Gemination, Degemination and Moraic Structure in Wolof[*]

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There is a rich system of concatenative morphology in Wolof, consisting mostly of suffixes that attach to verb and noun roots. A number of suffixes trigger changes in the root to which they attach, including gemination, degemination, vowel shortening, fricative-stop alternations, and vowel alternations. Previous analyses of Wolof consider these alternations to be morphological. I argue that, although morphologically triggered, the alternations result from systematic phonological processes. Using an Optimality Theoretic (OT) approach, I show that a moraic analysis of phonological structure in Wolof can account for restrictions on well-formed syllable types, the distribution of underlying geminates and prenasalized stops, and patterns of gemination and degemination.

1.   Introduction

Wolof is a West Atlantic language spoken in Senegal and the Gambia by about six million people. There is a rich system of concatenative morphology in Wolof, consisting mostly of suffixes that attach to verb and noun roots. A number of suffixes trigger changes in the root to which they attach. These changes include gemination, degemination, vowel shortening, fricative-stop alternations, and vowel alternations. Consider the examples below. In (1a), adding the inchoative suffix *-i* triggers no change in the root /lem/. However, the addition of the reversive *-i* causes the coda consonant of the same root to geminate in (1b). In (1c), the coda of the root /sonn/ degeminates when the causative suffix *-al* is added. Previous analyses of Wolof consider these alternations to be morphological. In this paper, I argue that, although morphologically triggered, the alternations in (1a-c) result from systematic phonological processes.

(1)   a. lem   +   -i   →   lemi
            'to fold'   inchoative   'to go and fold'

        b. lem   +   -i   →   lemmi
            'to fold'   reversive   'to unfold'

        c. sonn   +   -al   →   sonal
            'to be tired' causative   'to tire someone'

                                                        (Ka 1994)

The analysis I develop is based on observations about the structure of syllables and their distribution in Wolof. As I show below, Wolof exhibits a distributional asymmetry in its syllable structure: geminate consonants can only follow short vowels, while singletons can follow long or short vowels. This suggests that the syllable in Wolof is weight-sensitive, and that geminates contribute weight. Under such a view, *CVVCC syllables in Wolof are simply *too heavy*, and thus ill formed. Using an Optimality Theoretic (OT) approach, I show that a weight-based or *moraic* analysis of phonological structure in Wolof can account for restrictions on well-formed syllable types, the distribution of underlying geminates and prenasalized stops, and patterns of gemination and degemination. In addition, I argue that a moraic analysis is crucial to understanding other alternations that arise in the context of gemination.

The paper is organized as follows. In Section 2, I provide a basic overview of the segmental inventory of Wolof. I also discuss stress assignment and present the data on gemination, degemination, and concomitant vowel and consonant alternations. In Section 3, I describe the syllable structure of Wolof. I also look at the distribution and behavior of prenasalized stops. Based on the data from the first two sections, I argue for a moraic representation of the Wolof syllable in Section 4, where I present the basic representations that I will assume throughout the paper. In Section 5, I develop an OT analysis of gemination, degemination, and the alternations that accompany these processes in Wolof. I offer conclusions in Section 6.

2.   Phonological and morphological background

In this section I give the basic data on the Wolof segmental inventory (Section 2.1) and stress assignment (Section 2.2). In Section 2.3, I outline the aspects of Wolof morphology that are relevant to my analysis.

The data in this paper are drawn from various sources. The two main phonological studies of Wolof are by Ka (1994), who describes the Kajoor-Bawol dialect, and Ndiaye (1995), who also describes the Kajoor-Bawol dialect. These works provide the vast majority of data on gemination and phonological alternations. Other important sources include Diop (1976-1981), Church (1981), and the UCLA dictionary of Wolof, *Ay Baati Wolof,* by Munro and Gaye (1997). Finally, I collected some data on the Dakar dialect of Wolof while participating in a 1999 field methods course taught at Cornell University, and in subsequent consultation with two native speakers. Uncredited data come from my own fieldwork.

To begin, consider the consonant and vowel inventories of Wolof in Section 2.1.

2.1   Consonant and vowel inventories

The majority of the consonants shown in Table 1 below can occur in onset, medial or coda position, with the following exceptions. First, according to Ka (1994) and Ndiaye (1995), the voiceless stops /p/, /c/, /k/, /q/ do not occur in coda position, an issue that I address in Section 5. Ka (1994) also argues that the voiced stop /d/ is never a singleton coda in Wolof, although, as I show in Section 5, it can occur intervocalically (as an onset), or as a medial or word-final geminate. Second, the glottal fricative /h/ has a somewhat marginal status in Wolof, occurring principally as an onset. Ndiaye (1995, p. 218) argues for an underlying /h/ in cases of Ø→ kk alternations of the root coda in derived contexts – a position that I adopt in Section 5. Third, the glottal stop /ʔ/ occurs only as an onset, and is not actually contrastive; it is inserted in onsetless syllables.

In terms of their distribution, both /c/ and /j/ pattern with the other stops, and not as a separate class of affricates. Also, note that Wolof has four prenasalized voiced stops, /^{m}b/, /^{n}d/, /^{n}j/, /^{ŋ}g/, all of which pattern by-and-large as single segments. In addition, Wolof has four prenasalized stop clusters, /mp/, /nt/, /ɲk/, /ŋq/. These are voiceless stops

preceded by a place-assimilated voiced nasal. Following Ka (1988, 1994) and Ndiaye (1995), I consider these to be clusters and not single segments. In Section 3, I show that they pattern in many ways with geminates.

	labial	*alveolar*	*palatal*	*velar*	*uvular*	*glottal*
stops	p b	t d	c j	k g	q	?
nasals	m	n	ɲ	ŋ		
fricatives	f	s			x	h
liquids		r l				
glides			y	w		
prenasalized voiced stops	^{m}b	^{n}d	^{ɲ}j	^{ŋ}g		

Table 1: Consonant inventory of Wolof

Nasals and prenasalized voiced stops contrast. Consider (2a-i) below. The data in (2a-c) show the alveolar, palatal and velar nasals in a minimal set. In (2d-g) we see that prenasalized voiced stops contrast with nasal stops, and of course with each other, in onset position. Finally, (2h-i) show that prenasalized stops contrast in coda position.

(2) a. naan   'to drink'
      b. ɲaan   'to pray'
      c. ŋaan   'to open one's mouth really wide'
      d. ^{ɲ}jaam   'slavery'
      e. ^{ŋ}gan   'stay (n.)'
      f. maam   'grandparent, ancestor'
      g. ^{m}baam   'pig'
      h. ^{m}ba^{m}b   'gossip'
      i. ^{m}ba^{n}d   'to give a performance'

                                                (Ka 1994)

A subset of the singleton consonants in Wolof also occur as geminates. Consider the data in Table 2.

	labial	*alveolar*	*palatal*	*velar*	*uvular*
stops	pp bb	tt dd	cc jj	kk gg	qq
nasals	mm	nn	ɲɲ	ŋŋ	
liquids		ll			
glides			yy	ww	

Table 2: Geminate consonants in Wolof

As we see in Table 2, neither the fricatives /f/, /s/, /h/ and /x/ nor the alveolar /r/ occur as geminates in Wolof. Prenasalized stops are also absent from the list of geminates in Wolof. All other consonants occur as both singletons and geminates. I discuss the absence of geminate fricatives and geminate prenasalized stops in detail below in Section 5.

Consider the data on geminates in (3) below. Examples (3a-b) show a contrast between a singleton [t] and a medial geminate [tt], while (3c-d) and (3e-f) show contrastive singletons and geminates in coda position. In (3h), I illustrate a geminate triggered by the reversive suffix *-i*. The singleton [m] in (3g) is also followed by a morphological suffix, the inchoative *-i*, which does not trigger gemination. I discuss the representation of geminates in Section 4, and give an account of the gemination data in Section 5.

(3) a. fatu   'to be sheltered'
     b. fattu   'to have something in one's eye'
     c. nop   'to love'
     d. nopp   'ear'
     e. gən   'to be better (than someone)'
     f. gənn   'grinder, mortar; pipe'
     g. lemi   'to go and fold'
     h. lemmi   'to unfold'

                              (Munro and Gaye 1997)

Next, consider the vowel inventory of Wolof, illustrated in Table 3.

	[-back]	unmarked for [back]	[+back]
[+high]	i/ii		u/uu
[-high]	E/EE e/ee a	ə	O/OO o/oo a/aa

Table 3: Wolof Vowels

The Wolof vowel system has contrastive length and contrastive Advanced Tongue Root, or ATR. All vowels can be either long or short, except the [+ATR] /A/, which I represent as /A/ for ease of presentation, and the schwa /ə/. I argue that the latter is specified as [-back], based on vowel alternations that I will discuss below in Section 5. The schwa in Wolof patterns with other short vowels in its distribution. Also, as I discuss in Section 5, there are reasons to believe that schwa is featureless in Wolof. It is, as in many languages, the default epenthetic vowel.

There is ATR vowel harmony in Wolof, discussed in detail by Ka (1988, 1994) and Ndiaye (1995). I do not attempt an analysis of ATR vowel harmony in this paper, as it is not directly relevant to the topic at hand. For ease of presentation, and following Ndiaye (1995), I mark [+ATR] vowels /e/ and /o/ as /E/ and /O/ respectively. The high vowels /i/ and /u/ are [+ATR] and have no [-ATR] counterpart. Since there is no contrast, I represent /i/ and /u/ *without* [+ATR] marking.

To briefly illustrate the contrastive nature of vowel length and ATR in Wolof, consider the examples below. (4a-d) show that ATR and vowel length are both contrastive features in Wolof. A more in depth discussion of these facts is beyond the scope of this paper; I refer the reader to the excellent discussions in Ka (1988, 1994) and Ndiaye (1995).

(4)   a. ^{m}ba ^{m}b   'gossip'
        b. ^{m}bA^{m}b   'danger'
        c. tol   'type of fruit'
        d. tool   'garden; cultivated field'

                                        (Munro and Gaye 1997)

Having briefly presented the Wolof segment inventory, I now move on to a description of stress assignment.

2.2   Stress

In this section, I describe stress assignment in Wolof. The canonical position for primary stress is the leftmost syllable of the word. I illustrate some cases in (5a-d), where primary stress is marked with an acute accent (´) on the vowel. Primary stress normally falls on the first syllable of a word in Wolof. This holds true whether the first syllable has a long (5c,d) or a short (5a,b) vowel, or whether the second syllable is open (5b) or closed (5a).

(5)   a. wó.lof   'Wolof'
        b. wó.ne.wu   'to show off'
        c. báa.si   'couscous'
        d. cóo.ba.re   'will'

                                                    (Ka 1988)

Primary stress appears on the second syllable only when that syllable contains a long vowel and the first syllable does not, as shown by the data in (6) below. In (6a-e), long vowels attract stress away from the canonical leftmost position onto the second syllable. This suggests a weight contrast in Wolof syllables. It seems that syllables with long vowels are heavy, and those with short vowels are light. While the canonical position for stress is the first syllable, primary stress falls on the second syllable when that syllable contains a long vowel and the first syllable does not. Based on evidence from stress assignment, all syllables with short vowels are light, including: open syllables (6a-b); syllables closed by a consonant (6c-d); and syllables closed by a geminate (6e). Note also that heavy syllables are unique in attracting secondary stress (6d *vs*. 6b), further distinguishing the behavior of heavy and light syllables in terms of stress assignment.

(6)   a. ko.máa.se   'to start' (<French)
       b. wo.yáa.na.ti   'to beg once more'
       c. xa.^{n}dóor   'to snore'
       d. wax.táa.nu.kàay   'place for conversation'
       e. deg.góo   'understanding'

<div align="right">(Ka 1998)</div>

Finally, consider the data in (7). In (7a-c), we see words consisting solely of syllables with long vowels. In these cases, primary stress falls on the canonical first position. If the closed CVC syllables in (6d-e) above counted as heavy, we would expect to see a similar pattern of primary stress falling on the canonical leftmost syllable. However, only syllables with long vowels count as heavy for purposes of stress assignment – an important fact to remember when we consider the representation of geminates. As I show in (7d-e), syllables closed by a glide are also light: there are no diphthongs in Wolof (Ndiaye 1995, p. 122-123). If the first syllables in (7d) and (7e) were diphthongs, we would expect them to pattern with other heavy syllables in attracting primary stress, since diphthongs often pattern with long vowels. A final point exemplified by (7a-c) is that two adjacent syllables cannot both be stressed. Presumably, there is a constraint in Wolof against stress-clash.

(7)   a. xáa.raa.nàat   'to show up again unannounced'
       b. fáay.daal.wàat   'to consider seriously again'
       c. wóo.waat   'to call again'
       d. ɲOw.lÉEn   'come!'
       e. sEy.lÉEn   'get married!'

<div align="right">Hammond (1993)</div>

Following standard assumptions (Hayes 1989, Broselow 1995, and others), I will represent syllable weight in terms of *moras*. Syllables with a short vowel are *light*; I will assign short vowels one mora (μ); syllables with long vowels are *heavy*, and I will represent long vowels as associated with two moras ($\mu\mu$). All vowels are underlyingly moraic, while, as I will show, consonants are underlyingly moraic if they are geminates. Unlike syllables with long vowels, however, syllables closed by a geminate do not count as heavy for purposes of stress assignment. Apparently, there are two different weight computations at play in Wolof, one dealing with stress assignment and the other with

syllable structure. Based on this fact, it would be possible to argue that geminates are best represented as having two root nodes, in an analysis such as that of Selkirk (1990). However, I argue for a moraic representation of geminates, despite the fact that they do not pattern with long vowels in attracting stress. As I will show, adopting a moraic representation of geminates allows for a principled explanation of gemination and its concomitant alternations in a way that a two root node representation does not. I return to this point in Section 4. In the next section, I describe the morphological data relevant to this paper.

2.3   Gemination and degemination: The data

In this section, I present some details of Wolof morphology relevant to my analysis. Wolof has a complex system of verbal and nominal morphology, as described by Church (1981), Ka (1988, 1994) and Ndiaye (1995). More specifically, like many West Atlantic languages (Heine and Nurse 2000), Wolof shows rich patterns of nominal and verbal suffixal morphology. Wolof has dozens of morphological suffixes; Ka (1994, p. 13-22) lists a total of 36. Many of these suffixes exhibit ATR vowel harmony with the root to which they attach, as described by Ka (1994). While most suffixes have no effect on root consonants, there are three suffixes that trigger gemination of a root coda, and two suffixes that trigger degemination of a root coda. Consider first the suffixes that have no effect on root consonants. Among these are the inchoative *-i*, the benefactive *-al*, and the reflexive/passive *-u* suffixes, shown in (8).

(8)   a. lem 'to fold'   lemi   'to go and fold'
         b. takk 'to tie'   takki 'to go and tie'
         c. bey 'to cultivate'   beyal 'to cultivate for'
         d. bətt 'to pierce'   bəttal 'to pierce for'
         e. ub   'to close'   ubu   'to be closed'

                                                                          (Ka 1994)

As the data in (8) show, the addition of the verbal suffixes *-i*, *-al* and *-u* in no way affects the shape of the verb root. The coda does not geminate or degeminate, nor do we observe any vowel alternations. The suffix is simply attached to the end of the root.

Unlike the benign suffixes in (8), the reversive *-i*, corrective *-anti* and completive *-ali* suffixes all trigger gemination of a singleton coda. These three suffixes can also cause vowel alternations within the root, as shown by the data in (9). As we see in (9a-b), the addition of the suffix *-i* triggers gemination. Gemination also occurs in (9c-e), with the added vowel alternations from [a] to [A] in (9b) and [ə] to [i] in (9d). The geminating suffixes have no effect on root codas that are already geminates (9f), nor do they affect nasal-consonant clusters (9g) – although note that in both of these examples we still see vowel alternations. I propose an OT account of gemination and vowel alternations in Section 5.

(9) a. ub   'to close'   ubbi   'to open'
     b. lem   'to fold'   lemmi   'to unfold, mess up'
     c. tag   'to hang up'   tAgganti 'to unhand, take down'
     d. jOt   'to get'   jOttali   'to transmit'
     e. təj   'to close'   tijji   'to open'
     f. dəpp   'to put upside down'   dippi   'to put rightside up'
     g. samp   'to plant'   sempi   'to take out'

                                                    (Ndiaye 1995, pp.44-45)

Finally, there are two suffixes that trigger degemination of a root coda, causative *-al*, and nominalizer *-o*. Consider the data in (10a-e) below. As we see in (10a), the geminate /nn/ of the root becomes a singleton [n] when the causative suffix is added, and the geminate /gg/ becomes [g] in (10b). The two suffixes shown in (10) appear to have exactly the opposite effect of the geminating suffixes. They always trigger degemination in case the root coda is a geminate, but have no effect on long vowels in the root (10c), singleton codas (10d), or nasal-consonant clusters (10e).

(10) a. sonn   'to be tired'   sonal   'to tire someone'
      b. segg   'to filter'   segal   'to press oily products'
      c. fees   'to be full'   feesal 'to make full'
      d. bax   'to boil'   baxal   'to cause to boil'
      e. samp   'to plant'   sampal 'to make plant'

                                          (Ka 1994, pp. 97)

In addition to the concatenative processes of gemination and degemination discussed above, Wolof also exhibits cases in which there is no visible morpheme

attached to the root. Rather, in cases such as (11) and (12) below, we observe systematic changes in meaning that are signaled by addition of a feature or changes in the feature-specification of a segment within a word. In (11a-j) we see the voiced stop onsets (the verbal and non-diminutive forms on the left) alternating with prenasalized stop onsets (the nominal forms on the right). It is clear that the forms on the left have an additional feature [nasal] associated with the onset stop consonant. Note that in each case the nasal is place-assimilated with the stop. In a derivational account (cf. Ka 1994) these data can be described as nominalization marked by prenasalization.

		Verbal		Nominal	
(11)	a.	baax	'to be good'	f. ^{m}baax	'goodness'
	b.	dugg	'to shop'	g. ^{n}dugg	'shopping
	c.	jang	'to study'	h. jang	'study'
	d.	gəm	'to believe'	i. ^{ŋ}gəm	'belief'
	e.	doom	'child'	j. ^{n}doom	'small child'

<div align="right">(Ndiaye 1995)</div>

Now consider the alternations in (12) below. (12a-j) show nominalization, marked in this case by a different strategy- strengthening of a fricative into a stop. Note that in (12e) and (12j) no change occurs, as the onset of the verb is already a stop.

		Verbal		Nominal	
(12)	a.	fO	'to play'	f. pO	'game'
	b.	sacc	'to fly'	g. cacc	'flight'
	c.	xiif	'to be hungry'	h. qiif	'hunger
	d.	haand	'to be together'	i. kaand	'guest'
	e.	topp	'to follow'	j. topp	'following'

<div align="right">(Ndiaye 1995)</div>

In their derivational accounts, Ka (1988, 1994) and Ndiaye (1995) take the verbal forms on the left to be underlying. Both authors also argue that the data in (12a-j) involve prenasalization – that a nasal is appended to the onset in (12f-j). However, since nasal-fricative clusters are illicit in Wolof, the fricative becomes a stop. Then, owing to a restriction on voiceless nasal-stop (NC_{-v}) clusters in onset position, the nasal is deleted (or does not surface) in the nominal forms on the right. While this may be a valuable

diachronic observation, it is not immediately obvious what advantages it holds for a synchronic description of the grammar. I propose a non-derivational alternative below, in which I relate the data in (12) to other cases of fricative strengthening that occur in the context of gemination.

In the next section, I look at syllable structure and the distribution of prenasalized stops in Wolof.

3. Wolof syllable structure: Data and previous analyses

In this section I present data on Wolof syllable structure, including a list of canonical monosyllable and disyllable types (Section 3.1, Section 3.2). Then, in Section 3.3, I consider the distribution of prenasalized voiced stops and nasal-voiceless stop clusters. I show that there are strong parallels between prenasalized voiced stops and singletons on the one hand, and NC$_{-v}$ clusters and geminates on the other.

3.1 Monosyllables

First, consider in (13) the five allowable monosyllable shapes in Wolof. Open syllables are of the shapes CV and CVV as in (13a) and (13b). Closed syllables may be of three shapes: CVC , CVVC, and CVCC, where CC is either a geminate or a nasal-voiceless stop (NC$_{-v}$) cluster; there are no other tautosyllabic consonant clusters. Note that all of the examples in (13e) are verbs. This illustrates an interesting lexical component of syllable shapes in Wolof: CVCC roots are, with few exceptions, verbs.

(13)

		open			closed	
a.	**CV**	ba	'to abandon'	c. **CVC**	ʔan	'lunch'
		jə	'forehead'		def	'to do'
		so	'to set (sun)'		xop	'leaf'
		ne	'to say"		tek	'to start cooking'

b.	**CVV**	ⁿdaa	'water pot'	d. **CVVC**	baat	'neck'
		woo	'to call'		uul	'to be black'
		gee	'night prayer'		biig	'last night'
		taa	'to stagnate'		xeep	'to judge (someone)'

			e. **CVCC**	bokk	'to share'
				fatt	'to spoil'
				fomm	'to postpone'
				samp	'to plant'

(Ka 1994)

In (14) I summarize the syllable shapes in Wolof.

(14)   **CV   CVC   CVV   CVVC   CVCC**

Following Ka (1994), I list CV as a possible syllable shape. Of particular interest in (14) is the distribution of singletons and geminates with respect to long vowels. Singletons and voiced prenasalized stops can close a light (CVC) or a heavy (CVVC) syllable; their distribution is not affected by syllable weight. Geminates and voiceless prenasalized stops, on the other hand, can only occur following a short vowel; syllables of the shape *CVVCC are illicit in Wolof. If we consider geminates (and possibly voiceless prenasalized stops) to be weight-bearing segments, then this distributional asymmetry is easily explained: a geminate following a long vowel would contribute weight to an already heavy syllable, causing it to be overly heavy. Overly heavy syllables are not allowed in Wolof. I formalize this notion below.

In the next section, I illustrate the observed disyllables in Wolof.

3.2   Disyllabic words

Of the 14 disyllabic shapes in Wolof, seven are never underlying, but rather are derived through concatenative morphological processes such as those described in Section 2.3. However, there are seven underived disyllabic shapes, which I exemplify in (15).

(15)	a.	**CV.CV**	xa.le	'child'	
			nu.yu	'to greet'	
	b.	**CV.CVC**	ja.bar	'wife'	
			pe.tax	'pigeon'	
	c.	**CVC.CVC**	gur.met	'christian'	
			fud.dEn	'henna'	
			tEs.tən	'heel'	
	d.	**CVV.CVC**	xaa.lis	'money' (< Arabic)	
			fee.bar	'to be sick' (< Portuguese/French)	
			jaa.sir	'to be sterile'	
	e.	**CV.CVVC**	ga.naar	'chicken'	
			ji.geen	'woman'	
	f.	**CVV.CV**	fee.te	'to be situated'	
			maa.fe	'sauce (type of dish)'	
	g.	**CVC.CV**	gud.di	'night'	
			bol.de	'big stick'	
				(adapted from Ka 1994, pp. 75-77)	

The disyllabic shapes in (15a-g) occur in underived as well as derived words in Wolof. In addition, there are seven disyllabic shapes that occur only in derived words in Wolof. I illustrate these in shadow in (16).

(16)	a.	**CV.CVV**	xu.loo	'to quarrel'	
			so.^{n}goo	'to attack each other'	
	b.	**CVC.CVV**	(su) tog.gee	'(if) he/she cooks'	
			deg.goo	'understanding'	

c.	**CVC.CVVC**	wax.leen	'speak!'
		^{m}bəg.gEEl	'love'
d.	**CVV.CVV**	(su) suu.rEE	'(if) he/she is full'
		dEE.yOO	'to consult each other'
e.	**CVV.CVVC**	mii.nEEl	'usage, habit'
		rEE.rOOn	'had dinner'
f.	**CVVC.CV**	jiit.lE	'to help lead'
		^{n}door.te	'beginning'
g.	**CVVC.CVVC**	gaaw.leen	'hurry up!'

(Ka 1994, pp. 13-17)

Unlike the shapes listed in (15a-g), the disyllables in (16a-g) only arise in Wolof as a result of concatenative morphological processes. They are never found in underived lexical items. In Table 4 below I schematize the disyllabic shapes of Wolof. Disyllables marked with a √ are underlying. Those marked with a ⚡ occur only in derived forms.

As I show in Table 4, not all monosyllables can combine to form disyllables. Out of a possible 25 disyllabic shapes (predicted based on the number of monosyllables), only 14 were attested in the data available for this study; of these, seven are found in underived words. The absence of CVCC in disyllables is partly due to lexical facts. As I mentioned above, the shape CVCC is restricted by-and-large to monosyllabic verbs, and simply does not surface as the second syllable of a disyllable. The absence of CVCC as the first syllable is due to syllabification rules in Wolof. A geminate must syllabify across a syllable boundary in a disyllable. Since onset clusters are disallowed, syllables that end in a geminate trigger vowel epenthesis when a suffix with a consonant onset is added.

SYLLABLE 2➜ SYLLABLE 1⬇	CV	CVC	CVV	CVVC	CVCC
CV	√	√	⚡	√	
CVC	√	√	⚡	⚡	
CVV	√	√	⚡	⚡	
CVVC	⚡	(⚡)[1]	(⚡)	⚡	
CVCC					

Table 4: Distribution of Wolof disyllabic shapes

Next, consider the data in (17), in which a CVCC monosyllable is concatenated with a CVC suffix. The resultant word is not of the shape *CVCC.CVC, however, owing to the requirement that medial geminates must syllabify across a syllable boundary. This syllabification of medial geminates follows standard assumptions (Hayes 1989), and is well-attested in many languages (Ham 1998).

(17)   lekk   + kat →   lek.kə.kat
              'eat'   NOM   'eater'

                                                    (Ndiaye 1995, pp. 226)

          Based on the distinction between heavy and light syllables that I draw above, we can divide Wolof disyllables into four groups, where L = *light* and H = *heavy*. In *Table 4*, shapes in outline are only found in derived words. Primary stress is shown in **bold** on the feet in the top row. For example, ***L**.L* represents a CV(C).CV(C) foot stressed on the first syllable.

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[1] Based on the observed data, it is highly probably that CVVC occurs as the first syllable of derived disyllabic words of the shape CVVC.CVC and CVVC.CVV. However, there are no morphological suffixes of the shape CVC or CVV that combine with roots of shape CVVC in my sources. Thus, I put these two disyllabic shapes in parentheses, although I assume that they exist and would be found in a larger corpus of Wolof.

L.L	L.H	H.L	H.H
CV.CV	CV.CVVC	CVV.CVC	CVV.CVV
CV.CV	CV.CVV	CVV.CVC	CVV.CVVC
CVC.CV	CVC.CVV	CVVC.CV	CVVC.CVVC
CVC.CVC	CVC.CVVC	(CVVC.CVC)	(CVVC.CVV)

Table 5: Wolof disyllables as a function of syllable weight

In Table 5, we observe a striking asymmetry in foot distribution based on whether or not the disyllabic shape occurs in underived words. Six of the seven underived disyllables are feet of the shape **L**.L or **H**.L. In addition, note that the majority (four out of seven) of the underived disyllables are **L**.L feet. Syllables of the shapes L.**H** and **H**.H are all derived, with one exception. These data suggest a strong preference in Wolof for feet of the shape **L**.L. I discuss this asymmetry as it relates to degemination in Section 5.6 below.

There are also many polysyllabic words in Wolof. However, few of them are underlying. There appears to be a maximal word constraint operating in Wolof that generally prohibits underived words from being larger than two syllables. Very few roots in Wolof contain more than two syllables and many of these can be traced back to borrowings.

At this point, we have seen indications from stress assignment (Section 2.3) that Wolof syllables are sensitive to weight. Primary stress, usually assigned to word-initial syllables, is attracted to syllables with long vowels, i.e. *heavy* syllables, in second position when the first syllable is light. In addition, we have seen that geminates can never follow long vowels in a syllable, suggesting that they also contribute weight. However, it is clear from the data on stress assignment that syllables closed by a geminate do not contribute to stress, suggesting that two different weight computations are at work. Finally, we have seen in this section that Wolof prefers feet of the shape **L**.L to other foot shapes.

In the next section, I look at the distribution of prenasalized voiced stops and NC_{-v} clusters in Wolof.

3.3   Prenasalized voiced stops and nasal-stop clusters

Some languages have prenasalized voiced consonants that pattern identically to singletons. In Sinhala, for example, Letterman (1997, pp. 210-216) clearly establishes that prenasalized stops are "single complex segments" that, in addition to showing the same distribution as singletons, can geminate in environments where singletons geminate. Phonetic data on geminate length and prenasalized stop neutralization in coda position provide further evidence that prenasalized stops are single segments in Sinhala (Letterman 1997).

Prenasalized stops and fricatives in Luganda show the opposite behavior. Herbert (1975, p. 110) argues that "the two components [of a prenasalized stop in Luganda] are indeed always members of a separate syllable and are, therefore, not to be treated as comprising unitary (complex or not) segments." Herbert (1975) shows that all nasal-stop and nasal-fricative clusters in Luganda pattern with the (numerous) other consonant clusters in the language in terms of preceding vowel length and contribution to syllable weight.

In Wolof, prenasalized voiced stops $/^{m}b/$, $/^{n}d/$, $/^{ɲ}j/$, $/^{ŋ}g/$ have exactly the same distribution as singletons in monosyllables. Consider the data in (18).

(18)   Distribution of prenasal segments in monosyllables

a. ^{m}bee	'to bleat'	e. ^{n}dOOl	'to be poor'
b. ^{n}dox	'water, juice'	f. ^{m}bell	'deposit; mine'
c. ^{m}bA^{n}d	'big water jar'	g. ^{m}bant	'type of tree'
d. ja^{ŋ}g	'to teach'		

(Munro & Gaye 1997)

The data in (18a-g) show that prenasalized voiced stops can occur in onset or coda position. Also, they can occur after a long vowel, at least in the Kajoor-Bawol dialect as described by (Ndiaye 1995). There are no such contrasts in Ka (1994).

(19) a. haa^{n}d 'to be together'
      b. kaa^{n}d 'guest'[2]

<div align="right">(Ndiaye 1995, p. 41)</div>

Finally, prenasalized voice stops can be part of a consonant cluster:

(20) a. gay.^{n}dE   'lion'   d. dəw.lin 'cooking oil'
      b. ?ur.^{m}bəl   'voting booth'   e. jar.goɲ 'spider'
      c. tus.^{ŋ}gəl   'khôl' (Ka 1994, p. 76) f. tEs.tən   'heel'

<div align="right">(Ndiaye 1995:225)</div>

In (20a-c), we see that prenasalized voiced stops can be onsets of non-word-initial syllables following a coda consonant. Compare (20a-c) with (20d-f), which show similar consonant clusters in Wolof. In (18)-(20) above, Wolof prenasalized voiced stops behave identically to singletons in terms of their distribution.

However, Wolof prenasalized voiced stops are distinct from singleton stops in one way: they apparently do not geminate. Consider the data in (21a-d).

(21) a. jOt   'to obtain'   jOttali 'to transmit'
      b. si^{m}b 'to act like a lion' si^{m}bali 'to show great anger'
      c. sonn   'to be tired'   sonal   'to tire'
      d. jA^{ɲ}g 'to learn'   jA^{ɲ}gal 'to teach'

<div align="right">(Ka 1994, p. 89-117)</div>

In (21a), the singleton coda [t] of *jot* geminates when the completive suffix *-ali* is appended, yet following Ka (1994), there is apparently no change of length in the prenasalized coda [^{m}b] of *si^{m}b* (21b) when the same suffix is appended – although there are no phonetic studies that show this unequivocally. A study similar to that performed by Letterman (1997), in which she shows that closure duration for prenasalized stops in Sinhala is indeed longer in gemination environments, would be useful for this case in Wolof. In (21d), we observe that prenasalized voiced stops show no degemination effects similar to (21c). We do not expect prenasalized voiced stops to degeminate if we

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[2] Prenasalized voiced stops are rare in coda position in general, but appear to occur following long vowels in at least a few cases, as exemplified in (19).

maintain that they are single segments. However, why they do not geminate is a question that must be addressed, and to which I return below.

As I mention in Section 2.1 above, Wolof also has nasal-voiceless stop (NC₋ᵥ) clusters /mp/, /nt/, /ɲk/, /Nq/. Unlike prenasalized stops, I argue, *contra* Ka (1994), that these are true clusters that do not pattern with singletons but rather with geminates. First, consider the basic distribution of NC₋ᵥ clusters as illustrated in (22).

(22)   a. jant   'sun'
        b. jaɲq   'virgin; young unmarried woman'
        c. kumpa   'secret'
        d. feŋku   'to bump against (something) with one's hips'
                                                                        (Ka 1994)

NC₋ᵥ clusters have a more restricted distribution than prenasalized voiced stops. They occur only in coda and medial position, never as onsets and never following a long vowel in monosyllables. NC₋ᵥ clusters have the same distribution in syllables as geminates in all cases but one: they can follow a long vowel when in medial position in a disyllable. (I discuss this below.)   NC₋ᵥ clusters also pattern with geminates with respect to schwa insertion. Consider the data in (23)-(24).

(23)   samp + kat →   sampəkat   (*sampkat)
                plant   NOM   'planter'

(24)   lekk + kat →   lekkəkat   (*lekkkat)
                eat   NOM   'eater'
                                                        (Ndiaye 1995, p. 226)

Here, the NC₋ᵥ cluster /mp/ in *samp* patterns with the geminate /kk/ in triggering vowel epenthesis. To avoid an illegal consonant cluster, a vowel is inserted between the geminate and the onset of the nominalizing suffix *kat* in (24). We see the same process at work in (23), suggesting a structural parallel (at some level of the representation) between geminates and NC₋ᵥ clusters. Compare the data in (24) and (25).

(25)　a.　ɲaw + kat →　　　ɲawkat　(*ɲawəkat)
　　　　　sew　NOM　　　　'seamstress'

　　　　b.　jAᴺg + kat →　　　jAᴺgkat　(*jAᴺgəkat)
　　　　　study　NOM　　　　'student'

The data in (24) and (25) illustrate a further parallel between geminates and NC$_{-v}$ clusters on the one hand, and singletons and prenasalized stops on the other. Wolof allows medial consonant clusters composed of two singletons, even following long vowels, providing they are not tautosyllabic. Thus, (25a) is well-formed and does not trigger vowel epenthesis as (24a) does. Similarly, (25b) does not trigger epenthesis, showing that the coda /ᴺg/ is treated by the phonology as a singleton in this environment.

　　　　Finally, consider the data in (26).

(26)　a.　nu.yoon.te.waat　　'to greet each other again'
　　　b.　juum.te　　　　　　'a mistake'
　　　c.　ya.qoon.tu　　　　'to act like a spoiled child'
　　　d.　nek.kaa.lee.ti　　'to live together once more'

Unlike geminates (26d), NC$_{-v}$ clusters (26a-c) can follow a long vowel when they are medial. Ka (1994) states that examples like (26a-c), all of which are derived, are quite numerous. I will account for this difference between geminates and NC$_{-v}$ clusters in my representations below. In Table 6, I summarize the behavior of NC$_{+v}$ and NC$_{-v}$ clusters.

	NC$_{+V}$ (PRENASALIZED VOICED STOP)	SINGLETON	NC$_{-V}$ (NASAL- STOP CLUSTER)	GEMINATE
Allowed in onset	*yes*	*yes*	*no*	*no*
Allowed word-finally	*yes*	*yes*	*yes*	*yes*
Can close monosyllable with long vowel	*yes*	*yes*	*no*	*no*
Trigger vowel epenthesis	*no*	*no*	*yes*	*yes*
Can geminate	*no*	*yes*	*no*	*n/a*
Can degeminate	*n/a*	*no*	*no*	*yes*

Table 6: Behavior and distribution of NC$_{+v}$ and NC$_{-v}$ in Wolof

As I summarize in Table 6, there are strong parallels between singletons and prenasalized voiced stops on the one hand, and geminates and NC$_{-v}$ clusters on the other. Unlike singletons, prenasalized voiced stops apparently do not geminate[3] or degeminate. Unlike geminates, NC$_{-v}$ clusters do not degeminate. Also, NC$_{-v}$ clusters can appear following long vowels in disyllables, while geminates cannot. In the analysis I develop below, both of these facts are reflected in the different structures I propose for singletons, geminates, NC$_{-v}$ clusters and prenasalized voiced stops. In the next section, I discuss in detail the role of the mora in Wolof phonology and give the structural representations I will adopt in this paper.

4.   A moraic account of syllable structure in Wolof

In this section I formalize the notions about syllable weight mentioned above. To account for the observed syllable shapes in Wolof (and the absence of *possible* shapes such as *CVVCC), I develop an analysis in which segments that contribute weight to the syllable are associated with a mora, μ. This approach allows for a systematic treatment of the alternations described in Section 2.3 above. Before giving my analysis, I briefly consider previous analyses of Wolof phonology in the next section.

4.1   Previous phonological analyses of Wolof

Previous analyses of Wolof phonology (Ka 1994, Ndiaye 1995) adopt a CV-tier representation of syllable structure. In this approach, segments are linked to slots on the CV-tier, which in turn are organized into syllables. Ka (1994, p. 81) gives representations similar to the following for long vowels, geminate consonants and prenasalized stops.

(27)   a.   b.

        C V V   C V C C

        s   a   [saa] 'moment'   m u   j   [mujj] 'to be last'

        c.   d.

        C V C   C V C

        n d ə n d   [ndend] 'drum'   b a n t   [bant] 'cane'
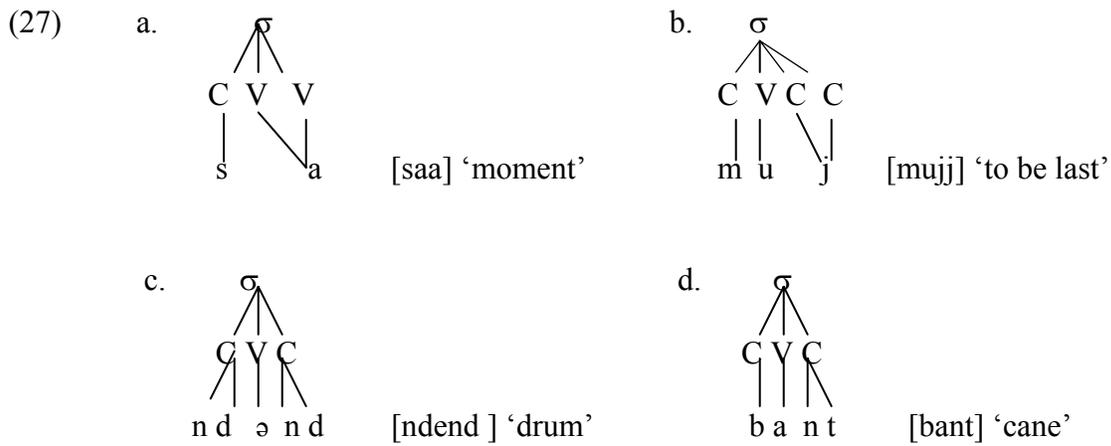
The structures in (27a-d) are from Ka (1994). Singletons and short vowels are represented by a one-to-one mapping from the CV-tier to the segmental tier. Long vowels (27a) and geminates (27b) are represented by a 'many-to-one' mapping from the CV-tier to the segmental tier; a geminate and a long vowel are taken to be two identical, contiguous C's or V's, respectively. Prenasalized voiced stops (27c) and NC$_{-v}$ clusters (27d) are both represented with a 'one-to-many' mapping; they are viewed as single C-slots with a nasal component and a stop component on the segmental tier.

While the structures in (27a-d) correctly represent segmental length and featural identity in the case of geminates, they make no reference to syllable weight and its effects on syllable structure. Thus, while they can predict well-formed syllables based on the number of allowable C-slots and V-slots, these representations cannot capture the generalizations about syllable weight outlined in the previous two sections of this paper:

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[3] I make this statement pending a complete phonetic study of Wolof along the lines of Goodman's (1995) study of Ponapean.

certain syllables are light, while others are heavy; certain segments contribute to syllable weight while others do not.

In addition, the CV-tier representations in (27c-d) assign identical structures to prenasalized voiced stops and NC$_{-v}$ clusters. Based on these structures, we predict that prenasalized voiced stops and NC$_{-v}$ clusters pattern together – and differently from geminates. This prediction is directly contradicted by the data in Section 3.3 above.

In the next section, I propose an analysis that can account for the Wolof data discussed above in a more systematic manner.

4.2   A moraic analysis

In this section I discuss the role of the mora (μ) in the phonological representation and analysis of syllables in Wolof. As we saw above, data from syllable structure (Section 2.1) show that a syllable cannot contain two long segments. Wolof does not allow syllables containing a long vowel to be closed by a geminate (*CVVCC). Under a moraic account, this fact can be explained as follows. First, following standard assumptions, I posit that vowels are *always* underlyingly moraic. Short vowels are associated with one mora (they are *monomoraic*), while long vowels are associated with two (they are *bimoraic*). Secondly, following Hayes (1989), I assume a moraic representation of geminates, *contra* the two C-slot analysis of Ka (1994) and Ndiaye (1995). With these assumptions in place, we can posit that syllables in Wolof can contain *at most* two moras – in line with the general cross-linguistic dispreference for superheavy (or *trimoraic*) syllables. At this point, it naturally follows that the absence of CVVCC syllables in Wolof results from a constraint against overly heavy syllables – that is, syllables associated with more than two moras.

Geminates are weight-bearing segments that influence the allowable syllable shapes in Wolof: they can never occur following a long vowel. However, the presence of a geminate does not affect stress assignment. The data in (Section 2.2) show that long (i.e. bimoraic) vowels are unique in attracting stress away from the canonical leftmost position of the word. Thus, it appears that there are two criteria that we must take into account for weight-bearing segments in Wolof. First, we must know if the segment is

associated with one mora or two moras. Secondly, we must know whether the segment is a vowel or a consonant; or, in featural terms, whether it is specified as [+cons] or [-cons] (see Zec 1995). Given these two pieces of information, we can explain the stress assignment facts while maintaining a mora-based representation of syllables. I discuss this in detail in Section 4.3 below.

Let us now turn to the structures I propose for syllables in Wolof. First, in (28), I give the representations for CV, CVV, CVC and CVVC syllables. I assume that root nodes, feature bundles and moras are underlying, and I represent them in **bold**.

(28) a. CV
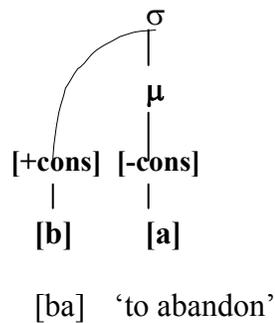
b. CVV
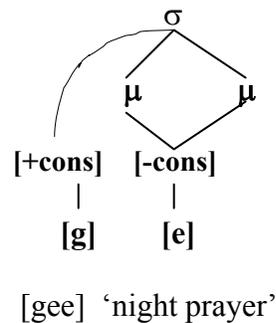
c. CVC
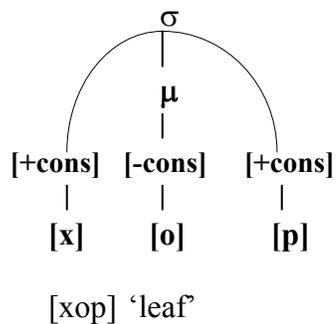
d. CVVC
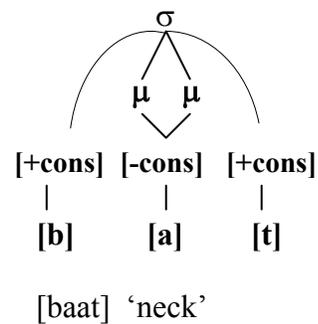
As I state above, it is possible that the syllable CV (28a) does not occur as a free-standing word in Wolof. I include it here for clarity and completeness. The segments in square brackets at the lowest level of each structure – for example [t] in the coda of (28d) – are shorthand notation for full feature geometry. Following McCarthy (1988), I assume that the root node of every segment is inherently specified for featural content. McCarthy

(1988) argues that root nodes are inherently (and inextricably) specified as both [±**cons**onant] *and* [±**son**orant].   In my analysis, I follow the specific proposal of Goodman (1995, p. 33-52), who argues for the separate status of [±cons] and [±son]. She assumes that [±cons] is inherently specified, reflecting "the broad classificatory function of this feature and its direct interaction with moraic structure (p. 52)."   Unlike some features – such as [±voice] and [±cont] – the feature [±cons] does not spread or alternate. To motivate the separate nature of a [±son] root node, Goodman (1995) shows that only [+son] segments in Ponapean can geminate; [-son] segments cannot. Wolof geminates do not show this asymmetry.   However, based on the arguments from Goodman (1995), my representations will include the [±cons] root node as the inherently specified feature that all segments invariably possess.

         Next, I give the phonological representation of geminates in Wolof.

(29)   Phonological representation of geminates in Wolof

         a. word-final geminates[4]   b. word-medial geminates
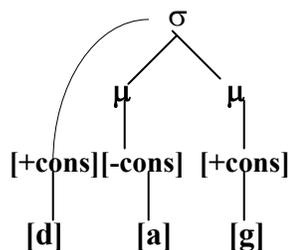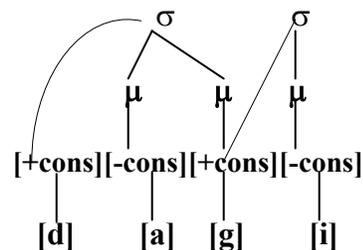
         [dagg] 'to cut'   [dag.gi] 'to go and cut'

Again, underlying material (moras, root nodes and feature bundles) is shown in bold. Geminates are associated with a single mora underlyingly. On the surface, the root node of final geminates is linked to a mora, which in turn is linked to the coda of a syllable (29a). In the surface representation of medial geminates (29b), the geminate is linked to

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[4] These "final geminates" are described as such by Church (1981), Ka (1988, 1994) and Ndiaye (1995). However, unlike medial geminates it is not clear that the primary acoustic cue for final geminates is closure

the coda position of the first syllable via a mora, and directly to the onset of the subsequent syllable. The mora of a medial geminate is associated with the coda, following standard assumptions (Hayes 1989) and the general ban on moraic onsets.

Next, I provide the representations of prenasalized voiced stops. Like singletons, prenasalized voiced stops are associated underlyingly with a single root node. However, unlike singletons, prenasalized voiced stops have a branching root node with a [+nasal] and a [-nasal] component (Sagey 1986, Clements and Hume 1995). This structure shows that prenasalized voiced stops have a more complex feature geometry than singletons below the level of the root node.

(30) a. Prenasalized voiced stop onset   b. Medial prenasalized voiced stop

→ [^{m}bee] 'to bleat'   → [maa.^{n}du] 'to be wise'
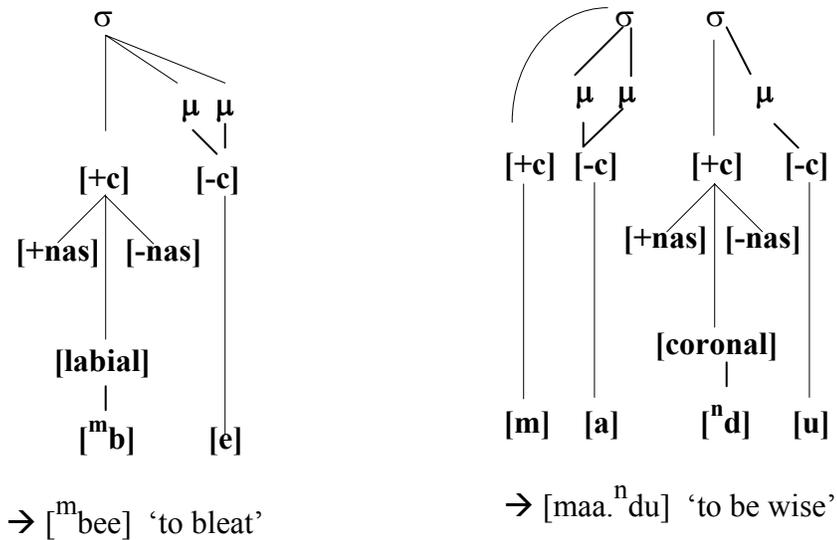
I follow Ka (1994) in analyzing prenasalized voiced stops as single segments in Wolof. In Ka's (1994) analysis, they are associated with a single C-slot. In my analysis, prensasalized voiced stops, like singletons, are associated with one [+cons] root node underlyingly. This node branches to include a [+nasal] and a [-nasal] component, while the entire root node is specified for place- [labial] in the case of (30a), [coronal] in (30b).

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duration. A pilot phonetic study (Bell 2000) suggests that final geminates are realized with a post-consonant schwa release, and that closure duration may not be as long as in medial geminates.

I follow the syllabification given by Ka (1988, 1994) in representing non-word-initial prenasalized stops as onsets (29b).

Recall from the discussion above that, according to Ka (1994), prenasalized voiced stops do not geminate in environments where singleton stops and nasals do. This is surprising, considering the broad similarities between prenasalized voiced stops and singletons in Wolof, and the existence of geminate prenasalized stops both cross-linguistically (for example in Sinhala (Letterman 1997)), and in related languages such as Fulfulde (McIntosh 1984). As I suggest above, a phonetic study would be extremely valuable in determining the status of prenasalized voiced stops in geminating environments. One possible result of such a study would be that, in fact, the closure duration of prenasalized voiced stops *does* lengthen, though perhaps not to the same extent as in other geminates. If prenasalized stops do not show any gemination effects, then we could propose a constraint against lengthening these segments (similar perhaps to the one I propose for fricatives in Section 5.3 below). I leave this question to future research.

Finally, consider the case of NC$_{-v}$ clusters. I state in this section that only vowels and geminates are underlyingly moraic in Wolof. However, we have observed the total absence of long vowels preceding NC$_{-v}$ clusters in monosyllables, indicating that they are weight-bearing (moraic) in some environments. Building on the idea of Moraic Prominence (Zec 1993), Goodman (1995) proposes that, in Ponapean, the more sonorous of the two segments in a nasal-stop cluster – i.e. the nasal – be associated with a mora. Although not underlyingly moraic, nasal-stop clusters are still weight bearing in Ponapean due to the association of the nasal with a mora. I propose a similar account for NC$_{-v}$ clusters in Wolof. Consider the representation in (31) below, which shows the nasal in an NC$_{-v}$ cluster in Wolof as being associated with a mora. This mora, which I co-index with the nasal, is not part of the underlying representation. Rather, it is inserted in case the NC$_{-v}$ cluster closes a monosyllable. This effectively gives the cluster weight-bearing status, equivalent to a geminate, explaining the similarities in distribution and behavior between geminates and NC$_{-v}$ clusters: they both contribute to syllable weight because they are both associated with a mora.

(31) Phonological representation of word-final NC₋ᵥ cluster

→ [bant] 'to cut'
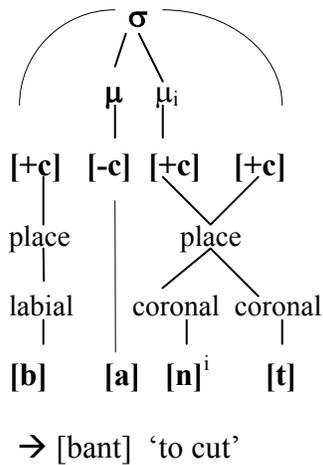
However, NC₋ᵥ clusters differ structurally from geminates, since each segment in an NC₋ᵥ cluster has its own root node. The two [+cons] root nodes in (31) share the same place node, following the cross-linguistic generalization that the nasal in homorganic NC clusters is placeless.

As we saw above in (26), nasals in NC₋ᵥ clusters are not always weight-bearing in Wolof. If they were, we would not find them following long vowels in disyllabic (and polysyllabic) words such as [*foon.tu*] 'to joke around'. The ban on trimoraic syllables prevents weight-bearing segments (i.e. geminates) from closing a syllable with a long vowel, yet NC₋ᵥ clusters can do precisely this. In monosyllables, NC₋ᵥ clusters are always moraic, since a mora is always associated with the nasal under Moraic Prominence. In disyllables, no mora is associated with the cluster, allowing NC₋ᵥ clusters to surface following long vowels. I provide a representation in of NC₋ᵥ clusters (32).

(32)   Phonological representation of word-medial NC$_{-v}$ clusters

→ [foon.tu] 'to joke around'
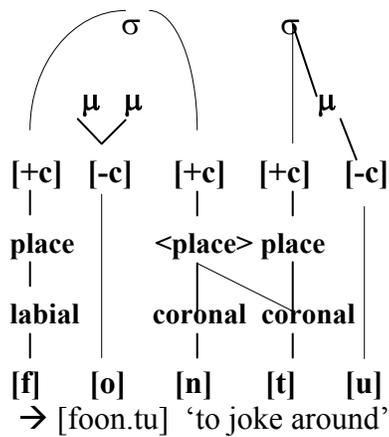
In (32), the mora associated with the nasal is not parsed. Such cases are easily explained in Optimality Theoretic terms. When the NC$_{-v}$ cluster is tautosyllabic, as in (31), the mora must be parsed. NC$_{-v}$ clusters are identical to geminates in this environment: they are always weight bearing. When the cluster syllabifies across a syllable boundary, as in (32), other well-formedness constraints – e.g. one calling for vocalic moras to be parsed in the output – outrank the constraint on parsing non-underlying moras such as the one associated with the nasal. Vowel shortening is not a valid repair strategy for the ill-formed trimoraic syllable that would result if all moras were parsed in (32). As I show below in Section 5, though, vowel shortening is precisely the repair strategy in Wolof when a geminate follows a long vowel in cases of gemination.

The failure to parse the mora associated with [n] does not affect the integrity of the NC$_{-v}$ cluster, as each segment has its own root node. This, as I discuss below, directly explains why degemination does not affect NC$_{-v}$ clusters. Although they may lose a mora, they remain sequences of two root nodes. Shortening an NC$_{-v}$ cluster would require underparsing of a root node, which is never observed in Wolof – e.g. there is no syncope.

Unlike CV-tier representations, the representations I propose above do not associate geminates and long vowels with two C-slots or V-slots, respectively. Instead, length is a manifestation of weight, encoded by the presence or absence of a mora.

Languages such as Icelandic (Selkirk 1990) and Lake Miwok (Tranel 1991) are argued to have so-called 'doubled consonants' – geminates that do not contribute weight to a syllable and are therefore not linked to a mora, but that are phonetically long nonetheless. Selkirk (1990) argues that such 'long consonants' are represented by two root nodes. Recent studies, including Broselow (1995), Goodman (1995), Hume et al. (1997) and Ham (1998), make it clear that both representations can exist in the same language: reference to root nodes provides the 'two timing slot' option, while reference to moras provides the weight-based option. Davis (1999), for example, argues for a "two root node" representation of initial geminates in Truckese, while other geminates in the language are weight bearing, i.e. moraic. However, based on the available evidence, there is no reason to posit divergent representations for Wolof geminates. Rather, I argue for a unified account in which all geminates – derived or underlying, medial or final – are associated underlyingly with a mora. Nasal-stop (NC$_{-v}$) clusters are different from geminates in having two root nodes, and having phonological weight only as the coda of a monosyllable. Prenasalized voiced stops are effectively single segments, especially as concerns syllable weight.

In the next section, I discuss moraic consonants and stress assignment.

4.3   Moraic consonants and stress assignment

To close Section 4, I return to the relationship between moraic segments, stress assignment, and syllable structure. As I noted above, only vowels affect stress assignment, while both moraic consonants and vowels play a role in syllable structure. To what can we attribute this apparent asymmetry in stress computation?

There are two possible routes to take. We could claim that geminates are best represented as non-moraic 'long' or 'doubled' consonants (Selkirk 1990). This would explain the stress facts, but not the syllable-structure facts. Furthermore, it would not allow for the unified analysis of gemination, segmental alternations and degemination that I develop below, which is closely tied to a moraic representation of geminates.

Fortunately, as I suggest above, Optimality Theory allows for another option, in which we can maintain moraic representations of geminates and also explain the stress

facts. Since all segments are specified as [±cons], we need simply to state that the only segments that affect stress assignment are both moraic *and* [-cons], i.e. vowels. Geminates are underlyingly associated with a mora, but they do not play a role in stress computation, owing to constraints on what types of segments can affect and/or bear stress. That is, segments specified as [+cons] play no role in stress assignment in Wolof.

In the next section, I develop an OT analysis of gemination, vowel and consonant alternations, and degemination based on the moraic representations of syllables that I have offered in Section 4.

5. Gemination and degemination

In this section I look in detail at gemination, concomitant vowel and consonant alternations, and degemination in Wolof. A number of morphological suffixes in Wolof trigger gemination of a coda consonant in the root (Section 5.1). These same suffixes also cause vowel and consonant alternations within the root to which they are added. Other suffixes cause degemination of a coda geminate, while some suffixes have no effect on the root. Previous analyses (reviewed in the relevant sections below) proposed a purely morphological account of these alternations. I argue in §5.2-5.5 that it is possible to explain them in phonological terms.

My analysis is grounded in three basic arguments. First, I propose that gemination, concomitant vowel and consonant alternations, and degemination are part of the same general process- changes to the root triggered by concatenation of certain morphemes. In other words, I posit a greater inter-relatedness between these alternations than is argued for in previous work. Secondly, I argue that, though morphologically triggered, these alternations still fit within the larger phonological patterns of the language. Thirdly, I argue, following one of the foundational ideas of generative phonology, that a phonological explanation is the null hypothesis. Given the argument that grammars are maximally simple for ease of processing and acquisition (cf. Mohanan 2000), we should if possible avoid an analysis in which forms are simply listed in the lexicon as "separate but related." If a systematic phonological explanation for these alternations *can* be given, then it *should* be given.

In the sections to follow, I put forth an Optimality Theory analysis (Prince and Smolensky 1993, McCarthy and Prince 1993b). In developing an OT account of the Wolof data, I propose a series of constraints that allow for the optimal (i.e. surface or observed) forms in Wolof, and rule out illicit forms – showing the characteristic interaction and tension between faithfulness and markedness.

With these ideas in place, let us move to a discussion of the data on gemination and degemination in the next section.

5.1   The data: A closer look

The data presented above in Section 2.3 show that Wolof has three varieties of morphological suffix. First, the vast majority of suffixes (31 of the 36 presented in Ka 1994) have no effect on the root. These I term *benign suffixes*. Secondly, there are three verbal suffixes in Wolof that trigger gemination and strengthening of root codas. These suffixes can also trigger vowel alternations and vowel shortening in the root to which they attach, and I term them *geminating suffixes*. Thirdly, there are two verbal suffixes that trigger degemination of a geminate root coda, and I term them *degeminating suffixes*. They trigger no vowel alternations.

Before moving to the data, I briefly discuss why, in all of the examples in this section, the suffixes in question are shown attached only to monosyllabic verb roots. There is a simple lexical explanation for this fact: virtually all underived verbs in Wolof are monosyllables of shapes CVC, CVVC or CVCC. The handful of geminating and degeminating suffixes all attach uniquely to verbs. Thus the data on morphologically triggered gemination and degemination in Ka (1994) and Ndiaye (1995) concerns mainly monosyllabic verb roots.

Now, let us look at the data, beginning with the benign group of suffixes. Most morphological suffixes in Wolof do not affect the root coda. In (33), I illustrate three of these suffixes, inchoative *-i*, benefactive *-al*, and passive *-u*. As we will see, two of these suffixes, *-i* and *-al*, are particularly interesting because they are homophonous with suffixes that affect changes on the root coda and/or root vowel. I will argue in Section

5.2 that the difference between benign and geminating suffixes is reflected in their underlying structure. First, consider some examples of three *benign* suffixes in (33).

As in all examples in this section, the forms on the left in (33) are roots, while on the right we see the root with the suffix appended. The Wolof verbal suffixes in (33), inchoative -*i*, benefactive -*al*, and passive –*u*, are among many that do not affect the root coda. Singletons (33a-b) do not geminate, nor do geminates (33c) degeminate. Nasal-stop clusters (33d) and prenasalized stops (33e) are unaffected, as are fricative codas (33f). Also, the benign suffixes do not trigger vowel shortening (33g) or any other vowel alternations. They have no effect on the root.

(33)   **No effect on root coda or vowel:** inchoative -*i*, benefactive -*al*, passive -*u*

a.	lem	'to fold'	→	lemi	'to go fold'
b.	ub	'to close'	→	ubu	'to be closed'
c.	takk	'to tie'	→	takki	'to go tie
d.	samp	'to plant'	→	sampal	'to plant for'
e.	si^{m}b	'to act like a lion'	→	si^{m}bi	'to go act like a lion'
f.	sof	'to join'	→	sofi	'to go join'
g.	boot	'to carry'	→	bootal	'to carry for'

(Ka 1995)

A small set of three verbal suffixes in Wolof can trigger the following alternations, depending on the shape and segmental content of the root: 1) gemination, 2) fricative strengthening, 3) vowel shortening, and 4) vowel alternation. These three suffixes are: reversive -*i*, corrective -*anti*, and completive -*ali*. I illustrate the four effects of these suffixes in (34-38) below.

The most common change effected by the geminating suffixes is, as one might expect, gemination of a singleton root coda. Whenever one of the three geminating suffixes is attached to a root with a singleton coda, the coda becomes a medial geminate. Consider the data in (34) below. The suffixes in (34) always trigger gemination of a singleton root coda. However, in case the root coda is already a geminate, or in case the root coda is a prenasalized voiced stop or a nasal-stop (NC$_{-v}$) cluster, the suffixes in (34) have no effect on the coda.

(34) **Gemination:** reversive *-i*, corrective *-anti*, completive *-ali*

    a. lem   'to fold'   →   lemmi   'to unfold'
    b. jot   'to obtain'   →   jottali   'to transmit'
    c. jub   'to be upright' →   jubbənti 'to rectify'

                                                             (Ndiaye 1995)

Next, consider the data in (35). These data show that the geminating suffixes have no effect on coda geminates, nasal-stop clusters, or (apparently) prenasalized voiced stops – though see Section 5.3 below for more discussion of this point. Note, however, that (35c) shows a vowel alternation [a] → [e]. Although this type of vowel alternation is only triggered by the geminating suffixes, the coda need not geminate, as in (34), for the vowel alternation to occur. One alternation can occur without the other.

(35) a. Agg   'to be completed' →   Aggali   'to complete'
      b. jekk   'to be all right'   →   jekkali   'to finish'
      c. samp 'to plant'   →   sempi   'to take out'
      d. si^{m}b 'to act like a lion' →   si^{m}bali 'to show great anger'
                                                          (Ka 1994)

In the analysis I propose in Section 5.2, the cases of morphologically triggered gemination in (34) are closely related to vowel shortening. Consider the data on vowel shortening in (36), which serve to illustrate that the geminating suffixes can also trigger vowel shortening in roots with long vowels. I argue in Section 5.2 that this alternation is related to a constraint against superheavy (or trimoraic) syllables in Wolof.

(36) **Vowel shortening:** reversive *-i* , corrective *-anti*, completive *-ali*

    a. suul   'to bury'   →   sulli   'to exhume'
    b. boot   'to carry'   →   botti   'to take off (the back)'
    c. yeew 'to tie'   →   yewwi 'to untie'
                                                      (Ndiaye 1995)

All singleton root codas geminate when a geminating suffix is attached. Stop, nasal and glide singletons, and the lateral /l/, surface as geminates with identical feature specifications in examples such as (34) above. Singleton coda fricatives, on the other hand, alternate with stops when a geminating suffix is attached. There are no geminate

fricatives in any environment in Wolof. I argue in Section 5.3 that fricatives cannot be geminates in Wolof owing to a constraint against weight-bearing (i.e. *moraic*) consonants specified as [+cont, -son]. First, consider the data in (37).

(37) **Fricative-stop alternations:** reversive *-i*, corrective *-anti*, completive *-ali*

      a. sof 'to join' → soppi 'to disjoin; to change'
      b. fas 'to tie' → fecci 'to untie'
      c. sox 'to load a gun' → soqqi 'to fire a gun'

                                                    (Ndiaye 1995)

I argue below that the cases of gemination illustrated above are the result of a *floating* or unassociated mora at the left edge of the suffix associating with the root coda. Vowel shortening results from the constraint against superheavy syllables. Fricative strengthening relates to the fact that fricatives cannot bear a mora in Wolof. Thus, I argue that the alternations in (34-37) are integrally related and triggered by the same structural property of the geminating suffixes.

      The three geminating suffixes under discussion can also trigger vowel alternations in roots to which they attach. Consider the data in (38).

(38) **Vowel alternations**: reversive *-i*, corrective *-anti*, completive *-ali*

      a. təj 'to close' → tijji 'to open'
      b. takk 'to tie' → tekki 'to untie'
      c. samp 'to plant' → sempi 'to take out'
      d. tag 'to be stuck' → tAgganti 'to take down'

                                               (Ka 1994, pp. 67-89)

The vowel alternations in (38) are triggered by the presence of one of the geminating suffixes. However, they are not related to syllable weight or mora distribution like the alternations in (34-37), since they occur with or without gemination. Rather, I argue that they are triggered by unassociated features at the left edge of the suffixes that caused vowels to raise and front. I propose an account of these data in Section 5.4.

      In (35) we observe that not all roots show alternations when a geminating suffix is attached. Certain roots are immune to the effects of the geminating suffixes simply by virtue of their shape and segmental content. A geminate coda cannot lengthen further; a

short vowel does not shorten further, and, as we have seen, some vowels do not alternate. Indeed, as I show below, the number of alternating vowels is limited to three. However, all of the alternations in (34-38) can freely combine, and a single root can show all four alternations. Consider the data in (39).

(39)   yaah 'to be large'   →   yAkkali 'to enlarge'

                                                                (Ndiaye 1995)

In (39) we see all four alternations caused by the geminating suffix *-ali* affecting the same root. In the form on the right, we can enumerate the following changes to the shape of the root on the left. The fricative coda [h] has 1) strengthened, and 2) geminated to [kk]; the vowel has 3) shortened, and 4) become [+ATR], i.e. more front, as I argue below in Section 5.4.

Finally, there are two suffixes in Wolof that trigger degemination of a root coda geminate: causative *-al* and nominalizing *-o*. These suffixes appear to have the opposite effect of the geminating suffixes: whenever they are added to a root with a geminate coda, the coda becomes a singleton. Consider the data in (40).

(40) **Degemination**: causative *-al* , nominalizing *-o*

       a. bətt   'to pierce'   →   bətəl   'to cause to pierce'
       b. takk   'to tie'   →   takal   'to cause to tie'
       c. segg   'to be filtered' →   segal   'to press oily products'
       d. sonn   'to be tired'   →   sonal   'to tire, to bother'

                                                                (Ndiaye 1995)

The two suffixes in (40) always cause a geminate coda to degeminate. Note that the causative *-al* is homophonous with the benign benefactive suffix *-al*, which triggers no change to the root coda. Therefore, following the general line of argumentation I am developing, I suggest that there is something distinct about the underlying structure of the degeminating suffixes *-al* and *-o*.

Recall from Section 3 above that Wolof has a strong preference for underived disyllabic words with foot shape **L.L**. Based on this fact, I argue in Section 5.5 below that a feature associated with the degeminating suffixes causes the derived form

(root+suffix) to prefer the least marked foot structure in Wolof, **L.L.** This feature essentially forces the degeminating suffix to be part of the prosodic word by causing the [+consonant] mora of the root coda to be underparsed, resulting in degemination.

As we have seen, geminating suffixes have no effect on geminate codas (35). Similarly, the degeminating suffixes have no effect on singleton codas. Like the geminating suffixes, degeminating suffixes also have no effect on prenasalized voiced stops or NC₋ᵥ clusters. Consider the data in (41).

(41)   a. fen   'to lie'   →   fenal 'to make lie'
         b. samp 'to plant' →   sampal 'to make plant'
         c. jAng 'to learn' →   jAngal 'to teach'
                                       (Ka 1994)

Unlike the geminating suffixes, the degeminating suffixes do not trigger vowel shortening or vowel alternations in roots. Consider the following data.

(42)   a. fees 'to be full' →   feesal 'to make full'
         b. ɲuul 'to be black' →   ɲuuləl 'to blacken'

(43)   a. bətt 'to pierce' →   bətəl 'to make pierce'
         b. am   'to happen' →   amal   'to cause'
                                       (Ndiaye 1995)

The data in (42a-b) show that degeminating suffixes do not trigger vowel shortening. The forms on the right, with the suffix *-al* added, have long vowels just as the underived verb roots on the left do. In (43a-b), we see that the degeminating suffixes do not trigger vowel alternations. As I show below, /ə/ and /a/ are the two alternating vowels in Wolof in geminating environments, so we would expect them to alternate in (43a-b) if the degeminating suffixes triggered vowel alternations. Apparently, they do not. Compare the data in (43a-b) with that in (38a-d) above.

In the next four sections I present my analysis of the data that we have seen in this section. I also briefly discuss previous analyses of the data where relevant. In Section 5.2, I propose an account of gemination and vowel shortening. In Section 5.3, I provide an analysis of fricative strengthening. Then, in Section 5.4, I tackle the vowel

alternations that occur when a geminating suffix is added to a root. Finally, in Section 5.5, I propose an analysis of degemination.

5.2   Analysis of morphologically triggered gemination

In this section, I offer an OT analysis of morphologically triggered gemination in Wolof based on the notion that geminates are weight bearing, or moraic. Recall the basic data on morphologically triggered gemination.

(44)   **Gemination:** reversive *-i* , corrective *-anti* , completive *-ali*

        a. jub 'to be straight' ➔   jubbǝnti 'to correct, rectify'
        b. dog 'to die'   ➔   doggali 'to close the eyes of the dead'
        c. lem 'to fold'   ➔   lemmi   'to unfold'
                                                 (Ka 1994, p. 94)

Ka (1988, 1994) attempts a rule-based account of the data in (44). He considers a rule of gemination that "in linear terms, lengthens a simple consonant in root-final position" (Ka 1994, p. 88). To account for this rule, which is triggered for example by the reversive *-i* but not the inchoative *-i,* Ka (1994) suggests that the geminating suffixes may have an unassociated C-slot in the onset that takes on the features of the preceding root coda. This, he says, would result in two identically specified C-slots, i.e. a geminate. However, Ka (1994) rejects this proposal on the following grounds:

(45)   a.   An unassociated C would lead to illicit CCC clusters in roots.
        b.   Vowel insertion (from a previously-posited rule) should break up
              sequences of (CCC), but does not
                                       (Ka 1994, pp. 88-91)

Given these problems, Ka (1994) abandons a phonological explanation of gemination, stating that "gemination and degemination may be alike in having been morphologicalized" (Ka 1994, p. 99).

Ndiaye (1995, pp. 140-168) offers a strict morphological explanation of the data in (44), positing a "flexible model of lexical creativity and memorization." His is an associative model in which underived and derived forms are separate entries in the mental lexicon. This approach effectively offers no systematic explanation of the data.

Following the initial idea of Ka (1994), I propose that there is unassociated material at the left edge of the geminating suffixes. However, this material is not an unassociated C-slot but an unassociated mora. It is clear, under a moraic account, that attaching a geminating suffix to a verb root in Wolof has one simple effect: it adds weight, in the form of a mora, to all non-moraic (i.e. singleton) codas. When one of the suffixes in (44) is added to a CVC or CVVC root, the coda geminates, i.e. becomes moraic.

Following Letterman's (1997) treatment of Sinhala, I propose that the geminating suffixes each contain a floating mora at their left edge in underlying structure. This mora is not associated with any segmental material. When a geminating suffix is attached to a root with a singleton coda, the floating mora is associated with the coda consonant, adding weight to a previously weightless segment. This added weight is realized as a geminate.

I offer the underlying representations of the three geminating suffixes in Figure 1.

$[\ ^{\mu}i^{\mu}]$ $[\ ^{\mu}a^{\mu}li^{\mu}]$ $[\ ^{\mu}a^{\mu}nt\ i^{\mu}]$
→ reversive /i/   → completive /ali/   → corrective /anti/[5]

Figure 1: Underlying representation of geminating suffixes in Wolof

In addition to their underlying vocalic moras, I propose that each geminating suffix possesses a floating mora, μ, associated with the left edge of the segmental content of the suffix. When the suffixes in Figure 1 are added to a CVC or CVVC root, the floating mora is aligned with the segmental material in the coda position of the root and parsed into higher prosodic structure, adding weight and triggering gemination. Therefore, the difference between the geminating reversive suffix *-i* and the non-geminating inchoative suffix *-i* is their underlying structure. The geminating suffix has a floating mora at its left edge, and the non-geminating suffix does not. Consider the output forms when each of these suffixes is appended to the root *lem,* 'to fold.'

---

[5] The NC$_{-v}$ cluster in *-anti* is medial and therefore, following the representation in Section 4, non-moraic.

(46)   a.   lem   + -*i*   →   le.mi
                'to fold'   'inchoative'   'to go fold'

        b.   lem   + $^{\mu}$*i*   →   lem$^{\mu}$.mi
                'to fold'   'reversive'   'to unfold'

In (46) I represent only the floating mora of the reversive suffix -*i*, although all vowels are also associated underlyingly with a mora, as in Figure 1. When the reversive suffix -*i* is attached to a root with a singleton coda, the mora associates with the coda, as in the form on the right [lem.mi]. In what follows, I develop an OT analysis of this proposal.

First, I posit two constraints requiring every mora present at the input to have a correspondent in the output (Goodman 1995, McCarthy 1997b). I argue that moras are subject to faithfulness constraints depending on the feature specifications of the segment with which they are associated, vowel or consonant. For example, as I discuss below in Section 5.5, moras associated with a consonant are more easily deleted in Wolof than moras associated with a vowel – i.e. Wolof has degemination. I provide the moraic faithfulness constraints in (47a-b).

(47) a. **PARSEC-μ**   A mora associated with a [+cons] segment must be parsed into
                         higher prosodic structure. (Goodman 1995)

      b. **PARSEV-μ**   A mora associated with a [-cons] segment must be parsed into
                         higher prosodic structure. (Goodman 1995)

The constraints in (47) require moras to be parsed into higher prosodic structure. There are separate constraints governing vocalic and consonantal moras, since, as we will see below, the two show distinct behavior in Wolof.

In gemination environments, we observe that the floating mora takes primacy over vocalic moras – i.e. Wolof has vowel shortening. However, in degemination environments, as I show in (40)-(43) above and Section 5.5 below, vocalic moras take precedence over consonantal moras: there is degemination but no vowel shortening. Therefore, it cannot be the case that PARSEC-μ outranks PARSEV-μ in cases of gemination. This suggests that parsing of the floating mora is handled by another constraint. As I argue below, Wolof has other unassociated or *floating* features besides

the floating mora. All floating material must in principle be parsed into higher prosodic structure, suggesting the following general constraint.

(48)   **PARSE-F**   "*Floating*" material must be parsed into higher prosodic structure.

The constraint in (48) requires "floating" or unassociated material to be parsed: in this particular case, the floating mora. We could posit a specific constraint requiring the floating mora to be parsed. However, the constraint in (48) can be applied to all cases of floating material in Wolof, and therefore has more general applicability.

      The floating mora associates with the root at its right edge. If the right edge of the root is a singleton coda, then association with a mora causes gemination of the consonant. However, there is a faithfulness constraint that militates against lengthening (or shortening) of a consonant:

(49)   **WEIGHT-IDENT CONSONANT**   No lengthening or shortening of consonants
                                                                              (McCarthy 1995, Keer 1999)

The constraint in (49) prohibits any change in weight of [+cons] segments. Because we observe gemination in Wolof (i.e. the floating mora does associate), WEIGHT-IDENT CONSONANT is clearly outranked by PARSE-F.

      Next, I propose a constraint calling for proper alignment of the geminating suffixal morpheme. The left edge of suffixes in Wolof is always aligned with the right edge of the root to which they attach, according to the following constraint.

(50)   **ALIGN-S-RIGHT**   Align the left edge of a suffix (S) with the right edge of a root.

This generalized alignment constraint for suffixes in Wolof follows constraints such as Prince and Smolensky's (1993) EDGEMOST and Letterman's (1997, p. 234) ALIGNCLITIC, both stemming from proposals by McCarthy and Prince (1993a) on alignment. ALIGN-S-RIGHT requires that the left edge of the geminating suffix be aligned with the right edge of the root. Since the left edge of the geminating suffix is not segmental material, but a floating mora, alignment takes on a rather particular interpretation in the case of Wolof geminating suffixes. When a geminating suffix is properly aligned with a root, the floating mora is *associated* with the right edge of that

root. To associate the mora with any other segment besides the right edge of the root would violate linearity. The left edge of a suffix is usually associated with the right edge of a root in Wolof, except in cases of glide insertion to break up an illicit vowel hiatus. This suggests that ALIGN-S-RIGHT is relatively highly ranked in Wolof.

Finally, I posit a constraint against moraic onsets. As is widely observed cross-linguistically, onsets are rarely moraic. In Wolof they are never moraic.

(51)   ***ONSET-μ**   Onsets are not moraic.

*ONSET-μ prevents the floating mora from linking to an onset. The mora must be associated with a coda. Although some languages have geminate onsets, they are rarely moraic (Hume et al. 1997, Ham 1998, Davis 1999). As I show above, Wolof does not allow geminate or complex onsets. These facts suggest a high ranking of *ONSET-μ. Below we will see a data-driven example of the importance of ranking *ONSET-μ above PARSE-F

Consider the constraint ranking and the evaluation of the input / lem+$^{\mu}$i/ that I provide in Tableau 1.

le$^{\mu}$m+$^{\mu}$i	ALIGN-S-RIGHT	*ONSET-μ	PARSE-F	WEIGHT-IDENTC
☞a. le$^{\mu}$m$^{\mu}$.mi				*
b. le$^{\mu}$.m$^{\langle\mu\rangle}$i			*!	
c. le$^{\mu}$m.m$^{\mu}$i		*!		
d. le$^{\mu}$e$^{\mu}$.mi	*!			*

ALIGN-S-RIGHT, *ONSET-μ >> PARSE-F >> WEIGHT-IDENT CONSONANT
Tableau 1: Floating-mora linking

The form (a) in Tableau 1 allows gemination and violates only the low-ranking constraint WEIGHT-IDENTC. Indeed, (a) is the optimal form, since it associates the floating mora with the coda position of the root and allows the mora to be parsed. The form in (b) does not parse the floating mora, violating PARSE-F̃ The form in (c) is sub-optimal due to a violation of *ONSET-μ. The mora is parsed, but onsets cannot be moraic in Wolof.

Finally, the form in (d) associates the floating mora with the vowel of the root, violating ALIGN-S-RIGHT and linearity.

Recall from Section 5.1 that geminating suffixes have no effect on geminate codas. Consider the data in (52), which show that the root coda does not lengthen further in case it is already a geminate.[7] Note that the leftmost syllable in (52) is already bimoraic, possessing a vocalic mora and a consonantal mora associated with the geminate.

(52)   jekk 'to be all right'   →   jekkali   'to finish'

The association of the floating mora with the (already moraic) coda in (52) would create a trimoraic syllable. This is ruled out by a constraint against superheavy, or trimoraic, syllables, given in (53).

(53)   ***[μμμ]**   No trimoraic syllables (McCarthy and Prince 1993b)

The constraint in (54) militates against syllables containing three moras. The presence of the geminating suffix following codas that are already geminates suggests that the constraint banning trimoraic syllables outranks PARSE-F. Indeed, since we never observe trimoraic syllables in Wolof, *[μμμ] may be undominated.

We could also explain the data in (52) above with a constraint prohibiting consonants from bearing more than one mora: *Cμμ. However, *[μμμ] has more general applicability in Wolof: it is also active in cases of vowel shortening. The constraint in (53) is argued to be active in languages that show similar behavior of geminates and long vowels to Wolof, such as Arabic (Broselow, et al. 1997), Ponapean (Goodman 1995), Sinhala (Letterman 1997) and Bernese (Ham 1998). Although trimoraic syllables exist in languages like Fulfulde, Hungarian and Finnish, they are strongly dispreferred cross-linguistically, and they are illicit in Wolof, again suggesting a high ranking of *[μμμ].

I give the evaluation of the input /je^{μ}k^{μ} +^{μ}ali/ in Tableau 2. For ease of presentation I represent only the floating mora in the suffix.

$je^{\mu}k^{\mu}+^{\mu}ali$	*[μμμ]	ALIGN-S-RIGHT	*ONSET-μ	PARSE-F	WEIGHT-IDENT
☞a. $je^{\mu}k^{\mu}.k^{\langle\mu\rangle}a.li$				*	
b. $je^{\mu}k^{\mu\mu}.ka.li$	*!				*
c. $je^{\mu\mu}k^{\mu}.ka.li$	*!	*			*
d. $je^{\mu}k^{\mu}.k^{\mu}a.li$			*!		*

*[μμμ], ALIGN-S-RIGHT, *ONSET-μ >> PARSE-F >> WEIGHT-IDENT

Tableau 2: Floating mora does not parse: root coda is already a geminate

The form (b) in Tableau 2 associates the floating mora with the coda geminate, creating a trimoraic syllable and fatally violating *[μμμ]. The form in (c) is also suboptimal, since it does not align the floating mora with the right edge of the root and also violates *[μμμ]. In (d), the floating mora is associated with an onset, fatally violating the constraint against moraic onsets. This form shows the crucial ranking of *ONSET-μ >> PARSE-F̃ The optimal form, (a) in *Tableau 2*, does not parse the floating mora, and adds no weight to the geminate coda. Thus we observe that geminate codas are unaffected by geminating suffixes in Wolof, and that *[μμμ] outranks PARSE-F.

Finally, recall the cases of vowel shortening from Section 5.1 above, which I repeat below.

(54) **Vowel shortening:** reversive -*i*, corrective -**anti,** completive –**ali**

    a. suul 'to bury' →   sulli   'to exhume'
    b. boot 'to carry' →   botti   'to take off (the back)'
    c. yeew 'to tie'   →   yewwi 'to untie'

                          (Ka 1994, p. 94)

The addition of a geminating suffix to the roots on the left in (54a-c) has two effects: the root coda consonant geminates and the root vowel shortens, as we see in the forms on the right. Whenever a geminating suffix is added to a CVVC stem, vowel shortening occurs. In the account that Ka (1988, 1994) and Ndiaye (1995) adopt, the short vowels in the forms on the right in (54) are listed in the lexicon as such. Gemination and concomitant vowel shortening are, according to Ka (1994) and Ndiaye (1995), morphologized

processes. Ka (1994) and Ndiaye (1995) offer no explanation of how vowel shortening fits in with larger phonological patterns of the language.

Again, relying on the moraic approach I adopt in this paper, I argue that vowel shortening in gemination environments is the direct result of the constraint against trimoraic syllables, *[μμμ], given in (53) above. This constraint interacts with the faithfulness constraints requiring the floating mora to be parsed, PARSE-F, and the constraint requiring underlying vocalic moras to be parsed into higher prosodic structure, PARSEV-μ.

Given the surface forms encountered in Wolof, we see that it is more important to parse the floating mora than it is to parse vocalic moras. Vowels shorten in (54) while geminates do not, showing that PARSE-F̣outranks PARSEV-μ. As we will see in Section 5.5 below, there is another crucial ranking of PARSEV-μin cases of degemination. While the floating mora takes precedence over vocalic moras, vocalic moras in turn take precedence over underlying consonantal moras, showing that PARSEV-μ outranks PARSEC-μ̃

I give a constraint ranking and an evaluation of the input /suul +$^{\mu}$i/, 'to exhume', in Tableau 3.

su$^{\mu}$u$^{\mu}$l+$^{\mu}$i	PARSE-F	*[μμμ]	PARSEV-μ
☞a. su$^{\mu<\mu>}$l$^{\mu}$.li			*
b. su$^{\mu}$u$^{\mu}$l$^{\mu}$.li		*!	
c. su$^{\mu}$u$^{\mu}$.l$^{<\mu>}$i	*!		
d. su$^{\mu<\mu>}$.l$^{<\mu>}$i	*!		*

PARSE-F̣*[μμμ] >> PARSEV-μ
Tableau 3: Vowel shortening in Wolof

The output form (b) Tableau 3 is ruled out by the constraint against trimoraic syllables. Both (c) and (d) violate PARSE-F, leaving (a), the output with a shortened vowel, as the

optimal form. Thus gemination, no change in geminate root codas, and vowel shortening all follow directly from the optimal interpretation of the floating mora in the suffix.

In the next section, I consider fricative-stop alternations in gemination.

5.3   Fricative-stop alternations

In this section I extend the OT analysis of gemination to the fricative-stop alternations that occur in gemination. Recall the data in (55) below, in which underlying singleton fricative codas /f/, /s/ and /x/ strengthen into geminate stops [p], [c] and [x] respectively. I argue that these alternations are directly related to gemination. Consider (55).

(55)   a. sof 'to join'   →   soppi 'to disjoin; to change'
        b. fas 'to tie'   →   fecci 'to untie'
        c. sox 'to load (a gun)' →   soqqi 'to unload'
                                                            (Ndiaye 1995)

Ka (1994) also documents what he calls a " Ø ~ kk alternation," as in (56).

(56)   dee   'to die'   →   dekki 'to resuscitate'   (Ka 1994, p. 69)

Following Ndaiye (1995), however, I will argue that the root on the left has an underlying /h/ in coda position.

Finally, there is an alternation between /r/ and [dd] as in (57).

(57)   a. teer   'to arrive' →   teddi   'to depart'
        b. xaar   'to wait' →   xAddi   'to tire of waiting'
        c. wEEr   'to lean' →   wEddi   'to take from a leaning position'
                                                            (Ka 1994)

Ka (1994, p. 84) explains the alternations in (55)-(57) as follows. First, he argues that /p/, /d/, /c/, /k/ and /q/ "do not appear phonetically in medial or final position.". Thus the example on the left in (55a) is /fac/ underlyingly, according to Ka. The rule of gemination in Ka (1994, p. 88) applies to the underlying stops in (55)-(57). Since

fricatives are never singletons underlyingly in coda or medial position, Ka argues, they can never surface as derived geminates.

To explain the apparent absence of singleton stops in coda position, Ka (1994, p. 98) posits a rule of spirantization that transforms singleton stops into fricatives. However, as Ka (1994) notes, /t/ *does* appear freely in coda position. Thus, the rule of spirantization "refers to an unnatural class of sounds" – a problem for which he has "no answer [. . .] at the present time" (p. 84). Despite its apparent shortcomings, this analysis has been adopted in subsequent work, including Keer (1999, p. 167), who states that, "the voiceless series [of Wolof stops] spirantize intervocalically and finally, as does the voiced stop d." In his brief discussion of Wolof, Keer (1999) follows Ka (1994) in arguing that Wolof stops are underlying, giving the following stop-fricative mapping for Wolof.

(58)   p → f
            c → s
            k → Ø
            q → x
            d → R

                                        (Keer 1999, p. 167)

Keer (1999) does not propose an analysis for gemination in Wolof, nor does he offer any insight into the fact that /t/ does not spirantize, and that spirantization therefore affects an unnatural class of sounds. He mentions the Wolof data only as it relates to a proposed *CONTINUANT constraint.[8]

Contra Ka (1994) and Keer (1999), I have found numerous examples of word-final voiceless stops /p/, /c/ and /k/. Consider the data in (59).

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[8] Keer (1999) argues that *VOICEDCONT is highly ranked in Wolof. However, it is unclear why this constraint would not block continuant glides /w/ and /y/ from surfacing in coda and medial position, which they do.

(59)   Counterexamples to the spirantization rule in Ka (1994).

Coda /p/   **Coda /c/**   **Coda /k/**
a. tәp   'to jump'   e. xooc 'to soak'   i. tek   'to start cooking'
b. rәp   'to be exciting' f. xәc 'to suffocate'   j. book   'then, in that case'
c. torop   'very'   g. doc 'rock'   h. nak   'and'
d. xeep   'to judge'   h. fac 'to cure'

                                                               (Munro & Gaye 1997)

In (59) I give some examples of word-final voiceless stops in coda position. There are also numerous examples of medial /k/. Examples of medial /c/ and /p/ are rare, owing to intervocalic voicing of these segments. In light of the data in (59), it is difficult to maintain Ka's (1994) claim that these segments never surface in coda position. Why would the spirantization rule not apply to the words in (59)? These data seem to separate the voiceless stops from /d/, which in fact never surfaces as a singleton in coda position in the data I have encountered. Yet, *contra* Ka (1994), /d/ does occur as a singleton in medial position, as I show in the following examples:

(60)   Counterexamples to the /d/ spirantization rule in Ka:

        a. wuude 'leather worker'   d. abada 'forever'
        b. bidaa   'superstition'   e. jaadu 'to be fair'
        c. daadi   'then'   f. jaaru 'to warm oneself'
                                           (Munro & Gaye 1997)

Although /d/ never appears as a singleton coda in Wolof, it does occur frequently in medial position, in both borrowings (60d, from Arabic) and native Wolof words. It is even contrastive with its supposed spirantized counterpart [r] in medial position, as I show in (60e-f). These data cast doubt on the analysis of Ka (1994), since it appears that the spirantization rule, if it exists at all, applies inexplicably to some words and not to others.

        To account for the data in (55)-(57) above, I propose a different approach. First, I argue that the r~d alternation is a separate case from the fricative~stop alternations. While /d/ never surfaces as a coda, the stops /p/, /c/ and /k/ do, as I show above. The r~d

alternation in gemination could be attributed to a ban on geminate /r/ in Wolof. Consider the data in (61).

(61)   **Root**   **+ reversive -*i***   **+ passive -*u***

   a. teer   'to arrive'   c. teddi   'to depart'   e. teeru   'to welcome'
   b. wEEr 'to lean'   d. wEddi 'to take from   f. wEEru 'to be leaning'
                                             a leaning position'

                                                                              (Ka 1994)

The data in (61a-b) show a singleton [r] in coda position. When the geminating reversive suffix -*i* is appended in (61c-d), the floating mora attaches to the coda and triggers gemination and vowel shortening. In (61e-f), we see that [r] is unaffected by the *benign* passive suffix -*u*. Therefore, the case of /r/ looks very much like other cases of gemination, with the added complication that /r/ never surfaces as a geminate, presumably due to a constraint against geminate /r/ which I do not formalize here. The absence of /d/ as a singleton coda could be due to a spriantization rule such as that proposed by Ka (1994). In OT terms, we could formalize this as a ban on singleton coda /d/. We are left with the intuition that /r/ and /d/ in final position are the same phoneme underlyingly in Wolof; /r/ surfaces only as a singleton, while /d/ surfaces only as a geminate.

Secondly, following Ndiaye (1995) and *contra* Ka (1994) and Keer (1999), I argue that the Ø~kk alternation as in (56) is actually an h~kk alternation. Ndiaye (1995) systematically transcribes examples such as (56) *dee* 'to die' with an /h/ in the coda, *deeh*. As I discuss below, a similar alternation in feature specification between /h/ and /k/ exists in non-concatenative morphology in Wolof. Therefore, I represent cases such as (56) above as follows:

(62)   deeh   'to die'   →   dekki 'to resuscitate'

If /r/ is taken as a separate case, we now have a natural class to work with- the voiceless fricatives /f/, /s/, /h/ and /x/. We observe that either fricatives never surface as geminates, or that there are no fricative geminates in Wolof. I argue that fricatives never surface in

Wolof due to a constraint against [+continuant,-sonorant] moraic segments (i.e. geminate voiceless fricatives). When a geminating suffix attaches to a root with a fricative coda, the floating mora associates with the singleton fricative. This process induces the fricative to geminate, because the floating mora must be parsed. However, segments specified as [+cont, -son] cannot geminate in Wolof. Therefore, a repair strategy of fricative strengthening allows the floating mora to be parsed, and the singleton fricative surfaces as a geminate stop. I offer the constraint in (63).

(63)   ***[+cont, -son]$_\mu$**   [+cont, -son] segments are never moraic.

The constraint in (63) is similar to the constraint against moraic continuants proposed by Bakovic (1995) and Keer (1999). However, *[+cont, -son]μ applies only to fricatives, and not to continuants generally. Recall that /w/ and /y/, specified as [+cont, +son], do surface as geminates in Wolof. We do not want to rule out these cases. Therefore, (63) refers specifically to non-sonorant continuants. The constraint in (63) is in direct conflict with the faithfulness constraint calling for the feature [+continuant] to be maintained.

(64)   **MAX[CONT]**   [+cont] segments in the input must remain [+cont] in the output.

We observe a change in feature specification from [+cont] to [-cont] in the case of fricative strengthening. This indicates that *[+cont, -son]$_\mu$ outranks MAX[CONT], I provide a constraint ranking for the data in (55) above, as well as an evaluation of the input form /sox +$^\mu$i/, in Tableau 4.

sox +$^\mu$i	*[+cont, -son]$_\mu$	PARSE-F	WEIGHT-IDENTCONS	MAX [CONT]
a. sox$^\mu$xi	*!		*	
b. so.x$^{<\mu>}$i		*!		
☞c. soq$^\mu$.qi			*	*

*[+cont, -son]μ, PARSE-F >> WEIGHT-IDENT CONSONANT, MAX [CONT]
Tableau 4: Fricative strengthening in gemination.

The form (a) in Tableau 4 associates the floating mora with the uvular fricative [x], violating *[+cont, -son]μ. The form in (b) does not parse the floating mora, violating PARSE-F. The optimal form, (c), strengthens the fricative to a stop, although, as in all cases of gemination, (c) violates the relatively low-ranking WEIGHT-IDENTC.

As I mentioned in Section 2.3 above, these are not the only cases of fricative strengthening in Wolof. There are also examples of non-concatenative morphology, in which a fricative onset of a verb becomes a stop, signaling nominaliztion. Consider the data in (65).

(65)   a. fO   'to play'   →   pO   'game'
        b. sacc   'to fly'   →   cacc   'flight'
        c. xiif   'to be hungry'   →   qiif   'hunger'
        d. haand   'to be together'   →   kaand   'guest'

                                                              (Ka 1994)

The forms on the right are derived from the forms on the left. In the data on the right, strengthening of a [+continuant] fricative onset into a [-continuant] stop signals nominalization. I do not propose an account of alternations related to non-concatenative morphology in Wolof. However, following the general ideas in my analysis up to this point, it is possible that the data in (65) also involve a floating feature. This feature, which we could call [-continuant], is not associated with a suffix as in the case of the floating mora, but rather takes the shape of a prefix. The fact that it affects only onsets in non-concatenative morphology means we could conceive of it as a prefix (which raises the possibility that the data in (65) *do in fact* involve concatenation, even if it is concatenation of a prefix with only featural content). When [-continuant] docks and is associated with the onset, fricative strengthening occurs.

Assuming the account outlined above is correct, there is a clear relationship between alternations in morphologically triggered gemination and the nominalization cases above in (65): both involve fricative strengthening. In gemination, [+continuant] fricatives cannot bear a mora and must become [-continuant]; in nominalization, a floating feature causes [+continuant] fricatives to become [-continuant] stops. Note that the data in (65) strengthen the hypothesis that the absence of geminate /r/ is separate from

fricative strengthening in gemination environments. There are no examples of r~d alternations in nominalization, suggesting that fricative strengthening is the operative process in both gemination and nominalization.

The approach to fricative strengthening I outline here has several advantages. First, it deals with the natural class of voiceless fricatives. Secondly, it relates the gemination and nominalization facts to the independent strategy of fricative strengthening. Thirdly, it allows for the counter-examples to the spirantization rule proposed by Ka (1994), since no spirantization rule is necessary.

In the next section, I propose an account of vowel alternations observed in cases of root coda gemination.

5.4   Vowel alternations

In this section I analyze stem vowel alternations that occur when a geminating suffix is attached to a verb root. Ka (1994) documents three alternating vowels, /ə/, /O/ and /a/, as I illustrate in (66).

(66) **Vowel alternations**: reversive *-i* , corrective *-anti* , completive *-ali*

	ə		➡	i	
a.	təj	'to close'		tijji	'to open'
b.	dəpp	'to put upside down'		dippi	'to put rightside up'

	O		➡	u	
c.	nOOx	'to stuff'		nuqqi	'to extract'

	a		➡	e	
d.	fas	'to tie'		fecci	'to untie'
e.	samp	'to plant'		sempi	'to take out'
f.	takk	'to tie'		tekki	'to untie'

	a		➡	o	
g.	mat	'to be enough'		mottali	'to complete'
h.	nas	'to thread'		nocci	'to take out a thread'

	a		➡	A	
i.	tag	'to be stuck'		tAgganti	'to take down'
j.	saf	'to be tasty'		sAppi	'to lose taste'

(Ka 1994, p. 95)

The data in (66) show vowel alternations in the roots (on the left) when a geminating suffix is appended (on the right). Recall that these vowel alternations occur regardless of whether gemination actually occurs (66a) or whether it is blocked by the presence of an NC₋ᵥ or a geminate coda (66b,e). Also, recall that all three geminating suffixes produce the same vowel alternations in root vowels.

In (66b) we observe /ə/ and /**O**/, specified as [-high], alternating with [i] and [u], specified as [+high]. In (66c-e) we see the data become slightly more complex. The low vowel /a/ alternates with one of three vowels: [o], [e] or [A]. It is apparent that these alternations are not based on ATR vowel harmony, since both [+ATR] and [-ATR] vowels alternate when confronted with the same root (66c-d). In what follows, I will argue that the alternations in (66) are tied to vowel height and backness. Consider the data in (67).

(67)   a. ub   'to close'   ubbi   'to open'
        b. lem   'to fold'   lemmi   'to unfold'
        c. bir   'to be clear'   biddənti   'to wake up late'

The data in (67) show that vowels specified as [-back] do not alternate. Only the vowels listed in (66) show the alternations I attempt to explain here. Alternations in the [a] of the suffixes *-anti* and *-ali*, such as in (66c), are examples of ATR harmony and are not relevant to my analysis.

Ka (1994) suggests that the data in (66) may be related to vowel harmony. Specifically, he proposes that the root vowel agrees in height with a vowel in the geminating suffix. This, he argues, would explain the alternations triggered by the reversive *-i*, but not the corrective *-anti* or the completive *-ali*, since "those suffixes have an initial low vowel" (Ka 1994, p. 96). However, as I argue below, it is not the final vowel in each of these roots that triggers the observed alternations. Instead I propose that some of the data in (66) are the result of an unassociated feature on the geminating suffixes.

First, let us take a closer look at the data in (66). There is one example of the alternation /O/ → /u/ (66c) in Ka (1994), and it is counter-exemplified, also by Ka (1994, p. 95), in the following example.

(68)   sof   'to join'   ➞   soppi   'to change'

In (68) we see the standard gemination expected of the reversive -*i* suffix, but not the vowel alternation. In light of the paucity and contradictory nature of the data in this case, I will not treat it as part of a systematic pattern. I assume that it is lexically specified.

Similarly, I will discount the /a/ ➞ [o] alternations in (66g-h). As Ka (1994, p. 96) states, "Sambou (1984) proposes to consider the alternation a/o as being non-existent: we should posit fol/folli, nos/nocci, and not fal/folli, nas/nocci." I adopt this position, although it must be noted that there is no in-depth phonetic study of Wolof to verify Sambou's proposal. This leaves us with the alternations in (66a-b, d-f, i-j), namely /ə/ ➞ [i], /a/ ➞ [e] and /a/ ➞ [A]. I schematize these alternations in Figure 2.
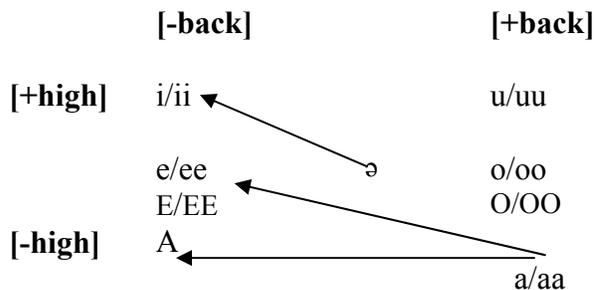
Figure 2: Wolof Vowel Alternations in Derived Geminates

As we see in Figure 2, the movement of all vowel alternations in geminating environments in Wolof is to the front and, generally, to a higher position. Ka (1994, p. 96) discusses these alternations at length, concluding that, "in the absence of a satisfactory phonological solution, we will assume that the stem vowel changes are a morphologized phenomenon." Contra Ka (1994), I suggest that the alternations in Figure 2 can be attributed to vowel feature agreement, or vowel harmony, with a floating feature in the geminating suffixes.

Each of the geminating suffixes contains the same final vowel, the [-back, +high] [i]. We could suggest that the alternations schematized in Figure 2 are simple cases of vowel harmony with the final [i] of the suffixes. However, there are benign suffixes that

also end in [i], and we do not observe vowel harmony in these cases. Furthermore, there is vocalic material intervening between [i] and the left edge of the suffix in two of the three suffixes: -*anti* and -*ali*. Positing agreement with features on the final [i] of the suffixes would violate linearity.

Building on my analysis of gemination above, I propose that the left edge of each geminating suffix contains an underlying floating vocalic feature bundle. This feature bundle is [-back, +high]. Consider the revised underlying representations (UR) of the geminating suffixes in (69).

(69)   UR of geminating suffixes including floating features at left edge

$$[^{[\text{-back, +high}]\ \mu}{}_{\text{i}}{}^{\mu}]$$ $$[^{[\text{-back, +high}]\ \mu}{}_{\text{a}}{}^{\mu}\text{li}^{\mu}]$$ $$[^{[\text{-back, +high}]\ \mu}{}_{\text{a}}{}^{\mu}\text{nt i}^{\mu}]$$

$\rightarrow$ reversive /i/ $\rightarrow$ completive /ali/ $\rightarrow$ corrective /anti/

In addition to the floating mora associated with the left edge of the geminating suffixes, each suffix also possesses floating vocalic features [-back, +high] at its left edge. The floating vowel features and the floating mora are not associated.[9] However, like the floating mora, the floating vowel features also associate with the root. While the floating mora associates with the root coda, the floating vowel features associate with the root vowel, i.e. the leftmost vowel – recalling that underived verb roots are monosyllabic. The floating features require the root vowel to be specified as [-back, +high]. However, owing to various faithfulness constraints that I discuss below, only the featureless schwa /ə/ is able to fully conform to the exigencies of the floating vowel feature (cf. Section 2; schwa is the epenthetic vowel). The schwa adopts the floating features [-back] and [+high] and becomes an [i].

The case of /a/ is more complex, since it alternates with two different vowels, [e] and [a2]. Ka (1994, p. 95) provides several examples of each alternation, but does not discuss whether there is any way to predict which root will yield which vowel when

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[9] The two floating features are not associated synchronically. However, as suggested to me by Abby Cohn (p.c.), historical data could reveal that these features were at some point part of the same segment, for example a vowel or a glide that was in onset position of the geminating suffixes. If this were the case, we could then posit that the segment (a vocalic segment associated with a mora and [-back,+high] features), decomposed and left the mora and the features behind at the left edge of the suffix.

concatenated with a geminating suffix. Indeed, there do not seem to be any systematic differences in shapes of roots that choose [e] versus roots that choose [a2], nor does Ka (1994) suggest that there is any free variation in particular roots vis-à-vis /a/ vowel alternations.

Based on the discussion in Ka (1994) and Ndiaye (1995), it appears that these alternations occur in all verbs of shape CVC, CVVC and CVCC where V is /a/. A brief look at the Munro and Gaye (1997) dictionary reveals dozens of verbs of these shapes. Whether /a/ moves to [a2] or [e] may be entirely lexically specified, as Ka (1994) claims. On the other hand, one alternation may be phonologically governed, while the other is the lexically specified exception. There may also be variation between the two in the same root. In any case, this issue deserves further research, beginning with a detailed phonetic study. The OT analysis I provide below attempts to push the limits of a phonological explanation of Wolof grammar.

To begin, it is noteworthy that /a/ always moves to [-back] whether or not it also becomes [+high]. This suggests that it is more important for /a/ to agree with the [-back] component of the floating vowel features than the [+high] component. /a/ always becomes [-back] in alternating environments, but it never becomes [+high]. Looking at the problem from the opposite direction, I argue that it is easier for the vowel /a/ to betray its [+back] status than its [-high] status. I formalize these two ideas as constraints (70) and (71).

(70)   **MAX[+back]**   Vowels specified as [+back] in the input are
                            specified [+back] in the output.

(71)   **MAX [-high]**   Vowels specified as [-high] in the input are
                            specified [-high] in the output.

The constraints in (70) and (71) militate against any change in feature specification for the [+back], [-high] vowel /a/. However, they are formulated to allow /a/ to conform as much as possible to the demands of the floating features; /a/ can move to a front position,

according to (71), as long as it remains [-high]. Since /a/ always remains [-high], it is clear that MAX[-high] outranks MAX[+back].[10]

In conflict with these faithfulness constraints are the constraints related to the presence of the floating features. The floating features, when associated with a verb root vowel, require that the vowel become [-back, +high].

(72)   ***[-high]**   No [-high] vowels.

(73)   ***[+back]**   No [+back] vowels.

The constraints in (72) and (73) force all vowels that are able (in this case only the featureless schwa /ə/) to be [-back, +high] when the floating vowel features are associated to the verb root vowel.[11] Note that the constraint *[-high] is in direct conflict with the MAX[-high] constraint. This tension helps to explain fact that /a/ moves towards /i/ while not actually becoming an /i/. Following the same logic as above, we can establish the ranking *[+back] >> *[-high]. The vowel /a/ always conforms to *[+back], so this constraint must outrank *[-high].

In (74a) we see an example of an /a/ → /A/ alternation, while (74b) shows an alternation between /a/ and /e/. I give a constraint ranking for both of these cases in (75). In *Tableaux 5* and *6,* I evaluate the inputs /*lalli*/ and /*yabbi*/.

(74)   a. lal   'to make the bed'   →   la2lli   'to unmake the bed'
              b. yab 'to load'   →   yebbi 'to unload'

(75)   *[+back], MAX[-high] >> MAX[+back], *[-high]

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[10] I propose that the constraints in (70)-(71) are process-specific to cases of vowel-alternations triggered by the presence of the floating vowel features (See McCarthy 1997a on process-specific constraints).
[11] These may also be process-specific constraints in Wolof.

lalli	*[+back]	MAX[-high]	MAX[+back]	*[-high]
☞a. la2lli			*	*
b. li lli		*!	*	
c. lolli	*!			
d. lulli	*!			*
e. lalli	*!			*

Tableau 5: Alternations in root vowel /a/: /lalli/

yabbi	*[+back]	MAX[-high]	MAX[+back]	*[-high]
☞a. yebbi			*	*
b. yibbi		*!	*	
c. yobbi	*!			
d. yubbi	*!			*
e. yabbi	*!			*

Tableau 6: Alternations in root vowel /a/: /yabbi/

In both (74a) and (74b) we observe an alternation in the root vowel /a/. When a geminating suffix is attached to the root *lal*, the coda geminates and the root vowel becomes [a2]. When the same suffix is attached to the root *yab* the coda also geminates, but the vowel becomes [e]. I argue that this is a direct result of the tie in optimal outputs we observe in Tableaux 5 and 6. The outputs in Tableau 5 and Tableau 6 violate the same lower-ranked constraints, while Tableau 5 (b-e) and Tableau 6 (b-e) are all sub-optimal, either because they move too far from the underlying vowel (violating faithfulness), or because they remain [-back] (violating markedness).

At best, this analysis shows that at least *one* of the two alternations observed for the vowel /a/ – either /a/ → /A/ or /a/ → /e/ – could potentially be phonologically governed. The fact that we observe a tie in the ranking means it is impossible to ascertain which of the two this might be. If we assume both of these alternations to be phonologically governed, then this is potentially an unstable situation for both language learners *and* users. For example, when a speaker encounters a new verb that should alternate, how does he or she know which vowel to choose? In future research, it would

be useful to look for dialectal variation in vowel alternations, gather acceptability judgments from native speakers (for example, is /lelli/ also well-formed?), and perform experiments testing new and nonsense verbs. Clearly, a systematic investigation of a large corpus of verbs would shed more light on the issue of vowel alternation in Wolof.

Under the analysis I propose, the absence of alternation in the front vowels /a2/ and /e/, and the rounded vowels /o/ and /u/, results from two high ranking correspondence constraints, MAX[-back] and MAX[+round]. Unlike the constraints in (70)-(71), these constraints militate against *any* change in feature-specification of vowels, and are (presumably in this case) highly-ranked. Neither [+round] nor [-back] vowels show any alternations.

In the final subsection of Section 5, I propose an analysis of degemination in Wolof.

5.5   Degemination

In this section, I propose an analysis of degemination in Wolof. Recall the degemination data from above, which I repeat here in (76).

(76)   causative *-al*, nominalizing *-o*

a.	bətt	'to pierce'	bətel	'to make pierce'
b.	sonn	'to be tired'	sonal	'to tire, bother'
c.	fees	'to be full'	feesal	'to make full'
d.	bax	'to boil'	baxal	'to cause to boil'
e.	jA^{n}g	'to learn'	jA^{n}gal	'to teach'
f.	samp	'to plant'	sampal	'to make plant'

(Ka 1994, p. 97)

When one of the degeminating suffixes is added to a CVCC root, where CC is a geminate, we observe degemination of the coda. In (76a-b), the geminate coda of the root on the left surfaces as a singleton onset in the forms on the right. The degeminating suffixes do not affect long vowels (76c), singletons (76d), prenasalized voiced stops (76e) or NC$_{-v}$ clusters (76f).

Ka (1994) suggests that geminates are blocked from surfacing by some element present in the onset of the degeminating suffixes. In Ka's (1994) proposal, which he ultimately rejects in favor of a purely morphological account, this element is an empty C-slot with a null feature matrix that is unable to accommodate new segmental material. Thus the geminate cannot spread to the onset of the suffix and has no choice, in OT terms, but to shorten, producing the output we observe.

However, as Ka (1994) notes, data on NC_{-v} clusters are problematic for this analysis. While geminates shorten, NC_{-v} clusters do not. Since the two are given identical structures by Ka (1994), this behavior is difficult to explain under his analysis. Furthermore, the empty C-slot analysis fails to explain why segmental material does in fact end up in onset position preceding the degeminating suffix. In principle this would create an illicit onset cluster. Below, I incorporate the ideas offered by Ka into an OT analysis of the degemination data, based on moraic structure and the optimal foot in Wolof. I argue, following the general analysis I have been developing, that these data also have a phonological explanation.

As I discuss above, Ka (1994) suggests, but ultimately rejects, a proposal in which the geminate "loses a C" (shortens) owing to the presence of an empty C-slot in the onset position of the degeminating suffix. If we adopt Ka's suggestion and state it in terms of moraic structure, loss of a consonant (C) in a geminate is simply the loss of the mora associated with the geminate. The geminate loses weight. Intuitively, then, there is a process of mora deletion or underparsing triggered by the presence of the degeminating suffixes. However, although gemination and degemination appear to be similar in terms of moraic structure – adding or deleting a mora – I will argue that the mechanism driving mora deletion in degemination is quite different from the mechanism driving gemination.

Below I repeat Table 5 from Section 3 above. Consider the underived (normal) and derived (shadow) disyllables in Wolof.

L.L	L.**H**	**H**.L	**H**.H
CV.CV	CV.CVVC	CVV.CVC	CVV.CVV
CV.CV	CV.CVV	CVV.CVC	CVV.CVVC
CVC.CV	CVC.CVV	CVVC.CV	CVVC.CVVC
CVC.CVC	CVC.CVVC	(CVVC.CVC)	(CVVC.CVV)

Table 5: Wolof disyllables as a function of syllable weight

As I discuss in Section 3, Wolof has a clear preference, in underived disyllables, for feet of the shape **L**.L. I argue that this reflects a general preference in the language for this foot type, especially since we see that no **L**.L syllables are purely derived.

Note that in the cases of degemination illustrated in (76), the forms on the right effectively lose a mora in the first syllable, and therefore surface as **L**.L rather than **H**.L feet. As suggested to me by Abby Cohn (p.c.), degemination may in fact be due to a well-formedness constraint on foot structure triggered by the presence of the degeminating suffixes. The degeminating suffix prefers to adjoin to a light root, and form an **L**.L foot – a foot that resembles an underived word in its structure and behavior vis-à-vis stress. Recall, however, that there are two separate computations for weight assignment in Wolof, one dealing with stress, the other with syllable structure. The cases of degemination appear to be one area in which the two separate computations interact.[12]

Hayes (1995) shows that there is a strong cross-linguistic preference for **L**.L trochees. This preference appears to be reflected in Wolof, since four of the seven underived disyllables in Wolof are of the shape **L**.L. The presence of one of the degeminating suffixes appears to trigger selection of this preferred foot shape. In OT terms, we can formulate this process-specific constraint as in (77).

(77)   **PREFER-LIGHT-ROOT**   Prefer roots of the shape **L**.

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[12] Note that degemination is only observed in roots of the shape CVCC. Verb roots in Wolof are monosyllabic. It would be interesting to see the effect of a degeminating suffix on a root of shape CV(V)(C).CVCC. However, roots of this shape do not exist in Wolof.

Languages showing a high ranking of this constraint generally avoid **H**.L trochees. Clearly, Wolof has a preference for **L**.L feet. However, many other foot-types are attested in Wolof, suggesting that either the constraint in (77) is not highly ranked, or that the constraint PREFER-LIGHT-ROOT is process-specific to degemination (cf. McCarthy 1997a on process-specific constraints). Based on the fact than many non-optimal foot types are observed, I argue that PREFER-LIGHT-ROOT is process-specific to degemination in Wolof. What makes this constraint active in cases of degemination? Although it is purely stipulative at this point, I suggest that the degeminating suffixes contain a feature *F* that requires the suffix to be part of the prosodic word. This feature causes the suffix to evaluate the foot shape it forms with a given root. If the foot shape does not conform to PREFER-LIGHT-ROOT, then a repair strategy of degemination occurs.

PREFER-LIGHT-ROOT outranks the constraint on parsing [+cons] moras, PARSEC-μ, and the constraint on weight identity of consonants, WEIGHT-IDENTC, since we observe degemination (i.e. underparsing of a [+cons] mora and a change in weight of a segment). At the same time, not all repair strategies are equally valid in the quest to conform to ideal foot structure. A [+cons] mora can be deleted, while a [-cons] mora cannot. We know from Section 5.2 above that vocalic moras are less highly valued than the floating mora, because Wolof allows vowel shortening in order to parse the floating mora. However, in the case I consider below, deletion or underparsing of a vocalic mora would mean that the syllable would have no nucleus. In addition, while consonants degeminate, vowels never shorten in the presence of a degeminating suffix. This suggests that the constraint on parsing vocalic moras, repeated below in (78), outranks PREFER-LIGHT-ROOT.

(78)   **PARSEV-μ**   A mora associated with a [-cons] segment must be parsed into
                              higher prosodic structure. (Goodman 1995)

The constraint in (78) requires vocalic moras to be parsed, and thus prevents deletion or underparsing of a vocalic mora in degemination environments. The only valid strategy to force feet to conform to the preferred shape **L**.L is underparsing of a [+cons] mora. I

offer the constraint ranking and evaluation of the input *sonnal* in Tableau 6. The input I consider is repeated in (79).

(79)   sonn 'to be tired'   sonal   'to tire, bother'

so^{μ}n^{μ}n +al	PARSEV-μ	PREFER-LIGHT-ROOT	PARSEC-μ	WEIGHT-IDENT
☞ a. so^{μ}.n$^{<μ>}$al			*	*
b. so^{μ}.n^{μ}al		*!		
c. so^{μ}n^{μ}.nal		*!		*
d. so$^{<μ>}$n^{μ}.nal	*!			*

PARSEV-μ >> PREFER-LIGHT-ROOT >> PARSEC-μWEIGHT-IDENT
Tableau 6: Degemination

The form (a) in Tableau 6 fails to parse the geminate mora, and incurs a WEIGHT-IDENTC violation by shortening the geminate coda to a singleton. Nonetheless, it is optimal since it conforms to the preferred foot structure **L**.**L**. The form in (d) fails to parse the vocalic mora, violating PARSEV-μ, while those in (b-c) yield less ideal **L**.**H** and **H**.**L** feet, respectively. Note that the form in (b) would also incur a violation of *ONSET-μ.

Singleton codas in CVC syllables remain unaffected by the degeminating suffixes, since they already form **L**.**L** feet with the suffix. CVVC syllables are also unaffected, as I showed in (76c). Although they do not form **L**.**L** feet when concatenated with a suffix, it is more important to parse vocalic moras of CVVC syllables than it is to respect the PREFER-LIGHT-ROOT constraint. The relative ranking of PARSEV-μ and PARSEC-μ reflects the primacy of underlying vocalic moras over underlying consonantal moras. Vowel shortening only occurs in cases where the *floating mora*, which in turn takes primacy over vocalic moras, must be parsed. As for NC$_{-v}$ clusters, I show in Section 4 that they are not underlyingly moraic, but moraic only under duress. In disyllables, they do not bear a mora, as illustrated by the occurrence of words with long

vowels preceding NC₋ᵥ clusters in Wolof.   Examples such as (76f) *sampal* form an ideal **L**.L foot.

In the final section, I offer a summary of my arguments in the paper and some conclusions.

6.   Conclusions

In this paper I argue for a moraic representation of geminates in Wolof.   In Sections 2-4, I develop an analysis of Wolof syllables as weight bearing.   I show that geminates contribute weight to a syllable, and I provide representations of all basic syllable types in Wolof.

In Section 5, building on the basic ideas from Section 4, I present a unified phonological analysis of gemination, vowel shortening, and fricative strengthening.   I show that these three alternations are phonologically governed and triggered by the presence of a floating mora at the left edge of geminating suffixes.   In my analysis, morphologically triggered gemination is a phonological process whereby weight is added, in the form of a mora, to a singleton coda consonant.   The ban on trimoraic syllables explains cases of vowel shortening in Wolof.   Expanding the scope of the moraic account, I show in Section 5.3 that fricative-stop alternations in gemination are the result of a general constraint in Wolof against moraic fricatives.

The same suffixes that trigger gemination also trigger alternations in the root vowels /ə/ and /a/.   I argue that these alternations are phonologically governed, although the [a] alternation may also have a lexical component.   Vowel alternations in gemination environments are induced by the presence of floating vowel features associated with the left edge of the geminating suffixes.   I present a series of constraints that can account for the behavior of root vowels when under the influence of the floating vocalic features.

Finally, in Section 5.5, I argue that degemination is also a phonologically governed process in Wolof, although it too is morphologically triggered.   The presence of the degeminating suffixes induces feet to conform to the ideal foot structure in Wolof-**L**.L.   I suggest that this behavior may be due to a process-specific constraint on foot shape that has a reflex in the general foot-shape preferences of the language.

Implicit throughout my discussion, and especially in more problematic areas such as vowel alternation, is the question of what can be explained by phonology, and what must be attributed to the morphology and/or the lexicon. The core data sets that I have analyzed – gemination, vowel shortening and fricative strengthening – lend themselves very well to a moraic account. By adopting moraic representations and an Optimality Theoretic framework, I am able to present a unified account of gemination in which I show disparate data involving segment length and feature alternations to be systematically governed by the phonology of Wolof.

In my analysis of vowel alternations and degemination, I investigate the limits of a purely phonological explanation. While I show that a phonological account of these data is *a priori* possible, there could in fact be a strong lexical component in either or both of these cases. Nonetheless, part of successful research in any field involves testing the outer edges of a theory – a particularly rewarding enterprise when the theory has proven to be a powerful analytical and explanatory tool.

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