops, affricates, sibilants and, in one dialect, sonorants) and the

(90a, c) are bimoraic, so in these cases, the geminate also satisfies #Ft1#.

laryngeals /ʔ h/ only occur in the final stressed syllables of words. Elsewhere, only lenis consonants, and no laryngeals, occur. The fortis consonants Hollenbach notes are articulatorily tense, voiceless unaspirated if obstruent, and longer than the lenis consonants. Lenis obstruents vary between voiced and voiceless, and are commonly fricated intervocalically. Since syllables can only be open, or 'checked' (closed by a single laryngeal), fortis segments are in every case pre-tonic segments. The salient properties of fortis segments in Trique serve to clearly demarcate the stressed syllable.

4.4 Conclusion

In this chapter I have shown that there is a single series of stops in Ngalakgan, which can be both singleton and geminate. Geminate stops have all the characteristics of clusters: they are consistently longer than singletons, they have the [spread glottis] articulation common to all obstruent clusters, they condition closed-syllable allophones in preceding vowels, and they have the distribution of clusters in syllables. Moreover, these characteristics apply both to tautomorphemic and to heteromorphemic geminates equally.

Geminates, and glottal stops, are commonly found at morpheme boundaries in Ngalakgan and neighbouring languages, suggesting historic gemination and laryngealisation rules. I have proposed constraints which demand that prominent constituents of prosody and morphology be associated with the same kind of junctural effect as the end of words, making these constituents highly salient within complex words. I have suggested that this correlation between phonological juncture and morpho-prosodic constituents aids the interpretation of complex words by hearers: an important task in such a morphologically complex language. Synchronic alternations demonstrate that these constraints are still active in the language, and in other languages.