MUNDURUKÚ:
PHONETICS, PHONOLOGY, SYNCHRONY, DIACHRONY

by

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Abstract

This dissertation offers an in-depth investigation of the phonology of Mundurukú, a Tupi language spoken in the Amazonian basin of Brazil, approached from three interrelated perspectives: phonetic, phonological and diachronic. It examines (i) the Mundurukú vowel and consonant inventories, (ii) syllable structure and syllabification, (iii) phonotactic patterns, (iv) nasal harmony, (v) consonant mutation, (vi) tone system and the tone-creaky voice interaction, (vii) reduplication, and (viii) the phonological behavior of various affixes.

The phonetic investigation focuses on several acoustic properties of segments (i.e. vowels and consonants), and on phonological contrasts observed in vowels, in particular the oral-nasal and modal-creaky voice oppositions, in addition to tonal distinctions. This is done with a view to determining how and to what extent such phonetic realizations can be imposed on phonological representations. These issues constitute an important part of the study, and are particularly relevant to the discussion about the coarticulatory effects observed in the realization of stops, nasals and laryngeals.

The study also offers a formal account of all major phonological processes attested in the language such as syllabification, nasal harmony, consonant mutation, tone, etc. The theoretical model adopted here is Optimality Theory (OT), which defends a representation of the structural design of grammars based upon a ranking of universal constraints. Each chapter contributes to the development of an OT-based grammar of the phonology of Mundurukú by examining new aspects of the language, and by situating them in a large-scale scenario until the OT-grammar is assembled. This result is presented in the last chapter.

In search of evidence for the synchronic analysis, and for a better understanding of some uncharacteristic patterns, the study turns to the historical development of the language. Using data from Kuruaya, a sister language to Mundurukú, hypotheses about the stage that preceded both languages, Proto-Mundurukú, are made available. In recovering this stage, and the stage that preceded the modern period, it is possible to recover many of the changes the grammar has undergone and which culminated in the synchronic patterns.

Ultimately, this study argues for an approach to synchronic grammars as a composite of universal and language-specific properties, determined by diachronic changes.

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CHAPTER 1

Introduction

1.1 *Wũyjũyũ* “Our people”

1768. *Bastien und Bastienne* by Wolfgang Amadeus Mozart, his first published opera, is performed in Vienna; Joseph Fourier, initiator of the Fourier series, is born in France; the Mundurukú Indians, whose language is the heart of this dissertation, enter Brazilian colonial history.

The Tupi were the first native American groups met by the Europeans in the early period of Brazilian colonization (in 1500). But the Mundurukú, also a Tupi tribe, were first reported only in 1768, in the *Roteiro da viagem da cidade do Pará até as últimas colônias do sertão da província* [Report of the trip from the city of Pará to the remote colonies of the province], written by the Vicar General of Rio Negro, José Monteiro de Noronha. First called Matucucu or Matucaru (they call themselves *Wũyjũyũ* “our people”; see below), the Mundurukú inhabited the banks of the Maué river, a tributary of the Amazon.

They became best known, and feared, from 1770 onwards, due to the devasting attacks they launched against white settlements and other tribes along the banks of the Tapajós river (see maps in (2) below), while expanding their territory in the region (Horton 1948, citing Manoel Baena 1885 and Almeida Serra 1779).

By the beginning of the XIXth century, the Mundurukú completely dominated the region between the Madeira and Tapajós rivers, a fact that led the historian Aires de Casal (1917-1976) to name the region after them: *Mundurucânia*.

The Mundurukú abandoned warfare around 1796, when defeated by a troop of expeditionaries. Peaceful contact was then established. Memories of those moments were kept alive until more than 150 years later: “In the old days our grandfathers were still wild and fought against the white men. The whites used to come up our rivers in their canoes, and we always battled. One day a group of them came up, and there was a fight and our men were driven off. Two of our young men were wounded and were left behind. They were captured and taken away. The next time the white men came we were about to attack when the two men who were captured stood up in the canoe and told us not to do anything as these people were our friends. They then came forward and showed us clothes, knives, axes, and many other good things that the whites gave them. They said that if we gave rubber and farinha to the whites, we too would receive these things. The elders decided to do this and ever since we have been friends of the white men." Murphy (1960: 27)

The Mundurukú call themselves *Wũyjũyũ* [w̃ə̃̀ỹʤə̃́ỹə̃̀] which means "our own, our people" (*wəy-* '1st person plural inclusive', *-ʤə* 'with, together', and *-yə̃* 'plural'). The name Mundurukú (or its variants) denotes a species of ant, and was given to them by another group, the Parintintin (Strömer 1932, cited in Horton 1948). They were also known as *Paikise* (Father Knife), because of their head-hunting activities, or *Caras-Pretas* (Black Faces), because of their facial tattooing (Kruse 1934). In fact, tattooing was a noticeable feature of the Mundurukú culture, an activity beginning early in childhood and continuing until the adult phase when their whole body was eventually tattooed (e.g. Leopoldi 1979).

Very little is known about the Mundurukú culture prior the contact. But they were well-known for being one of the most ferocious tribes, often in the hunt for trophy heads, the greatest honor for a Mundurukú warrior. War was then its best source for this activity (Spix and Martius 1823; Murphy and Murphy 1954; Acquaviva 1976; Leopoldi 1979).

Socially, the group had a well-developed moiety and sib system (Kruse 1934; see also Murphy 1959), divided into two exogamic moieties, "White" (*Iriritayũ*) and "Red" (*Ipakpukayũ*), each of which consisting of various families. The families had eponymous animals or plants, and believed themselves to be related to them – for example, White moiety: *borõ* 'cotton plant, *ikopi* 'wasp', *tawe* 'monkey', etc.; Red moiety: *bio* 'tapir', *witõ* 'curassow', *parawa* 'red macaw', *apak* 'tree, sp.', etc. According to the Mundurukú culture, this organization was determined by *Karosakaibu*, the mythologic hero responsible for the unification of the group.

The Mundurukú still make use of the moiety system and eponymous nomenclature, despite their adoption of Portuguese names. However, the former denominations, which once served to organize the group into clans, are now hardly referred to among themselves.

A typical Mundurukú village consisted of a men's house (*eksa*) and a few dwelling houses. Each village had a set of sacred instruments, in which their ancestors' spirits were believed to be embodied. These instruments were kept in the men's house (*eksa*) and could by no means be seen by women.

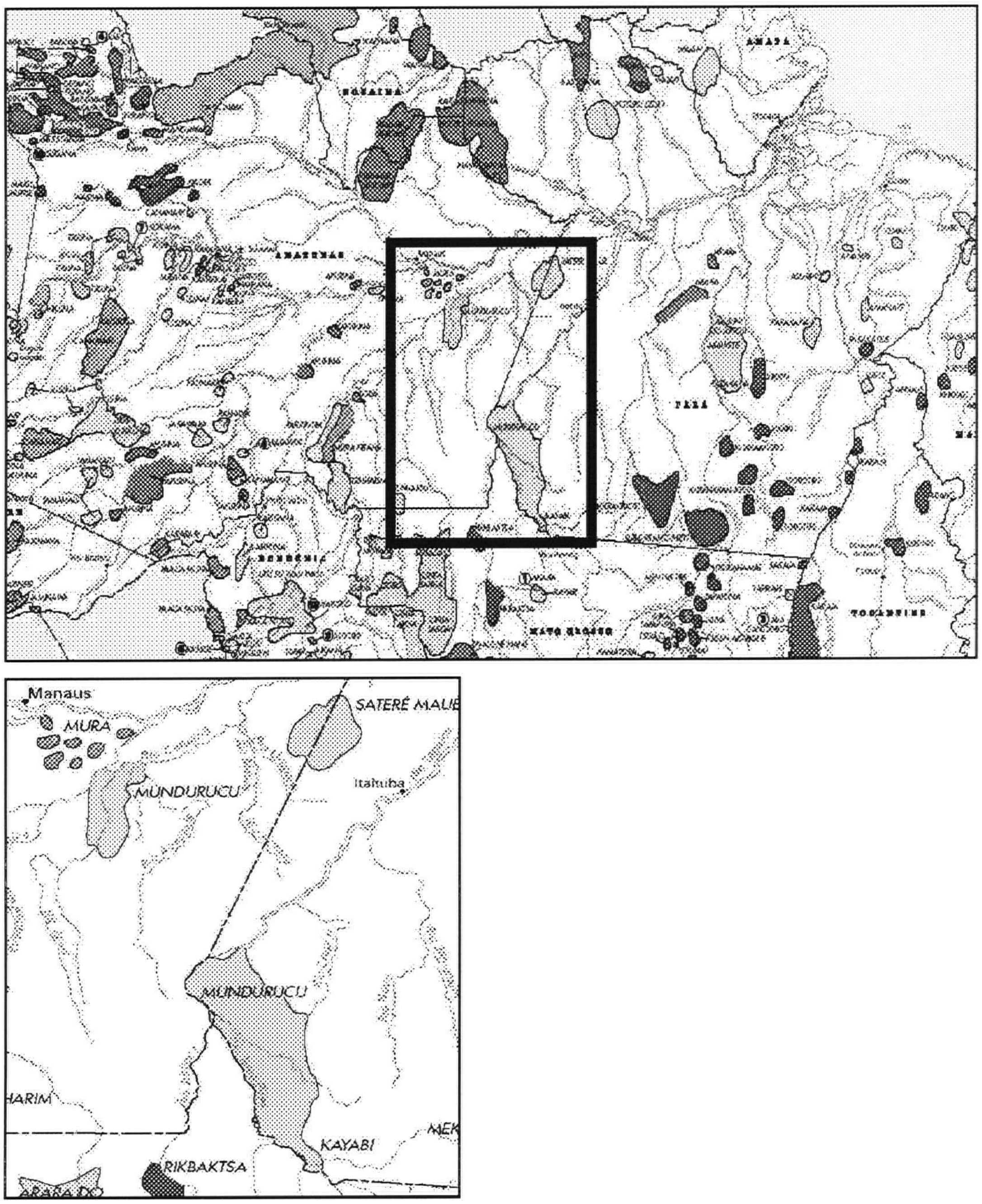
Game animals (*puca*) were also believed to have spirit mothers (*puca xi*) to protect the species. A man who killed an animal without cause could have his soul taken by the animal's spirit mother and placed in inferior animals. Hunting was acceptable only for their own subsistence, which also included fishing, gathering and horticulture.

For further information about the Mundurukú history, culture, and other related topics, see: Gonçalves Tocantins (1877), Barbosa Rodrigues (1882), Hartt (1885), Coudreau (1897-1977), Aires de Casal (1917-1976), Kruse (1934), Nimuendaju (1938, 1949), Kempf (1945a, b), Mense (1946-1947), Horton (1948), Murphy (1954, 1956, 1958, 1959, 1960), Brown (1957), Wilson (1958), Frikel (1959), Murphy and Murphy (1974), Spix and Martius (1976), Acquaviva (1976), Ramos (1978), and Leopoldi (1979).

Nowadays the Mundurukú are mainly settled in the south of the Amazon, geographical centre of Brazil, as in the map in (1). Strictly speaking, the area is situated in the southwestern corner in the state of Pará, shown in the map in (2) below. With a population of approximately 7,000 individuals, they are spread around more than 50 villages in the Mundurukú Indigenous Reserve. (Source of maps: www.bondy.ird.fr/carto/linguas.html; originally from Queixalos and Renault-Lescure 2000.)

(1) Map of Brazil

(2) Map insets of (i) the Mundurukú territories and (ii) the Amazon basin

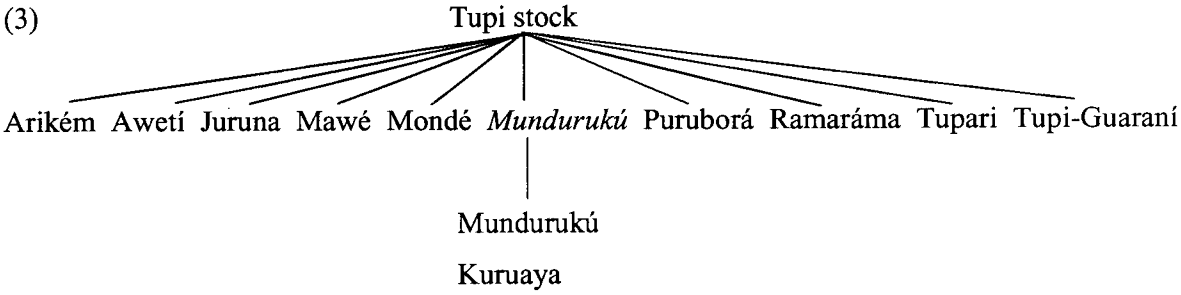


These more than 200 hundred years of contact had a strong effect on their aboriginal culture, and very little resembles the former cultural pattern. But, fortunately, the language survives.

1.2 The Tupi stock

The Tupi stock (Nimuendaju 1948; Rodrigues 1958a-b, 1964, 1970, 1986, 1999; Loukotka 1968; Lemle 1971) comprises ten families of languages, one of which is the Mundurukú family, with two languages: Mundurukú (§1.2.1) and Kuruaya (§1.2.2).

(3)



1.2.1 Mundurukú

Mundurukú is a Tupi language of the Mundurukú family. Their linguistic situation is relatively stable, but the population living in villages close to the city are beginning more and more to make use of the national language, Portuguese. A fair amount of them have already moved to the city, and have become fluent speakers of Portuguese, especially the young people. There is also a considerable number of monolinguals, in particular, elders, women, children, and those living in more remote villages. It is unknown how many dialects the language presently has. Crofts (1967) is the only source in this area.

Mundurukú has been my research language since March 1996, as an undergraduate student and member of the Tupi Comparative project of the Linguistics Division of the Museu Paraense Emílio Goeldi, in Belém-Pará. It was when I heard my first Mundurukú word, *wuykat* /wə̰ykḭt/ 'Good afternoon'; at that time I transcribed it as [weyka]. It was not the best word to initiate the study of the language, especially because of the creaky vowels (as we will see throughout this work), and which I did not notice at that time.

The Mundurukú data presented here are from my own field notes, unless otherwise indicated. Data collection took place anually, for a period of approximately 1-3 months every year since 1996, and mostly in Belém-Pará, where the Mundurukú constantly go. Fieldwork on the language also includes a visit to five Mundurukú villages in 1999, and to Jacareacanga in 2003, a town near the reserve and to where many Mundurukú families have already moved. During these 9 years of intermittent fieldwork, I have had the opportunity to work with 19 native speakers, who kindly collaborated with my research and to whom I express my gratitude: Adalto

Akay (26 years old), Adonias Kabá (27, Jacareacanga), Antônio Tawé (38, Missão Cururu village), Carlos Pag̃o (28, Caboroá village), Dionísio Borõ (37, Caboroá), Edelson Mundurukú (26, Jacareacanga), Genivaldo Kabá (29, Porto village), Inês Kabá (66, Jacareacanga), Jairo Torres (36, Sai-Cinza village), João Maria (20), José Crixi (42, Missão Cururú), Lorival Borõ (approximately 28, Missão Cururú), late Luciano Borõ (approximately 45, Missão Cururú), Maria Zilda (approximately 45, Missão Cururú), Martinho Borõ (62, Missão Cururú), Nilza Kabá (14, Caboroá), Rafael Pag̃o (approximately 50, Caroçal village), Raimundo Borõ (27, Missão Cururú), and Valmar Kabá (approximately 28 and 23, Missão Cururú). The results of this research are presented here. All errors are my own.

This is not the first study of Mundurukú; yet, it is certainly the most detailed. The language has a relatively vast literature on different aspects of its grammar, which go from word lists and notes (for example, Friar Hugo Mense's material published by Rodrigues in 1947) to studies with pure linguistic focus (e.g. Braun and Crofts 1965; Crofts 1967, 1971, 1973, 1985; Gonçalves 1987; Angotti 1998; Picanço 1997, 1999, 2001, 2002a-d, 2003a-c, 2004a-b; 2005a-b; Gomes 2000, 2002; Pica et al. 2004).

However, since Braun and Crofts' (1965) preliminary proposal of the Mundurukú segmental and tonal phonology, very little has been done on this part of the grammar (see also Picanço 1997, 1999, 2002a-c, 2004b). This study counters many of the previous claims about the phonology of Mundurukú, and in addition, provides a detailed analysis of the majority of the phonological processes observed in the language. It also offers a systematic investigation of the phonetics of the language, which was, until Picanço's manuscript (2002d; also Peterson and Picanço 2003), completely unexplored. As an additional benefit, the language is approached from a historical point of view, which not only helps but sometimes provides a better explanation for the various irregularities of the synchronic patterns. This diachronic investigation (see §1.4.3 below) compares Mundurukú to its sister language Kuruaya.

1.2.2 Kuruaya

Kuruaya is an extremely endangered language, and will be extinct soon. There are, according to Costa (1998) and Rodrigues (1999), only five elder speakers, four of them live in the Altamira city, in north-central Brazil, in the state of Pará. My research on this language began in 2002, working with two elder speakers, Maria Curuaia (82 years old) and Paulo Curuaia (89 years old).

The history of the group is unknown, and the language underdescribed. There seems to be available only a few word lists (Snethlage 1910; Nimuendaju 1930), and a preliminary study of its segmental phonology (Costa 1998; see also Picanço 2003b, 2005a-b). Although Kuruaya will not be the focal point of this dissertation, many aspects of its phonology are explored; for example, its segmental phonology and phonological processes such as nasal harmony, consonant mutation, etc. All the hypotheses and data for this language are based on my own field notes, unless otherwise cited. Data collection took place in Altamira in July 2002 and in January 2003.

1.3 Major goal

The investigation of Mundurukú is approached from three viewpoints: phonetic, phonological and diachronic. The ultimate question that the study attempts to answer is: What is the connection between how the language is spoken, how it is represented and how it was represented in the past? It is, by no means, the purpose of this work to offer a profound theoretical discussion on the matter, although theoretical assumptions have to be made. Rather, I attempt to provide a detailed description of the phonetic and phonological structures of the language, and formalize them (see §1.4.2 below). Where a purely synchronic explanation of the facts fails, the analysis turns to the historical development of the language (§1.4.3), which most of the time provides a better understanding of the patterns.

1.4 Organization of the dissertation

1.4.1 Acoustic analysis

The phonetic analysis is acoustic, in which more than 1,500 tokens were examined. The data were recorded in the field using a DAT tape-recorder and a Sony lapel microphone. Three male speakers, Adonias Kabá (AK, 27 years), Jairo Torres (JT, 36 years), and Edelson Mundurukú (EM, 26 years), all of whom speak the same variety of Mundurukú and are familiar with the Mundurukú orthography, were asked to read the target words in the Mundurukú sentence in (4), a sentence in which the test word is pronounced without emphasis, in addition to being relatively independent syntactically so that its tones cannot be affected by neither preceding nor following words.

(4) Orthographic convention “Ijop ____ g̃asũ” “This is ____ now”.

Phonemic representation /íʤop ____ ŋásə̃́/

Phonetic transcription [íʤòp ____ ɲásə̃́] (this.one (is)…now)

Because the orthography does not mark contrasts of tone or creaky voice, I introduced the conventional marking (v̰) to distinguish minimal pairs. Pairs contrasting for creaky voice, e.g. /wida/ 'clay' and /wḭda̰/ 'jaguar', which in the orthography are both written as "*wida*", appeared in the stimuli with the creaky vowel marked by a tilde placed under the vowel: "Ijop *wḭda̰* g̃asũ" 'This is *jaguar* now'; pairs contrasting for tone, e.g. /e/ 'tobacco' which has a low tone level and /é/ 'path' a high tone level, both written as "*e*" in the orthography, received an acute accent marking the high-tone form: "Ijop *é* g̃asũ" 'This is *path* now'. Words that were not minimally contrastive were in the stimuli as they are in the orthography. This method turned out to be efficient as the speakers could easily recognize the words after a quick training before the recordings were made.

The recordings were digitized at sampling frequency of 22050 Hz and analyzed using the program for speech analysis *Praat* (www. fon.hum.uva.nl/praat). The acoustic analysis consists of basic measurements of duration, fundamental frequency, formant frequency, etc. The targets of the acoustic analysis include consonants and vowels, and phonological contrasts such as creaky versus modal types of phonation, oral versus nasal quality of vowels, and finally tones. Further details of each measurement are given especially in chapters 2 and 3, and as necessary.

1.4.2 Phonological analysis: Optimality Theory

The phonological analysis of Mundurukú is based mainly on a database with approximately 2,599 items, divided into: (i) monomorphemic items – 254 noun roots, 217 verb roots, plus 106 morphemes (e.g. affixes, postpositions, particles, etc.); and (ii) non-monomorphemic items – 489 nouns, 506 verbs, plus other 1027 items (e.g. reduplicated and inflected forms, etc.). Many of these were also elicited in larger contexts such as full sentences or small phrases (e.g. possessive constructions, nominalizations, etc.), for which the total number is not available at this point.

The phonological processes examined here are formalized within Optimality Theory (Prince and Smolensky 1993; McCarthy and Prince 1993a). Optimality Theory (OT) defends a model for the architecture of grammars based upon five primary concepts.

(5) Principles of OT (from McCarthy and Prince 1994: 3)
    (a) Universality – Universal Grammar (UG) provides a set CON of constraints that are universal and universally present in all grammars.
    (b) Violability – Constraints are violable; but violation is minimal.

(c) Ranking – The constraints of CON are ranked on a language-particular basis; the notion of minimal violation is defined in terms of this ranking. A grammar is a ranking of the constraint set.

(d) Inclusiveness – The constraint hierarchy evaluates a set of candidate analyses that are admitted by very general considerations of structural well-formedness.

(e) Parallelism – Best-satisfaction of the constraint hierarchy is computed over the whole hierarchy and the whole candidate set. There is no serial derivation.

In OT, Universal Grammar provides the formal mechanism from which grammars are constructed; this includes the following.

(6) (a) CON – The set of constraints that make up grammars, all of which hierarchically organized in a ranking.

(b) GEN – A generation function that produces the range of candidates (outputs) for every underlying representation (input).

(c) EVAL – An evaluation function composed of individual constraints that comparatively evaluates the outputs with respect to a given constraint in the ranking.

(7) gives an illustration of an Optimality-based approach. The constraints assess each candidate by assigning it a number of violations (indicated by an asterisk '*'); if a candidate violates higher ranked constraints, while others pass, this candidate is eliminated (indicated by an exclamation mark '!'). Evaluation continues until there is only one candidate left; this is the optimal output (marked by '☞').

(7) Constraint tableau

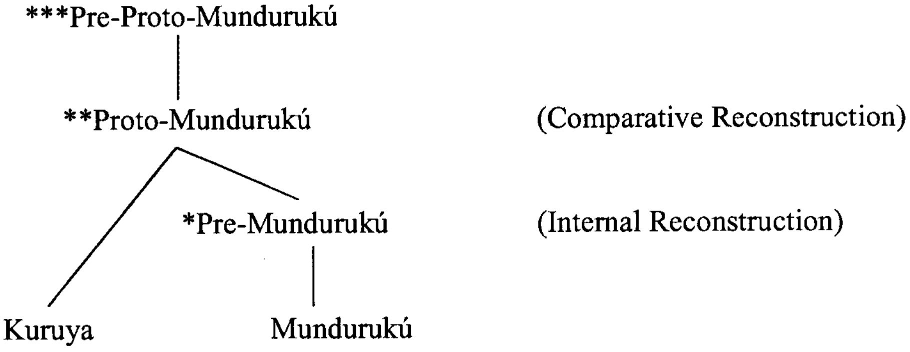
Input	Constraint A	Constraint B	Constraint C
☞ Cand 1			*
Cand 2	*!		
Cand 3		*!	

The formalization of the phonology of Mundurukú within the Optimality Theory is not intended to prove or disprove its efficacy as a model. The primary purpose is to propose an account of the major generalizations that can be made about the phonology of Mundurukú, and to construct a grammar based on a system of choices amongst constraints, and their ultimate hierarchical organization. From a theoretical point of view, this brings the language into the debate about the universal versus specific nature of grammars. OT defends that constraints are universal but constraint rankings are language-specific. The study of Mundurukú reveals that language-specific constraints must be invoked, though minimally. In particular, it shows that what is specific to this language is by and large rooted in the various diachronic changes that took place in the development of its grammar.

1.4.3 Diachronic analysis

The study of Mundurukú goes beyond its current stage; it also examines how the language has changed over time. This was done through the reconstruction of two prehistoric stages: (i) the earlier stage of Mundurukú itself (Pre-Mundurukú), and (ii) the common ancestor of both Mundurukú and Kuruaya (Proto-Mundurukú), as schematized in (8). In some cases, the analysis requires reference to a stage previous to Proto-Mundurukú, which I call Pre-Proto-Mundurukú. As a convention, pre-proto-forms will be marked with three asterisks (***Pre-PMu), proto-forms with two asterisks (**PMu), and pre-forms with a single asterisk (*Pre-Mu); forms without an asterisk are synchronic.

(8)



The comparative method, one of the most widely used methods in linguistic reconstruction, was the method used in the reconstruction of Proto-Mundurukú. It comprises three basic steps (e.g. Fox 1995): (i) compilation of a list with regular correspondences in the lexicon; (ii) establishment of the correspondence sets; and (iii) reconstruction of hypothetical forms.

The notations used throughout this dissertation are as follows (e.g. Hock 1991; Fox 1995).

(9)	(a)	$x > y$	‘x’ changes/develops into ‘y’
	(b)	$y < x$	‘y’ develops out of ‘x’
	(c)	$x > y / z \_$ or $x > y / \_z$	‘x’ changes into ‘y’ following or preceding ‘z’
	(d)	$x \subset y$	‘x’ merges with ‘y’
	(e)	$x > x/y$	‘x’ splits into ‘x’ and ‘y’

The historical approach is of singular value. In addition to being the first proposed for the Mundurukú family, it elucidates many of the irregularities in the patterns observed synchronically (see especially chapters 5, 6 and 7).

1.4.4 Overview of the chapters

I begin the investigation of Mundurukú by examining the phonetic and phonological structures of its segment inventory. Chapter 2 deals with the vowel system; the language has five vowel qualities, /i, e, ɘ, a, o/, and additional contrasts of nasality and creaky voice. From these, four series of vowels result: oral versus nasal modal vowels, and oral versus nasal creaky vowels. The chapter begins by providing an acoustic analysis of the five vowel qualitites, and proceeds to the acoustic properties of the oral-nasal and modal-creaky oppositions. Following Gordon and Ladefoged (2001), a number of properties typically associated with phonation differences were examined; these are: (i) periodicity, (ii) formant frequency (F1, F2, F3), (iii) fundamental frequency (F0), (iv) overall duration, and (v) spectral tilt.

Chapter 3 follows up the investigation of segments by focusing on the consonant inventory, which comprises seventeen consonants: /p, t, ʧ, k, b, d, ʤ, s, ʃ, m, n, ŋ, r, w, y, ʔ, h/. The phonetic analysis is centered around the acoustic characteristics of intervocalic stops, nasals and laryngeals, with additional investigation of stops and nasals in coda position. The acoustic analysis provides the basis for the following chapters, especially Chapter 4.

Chapter 4 deals with several issues in syllable structure and syllabification, in particular: syllabification of sequences of vowels and consonant clusters, the prohibition of the sequence /t/+coronal, restriction on the occurrence of /r/ and /h/ word-initially, and fusion of the aspect suffix {-m} with voiceless stops.

Phonotactic restrictions are examined in Chapter 5. Its focal point is on the history of consonants and the restrictions on their distribution. From the eleven restrictions detected synchronically – *wo, *yi, *ʔy̱, *dṽ, *ʧi, *ʤi, *si, *ʃə, *mi, *ni, and *ŋi – the synchronic and diachronic analyses show that six of these are historical accidents, *ʧi, *ʤi, *si, *mi, *ni, *ŋi, and five are systematic, in the sense that there is evidence from alternations that they are in fact prohibited in the language; these are: *wo, *yi, *ʔy̱, *dṽ, *ʃə.

Nasal harmony comes next, in Chapter 6. The chapter approaches the process from synchronic and diachronic perspectives, comparing the systems of both Mundurukú and Kuruaya. It shows a step-by-step analysis of the changes since Proto-Mundurukú, as well as their consequences for the grammar of Mundurukú. The chapter concludes with an OT account of the change in nasal harmony.

Another phonological process examined is consonant mutation, Chapter 7, which also receives synchronic and diachronic treatments. Mundurukú has a peculiar process of voicing alternation by means of which /p, ʧ/ are voiced intervocalically, whereas /d/ is devoiced postconsonantally. The historical account comes into the picture to support the hypothesis that the process is a consequence of a sound change that failed to apply regularly to some morphemes.

Chapter 8 deals with the phonology of tone and phonation types. Mundurukú is a language that makes use of two levels of pitch, low (L) and high (H), to lexically distinguish items. On the surface we find five tonal behaviors: stable versus unstable H tones, active versus inert L tones, and tonal polarity. The account relies on lexical distinctions to explain the five behaviors. Lexical H tones are stable, lexical L tones are active, triggering dissimilation of a following L, and toneless moras surface L but this tone is inert. Unstable H and polar tones are the manifestation of a floating H tone. The analyis then proceeds to explore the tone-creaky voice interaction. Phonologically creaky vowels do not exhibit contrasts of tones, being restricted to a L tone. Creaky voice was in the past (Braun and Crofts 1965) analyzed as a tonal feature, but Chapter 8 shows that tones are independent of phonation oppositions. The major achievement of the study is that the tonal system of the language can be reduced to two distinctive levels, rather than the four previously proposed.

Chapter 9 concludes this work by assessing the pros and cons of the analysis proposed in the preceding chapters. It attempts to put together all the constraints (see list in the Appendix) out of which the grammar of the Mundurukú phonology can be constructed, its OT-based grammar.

CHAPTER 2

Phonetic and phonological structures of vowels

2.1 Introduction

Chapters 2 and 3 are devoted to the phonetic and phonological structures of vowels and consonants in Mundurukú. The first proposal of its segmental phonology is found in Braun and Crofts (1965). They suggest an inventory composed of sixteen consonants and six vowels, with their six nasal counterparts.[1]

(1) Mundurukú phonemic inventory (adapted from Braun and Crofts 1965)

(a) Consonants

	Labial	Alveolar	Palatal	Velar	Glottal
Stop	p b	t		k	ʔ
Affricate			ʧ ʤ		
Fricative		s	ʃ		h
Nasal	m	n		ŋ	
Liquid		r			
Glide	w		y		

(b) Vowels

	Front	Central	Back
High	i ĩ	ɨ ɨ̃	u ũ
Mid	e ẽ	ə ə̃	
Low		a ã	

---

[1] The language also contrasts modal versus creaky vowels; however, Braun and Crofts (1965; Crofts 1973, 1985) analyze nonmodal phonation as a tonal feature. See §2.2 and §2.3 for a proposal of creaky voice as a property of vowels, and especially Chapter 8 for the phonological behavior of creaky phonation and its interaction with tones.

In later work, Crofts (1973) adds two consonants to the inventory, the voiced alveolar stop /d/ and the palatal nasal /ɲ/; the vowel inventory is reduced to five oral and five nasal vowels, with /o/ standing for previous /u/, and no contrast between /ɨ/ and /ə/.

(2) Mundurukú phonemic inventory (adapted from Crofts 1973)

(a) Consonants

	Labial	Alveolar	Palatal	Velar	Glottal
Stop	p	t		k	ʔ
	b	d			
Affricate			ʧ		
			ʤ		
Fricative		s	ʃ		h
Nasal	m	n	ɲ	ŋ	
Liquid		r			
Glide	w		y		

(b) Vowels

	Front	Central	Back
High	i ĩ	ɨ ɨ̃	
Mid	e ẽ		o õ
Low		a ã	

The last modification of the inventory is found in Crofts (1985); the palatal nasal [ɲ] is treated as an allophone of the velar nasal /ŋ/ syllable-initially, as in (3). There was no other alteration of the vowel inventory.

(3) Consonants (adapted from Crofts 1985)

	Labial	Alveolar	Palatal	Velar	Glottal
Stop	p	t		k	ʔ
	b	d			
Affricate			ʧ		
			ʤ		
Fricative		s	ʃ		h
Nasal	m	n		ŋ	
Liquid		r			
Glide	w		y		

I consider the inventory of consonants in detail in Chapter 3, maintaining the number of consonants as proposed in Crofts (1985), and based on phonetic and phonological evidence, dividing them into four classes: stops, fricatives, nasals and approximants. The laryngeals /ʔ, h/ are grouped with approximants, along with /r, w, y/, and affricates are classified as stops. (See Chapter 3 for details.)

(4) Consonant inventory (as proposed here)

	Labial	Alveolar	Palatal	Velar	Glottal
Stop	p	t	ʧ	k	
	b	d	ʤ		
Fricative		s	ʃ		
Nasal	m	n		ŋ	
Approximant	w	r	y		ʔ, h

In this chapter I examine the phonetic and phonological structures of vowels, with special attention to (i) the acoustic properties of vowel qualities, (ii) the oral-nasal and (iii) modal-nonmodal oppositions. To this date, there are only two preliminary studies which have approached some phonological aspects of the language from a phonetic point of view (Picanço 2002d, 2004b).

In previous proposals of the vowel system (Braun and Crofts 1965; Crofts 1973, 1985), it is maintained that vowels exhibit an oral-nasal opposition, in addition to tone. Creaky phonation, best known as laryngealization in the literature on Mundurukú, was also analyzed as a tonal feature. Here I propose that creaky voice is a contrastive property of vowels, in opposition to modal vowels. (Chapter 8 presents phonological evidence for treating creakiness as a feature of vowels, like nasality.) The term "creaky voice" describes a mode of vocal fold vibration that involves harshness accompanied by lowered pitch (Ladefoged 1971). Articulatorily, creaky voicing is produced by pressing the arytenoid cartilages tightly together, allowing the vocal cords to vibrate only at the other end (Ladefoged 1971). This type of phonation is used to distinguish words such as the following.

(5)	(a)	Modal voice		(b)	Creaky voice	
		wida	'clay'		wḭda̰	'jaguar'
		áy	'rodent, sp.'		a̰y	'sloth' (monkey, sp.)

Braun and Crofts (1965: 26; see also Crofts 1973, 1985) propose that creaky phonation is one of the "four accents" – accent 1 is a super-high tone, accent 2 a mid level tone, accent 3 a low level tone, and accent 4 creaky voice. An alternative analysis has already been proposed by Picanço (1999, 2002b-c; and Chapter 8), who presents phonological evidence against the tonal status of creaky voice, despite its relation to tones. In addition, it is proposed here (see also Picanço 2002b-c; Chapter 8) that there are only two contrastive tones: High (marked with an acute accent, "v́") and Low (generally unmarked, except in phonetic transcriptions where it is marked as "v̀"). (Tones and tone-creaky voice interaction are taken up in Chapter 8.)

Another difference from the previous proposal concerns the quality of the nonlow central vowel, which, as shown in the acoustic analysis below, is a mid vowel [ə] (see also Picanço 1997, 1999), not a high vowel [ɨ] as proposed by Braun and Crofts.

The chapter is organized as follows. §2.2 shows the distribution of the vowel qualities within the acoustic space, based upon values for the first two formants (F1, F2). §2.3 takes up the oral-nasal opposition, focusing on the effects of nasalization on vowel height. §2.4 turns to the phonetic aspects of another phonological contrast, the modal-nonmodal contrast. Following Gordon and Ladefoged (2001, and others), five acoustic properties were measured for Mundurukú data: formant frequencies (§2.4.3.1), overall duration (§2.4.3.2), fundamental frequency (§2.4.3.3), periodicity (§2.4.3.4), and spectral tilt (§2.4.3.5). The findings reveal that fundamental frequency, periodicity and spectral tilt reliably signal the modal-creaky contrast in the language; the results obtained for measurements of fundamental frequency are especially important for the tone-creaky voice interaction.

2.2 Vowel qualities

The phonemic vowel system of Mundurukú distinguishes five vowel qualities, as illustrated in (6). There is one vowel in the high front region, [i], three in the mid region – mid front [ɛ], here represented phonemically by /e/, mid central [ə], and higher mid back [o] – and one low vowel [a].

(6) Vowel qualities

(a)	/i/	[i]	i-ba̰-pík	His/her arm is burned.
			3-arm-be.burned	
(b)	/e/	[ɛ]	i-ba̰-pék	His/her arm is yellow.
			3-arm-be.yellow	
(c)	/ə/	[ə]	i-bapə́k	It's visible.
			3-be.visible	
(d)	/a/	[a]	i-ba̰-pák	His/her arm is red.
			3-arm-be.red	
(e)	/o/	[o]	i-mə-pók	to beat someone up
			3Ob-CAUS-be.hurt	

The five-vowel system is greatly expanded by contrasts of nasality and creaky voice, resulting in an inventory with four series of vowels: oral and nasal modal vowels, and oral and nasal creaky vowels (after Picanço 1997). The series are given in (7); creaky voice is indicated by (v̰) placed under the vowel, and nasalization by a tilde (ṽ) above the vowel. Vowels also contrast for tones, but only modal vowels may surface on a High or Low tone; creaky vowels are restricted to Low tone. (On tone distinctions, see Chapter 8).

(7) Series of vowels (after Picanço 1997)

	Modal vowels			Creaky vowels		
High	i ĩ			ḭ ḭ̃		
Mid	e ẽ	ə ə̃	o õ	ḛ ḛ̃	ə̰ ə̰̃	o̰ õ̰
Low		a ã			a̰ ã̰	

The Mundurukú vowel system is typologically uncommon due to the gap in the back region, where it lacks the high back vowel /u/. The system is also not fully balanced in the mid region as the mid front vowel [ɛ] is not matched in height by mid back [o]. According to Crothers (1978; see also Greenberg 1966; Maddieson 1984, and others), the most prevalent vowel systems include primarily /i, a, u/, the vowels that are located at the most extreme points in the phonetic space, and then mid vowels.

Proposals have been made to explain universal patterns of vowel distribution based upon the principle of vowel dispersion (e.g. Liljencrants and Lindblom 1972; Lindblom 1986). This principle states that vowels tend to be evenly and widely dispersed in the acoustic space available for vowels (see below). Mundurukú seems to contradict this principle because its system has a major gap in the high back region and an uneven distribution of mid vowels. Nonetheless, internal evidence suggests that the language is in accordance with Liljencrants and Lindblom's model (and Lindblom 1986) so that the gaps can be accounted for in a principled way.

2.2.1 Vowel dispersion

Languages tend to show a balanced and symmetrical distribution of their vowel systems. In a language with three vowels, the system is typically triangular: /i, a, u/. In one with five vowels, the system includes /i, a, u/ plus two mid vowels, usually /ɛ, ɔ/ (Maddieson 1984).

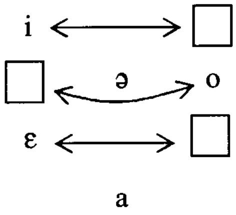
In attempting to explain such patterns, Liljencrants and Lindblom (1972) proposed the principle of vowel dispersion, which states that vowels tend to be widely and evenly dispersed within the acoustic space for vowels. In this sense, a triangular system takes advantage of this acoustic space by distributing its vowels to the most extreme points, as in (8)a. In a five-vowel system, these three points are first filled up and the remaining vowels are then distributed to intermediate points, i.e. the mid region, (8)b.

(8) (a) Triangular system (b) Five-vowel system

(a)			(b)		
i		u	i		u
			ɛ		ɔ
	a			a	

The dispersion principle predicts optimal systems, with distributions that first include maximally distant points, and then intermediate ones, depending on the number of vowels a language has. But there are exceptions, systems that do not conform to the maximal distribution of their vowels. Mundurukú, for example, has three deviations: high back [u], mid front [e] and mid back [ɔ], which are the counterparts for [i], [o], and [ɛ] respectively.

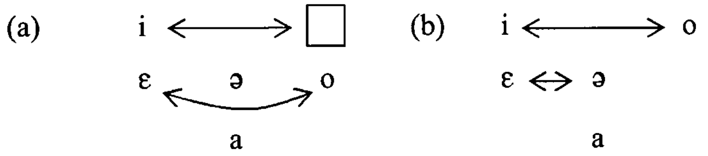
(9) Gaps in the Mundurukú vowel system



However, let us suppose, following Disner (in Maddieson 1984), that gaps in defective systems tend to be compensated for, or complemented by, other vowels in the system. Strictly speaking, the vowels available are distributed in a way that brings the system close to one with a symmetrical distribution. Disner reports three major types of complementary vowels (p. 144): (i) a central vowel; (ii) a front rounded or back unrounded vowel; or (iii) a peripheral vowel similar to the missing vowel but lacking a counterpart of equal height and opposite rounding elsewhere in the system.

Now suppose that the gaps in Mundurukú are compensated for by other vowels in the system. Consider the two possibilities in (10). Compensation in (10)a corresponds to type (iii) above, in which the gap in the mid region is compensated for by the mid back [o], a vowel that is similar to missing [ɔ] and lacks a counterpart of equal height and opposite rounding, i.e. [e]. In this sense, the system has a gap in the high back region, but is fully balanced in the mid region. A second possibility is as in (10)b, which corresponds to types (i) and (iii) together. The gap in the high back region is compensated for by the vowel [o] which is similar to missing [u] (type (iii)), and we can suppose that the mid central vowel [ə], although not a perfect counterpart for [ε], balances the system in the mid region (type (i)). In this case, Mundurukú is not a counterexample to the dispersion principle.

(10) Compensation of gaps



Assuming that defective systems tend to have vowels that somehow complement each other, the question is as to whether the distribution of these vowels within the acoustic space reflects their role as complementary vowels. In other words, do complementary vowels tend to be acoustically comparable, either in height or in the front-back dimension, to the missing vowel?

In the following section I address this question, examining how Mundurukú vowels are distributed within the acoustic space. If compensation is as in (10)a, we can suppose that [o] is closer in height to [ε] than to [i]; but if compensation is as in (10)b, then [o] is closer to [i] than to [ə] or [ε].

To investigate if complementary vowels are distributed as close as possible to the vowels they are compensating for, a two-sample t-test analysis was performed, with height (i.e. F1 values) as a factor. Unless otherwise indicated, the significance level, here and everywhere in this dissertation, is $p<0.05$.

2.2.2 *The acoustic space of Mundurukú vowels*

The first step is to determine whether the five-vowel qualities are evenly distributed in the acoustic space, and thus compatible with Liljencrants and Lindblom's model of maximization of contrast in vowel systems. The list of words selected to represent the five vowel qualities is given in (11). Three male speakers were recorded (AK, JT and EM), resulting in a total of 149 tokens, with an average of 29 tokens for each vowel.

(11) Word list for vowel qualities

(a)	ibapík	'His/her arm is burned.'
	íhí	'winter'
(b)	ibapék	'His/her arm is yellow.'
	hém	'It's really a path!'

(c)	ibapə́k	'It's visible.'
	ʤeə́hə́m	'to go up'
(d)	ibapák	'His/her arm is red.'
	iáhám	'to bite something'
(e)	iməpók	'to beat someone up'
	óhóʔa	'flute'

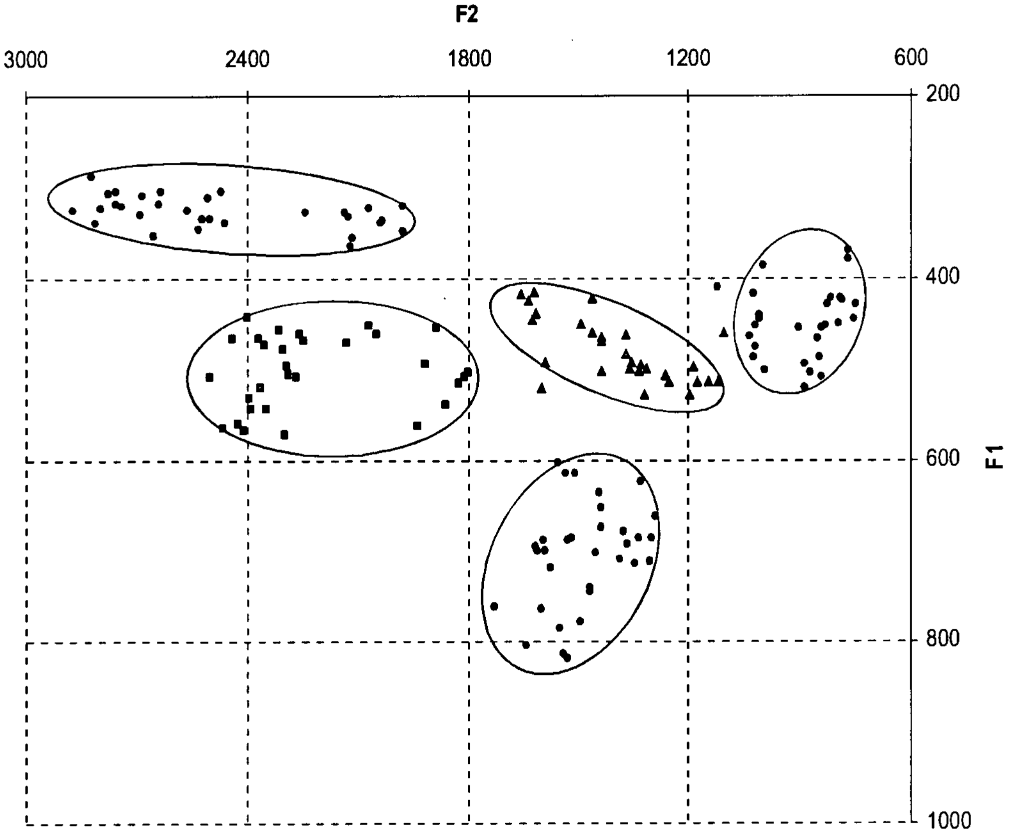
The vowels were characterized in terms of the frequencies of the first two formants (F1, F2); F1 characterizes the height, vertical position of the tongue, and F2 the front-back, horizontal position. The formants were measured from wideband spectrograms near the middle of the vowel where they are steady, without the transition effects of consonants. Table 2.1 gives mean values and standard deviations for all vowels.

Table 2.1. F1, F2, F3 mean values and standard deviations for Mundurukú vowels.

		F1	F2	F3
i	Mean	327	2467	3109
	s.d.	17	294	255
e	Mean	504	2212	2847
	s.d.	40	220	210
ə	Mean	480	1387	2510
	s.d.	34	165	226
a	Mean	705	1481	2436
	s.d.	56	111	154
o	Mean	450	894	2453
	s.d.	39	106	175

Figure 2.1 gives a representative chart of the acoustic space of Mundurukú vowel qualities. In the height dimension, all three speakers distinguish three major degrees of openness: one high vowel [i]; three mid vowels – [ɛ], [ə], and [o] (which ranges from [o] to [u] and occupies a region between mid and high vowels); and one low vowel [a].

Figure 2.1. Formant plots of Mundurukú vowel qualities. (3 speakers: AK, JT, and EM; about 29 tokens for each vowel.)



The five vowel qualities proposed here diverge from previous proposals only with respect to the quality of the central vowel [ə], which Braun and Crofts (1965; also Crofts 1973, 1985) posit as being a high central vowel [ɨ], but as shown in Figure 2.1, and in (12), this vowel is much lower than what is expected for [ɨ], and closer to a mid vowel than to [i].

(12)	/e-ə/:	t=2.40	s.d.=37.7	d.f.=57	p=0.020
	/o-ə/:	t=3.07	s.d.=37.2	d.f.=55	p=0.0033
	/i-ə/:	t=-21.4	s.d.=27.5	d.f.=57	p<0.0001

Comparing the mid front vowel /e/ to /ə/ above and to /o/, in (13), the difference in height is significantly greater for the pair /e-o/ (p<0.0001) than for /e-ə/ (p=0.020), making it plausible to suggest that [ə] compensates as the back counterpart for [ɛ], rather than [o]. There is also a significant difference in height between [i] and [o], which is higher than that obtained for the pair /e-o/.

(13) /e-o/: t=5.15 s.d.=39.8 d.f.=56 p<0.0001

/i-o/: t=-15.6 s.d.=30.1 d.f.=56 p<0.0001.

This acoustic investigation thus confirms deviations in the distribution of Mundurukú vowels within the acoustic space, but does not entirely exclude the possibility that compensation of the gaps by other vowels in the system may affect the acoustic realizations of these vowels. The results for Mundurukú suggest that the acoustic distribution of /i, e, ə, o, a/, with respect to the height dimension, is i > o > ə > e > a (">" stands for "higher than"). Taking it this way, the system distributes its vowels first to the most extreme points, and then to intermediate ones.

On the phonological side, the five vowels are here distinguished in terms of the features [high, low, back], as in (14). (Below I present some evidence in support to these distinctions.) The back vowel /o/ is in opposition to /i/ so both are [+high], but /o/ is also [+round], in contrast to /ə, a/ which are [+back, -round]; /ə/ balances the system in the mid region, in opposition to /e/, which is [-back]. Even though the high back vowel should be represented by /u/, since it is classified as [+high], I will continue to represent it as /o/ in order to be consistent with the Mundurukú orthography, and in which "u" stands for /ə/.

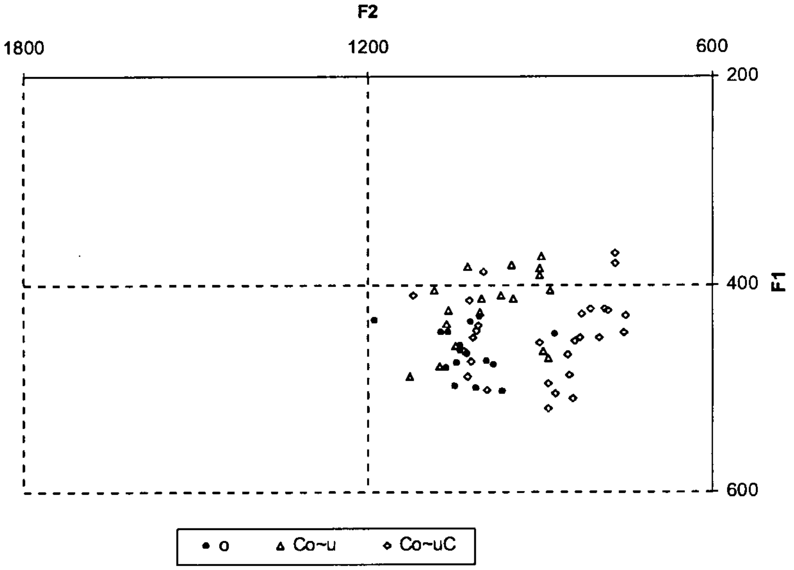
(14) Vowel features

	-back	+back	
		-round	+round
+high	i		o
-high, -low	e	ə	
+low		a	

There is some evidence suggesting that missing /u/ is compensated for by the mid back vowel /o/, justifying stipulation of [+high] for this vowel. In normal speech, /o/ varies freely between [o] and [u], as seen above, and in Figure 2.2 below. There are some exceptions to this variation: *okp[o]t* **okp[u]t* 'my son (male speech)', *it[o]p* **it[u]p* 'her husband', and *[o]p* **[u]p* 'arrow'. The absence of the alternation [o~u] in these cases might suggest a contrast, say, between /u/ and /o/ in the back region, in that /u/ varies between [u] and [o], and /o/ is always

[o]. I believe that a contrast /u/ versus /o/ brings about some complications for the vowel system of the language. First, whether or not a back vowel [o] alternates with [u], there is considerable acoustic overlap in their realizations, as Figure 2.2 shows.

Figure 2.2. A comparison between [o] and [o~u]. Words *okpot* ‘my son (male speech)’, *itop* ‘her husband’, *imǝpók* ‘to beat s.o. up’, *irore* ‘It’s loose’ and *aró* ‘parrot’. (Legend: “o” = nonalternating [o] (16 tokens), “Co~u” = [o~u] alternation in an open syllable (18 tokens), and “Co~uC” = [o~u] alternation in a closed syllable (14 tokens))



Second, the number of items containing a non-alternating /o/ is extremely small; thus far the corpus includes only the three cases cited above. And third, the system is symmetrical with respect to the contrasts oral-nasal and modal-nonmodal. If we make a distinction between /u/ and /o/, the inventory would have six oral modal vowels, /i, e, ǝ, a, o, u/, but only five nasal modal vowels, /ĩ, ẽ, ǝ̃, ã, ũ/, five oral creaky vowels, /ḭ, ḛ, ǝ̰, a̰, ṵ/, and five nasal creaky vowels, /ḭ̃, ḛ̃, ǝ̰̃, ã̰, ṵ̃/, as there are no cases attested of a nonalternating /o/ in these three series.

Given all the above, it is of no detriment to posit only the back vowel /o/, specified for the features [+high, +round], as in (14) above. A phonological fact that supports the analysis is illustrated in (15). In combinations glide + vowel, the language disallows cooccurrence of /o/ with the glide /w/ in the same syllable, a prohibition that is parallel to the restriction on combinations of a high front vowel /i/ with the palatal glide /y/. (See Chapter 4 for an account of the restrictions in combinations glide + vowel.)

(15) Combinations glide + vowel

(a)	ka̰.wí	'clay'	*yi	
(b)	ta.wé	'monkey'	e.pe.ye-	'2pl.CoRef'
(c)	mə́.wə́	'bird, sp.'	yə.ʔə́k	'his/her belly'
(d)	wa.ʔá	'my head'	ya.ʔá	'his/her head'
(e)	*wo		yo.boŋ	'It's big'

Another observation of interest concerns the mismatch in the mid region, where the mid front vowel [ɛ] lacks a back counterpart [ɔ], a vowel with corresponding height and opposite backness for [ɛ]. One possible explanation is that a diachronic change neutralized height distinctions in the back region. Kuruaya, the other language of the Munduruku family, has a system with six qualities of oral vowels: /i, e, ɨ, a, o, ɔ/ (Costa 1998; Picanço 2003c; and also Chapter 5), as shown in (16)a. Most importantly, Kuruaya makes a contrast between /o/ and /ɔ/. Comparing the two systems, a hypothesis is that the system presently observed in Munduruku may have developed out of a system fully balanced in the mid region, as it is in Kuruaya. Two major changes seem to have taken place: one merged /o/ and /ɔ/, neutralizing the contrast between the two back vowels and leaving /e/ without a counterpart in Munduruku, (16)b; and another lowered /ɨ/ to /ə/, perhaps to balance the system in the mid region. (Chapter 5 gives more details of historical changes in the vowel inventory).

(16) (a) Kuruaya (b) Mundurukú

On the basis of these observations, we can argue that the vowel system of Munduruku achieves Liljencrants and Lindblom's predictions of maximal dispersion, though it does so by means of compensation of gaps. Compensation does not necessarily affect the acoustic distribution of vowels, as seen above, but can be expressed phonologically, as in the case of /o/ which patterns with /ɨ/ in Munduruku, or historically, as the change that lowered /ɨ/ to /ə/ to balance the system in the mid region. The observation made in Maddieson (1984: 154) proves to be correct in that the majority of vowel systems that are likely to be exceptions to the dispersion theory "(...) tend toward a balanced distribution of vowels in the available space, either by complementation with a vowel of unexpected quality or by a displacement toward the gap of some or all vowels in the system." Mundurukú vowel system supports this assumption.

The next step in the analysis is to investigate other contrasts in the language. So far I have considered only vowels produced with a particular state of the glottis, normal voice. There is another set which requires a different adjustment of the glottis: the set of creaky vowels. Both modal and creaky vowels exhibit an opposition between oral and nasal vowels so that the inventory is quite symmetrical, although nasal creaky vowels are much less frequent than nasal modal vowels. In the following sections I examine the acoustic properties of modal-creaky and oral-nasal contrasts, beginning with modal vowels and the oral-nasal opposition. The creaky-modal contrast is examined in §2.4.

2.3 Modal vowels: the oral-nasal contrast

Nasalization is a contrastive property of Mundurukú vowels; there are nasal counterparts to all five oral vowels, irrespective of phonation differences or the environment at which they occur: open and closed syllables, or adjacent to a nasal consonant, in particular, a nasal in coda position. Illustrations of the oral-nasal opposition in modal vowels are given in (17). The contrast in the environment of nasal consonants is crucially achieved at the expense of a further adjustment of velic movement. A nasal consonant is plain only if preceded by a nasal vowel; for example, sequences /ṽm, ṽn, ṽŋ/ result in phonetic sequences such as [ṽm, ṽn, ṽŋ]. If preceded by an oral vowel, for example /vm, vn, vŋ/, the nasal is partially oralized, resulting in phonetic sequences such as [v^{b}m, v^{d}n, v^{g}ŋ]. A hypothesis is that the reinforcement of the oral-nasal contrast in the environment of nasal consonants causes lowering of the velum to be delayed until after the oral closure is complete (see Chapter 3). In this sense, preoralization is a strategy used by speakers to preserve a phonological contrast.[2] The oral-nasal contrast for all vowels is illustrated below: /i-ĩ/ in (17), /e-ẽ/ in (18), /ə-ə̃/ in (19), /a-ã/ in (20), and /o-õ/ in (21).

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[2] These examples also illustrate leftward nasal spread to [+sonorant] segments, triggered by a nasal vowel. Nasal harmony is examined in Chapter 6, and preoralization of nasal consonants in Chapter 3.

(17)	(a)	íhí	[íhí]	'winter'
		ã́ĩhĩ́	[ã̀́ĩh̃ĩ́]	'mother'
	(b)	káʃi	[káʃì]	'sun/moon'
		aʃi	[àʃì]	'pepper (tree)'
	(c)	y-op-tiŋ	[yòptì^{g}ŋ]	'smoke from a stick'
		3-CL-smoke		
		itíŋ-ʔa	[ìtíŋʔà]	'pot'
		pot-CL		
(18)	(a)	hém	[hɛ́^{b}m]	'It's really a path!' (Emphatic)
		t-aẽ́-hẽ́-m	[tã̀ɛ̃́h̃ɛ̃́m]	'to choose'
		3O-choose-RED-IMPRF		
	(b)	e-díŋ	[ɛ̀dí^{g}ŋ]	'tobacco smoke'
		tobacco-smoke		
		ẽdí	[ɛ̃̀^{n}dí ~ ɛ̃̀dí]	'kind of net (for fishing)'
	(c)	ʔé	[ʔɛ́]	'AUX(iliar)'
		ʔẽ	[ʔ̃ɛ̃̀]	'mortar'
(19)	(a)	ʤe-ə́-hə́-m	[ʤɛ̀ə́hə́^{b}m]	'to go up'
		CoRef.Poss-up-RED-IMPRF		
		ə́rə̃́	[ə̃́r̃ə̃́]	'maracanã bird'

(b) i-wə́y [ìwə́y] ‘to wash s.t.’
3Ob-wash
i-wə̃́y [ìw̃ə̃́ỹ] ‘to shoot s.t. (with an arrow)’
3Ob-shoot

(c) o-rə́-n [òrə́^{d}n] ‘I will be white.’
1Su-be.white-IMPRF
o-nə̃́n [õ̀nə̃́n] ‘my feces’
1-feces

(20) (a) i-á-há-m [ìáhá^{b}m] ‘to bite’
3Ob-bite-RED-IMPRF
awã́ [ã̀w̃ã́] ‘a baby girl’

(b) áwáwá [áwáwá] ‘grandmother’
ʤe-wã́-wã́-wã́-m [ʤɛ̃̀w̃ã́w̃ã́w̃ã́m] ‘to scream’
CoRef.Poss-call-RED-RED-IMPRF

(c) aʃiwa-ʔá [àʃìwàʔá] ‘fish, sp.’
fish-CL
iʃíwã́-ʔa [ìʃíw̃ã́ʔà] ‘termite’
termite-CL

(21) (a) óhó-ʔa [óhóʔà] ‘flute’
flute-CL
e-ṍhṍ-ʔa [ɛ̃̀ṍh̃ṍʔà] ‘head of your domestic animal’
2-domestic.animal-CL

(b)	i-ʔó-m	[ìʔó^{b}m]	‘to eat s.t.’
	3Ob-eat-IMPRF		
	i-ṍm	[ìṍm]	‘to enter’
	3Su-enter		
(c)	dekó	[dɛ̀kó]	‘coatá monkey’
	e-kṍ[ʔ]	[ɛ̰̀kṍ]	‘your tongue’
	2-tongue		

The hypothesis that preoralization is a strategy to maintain the oral-nasal contrast on vowels in the environment of nasal codas is supported by neutralization of the contrast in other environments. First, vowels are always nasalized between nasal consonants (e.g. *nõŋʔá* ‘flea’, *inə̃́m* ‘to sew s.t.’, *imṍŋ* ‘to put s.t.’).

In addition, vowels can be nasalized preceding heterosyllabic nasals (e.g. *a[ʃĩ]má* ‘fish’, *[kã́]ŋa* ‘sugar-cane’), or optionally nasalized after a nasal onset (e.g., *[mə]dí* ~ *[mə̃]dí* ‘rodent, sp.’, *aʃi[má]* ~ *aʃi[mã́]* ‘fish’), except when the vowel is contrastively nasal, in which case nasalization is obligatory (e.g. *nobá[nṍ]* ‘gun’, *we[nə̃́ỹ]* ‘Brazil nut’).

Most importantly, oral vowels that cause preoralization also assimilate nasality in nasal harmony; compare *teí-m* [tɛ̆í^{b}m] ‘future price’ and *teí-ʔĩt* [tɛ̃̆í̃ʔ̃it] ‘It’s cheap’. (Nasal harmony is examined in Chapter 5.)

Nasal vowels occur less frequently in syllables closed by a voiceless stop (e.g. *sə̃́sə̃t* ‘monkey, sp.’, *naʔórẽk* ‘lizard’), in contrast with nasal vowels followed by a nasal consonant (e.g. *sə̃́sə̃́n* ‘to be ashamed, embarrassed’, *itabẽŋ* ‘S/he’s alert’), and oral vowels followed by stops and nasals (e.g., *irət* ‘It’s white’, *iwek* ‘It’s torn’, *iməísə́n* ‘to clean s.t.’, *yə̰kréŋ* ‘She’s pregnant’).

2.3.1 Acoustic effects of nasalization on vowel height

There is a trend across languages for nasalized vowels to exhibit height differences relative to the corresponding oral vowels (Baht 1975; Ohala 1974, 1975; Wright 1975, 1986; Beddor 1983; Maddieson 1984, and others). Beddor’s (1983) study provides an excellent overview of, as well as objections to, previous proposals about the effects of nasalization on vowel height. It reveals significant cross-linguistic tendencies concerning the direction of such changes. Her findings establish five cross linguistic patterns in the height dimension, shown in (22). In general, high vowels lower and low vowels raise due to nasalization. Beddor distinguishes between non-contextual, contrastive, nasalization and contextual-dependent nasalization, which refers to nasalization of a vowel adjacent to a nasal consonant, relevant to show systematic changes in the case of mid vowels.

(22) Cross-linguistic patterns (Beddor 1983: 99)

- (a) High nasal vowels lower.
- (b) Low nasal vowels raise.
- (c) Mid non-contextual nasal vowels lower.
- (d) Mid back contextual nasal vowels raise.
- (e) Mid front contextual nasal vowels lower, except if nasalization affects both front and back vowel height, in which case both front and back nasal vowels raise.

Acoustic data relating the effects of nasalization on Mundurukú vowels were examined for 3 speakers (AK, JT and EM). The focus was on vowels that exhibit phonologically contrastive nasalization, as in (23), including oral and nasal vowels contiguous to nasal consonants. A list with 20 words with contrastive nasalization was recorded.

(23) Words for comparing oral and nasal vowels in Mundurukú.

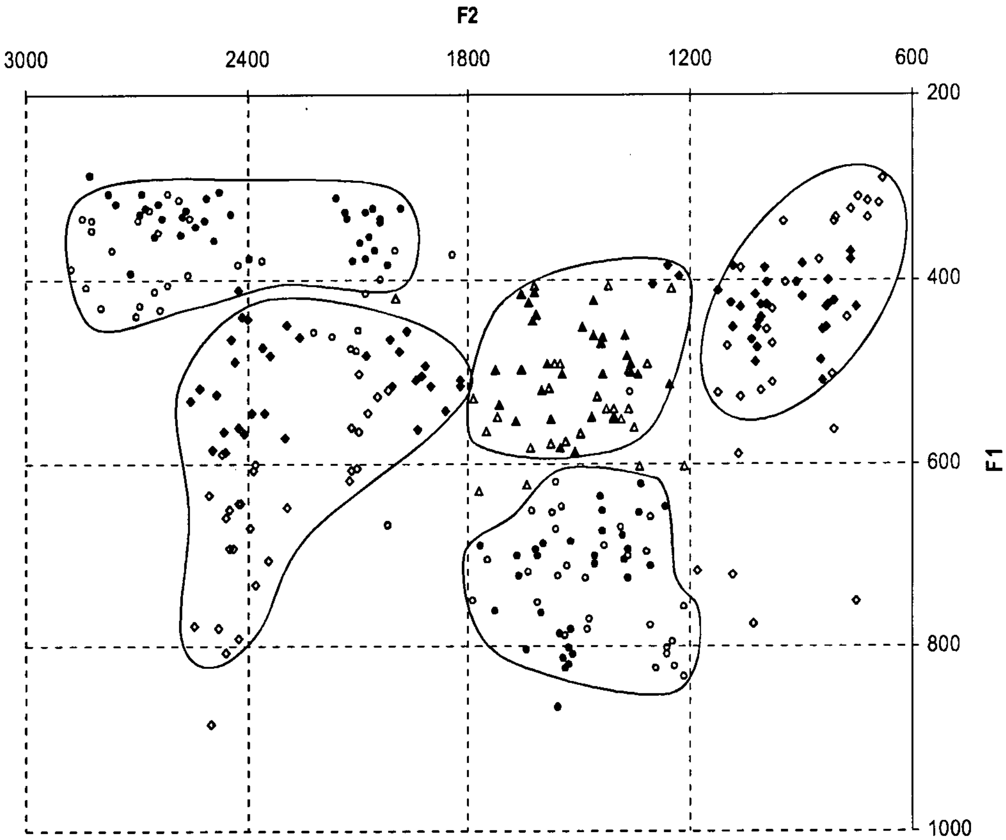
i / ĩ	**ĩ́hĩ́**	'winter'	ã́**hĩ́**	'mother, Voc.'
	káʃ**i**	'sun/moon'	aʃ**i**	'pepper tree'
e / ẽ	**hém**	'path, Emphatic'	taẽ́**hẽ́m**	'to choose'
	edíŋ	'tobacco smoke'	**ẽd**í	'kind of net for fishing'
ə / ə̃	ʤeə́**hə́m**	'to go up'	**ə́rə̃́**	'maracanã bird'
	orən	'I'll be white'	**onə̃́n**	'my feces'
a / ã	iá**hám**	'to bite'	a**wã́**	'baby girl'
	aʃi**wa**ʔá	'fish, sp.'	iʃí**wã́**ʔa	'termite'

o / õ	ó**hó**ʔa	‘flute’	eṍ**hṍ**ʔa	‘head of your domestic animal’
	de**kó**	‘coatá monkey’	e̱**kṍ**	‘your tongue’

Cross-linguistic patterns indicate that under the effects of nasalization, high and mid vowels lower and low vowels raise. Ohala (1974, 1975) attributes the changes in vowel height to the perturbation nasalization causes in the frequency of the first formant. Wright (1986: 49) observes that because “vowel height is inversely related to first-formant frequency, it would be expected that vowel nasalization would cause high and mid vowels to lower auditorily and the low vowels either to lower or to raise depending on the speaker and vowel.” There seems to be a general observation that nasal coupling manifests itself differently depending on the vowel quality, and that much of the effect nasalization has on these vowels is correlated with changes in the frequency of the first formant. The reason, as Wright (1986) and Beddor (1986) state, is because nasalization introduces a nasal formant with fixed and relatively low frequency, typically close to F1.

Acoustic data of oral-nasal pairs in Mundurukú indicate that nasalization has a strong effect in the quality of some vowels. This is shown in Figure 2.3.

Figure 2.3. F1 vs. F2 plots of Mundurukú oral-nasal vowels. In each pair of vowels, black stands for oral vowels and white for nasal vowels. Speakers: AK, JT and EM (Average of 29 tokens for each vowel)



Overall, all vowels are affected, except for /a/ and /o/, for which oral and nasal qualities are very similar.

(24) /ã-a/: t=0.187 s.d.=67.6 d.f.=59 p=0.85

/õ-o/: t=-1.46 s.d.=100 d.f.=59 p=0.15

There is a lowering effect of high and mid front nasal vowels; /i-ĩ/ and /e-ẽ/ differ significantly. The oral-nasal pair /ə-ə̃/ is also different:

(25) /ĩ-i/: t=-5.51 s.d.=39.4 d.f.=62 p<0.0001

/ẽ-e/: t=-7.77 s.d.=72 d.f.=59 p<0.0001

/ə-ə̃/: t=-2.77 s.d.=56.1 d.f.=55 p=0.0077

If we suppose that these results represent the Mundurukú community as a whole, the main effect nasalization has on vowel height is lowering of the high, mid front and central vowels.

Another observation is the effect of nasalization on the front-back dimension, determined by F2. Oral vowels are more likely to be concentrated in a small space, with less variation of formant frequencies, in particular F1 and F2; nasal vowels, on the other hand, exhibit greater variations. The means and standard deviations of formant frequencies are given in Table 2.2.

Table 2.2. Mean values (in Hz) and standard deviations of formant frequencies of oral and nasal vowels.

	F1	F2	F3
i	338	2386	3064
	26	278	191
e	508	2223	2898
	46	243	233
ə	493	1513	2566
	48	124	269
a	727	1502	2496
	63	124	154
o	427	973	2448
	34	140	188

	F1	F2	F3
ĩ	392	2492	3231
	50	302	214
ẽ	652	2319	3059
	92	169	175
ə̃	534	1513	2372
	62	178	315
ã	724	1461	2455
	70	188	302
õ	464	907	2300
	138	145	327

Another contrastive property of Mundurukú vowels is the modal-creaky contrast. To my knowledge, Mundurukú is the only Tupi language that has a contrast between nonmodal and modal voice. In the following section I shall consider a number of acoustic properties that are most likely to signal this opposition in the language, with the expectation that this analysis will contribute to the interface relation between phonetics and the phonological behavior of creaky vowels.

2.4 Phonation types

The different ways the vocal cords vibrate, or do not vibrate at all, create a variety of phonation types (Catford 1977; Ladefoged 1971). As suggested by Ladefoged (1971; see also Catford 1964), these various glottal states may be represented in the form of a phonation continuum, "[...] defined in terms of the aperture between the arytenoid cartilages, ranging from voiceless (furthest apart), through breathy voiced, to regular, modal voicing, and then through creaky voice to glottal closure (closest together)." (Gordon and Ladefoged 2001: 384). This continuum is schematically represented in (26).

(26) Continuum of phonation types (from Gordon and Ladefoged 2001: 384)

	Most open ←			→	Most closed
Phonation type	Voiceless	Breathy	Modal	Creaky	Glottal closure

During voiceless sounds the vocal cords are apart and do not vibrate, but are still close enough to allow for some turbulence in the airstream, for example, for the production of [h] (Ladefoged 1971). The voiceless-voiced opposition occurs in the majority of languages, particularly to make distinctions among consonants (e.g. voiced /b/ versus voiceless /p/).

Languages may also exploit other points on the continuum to manifest linguistic oppositions. Hmong (Huffman 1987) and Gujarati (Fisher-Jorgensen 1967) make a contrast between breathy and modal voice, Jalapa Mazatec (Kirk, Ladefoged and Ladefoged 1993) contrasts creaky, breathy and modal voice, and Kedang (Samely 1990) contrasts creaky and modal voice. Munduruků contrasts creaky and modal voice (Braun and Crofts 1965; Crofts 1973, 1985; Picanço 1997).

Modal is the normal way of vibration. The vocal folds are adducted along their full length and with a suitable degree of tension as to allow vibration in a rhythmic manner, i.e. opening and closing at regular intervals of time. In breathy phonation, or murmur, the vocal cords are vibrating but never completely closed; as a result, a significant amount of airflow can still escape through the glottis causing turbulence (Catford 1977; Laver 1980). In creaky phonation, often called 'laryngealization' or 'vocal fry', the arytenoid cartilages are held tightly together allowing only the front portion of the vocal cords to vibrate. The result is a sound produced as 'a rapid series of taps' (Catford 1964: 32) and at a very low frequency (Ladefoged 1971; Laver 1980). And finally, glottal closures, characterized by holding together the vocal folds so as to inhibit vibration. However, as Ladefoged and Maddieson (1996: 75) point out, glottal stops are often realized in the form of creaky voice on surrounding vowels, especially intervocalically, in the majority of languages, and not as a complete closure.

2.4.1 The modal-creaky voice opposition

Mundurukú contrasts on vowels two modes of laryngeal vibration: modal and creaky voice. The following words illustrate oral vowels with modal and creaky types of phonation. The pair /i-ḭ/ is illustrated in (27), /e-ḛ/ in (28), /ə-ə̰/ in (29), /a-a̰/ in (30), and /o-o̰/ in (31).

(27) (a) ʤe-ʃi-ʃi-m 'to spit'
CoRef.Poss-spit-RED-IMPRF
(b) ʤe-ʃḭ-ʃḭ-ʃḭ-m 'to tremble'
CoRef.Poss-tremble-RED-RED-IMPRF

(c) wida 'kind of clay'
(d) wḭda̰ 'jaguar'

(28) (a) ʤe-de-de-m 'to play an instrument'
CoRef.Poss-play-RED-IMPRF
(b) i-dḛ-dḛ-m 'to grate'
3Ob-grate-RED-IMPRF

(c) i-rore 'It's loose.'
3Su-be.loose
(d) i-ḛro̰-rḛ 'It's ripe.'
3Su-be.ripe-RED.Have

(29) (a) i-ə 'It's light.'
3Su-be.light
(b) i-yə̰ 'It's salty.'
3Su-be.salty

(c) o-í-tʃək 'It broke.'
3Su-í-be.broken

(d) ka-ʤə̰k 'to be cold'
thing-be.cold

(30) (a) dat 'scorpion'
(b) da̰t 'vomit (N)'

(c) áy 'rodent, sp.'
(d) a̰y 'sloth (monkey, sp.)'

(31) (a) i-rore 'It's loose.'
3Su-be.loose
(b) i-ḛro̰-rḛ 'It's ripe.'
3Su-be.ripe-RED.Have

Creaky vowels also contrast for nasalization, but these are rare in the language. The following are some examples of creaky nasal vowels.

(32) Nasal creaky vowels

(a) kara-bḭ̃ŋ-bḭ̃ŋ 'a hole with water'
?-?-RED

(b) i-mə-kénḛ̃ŋ-kénḛ̃ŋ 'to make little cuts in s.t. (e.g. fish)'
3Ob-CAUS-cut-RED

(c) i-kə̰̃y 'hole of s.t.'
3-hole

(d) i-mə-pã̰ 'to beat s.t./s.o. up'
3Ob-CAUS-be.hurt(?)

(e) i-kara-bõ̰n-bõ̰n 'It's curly.'
3Su-?-be.curly-RED

Because creakiness is primarily characterized by lowered pitch in Mundurukú (see §2.4.3.3), Braun and Crofts (1965; Crofts 1973, 1985) proposed that creaky voice is a tonal feature. According to them, creaky voice represents the lowest pitch level, or 'accent 4'. Despite its interaction with tones, this study (see Chapter 8) differs from Braun and Crofts in treating creaky voice as a property of vowels, like nasality, not as a tonal feature. (As will see in Chapter 8, creaky and L-tone modal vowels form a single class phonologically.)

No tonal contrasts are observed in creaky voice: if a vowel is creaky, or [+constricted glottis], then it has Low tone; modal vowels, on the other hand, may surface on a Low or High tone. Lowered pitch is in fact one of the primary manifestations of creaky voicing in the language. As already noticed by Braun and Crofts (1965), and confirmed later by Picanço (2002d), creakiness is usually accompanied by a pitch lower than that of modal vowels. I will not deal with the phonology of creaky voice or its interaction with tones in this chapter. First I want to investigate its phonetic aspects as a contrastive feature of vowels to determine what acoustic cues better signal the creaky-modal contrast in Mundurukú; all of which have been proven to be good indicators of phonation differences in a number of languages (e.g. Ladefoged, Maddieson and Jackson 1988; Kirk et al. 1993; Gordon and Ladefoged 2001). Because of the rare occurrence of nasal creaky vowels in the language, and absence of good pairs to be contrasted, I will limit myself to examining the creaky-modal opposition in oral vowels only.

2.4.2 Acoustic properties of the creaky-modal contrast

Creaky vowels are not heavily creaky in Mundurukú.[3] The waveforms in Figure 2.4 are illustrations of the contrast; they contain a modal vowel [a] (in the top waveform) in the word *dat* 'scorpion', and a creaky vowel [a̰] in *da̰t* 'vomit'. The waveforms show the full length of the vowel, from the first complete or nearly complete cycle until the last complete or nearly complete pulse. Note that the duration is similar for both vowels: creaky [a̰] is only 2 ms longer

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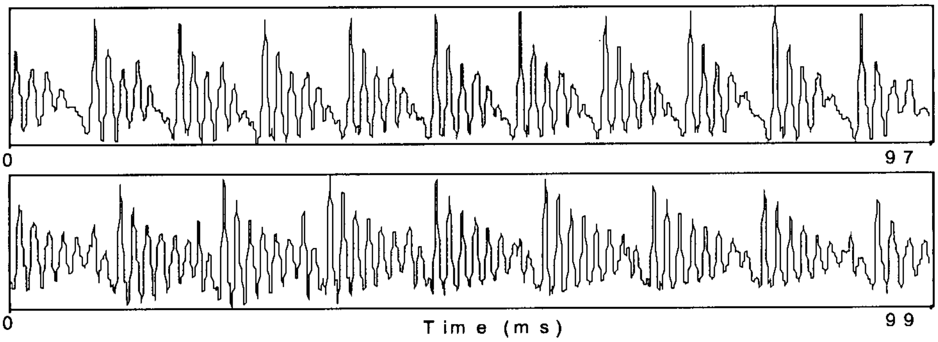
[3] I must point out that the degree of constriction varies according to the rate of speech; in a sentence, speakers tend to produce creaky vowels with less constriction, but if the same words are pronounced in isolation, the vowels may be heavily creaky.

than modal [a]. They differ, however, with respect to the number of glottal pulses realized for each vowel: 11 pulses for the modal, and 9 for the creaky vowel. Another observation is that adjacent glottal pulses occur at more or less regular intervals of time in both cases, although individual pulses are longer in duration for [a̰]: approximately 8 ms for [a] versus 9 ms for [a̰], and getting longer towards the end as creakiness increases. Creaky voice is in this sense manifested as a gradual fall in pitch.

Figure 2.4. Waveforms illustrating modal [a] and creaky [a̰]. Words: *dat* 'scorpion' and *da̰t* 'vomit', respectively.



Lowered fundamental frequency, glottal pulses with longer duration, and variation between adjacent glottal pulses are some cues associated with the creaky-modal voice distinction in Mundurukú. According to Ladefoged, Maddieson and Jackson (1988), Kirk et al. (1993), and Gordon and Ladefoged (2001), the various laryngeal configurations produce certain acoustic outcomes that can be used to quantify the nonmodal-modal opposition in a given language. Gordon and Ladefoged suggest a number of acoustic properties that are typically associated with phonation types, five of which were examined for creaky-modal pairs of vowels in Mundurukú: (i) formant frequencies, (ii) overall duration, (iii) fundamental frequency, (iv) periodicity, and (v) spectral tilt.[4]

Formant frequencies. Phonation differences may imply differences in formant values. The reason is that nonmodal phonation may involve a raising of the larynx, as Kirk et al. (1993) suggest for creaky voice in Jalapa Mazatec, or lowering, as Thongkum (1985) suggests for breathy phonation in Chong. Raising of the larynx affects frequency values by shortening the oral tract and so raising F1; lowering would have the opposite effect.

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[4] Gordon and Ladefoged include another property, intensity, but this was not measured for Mundurukú data because of technical difficulties.

Duration. Nonmodal vowels may have longer duration (e.g. Kirk et al. 1993). A related observation is that nonmodal phonation is often confined to a certain portion of the vowel rather than throughout its length, sometimes lasting for less than half of the vowel (Silverman et al. 1995; Blankeship 2002). Silverman (1995) proposes that nonmodal phonation obscures the perception of other phonological contrasts, for instance the realization of tonal contrasts; with sufficient duration, and by confining nonmodal phonation to only a portion of the vowel, other simultaneous phonological contrasts are also recoverable.

Fundamental frequency. In general, nonmodal phonation is usually correlated with lowered fundamental frequency, whether or not the language uses tones contrastively. This is true for Mundurukú creaky vowels where creakiness can only be realized in a low tone vowel, or is lost otherwise (Picanço 2004b, and Chapter 8).

Periodicity. Creaky voice is characteristically marked by aperiodic glottal pulses. Periodicity refers to measurements of the variation in the duration of consecutive glottal pulses, or *jitter*. Compared to modal voice, creakiness exhibits more jitter. It is possible to quantify this variation by measuring the duration of adjacent pulses in a given portion of the vowel.

Spectral tilt. Creaky voice can also be characterized in terms of spectral tilt. Measures of spectral tilt compare the differences between the amplitude of the fundamental (F0) and that of higher harmonics, in particular h2 (F0-h2) and the harmonic closest to F1 (F0-F1). In creaky vowels the level of energy is greater in the higher harmonics, i.e. the second harmonic has slightly greater amplitude than the fundamental, and the harmonic closest to F1 has much greater amplitude. For modal vowels the second harmonic has less amplitude than the fundamental, and the harmonic closest to F1 has similar amplitude.

2.4.2.1 Procedures

Similar measurements were conducted in a preliminary study (Picanço 2002d) where a minimal pair was examined, *dat* 'scorpion' and *da̰t* 'vomit', as produced by two male speakers. The results showed that fundamental frequency is consistently used by speakers to distinguish creaky from modal vowels. Despite the differences in the degree of creakiness, both speakers produced the creaky vowel [a̰] with fundamental frequency lower than modal [a]. Jitter and periodicity also reliably identified differences in phonation types; formant frequencies and overall duration overlapped, and did not seem to be a strong indication of the contrast, but new measurements show that there is an effect on formant values, as we will see next.

For this study, the five pairs of modal and creaky vowels, /i-ḭ/, /e-ḛ/, /ə-ə̰/, /a-a̰/ and /o-o̰/, were recorded by two male speakers, AK and JT, and measured for the five properties described above. Each vowel token was divided into two halves and the measurements were obtained from the second half, given that creaky voice is mostly localized to this portion of the vowel. The *formants* were measured as close as possible to the middle of the vowel (between 50 and 75%), but still at a point where creakiness was relatively salient, in order to avoid consonant transition effects on both ends. *Duration* was measured from the first complete or near complete pulse until the last complete or near complete one. *Fundamental frequency* (F0) was measured at five different points of the vowel, and each point was 1/6 apart from the other; for example, if the duration of a vowel is 150 ms, these were divided by 6 (150/6=25), so F0 was measured every 25 ms of the vowel: 25, 50, 75, 100, and 125 ms. This way we can obtain the drop in pitch that is characteristic of creaky vowels. For *periodicity*, the last 6-10 successive pulses (excluding the very last pulse) were measured for both modal and creaky vowels; shorter vowels, e.g. /i-ḭ/, had only 6 pulses measured, whereas /a-a̰/ had about 10. *Spectral tilt* was also measured at the same point the formant values were obtained. The following words were used for the creaky-modal contrast.

(33) The Mundurukú sample words.

	Modal		Creaky	
i-ḭ	ʤeʃi**ʃim**	'to spit'	ʤeʃḭ**ʃḭm**	'to tremble'
e-ḛ	ʤede**dem**	'to play'	idḛ**dḛm**	'to grate'
ə-ə̰	oíʧ**ək**	'It broke.'	ka**ʤə̰k**	'to be cold'
a-a̰	wi**da**	'clay'	wḭ**da̰**	'jaguar'
o-o̰	i**ro**re	'It's loose.'	iḛ**ro̰**rḛ	'It's ripe.'

2.4.3 Results and discussion

2.4.3.1 Formant frequencies

The effect of creaky phonation on vowel height, determined by F1, varies depending on the vowel. Table 2.3 provides the overall means and standard deviations for the modal-creaky pairs of vowels; the results are based on the measurements of 100 tokens produced by the two speakers, AK and JT, with a total 10 tokens for each vowel.

Table 2.3. Mean values and standard deviations of the formant frequencies (in Hz) of modal and creaky vowels.

Modal	F1	F2	F3
i	345	2430	2998
	20	138	195
e	505	2289	3016
	40	95	131
ə	483	2015	2605
	34	104	168
a	815	1629	2701
	74	111	32
o	395	966	2499
	17	48	202

Creaky	F1	F2	F3
ḭ	361	2387	2919
	18	153	236
ḛ	568	2232	3038
	36	127	150
ə̰	447	2079	2856
	30	258	319
a̰	811	1672	2768
	59	153	162
o̰	435	949	2384
	23	83	249

The vowel chart in Figure 2.5 compares the distribution of modal-creaky pairs for all tokens.[5]

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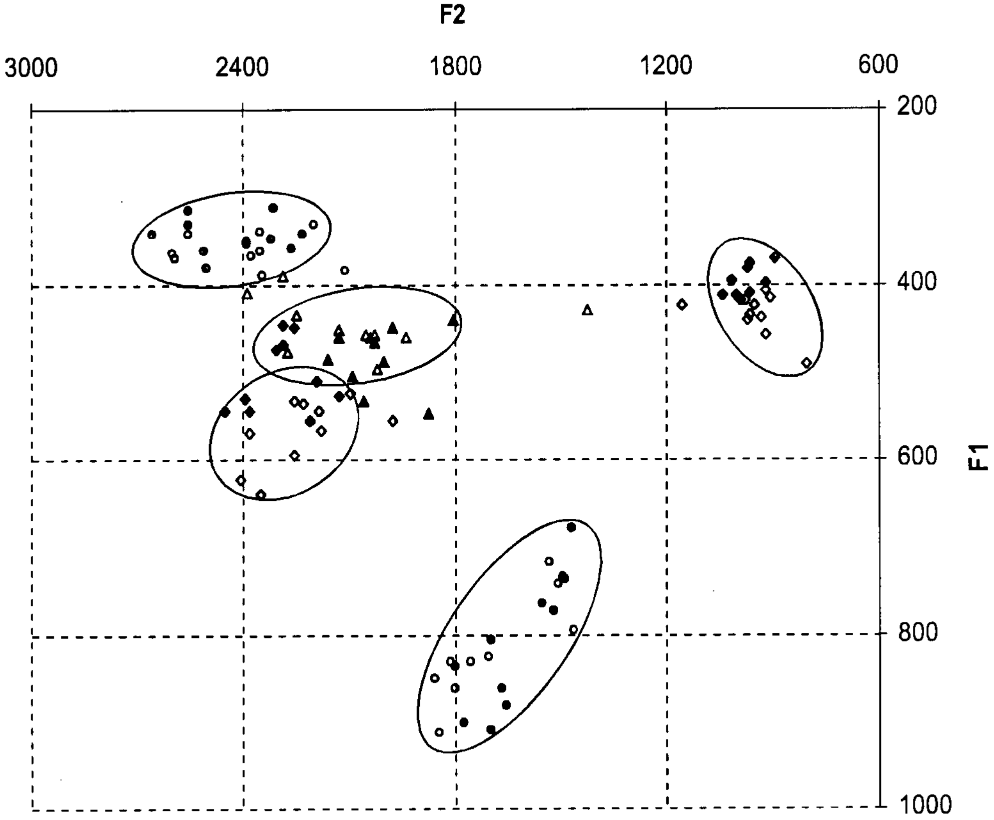
[5] The mid central pair [ə-ə̰] in the words *oíʧək* 'It broke' and *kaʤə̰k* 'to be cold' exhibits a large coarticulatory effect of the preceding palatal consonants [ʧ] and [ʤ], causing them to be realized closer to front vowels, i.e. with higher F2 values, in the words examined; recall from §2.2.2 that [ə] has a F2 mean value of 1387 Hz.

Figure 2.5. F1 vs. F2 plots of Mundurukú creaky-modal vowels. For each group, modal vowels are in black and creaky vowels in white. Speakers: AK, JT (10 tokens for each vowel)



The effect of creakiness is significant only in the pairs /e-ḛ/ and /o-o̰/, and there is a small difference in the pair /ə-ə̰/.

(34) /e-ḛ/: t=-3.52 s.d.=40.2 d.f.=18 p=0.0025

/o-o̰/: t=-4.12 s.d.=21.5 d.f.=18 p=0.0006

/ə-ə̰/: t=2.44 s.d.=33.6 d.f.=18 p=0.025

Creaky voice did not reach significance in the pairs /a-a̰/ and /i-ḭ/.

(35) /a-a̰/: t=0.130 s.d.=70.4 d.f.=18 p=0.90

/i-ḭ/: t=-1.78 s.d.=20 d.f.=18 p=0.092

2.4.3.2 Overall duration

Duration means are given in the following table.

Table 2.4. Duration means and standard deviations (in ms) for Mundurukú modal-creaky vowels. (2 speakers: AK and JT; 10 tokens for each vowel.)

	i	ḭ	e	ḛ	ə	ə̰	a	a̰	o	o̰
Mean	66	69	89	95	67	79	137	153	232	198
s.d.	11	10	10	8	8	11	32	19	16	25

The differences in duration between modal and creaky are significant for the modal-creaky pairs /o-o̰/ and /ə-ə̰/:

(36) /o-o̰/: t=3.42 s.d.=22.1 d.f.=18 p=0.0030

/ə-ə̰/: t=-2.48 s.d.=10.2 d.f.=18 p=0.023

There were no significant differences in other modal-creaky pairs.

(37) /i-ḭ/: t=-0.634 s.d.=11.1 d.f.=18 p=0.53

/e-ḛ/: t=-1.41 s.d.=9.66 d.f.=18 p=0.17

/a-a̰/: t=-1.35 s.d.=27.4 d.f.=18 p=0.19

2.4.3.3 Fundamental frequency

The measures of fundamental frequency showed that the creaky-modal distinction is primarily associated with differences in pitch: creaky phonation is manifested by lowered fundamental frequency (F0) relative to modal vowels. The results obtained for this property are based on the measures of 150 tokens (2 speakers): 50 tokens for L-tone vowels (=10 tokens for each vowel quality), 50 tokens for H-tone vowels, and 50 for creaky vowels.[6] As previously explained, five points were measured for each token, chosen by dividing the overall duration of

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[6] The following words with High-tone vowels were used for the comparison with corresponding Low-tone and creaky vowels: [í]: ipo**ʃím** 'It'll be heavy'; [ɛ́]: dáp**sém** 'deer'; [ə́]: **okə́k** 'Take care of me.'; [á]: wi**tá** 'grater'; [ó]: a**ró** 'parrot'.

the vowel by 6; for instance, if the duration of the vowel was 150 ms, each point measured was 25 ms apart from the other: 25-50-75-100-125 ms, excluding thus the first and last 25 ms of the vowel.

F0 contours for each token are plotted separately for AK and JT in the figures below (from Figure 2.6 to Figure 2.10). Note that the speakers realize F0 contours similarly for both types of phonation: there is a lowering effect on F0 towards the end of the vowel, with the exceptions of H-toned /ó/ that shows a raising effect, and /á/ that is more or less steady. For AK, H-tones are distinctly higher in all cases; L-tone and creaky vowels, on the other hand, overlap depending on the vowel. This overlap is mostly observed in the pair /i-ḭ/, as shown in Figure 2.6. (The results for significance tests are given below.) For other vowels, AK produces L-tone and creaky voicing with some overlap in the pairs /e-ḛ/ and /ɘ-ɘ̰/, shown in Figure 2.7 and Figure 2.8 respectively, but the tendency is for creaky vowels to be realized with a pitch level lower than that of L-tone modal vowels. The observations for the second speaker (JT) are similar. H-tones have higher F0, although the speaker produces them only a few Hertz higher than L-tones. The results are also comparable with respect to the realization of F0 in the different types of phonation. For both speakers, the low vowel /a/ shows the lowest values, and the high front vowel the highest ones.

Figure 2.6. Graphs showing F0 realization for H-tone, L-tone and creaky vowels. Dashed lines are for H-tone /í/, solid lines for L-tone /i/, and dotted lines for creaky voice /ḭ/.

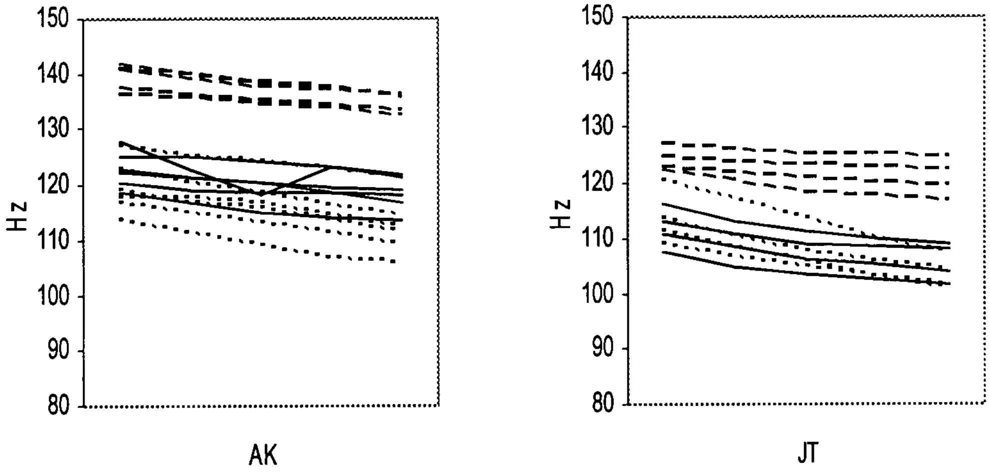


Figure 2.7. Graphs showing F0 realization for H-tone, L-tone and creaky vowels. Dashed lines are for H-tone /é/, solid lines for L-tone /e/, and dotted lines for creaky voice /ḛ/.

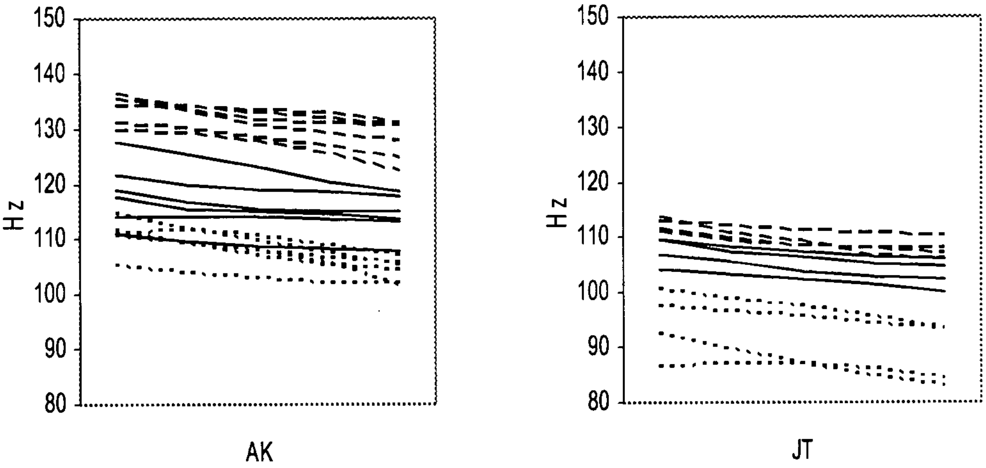


Figure 2.8. Graphs showing F0 realization for H-tone, L-tone and creaky vowels. Dashed lines are for H-tone /ə́/, solid lines for L-tone /ə/, and dotted lines for creaky voice /ə̰/.

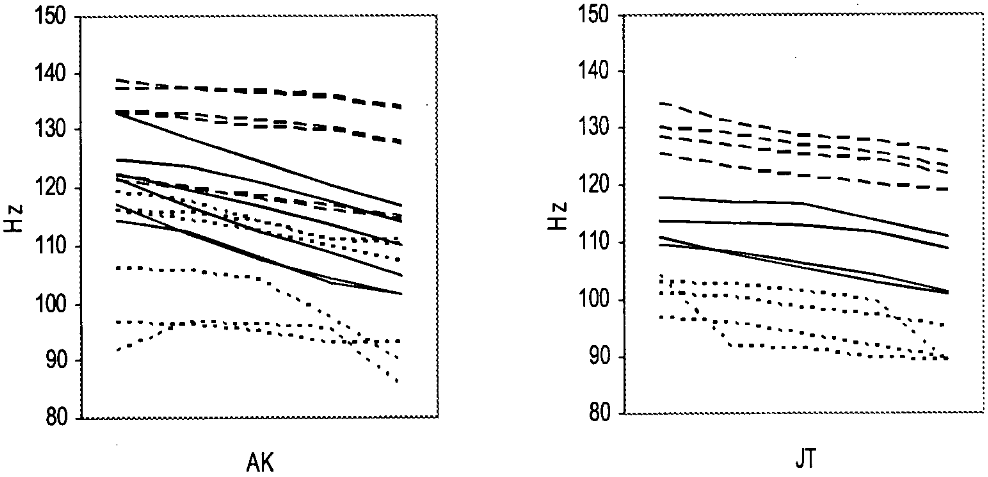


Figure 2.9. Graphs showing F0 realization for H-tone, L-tone and creaky vowels. Dashed lines are for H-tone /á/, solid lines for L-tone /a/, and dotted lines for creaky voice /a̰/.

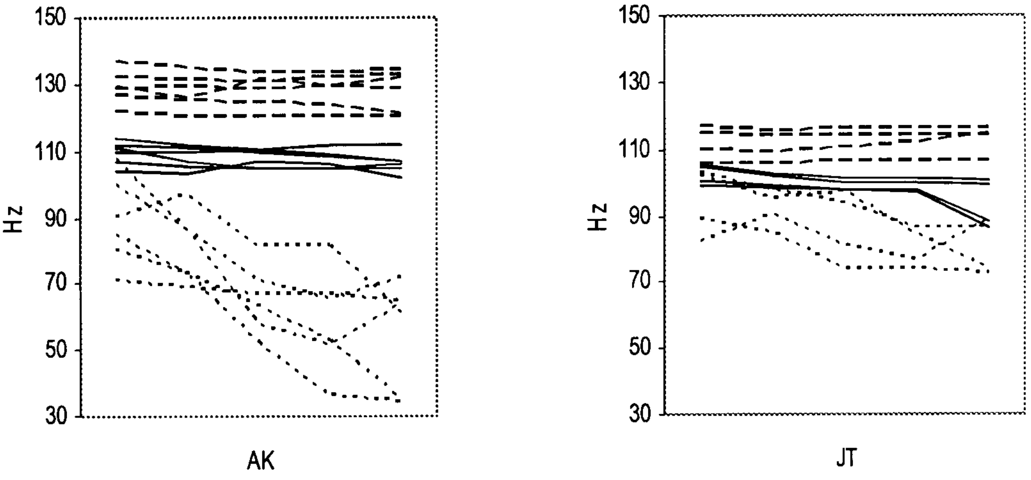


Figure 2.10. Graphs showing F0 realization for H-tone, L-tone and creaky vowels. Dashed lines are for H-tone /ó/, solid lines for L-tone /o/, and dotted lines for creaky voice /o̰/.

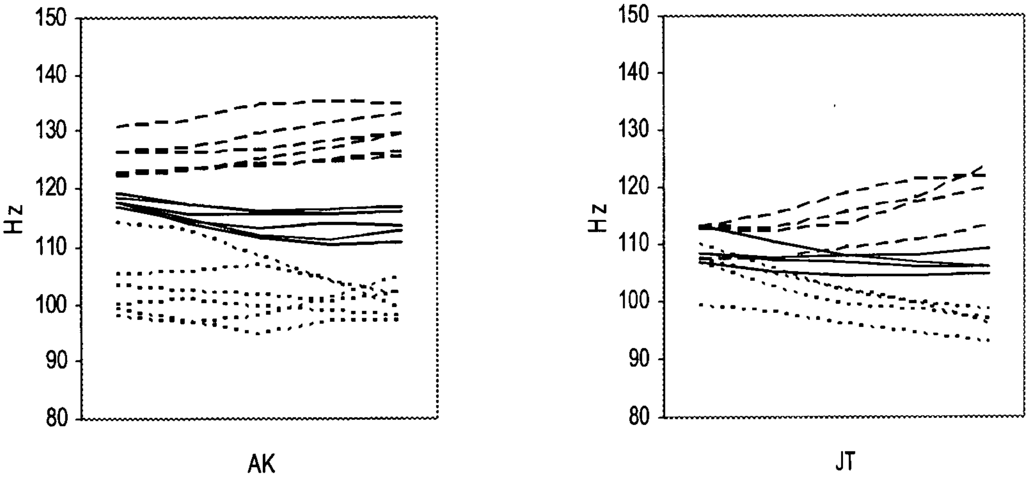
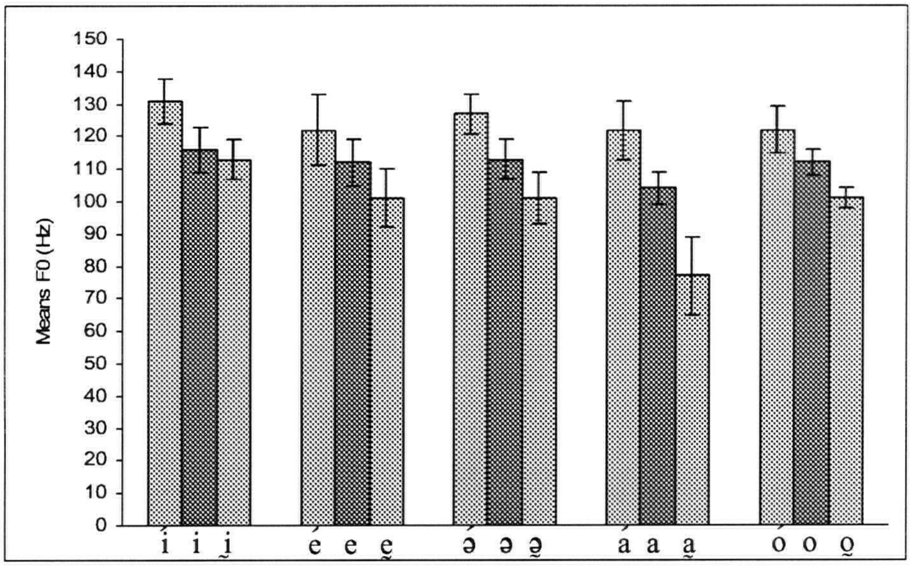


Figure 2.11 gives the mean F0 values for vowels with differences in tone and mode of phonation. The five points measured over the vowel were averaged to obtain a representative F0 value for each vowel token. These values were then averaged and one single F0 value representing each combination of vowel-tone and vowel-creaky voice was obtained. These are shown in the figure.

Figure 2.11. Mean F0 values for Mundurukú vowels with H-tone, L-tone and creaky voice. Speakers: AK, JT (10 tokens for each vowel).



The significance tests were conducted separately for both speakers, because of the differences in F0 ranges of tonal realizations. H-tone, for example, is produced at about 130 Hz for AK, but below that for JT. Only the results for AK are presented here, because the small number of tokens recorded by JT (4 tokens for each vowel) were not sufficient to obtain satisfactory results. (See Chapter 8 for further details on tone distinctions.)

As previously observed, there is considerable F0 overlap in the pair /i-ḭ/; the results in the table show that the two vowels exhibit no distinction with respect to pitch (p=0.091). We find a very small difference in the pair /ə-ə̰/ (p=0.048), but not as significant as the results obtained for other vowels, for which the effect of creaky voice in the realization of pitch is highly significant.

Table 2.5. Results for significance tests: L-tone versus creaky voice. (Speaker: AK)

AK	i-ḭ	e-ḛ	ə-ə̰	a-a̰	o-o̰
t	1.87	3.85	2.26	8.59	7.70
s.d.	4.17	3.90	8.19	7.76	3.04
d.f.	10	10	10	10	10
p	0.091	0.0032	0.048	<0.0001	<0.0001

In contrast, the table below shows that L-tone and H-tone vowels are clearly distinct. In general, the probability for H and L tone levels to coincide is less than 0.0001, except for the pair /ə-ə́/ (p=0.014).

Table 2.6. Results for significance tests: L-tone versus H-tone. (Speaker: AK)

AK	i-í	e-é	ə-ə́	a-á	o-ó
t	-11.8	-6.44	-2.98	-8.75	-7.39
s.d.	2.35	3.95	7.47	3.96	2.77
d.f.	10	10	10	10	10
p	<0.0001	<0.0001	0.014	<0.0001	<0.0001

Specifically with respect to the realization of pitch across vowels, the results indicate a correlation between F0 and vowel quality. The front high vowel /i/ exhibits the highest F0 values (relative to other vowels) for H- and L-tones, as well as creaky voice. There is still not sufficient data for this correlation, but some observations are worth being addressed here.

Many studies have examined intrinsic F0 (IF0) in tone languages and found correlations between IF0 and vowel height (Whalen and Levitt 1995 provide an excellent overview; Connell 2002 is another good example). The assumption is that high vowels have higher F0 values than low vowels. Whalen and Levitt observed that tone languages are also subject to IF0, although the differences are mostly observed in H-tone vowels, and typically neutralized in L-tone vowels. The list used for this study does not provide a good corpus for a comparison across vowels, but in principle vowel height may influence the realization of F0 in Mundurukú.

The differences observed for H-tone vowels in Mundurukú more or less conform to the observations made for other languages; while the high front vowel /i/ exhibits F0 values higher than any other vowel – a difference that is carried over to L-tones and nonmodal phonation – the low vowel /a/ exhibits the lowest values in similar contexts. As discussed above, H-tone is clearly distinct from L-tone and creaky phonation for all vowels, and exhibits higher F0 values, typically between 120-130 Hz. Despite the overlaps, L-tone is relatively distinct from creaky phonation, and ranges from approximately 100 Hz to 120 Hz; these values are closer to, but still higher than creaky phonation, which is realized with F0 below 100 Hz for most vowels.

In one extreme we find the high front vowel /i/ with means of 131 Hz for H-tone /í/, 116 Hz for L-tone /i/, and 113 Hz for creaky /ḭ/. At the other extreme, we find the low vowel /a/ with means of 122 Hz for /á/, 104 Hz for /a/, and 77 Hz for /a̰/. The low vowel /a/ has F0 values similar to those for /e/ and /o/ when H-toned, but has the lowest values if realized with a L-tone or creaky voice. In particular, creaky /a̰/ exhibits F0 values that begin around 100 Hz, and fall abruptly towards the end (see Figure 2.9 above). If IF0 is a function of vowel height, it seems reasonable to suppose that creaky phonation is fully compatible with a low vowel, but tends to be in conflict with a high vowel. Taken this way, the overlap in pitch between L-tone /i/ and creaky /ḭ/ discussed earlier can be properly understood.

One of the effects of creaky phonation is F0 lowering (e.g. Gordon and Ladefoged 2001), so it may be that there is a conflict between this effect and the elevated F0 characteristically found in high vowels. This is noticeable in the realization of creaky /ḭ/ in Mundurukú, which has pitch higher than other vowels, and overlaps considerably with the low pitch of a modal /i/. The low vowel, on the other hand, is distinctly lower in pitch during nonmodal phonation. This difference allows us to suppose that IF0 is a property that is carried over, not only to tones, but also to nonmodal phonation. Of course, the correlation between F0 and vowel height as a general trend in Mundurukú is not at this point well substantiated. As I pointed out earlier, the data used for this study do not permit an accurate examination across vowels, and the observations made above may be accidental.

The association of creaky voice with low pitch is not only phonetic but also phonological. The phonological behavior of creaky voice, specifically its relation to tones, is examined in detail in Chapter 8. It is demonstrated there that, phonologically, creaky voice is not a tonal property, as it has been argued since Braun and Crofts (1965). The tone associated with creaky vowels on the surface is always L, and like L-tone modal vowels, they are subject to the same processes. It is true that creaky vowels tend to have F0 values lower than modal vowels on a L tone, but I suggest that this is a phonetic effect associated with creaky voice (e.g. Gordon and Ladefoged 2001), and not a phonological property (see Chapter 8 for further discussion). While H-tone vowels act as a distinct set, creaky and L-tone modal vowels pattern together phonologically. This follows from the assumption that contrastive tones in Mundurukú occupy only two areas in the pitch range: one defines High tones and the other defines Low tones. In Chapter 8 I further suggest that, underlyingly, vowels may be modal, [-constricted glottis], or creaky, [+constricted glottis], and that this opposition is independent of tonal distinctions, as shown in (38).

(38) Distinctions between modal and creaky vowels (LN=Laryngeal Node)

(a) Modal vowels

V
|
LN
|
[-c.g.]

(b) Creaky vowel

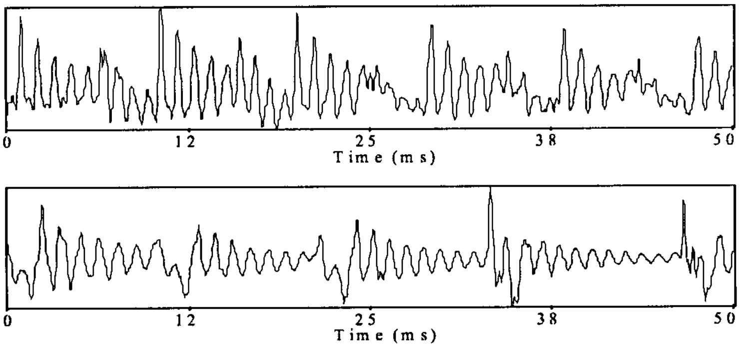
V
|
LN
|
[+c.g.]

I now turn to the results of two other properties: periodicity and spectral tilt, which are also good indicators of the modal-creaky contrast.

2.4.3.4 Periodicity

Measurements of the variation in the duration of adjacent pulses (jitter), have been used to establish differences in phonation types (e.g. Gordon and Ladefoged 2001; Ladefoged, Maddieson and Jackson 1988). Adjacent pulses vary less during modal vowels than during creakiness, typically characterized by irregularly spaced pulses. Jitter is another property examined for modal-creaky pairs of vowels in Mundurukú. The results indicate that the degree of variation during creaky phonation is higher then the variation observed in modal voice (see below). However, the difference between creaky and modal voicing may be better described as a difference in the duration of individual glottal pulses; creaky vowels are more or less realized with regular glottal pulses, but these are longer in duration. This is illustrated in Figure 2.12 which shows 50 ms displays of waveforms for modal [a], on top, and creaky [a̰], on bottom, in the words *wida* 'clay' and *wḭda̰* 'jaguar'. While modal [a] is realized with at least five complete cycles, creaky [a̰] has only four.

Figure 2.12. Waveforms (50 ms) illustrating duration of adjacent glottal pulses of modal [a] and creaky [a̰], respectively.



The results of jitter measurements are given in Table 2.7. Creaky vowels tend to have more jitter, as the respective standard deviations imply. But note that the reference values for duration of individual pulses also differ. Overall, mean values for creaky vowels are higher, indicating that they are longer in duration.

Table 2.7. Means and standard deviations for measures of jitter (in ms).

		Modal	Creaky
i	Mean	7.76	8.13
	s.d.	0.43	0.47
e	Mean	8.07	8.71
	s.d.	0.49	0.58
ə	Mean	7.97	9.54
	s.d.	0.83	1.61
a	Mean	7.04	9.77
	s.d.	0.35	1.13
o	Mean	8.40	9.56
	s.d.	0.49	0.54

A significance test was conducted for the duration of adjacent glottal pulses for both modal and creaky voice. The results showed that the duration of glottal pulses during creaky voice is significantly higher relative to modal voice.

Table 2. 8. Results for significance tests: Duration of glottal pulses for creaky-modal pairs.

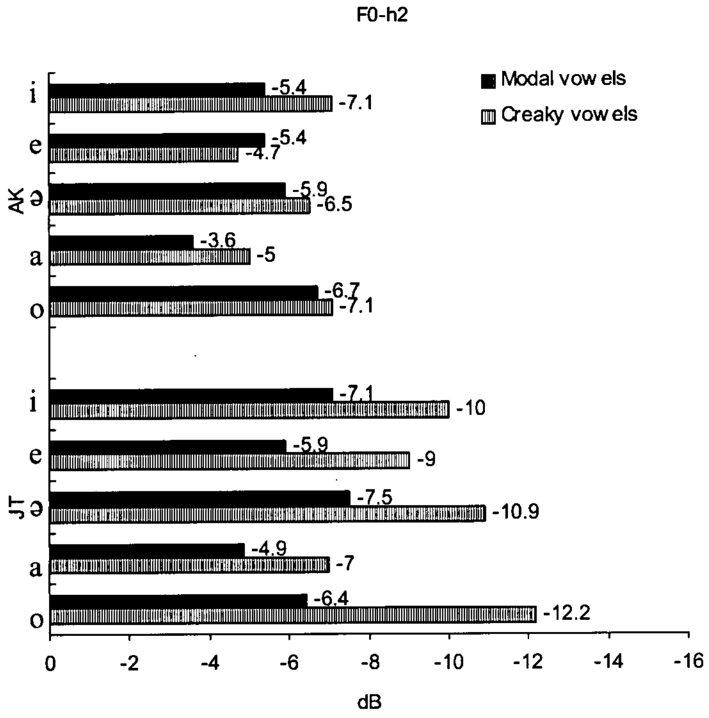
	i-ḭ	e-ḛ	ə-ə̰	a-a̰	o-o̰
t	-3.56	-5.78	-5.29	-15.9	-10.0
s.d.	0.45	0.53	1.30	0.84	0.52
d.f.	73	92	76	94	94
p	0.0007	<0.0001	<0.0001	<0.0001	<0.0001

2.4.3.5 Spectral tilt

Gordon and Ladefoged (2001: 397; and Ladefoged, Maddieson and Jackson 1988) suggest that spectral tilt provides "one of the major parameters that reliably differentiates phonation types in many languages." Spectral tilt compares the difference between the amplitude of the fundamental and the amplitude of the higher harmonics. Here I compare the amplitude of the fundamental (F0) relative to that of the second harmonic (h2) and the greatest harmonic in F1. In both modal and creaky phonation, the fundamental tends to have less energy than h2 and F1, but the differences between F0-h2 and F0-F1 are usually higher for vowels with creaky phonation.

The differences between the amplitudes of F0 and h2 (F0-h2) for all vowels are given in Figure 2.13. For both speakers the amplitude values for creaky vowels are higher than the values obtained for modal vowels, with the exception of the modal vowel /e/ which is higher (-5.4 dB) than the corresponding creaky vowel (-4.7 dB) for AK. Speakers differ in the values for each modal-creaky pair. For instance, the results for JT show a greater difference than the results for AK, but overall the amplitude difference F0-h2 serves as an indicator of phonation types in the language.

Figure 2.13. Means for amplitude differences between the fundamental (F0) and the second harmonic (h2) for all vowels.



Interestingly, creaky vowels tend to have amplitude values much lower, often negative, than those of modal vowels, often positive. This difference is illustrated in the graph below.

Figure 2.14. Mean values of the amplitude of the fundamental for modal-creaky pairs of vowels. The vowels appear in the following order, from left to right: /i, e, ə, a, o/.

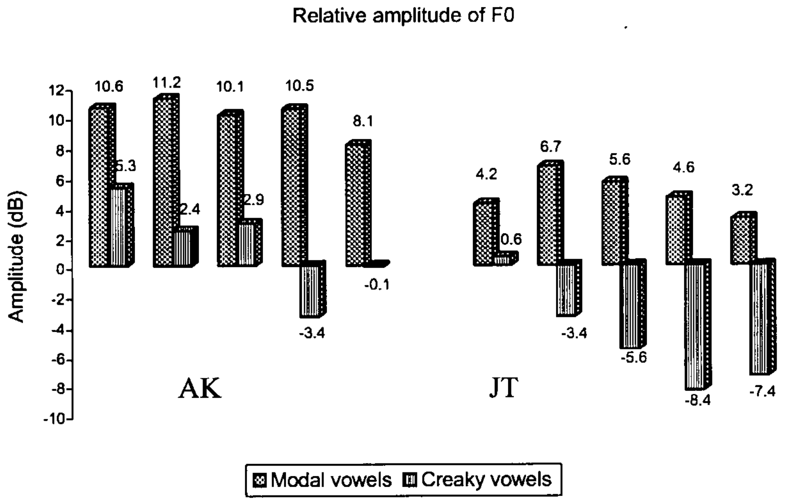
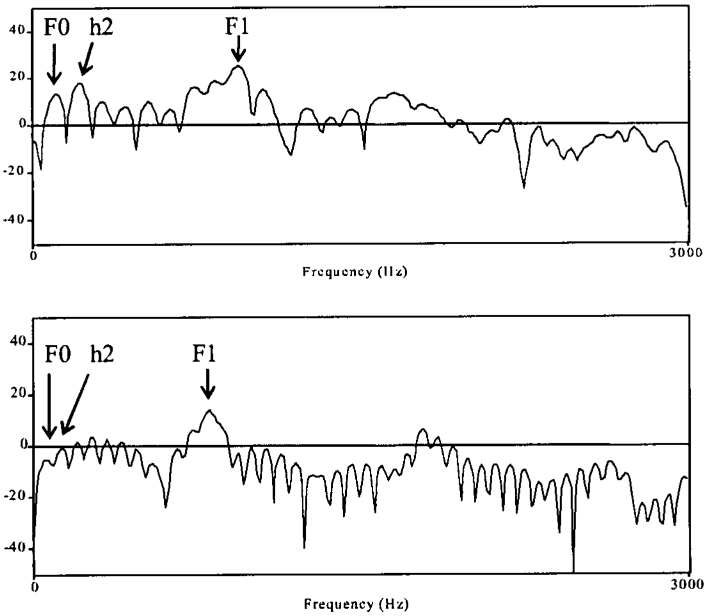


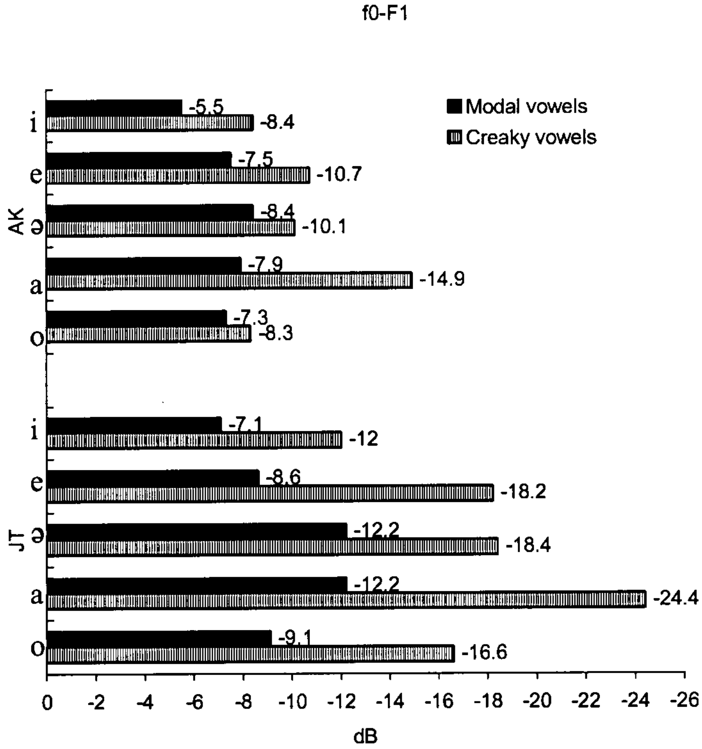
Figure 2.15 is a FFT spectra for modal [a] (in the top figure) and creaky [a̰] (on the bottom) to illustrate the difference in the amplitude of the fundamental, which has negative values for the creaky vowel.

Figure 2.15. FFT spectra of modal [a] and creaky [a̰] in the Mundurukú words *wida* 'clay' and *wḭda̰* 'jaguar' (AK).



The differences between modal and creaky phonation can also be quantified by comparing the amplitude difference between the fundamental and the harmonic closest to F1 (F0-F1). The results are shown in Figure 2.16. For both speakers, creaky vowels have much greater energy in the region of F1, relative to the amplitude of the fundamental. This can also be seen by comparing F0 and F1 for both types of phonation in the spectra in Figure 2.15 above. The F0-F1 amplitude differences are also greater for modal phonation but not as high as the ones obtained for creaky vowels.

Figure 2.16. Means for amplitude differences between the fundamental (F0) and harmonic closest to F1 for all vowels.



Measurements of spectral tilt, defined by amplitude differences between the fundamental and higher harmonics (F0-h2 and F0-F1), provide another good way of quantifying differences in phonation types in the language. The second harmonic and the harmonic closest to F1 have greater energy relative to that of the fundamental in creaky phonation, whereas the difference is smaller in modal phonation. These results conform to general observations that spectral tilt reliably differentiates between phonation types (see Gordon and Ladefoged 2001, and references therein).

2.5 Conclusion

To conclude the acoustic investigation of vowels in Mundurukú, I summarize some of the main findings of this chapter.

The vowel system of Mundurukú contains a gap in the high back region due to a missing /u/. The gap is compensated for phonologically by /o/, which I classifiy as [+high] based on phonological evidence. The imbalance in the mid region – because /e/ [ɛ] does not have a back counterpart of same height /ɔ/ – is the result of a historical process of neutralization between /ɔ/ and /o/. This hypothesis is supported by Kuruaya, a related language, which has a contrast between /ɛ/ and /ɔ/. This uneven distribution is more or less balanced by /ə/, which is acoustically closer to the mid front vowel /e/. Taking this approach, we can suppose that the distribution of vowels in Mundurukú conforms to the principle of vowel dispersion (Liljencrants and Lindblom 1972).

Section §2.3 dealt with the acoustic analysis of the oral-nasal contrast. We saw that nasalization affects height differences mostly in front vowels, which are lower than their oral counterparts.

The analysis then proceeded to the investigation of modal versus creaky vowels. Five acoustic properties were measured for all pairs of vowels: /i-ḭ/, /e-ḛ/, /ə-ə̰/, /a-a̰/ and /o-o̰/. From these, fundamental frequency, periodicity and spectralt tilt were very efficient in differentiating the contrast. Thus, speakers have available three good indicators of the creaky-modal distinction, but at this point of the investigation it is not possible to indicate one dominant perceptual cue. This study does not include perceptual data, but many studies have addressed similar questions. Klatt and Klatt (1990), for instance, conducted a perceptual experiment with American English speakers and, using synthesized speech, they observed that breathiness was more reliably identified by the amplitude of aspiration noise. However, different cues may be employed to differentiate types of phonation, meaning that a parameter used by speakers may not be the same, or not as relevant as, the one used by others in another language. Fundamental frequency may be an important candidate to the position, especially because of the restriction on the creaky-tone interaction. I will come back to this in Chapter 8.

CHAPTER 3

Phonetic and phonological structures of consonants

3.1 Introduction

This chapter describes a number of acoustic properties of Mundurukú consonants, with one question in mind: To what extent must phonetic variations be considered phonologically relevant?

A particularly interesting case involves the realization of voiceless stops in intervocalic position (Section 3.3). Consider three contexts for a stop – (i) internal or initial in the morpheme, preceded by a vowel (VCV or V+CV), (ii) morpheme-finally followed by a morpheme-initial vowel (VC+V), and (iii) morpheme-finally preceding an identical stop in the following morpheme (VC_1+C_1V). The phonology of the language determines that VCV and V+CV sequences be syllabified as V.CV (where "." marks a syllable boundary), and VC+V and VC_1+C_1V as VC.CV, with gemination of C in sequences VC+V. (Syllabification is examined in detail in Chapter 4.) Phonetically, however, a voiceless stop is ambisyllabic intervocalically, independent of its position in the morpheme, and serves both as coda for the preceding syllable and onset for the following, as argued on the basis of acoustic evidence in §3.3. Therefore, sequences VCV, V+CV and VC+V should *a priori* be phonetically equivalent to sequences where two identical stops are brought together by morpheme concatenation, that is, VC_1+C_1V. But according to the phonology, only VC+V and VC_1+C_1V are expected to be equivalent. Measurements of closure duration for stops in these sequences contradict the phonology. The results indicate that a stop tends to have greater duration in sequences VCV/V+CV than in VC+V, and are closer to VC_1+C_1V sequences. In addition, the results vary according to individual stops and sequences. This is discussed in Section 3.3, which also examines other acoustic properties of voiceless stops such as Voice Onset Time, and vowel duration preceding a voiceless stop, in comparison to a vowel preceding a voiced stop and a vowel in open or closed syllables.

Section 3.4 deals with the acoustic properties of voiced stops, and discusses some acoustic correlates of the voiced-voiceless distinction in the language, including Voice Onset Time (VOT), closure duration in intervocalic position, and duration of the preceding vowel.

Nasal consonants are examined in Section 3.5. The contrast between oral and nasal vowels seen in Chapter 2, is a determining factor in the phonetic realizations of tautosyllabic nasals:

following an oral vowel, nasals are preoralized, and following a nasal vowel, they are plain nasals. The analysis compares preoralized versus plain nasals, and shows that preoralization can be treated as a coarticulatory effect to avoid neutralization of the oral-nasal contrast on vowels in the context of a tautosyllabic nasal consonant.

Section 3.7 is devoted to the phonetic realizations of /h/ and /ʔ/. It shows that the realization of laryngeals is determined by context. /h/ is realized as the voiceless counterpart of adjacent vowels, and /ʔ/ is realized as creaky voice following sonorants, and with a complete closure otherwise. Their realizations as products of the environment provide further support for their phonological behaviour, especially in nasal harmony (to be examined in Chapter 6).

I conclude the chapter by discussing some important features for consonants (Section 3.8), based on phonetic and phonological observations.

3.2 The inventory

The consonant inventory of Mundurukú consists of seventeen consonants, illustrated below. (The nasal velar /ŋ/ is realized as [ɲ] syllable-initially (see §3.5)).

(1) Consonants

/p/	a**p**át	[àpát]	'alligator'	
/b/	ka**b**á	[kàbá]	'parrot, sp.'	
/t/	we**t**á	[wὲtá]	'my eyes'	
/d/	ipá**d**á	[ìpádá]	'macaw, sp.'	
/ʧ/	pə**ʧ**a	[pə̀ʧà]	'animal game'	
/ʤ/	pá**ʤ**a	[páʤà]	'sword'	
/k/	ba**k**át	[bàkát]	'tree, sp.'	
/s/	ta**s**ak	[tàsàk]	'It's (e.g. manioc) sour.'	
/ʃ/	da**ʃ**á	[dàʃá]	'fire, firewood'	
/m/	aʃi**m**á	[àʃìmá]	'fish'	
/n/	í**n**aká	[ínàká]	'despite'	
/ŋ/	pi**ŋ**á	[pìɲá]	'fish hook'	(onset /ŋ/)
	pə̃́**ŋ**	[pə̃́ŋ]	'one'	(coda /ŋ/)

/w/	á**w**á	[áwá]	‘grandmother’
/y/	ipa**y**á	[ìpàyá]	‘to stretch’
/r/	pá**r**át	[páɾát]	‘sieve’
/ʔ/	yaʔá	[yàʔá]	‘his/her head’
/h/	iá**h**á	[ìáhá]	‘to bite’

The consonants are distributed at five major places of articulation: labial, alveolar, palatal, velar, and glottal, as in Table 3.1. Voicing is contrastive only in the stop series, in particular in stops articulated at more anterior places. The absence of a voiced velar /g/ reflects a well known aerodynamic constraint between obstruents and voicing. As Ohala (1983) explains, voicing, the vibration of the vocal folds, requires sufficient airflow through the glottis. During the production of a stop, air accumulates rapidly in the oral cavity – because it is produced with a complete closure – raising oral air pressure, and consequently inhibiting vibration of the vocal folds. In back articulated stops, like [g], the space between the point where the stop is articulated (velar region) and the glottis, where voicing is produced, is smaller than in front articulated stops like [b], whose point of articulation is the lips. Thus air accumulates more rapidly during the production of [g] than during the production of [b], causing voicing to be extinguished sooner for the former. Therefore, while voicing is threatened for obstruents in general, the anterior versus posterior sites of constriction also play a leading role in that voiced back-articulated stops are most threatened and, therefore, more likely to be absent in phonological systems.

Table 3.1. Mundurukú consonant inventory.

	Labial	Alveolar	Palatal	Velar	Glottal
Stops	p b	t d	ʧ ʤ	k	
Fricatives		s	ʃ		
Nasals	m	n		ŋ	
Approximants	w	r	y		ʔ, h

The following sections examine the phonetic structures of consonants, and serve to support the analysis of syllabification in Chapter 4, and other phonological processes in subsequent chapters. In §3.3 I examine voiceless stops with respect to closure duration, VOT and the effect they have on the duration of the preceding vowel in sequences VCV. §3.4 takes up voiced stops, which can be characterized by the presence of a negative VOT word-initially and shorter closure intervocalically relative to voiceless stops. In §3.5 I examine nasal consonants with respect to the plain versus preoralized realizations. It is argued that preoralization results from the attempt to preserve the oral-nasal contrast in vowels in the context of a tautosylabic nasal. The glottal approximants /h, ʔ/ are examined in §3.7.

3.3 Voiceless stops

The voiceless stops /p, t, ʧ, k/ are realized as plain stops [p, t, ʧ, k] syllable-initially, and unreleased [p˺, t˺, k˺] syllable-finally, with the exception of /ʧ/ because it is restricted to onset position.[1]

(2) Syllable-initially: plain stops, [p, t, ʧ, k]

(a)	párát	pá.rát	[páɾát˺]	'sieve'
(b)	tawé	ta.wé	[tàwɛ́]	'monkey'
(c)	ʧo-ʔá hill-CL	ʧo.ʔá	[ʧòʔá]	'hill'
(d)	kák	kák	[kák˺]	'fox'

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[1] In coda position, only voiceless stops /p, t, k/, nasals /m, n, ŋ/ and glides /w, y/ may occur (see Chapter 4).

(3) Syllable-finally: unreleased variants, [p̚, t̚, k̚]

(a)	kíp	kíp	[kíp̚]	‘louse’
	o̰-t-ə́p-ʔat	o̰.tə́p.ʔat	[ò̰ᵗtə́p̚ʔàt̚]	‘A leaf fell.’
	3Su-3-leaf-fall			
(b)	o-ʃat	o.ʃat	[òʃàt̚]	‘my food’
	1-food			
	ʔot-pə́	ʔot.pə́	[ʔòt̚pə́]	‘worm’
	worm-CL			
(c)	kák	kák	[kák̚]	‘fox’
	ək-ʔá	ək.ʔá	[ək̚ʔá]	‘house’
	house-CL			

Intervocalically, voiceless stops are ambisyllabic irrespective of their morphemic affiliation, i.e. either tautomorphemic or heteromorphemic. I use the term “ambisyllabicity” to refer to a phonetic effect of consonant lengthening, and “gemination” to refer to a lengthening effect that is phonologically relevant (see below). Mundurukú does not have a phonological contrast between single and long consonants, but measures of closure duration and duration of a preceding vowel reveal that voiceless stops are produced as long consonants intervocalically.

There are three morphological environments to consider for a medial voiceless stop: morpheme-internally (VCV), morpheme-initially preceded by a vowel (V+CV), and morpheme-finally followed by a morpheme-initial vowel (VC+V). In all these cases, the stop is ambisyllabic: its serves as coda for the preceding syllable and onset for the following.[2] Some examples are provided in (4). A raised “^{C}” preceding “C” indicates that closure for the stop is anticipated – these refer to sequences VCV and V+CV – and “C^{C}” indicates that the stop is orally released onto the following vowel – these refer to sequences VC+V.

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[2] A reason to assume that intervocalic stops are ambisyllabic is that a vowel preceding a voiceless stop is as short as a vowel in a closed syllable (see §3.3.2).

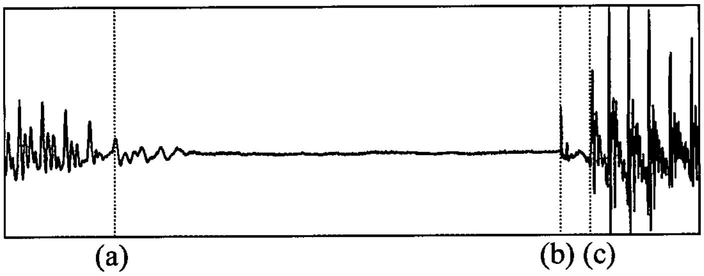
(4)	VCV and V+CV			
	(a)	o-dopá	[ò.dòᵖ.pá]	‘my face’
		1-face		
		i-pík	[ìᵖ.pík˺]	‘It’s burned.’
		3Su-be.burned		
	(b)	potíp	[pòᵗ.típ˺]	‘fish, sp.’
		ka-tõ	[kàᵗ.tõ̀]	‘a village name’
		thing-purple		
	(c)	pəkasó	[pə̀ᵏ.kà.só]	‘pidgin’
		o-kát	[òᵏ.kát˺]	‘my cultivated garden’
		1-garden		
(5)	VC+V sequences			
	(a)	i-kop=át	[ìᵏ.kòp.ᵖát˺]	‘One who went down.’
		3Su-go.down=NOM		
		i-díp=át	[ì.díp.ᵖát˺]	‘One who is beautiful.’
		3Su-be.beautiful=NOM		
	(b)	ʃípat=át	[ʃíᵖ.pàt.ᵗát˺]	‘the good one’
		be.good=NOM		
		i-kot=áp	[ìᵏ.kòt.ᵗáp]	‘an object for digging’
		3Ob-dig=NOM		
	(c)	i-kək=áp	[ìᵏ.kə̀k.ᵏáp˺]	‘an object for holding’
		3Ob-hold=NOM		
		ʤe-órók=át	[ʤɛ̀.órók.ᵏát˺]	‘hunter’
		CoRef.Poss-hunt=NOM		

Measures of closure duration were conducted for sequences VCV, V+CV and VC+V. The question addressed was as to what extent closure durations for a stop in VCV/V+CV sequences are comparable to, or diverge from, duration for stops in VC+V sequences. Here sequences VCV refer to both monomorphemic VCV and bimorphemic V+CV. I measured V+CV sequences separately from monomorphemic VCV to check if morpheme boundary had an effect on the duration of the consonant; the statistical analysis showed that they are alike: V+pV versus VpV: p=0.15, V+tV versus VtV: p=0.35, and V+kV versus VkV: p=0.65. Given this result, sequences VCV and V+CV will be treated as a single category, namely VCV.

3.3.1 Instrumental analysis: procedures

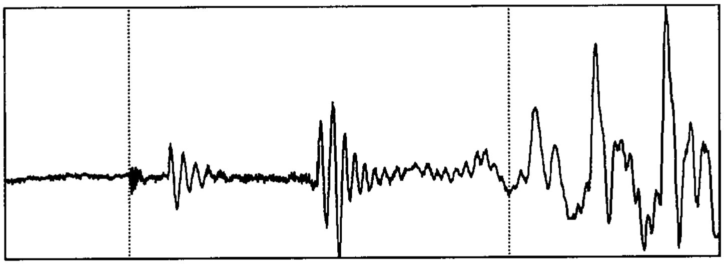
Durations were measured with reference to waveforms and spectrograms to locate the initiation of stop closure. The pairs examined compare onset (V.CV) versus morpheme-final (coda) stops (VC+V). Three points were tagged on each digitized token, as illustrated in the waveform in Figure 3.1. The first point (a) marks the beginning of stop closure, (b) marks the point where the stop is released, and (c) marks the initiation of voicing in the following vowel.

Figure 3.1. A waveform illustrating duration measures: (a) initiation of stop closure, (b) stop release, and (c) onset of voicing for the following vowel.



Two measures of duration were taken from the points marked. The first is closure duration, which was measured from the beginning of stop closure (a) to the point where the stop is released (b). The second is VOT, which measures from the stop release (b) to the beginning of voicing in the following vowel (c). For consonants with more than one burst event – the velar stop [k] in particular is characteristically marked by double release – VOT was measured from the point of the first release to the onset of voicing, as illustrated below.

Figure 3.2. A waveform showing a typical burst event for voiceless stop [k]. VOT was measured from the first burst to onset of voicing.



Measures of closure duration for intervocalic stops in VCV and VC+V sequences were also compared to the durations of identical stops in sequences VC_1+C_1V. These sequences are illustrated in (6).

(6) VC_1+C_1V sequences

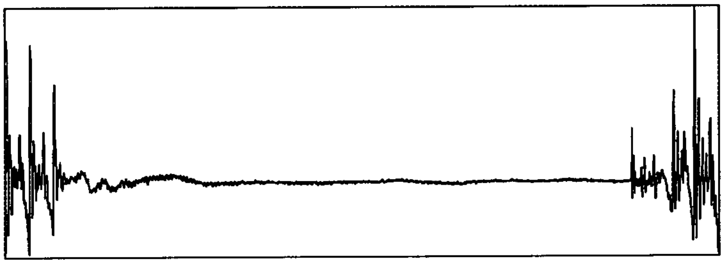
(a) o-t-ap-pə́ 'I got feathers.'
3Su-3-hair-pick
t-ip-pík 'The plantation is burned.'
3-bush-be.burned

(b) o-ʃát-ta 'my food'
1-food-CL
o-ʃát-təp 'my food'
1-food-CL

(c) i-mə-kírik-kíri̯-ŋ 'to tie s.t.'
3Ob-CAUS-tie-RED-IMPRF
i-mə-kə́k-kə́-ŋ 'to hold s.t.'
3Ob-CAUS-hold-RED-IMPRF

A sequence of identical consonants created by morpheme concatenation is typically realized with single closure and burst events, as illustrated in Figure 3.3 which shows the sequence [t-t] in the word *ofát-ta* 'my food'. A comparison with single medial stops in sequences VCV and VC+V will help answer the question as to whether single medial stops differ in duration from identical stops in sequences VC_1+C_1V.

Figure 3.3. Illustration of stop closure in the sequence [t-t] in the Mundurukú word *ofát-ta* 'my food'.



Finally, reference values of closure duration and VOT for each stop were also obtained from sequences VN+CV, in (7), where N is a nasal consonant and C is /p/, /t/, or /k/. These values were used as references for comparison with the values obtained from the sequences VCV, VC+V, and VC_1+C_1V. Assume that closure durations of voiceless stops after a nasal consonant are the 'normal' realization, and any deviations from these will be considered shortening or lengthening.

(7) (a) pə̃́ŋ-pə 'one long, flexible object (e.g. snake)'
one-CL

(b) pə̃́ŋ-ta 'one seed-like object'
one-CL

(c) i-mẽn-kə́ 'It's real/true.'
3-true-?

All these sequences were chosen because closure duration is a potential acoustic property distinguishing between single and geminate consonants (e.g. Lisker 1958; Pickett and Decker 1960; Catford 1977; Lahiri and Hankamer 1988). Phonologically, VCV sequences (C=stop) are syllabified as V.CV, whereas VC+V and VC_1+C_1V are both syllabified as $VC_1.C_1V$, in that the morpheme-final stop in sequences VC+V is lenghthened to provide an onset for the following vowel. (A complete analysis of syllable structure and syllabification is provided in Chapter 4.) Hence, a stop is expected to have shorter closure in sequences VCV than in VC+V or VC_1+C_1V. However, given the fact that ambisyllabicity happens irrespective of morphemic affiliation, the question is as to whether the phonetic realizations of medial stops signal their phonological behavior. In other words, are there durational differences between sequences VCV and sequences VC+V and VC_1+C_1V? The results are discussed in §3.3.2.

Another good indicator for single versus geminate consonants is the duration of preceding vowels (e.g. Maddieson 1985). In general, a vowel is shorter in closed syllables than in open syllables. If medial voiceless stops are ambisyllabic, it is expected that the preceding vowel be shorter than one preceding a voiced stop or word-finally in an open syllable. Durational measurements were conducted for vowels in the following contexts: word-final open syllable, word-final closed syllable, and preceding heterosyllabic voiceless and voiced stops. The results for each context are compared and discussed below. Two speakers were recorded, AK and JT, with approximately 74 tokens for each stop in all sequences – VCV: 20 tokens for each stop, VC+V: /p/=20, /t/=19, /k/=20, VC_1+C_1V: 20 tokens for each stop, and VN+CV:14 tokens for each stop. In VCV and VC+V sequences, measures of duration included both the consonant and the preceding vowel, which were compared to measures of vowels in open and closed syllables word-finally.

3.3.2 Results

Table 3.2 gives the averages and standard deviations of all tokens of each word.

Table 3.2. Closure duration means (in ms) for [p, t, k] in sequences VN+CV, VCV, VC+V, and VC_1+C_1V.

		VN+CV	VCV	VC+V	VC_1+CV_1
p		156	235	188	265
	s.d.	21.8	28.5	25.5	28.5
t		152	239	193	225
	s.d.	31.2	31.5	29.1	23.4
k		130	147	169	144
	s.d.	20.8	41.1	41.5	40.3

Table 3.3 compares the durational differences of the various sequences. All sequences with [p] are significantly different from each other, but the results for [t] show similarity in VtV versus Vt+tV sequences (p=0.13), and a significant difference otherwise. Conversely, sequences with the velar stop [k] are very similar in most sequences compared, except for Vk+V versus VN+kV (p=0.0027).

Table 3.3. Results of closure duration for [p, t, k] in sequences VN+CV, VCV, VC+V, and VC$_1$+C$_1$V.

		VCV *vs* VN+CV	VCV *vs* VC$_1$+C$_1$V	VCV *vs* VC+V	VC+V *vs* VN+CV	VC+V *vs* VC$_1$+CV$_1$
p	t	8.75	-3.36	5.47	3.87	-9.01
	s.d.	26.0	28.5	27.0	24.1	27.0
	d.f.	32	38	38	32	38
	p	<0.0001	=0.0018	<0.0001	=0.0005	<0.0001
t	t	7.91	1.55	4.67	3.89	-3.77
	s.d.	31.4	27.8	30.4	30.0	26.3
	d.f.	32	38	37	31	37
	p	<0.0001	=0.13	<0.0001	=0.0005	=0.0006
k	t	1.46	0.279	-1.66	3.26	1.95
	s.d.	34.3	40.7	41.3	34.3	40.9
	d.f.	32	38	37	31	37
	p	=0.15	=0.78	=0.10	=0.0027	=0.058

Based on these results, the observation is that [p, t, k] are distinctly longer intervocalically, but durational differences in VCV, VC+V and VC$_1$+C$_1$V sequences depend largely on individual stops, with no systematic relation between them. For instance, [p, t] tend to be longer in VCV sequences than in VC+V, but [t, k] pattern together if we compare VCV versus VC$_1$+C$_1$V, whereas VpV versus Vp+pV are different (p=0.0018). In addition, only [p, t] are significantly different in VN+CV versus VCV and VC+V.

An additional selection of sequences VCV, VC+V and VC$_1$+C$_1$V for all three stops was included in the previous measurements, including data from a third speaker (EM), and the results are consistent with the results above, as shown in the following table. VCV versus VC$_1$+C$_1$V differ significantly for [p], but not for [t, k], whereas VCV versus VC+V, and VC+V versus VC$_1$+C$_1$V are significantly different for [p, t], but similar for [k].

Table 3.4. Results of a random selection of sequences VCV, VC+V and VC_1+CV_1.

		VCV *vs* VC_1+C_1V	VCV *vs* VC+V	VC+V *vs* VC_1+C_1V
p	t	-7.75	2.70	-11.6
	s.d.	32.9	29.9	28.8
	d.f.	74	78	74
	p	<0.0001	=0.0085	<0.0001
t	t	1.64	5.60	-4.86
	s.d.	29.8	32.6	26.7
	d.f.	73	76	73
	p	=0.11	<0.0001	<0.0001
k	t	1.11	-0.148	1.26
	s.d.	38.0	40.8	37.9
	d.f.	71	77	70
	p	=0.27	=0.88	=0.21

Similarly, measures of Voice Onset Time (VOT) do not favor any of the sequences. Table 3.5 gives VOT values for the voiceless stops in the same sequences. The one difference is the effect of place of articulation on burst duration, as already noticed for a number of languages (Cho and Ladefoged 1999). The velar stop [k] exhibits the greatest VOT in all sequences, with average 30 ms and up; the mean values for [p] and [t] are close but burst durations are longer for the alveolar than for the labial.

Table 3.5. VOT means (in ms) by place of articulation.

		VN+CV	VCV	VC+V	VC_1+C_1V
p		10.7	11.8	12.6	12.8
	s.d.	1.77	2.18	4.39	5.45
t		13.0	17.2	17.2	13.2
	s.d.	4.15	4.28	5.38	3.98
k		36.9	39.2	30.9	36.9
	s.d.	9.61	6.93	6.02	8.0

The VOT for [p] shows no distinction in the sequences compared. The results for [t] show a difference in VtV versus NV+tV and Vt+tV. The sequences Vt+V are similar to VN+tV and slightly different from Vt+tV (p=0.011). For [k], VOT is significantly different in VkV versus Vk+V, and slightly different in Vk+V versus Vk+kV, but similar otherwise.

Table 3.6. Results of VOT for [p, t, k] in sequences VN+CV, VCV, VC+V, and VC$_1$+C$_1$V.

		VCV *vs* VN+CV	VCV *vs* VC$_1$+C$_1$V	VCV *vs* VC+V	VC+V *vs* VN+CV	VC+V *vs* VC$_1$+C$_1$V
p	t	1.51	-0.80	-0.77	1.54	-0.12
	s.d.	2.02	4.15	3.46	3.56	4.95
	d.f.	32	38	38	32	38
	p	=0.14	=0.43	=0.44	=0.13	=0.90
t	t	2.81	3.07	-0.15	2.41	2.6
	s.d.	4.23	4.13	4.85	4.91	4.72
	d.f.	32	38	37	31	37
	p	=0.0085	=0.0040	=0.99	=0.022	=0.011
k	t	0.83	0.98	4.02	-2.21	-2.66
	s.d.	8.13	7.48	6.50	7.73	7.11
	d.f.	32	38	37	31	37
	p	=0.41	=0.33	=0.0003	=0.035	=0.012

A good indication of the ambisyllabic behavior of medial stops is a difference in the duration of a preceding vowel (Maddieson 1985). First, the duration of a vowel in Mundurukú correlates with vowel height in that the lower the vowel, the greater its duration; thus /i/ is the shortest vowel, and /a/ the longest; mid vowels are in the middle. This is the pattern for both open and closed syllables, as shown in Table 3.7. Note that a vowel in a closed syllable is shorter than the same vowel in an open syllable.

Table 3.7. Vowel duration (in ms) in word-final CV and CVC syllables. (The values refer to a mean of 20 tokens for each vowel in CV# and 20 in CVC#; 2 speakers: AK and JT.)

		i	e	ə	a	o
CV#		133	144	137	148	124
	s.d.	28.4	37.3	35.1	24.4	20.1
CVC#		65	77	79	83	68
	s.d.	11.3	9.3	16.2	11.8	8.0

In comparison to these, the results of the phonetic length of a vowel preceding a voiceless stop in the sequences VCV and VC+V show that the vowel is also shorter, with mean values that are very similar to those obtained for vowels in closed syllables. The duration means of a vowel before [p, t, k] in the words examined are in the order of 64-88 ms for VCV sequences, and 76-88 ms for VC+V. Thus, a vowel before a voiceless stop is as short as a vowel in a closed syllable, providing a better and much stronger piece of evidence for the ambisyllabicity effect of voiceless stops in the language.

Table 3.8. Duration means (in ms) for vowels before [p, t, k] in sequences VCV and VC+V. (20 tokens for each sequence, 2 speakers: AK and JT).

	VpV	Vp+V	VtV	Vt+V	VkV	Vk+V
Mean	87	76	88	78	64	88
s.d.	8.1	9.5	11.0	9.1	12.0	10.9

To conclude the acoustic investigation of voiceless stops, a few words can be added about the voicless affricate /ʧ/. This consonant is produced with a long stop component and little frication. I measured 20 tokens of the Mundurukú words *daʧé* 'hawk, sp.' and a*yáʧát* 'woman', as produced by the two speakers, and the results, given in Table 3.9, confirm that the stop portion of the affricate is much longer than the fricative portion (means of 179 ms versus 64 ms respectively), which is in between the means obtained for [t] in sequences VN+CV (152 ms) and VC+V (193 ms). The overall mean duration of [ʧ], including the fricative portion, is 242 ms (s.d. 16.7). Like in the case of voiceless stops, /ʧ/ seems to be ambisyllabic, hence the preceding vowel is shorter than a vowel in an open syllable (mean of 99 ms), although not as short as one in a closed syllable (65-83 ms), or preceding a voiceless stop (64-88 ms); 99 ms is higher than, but still relatively close to, the duration of a vowel preceding [t] in VtV sequences (t=-2.70, s.d.=13.1, d.f.=38, p=0.010).

Table 3.9. Results of the palatal affricate [ʧ] in intervocalic position. (20 tokens, 2 speakers: AK and JT.)

	Stop portion	Fricative portion	Vowel duration
Mean (ms)	179	64	99
s.d.	21.9	10.1	14.3

The conclusion we reach with the acoustic investigation of voiceless stops is that their phonetic realizations do not pattern with their phonological behaviour. The ambisyllabic character of these stops is phonologically relevant for syllabification of medial stops as geminates only in sequences VC+V; hence VC.CV, which satisfies the requirements of the phonology by aligning a morpheme-boundary with a syllable-boundary, and at the same time provides an onset for the following syllable. (A complete analysis of syllable structure and syllabification is proposed in Chapter 4.) For the phonology, these sequences are similar to those involving a sequence of identical stops (VC_1+C_1V). Phonetically, however, both sequences differ with respect to closure duration; a stop tends to be shorter in a VC+V sequence than in VCV or VC_1+C_1V. Despite this, Chapter 4 provides phonological evidence for syllabification of VC+V as VC.CV, not V.CV. In addition, the fact that a stop has greater closure duration in sequences VCV does not appear to be phonologically significant. Phonologically, the stop behaves as a single consonant, and is syllabified as onset, i.e. V.CV.

Another good reason to not assign a phonological value to durational differences is the divergence across the results of individual stops. Closure durations for /p/ are different in all sequences compared; for /t/, the results vary between similar in some cases and different in others; and for /k/, the results show that this stop is mostly realized with similar closure duration, with the exception of Vk+V versus Vk+kV. To integrate these results into the phonology, several arrangements would have to be made in order to capture the details of their phonetic realizations. From a phonological point of view, there is no need to make a distinction between /p/, /t/, and /k/, because they function as a single class in all phonological processes examined in this work, as we will see in the following chapters.

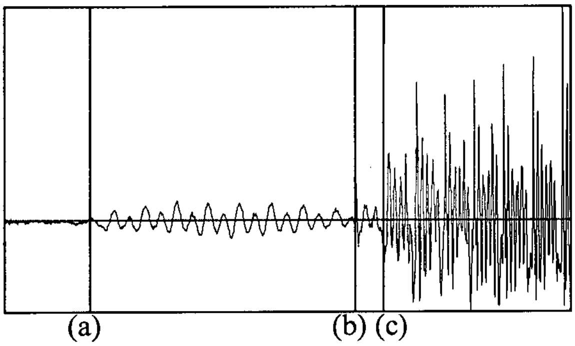
3.4 Voiced stops

Voiced stops /b, d/ may be affected by the environment at which they occur, but their typical realization is as [b, d] respectively. There is an optional prenasalized variant, [ᵐb, ⁿd], that occurs after a nasal vowel. Relative to /b, d/, the phonetic realization of the voiced affricate /ʤ/ is more variable, ranging from a palatal affricate [ʤ], to a palatal stop [ɟ], palatalized [dʲ], and sometimes a glide [y], which occurs only intervocalically.

Measurements were made for possible acoustic correlates of the voiced-voiceless distinction. One is duration of VOT in word-initial /b, d/, following Lisker and Abramson (1964; see also Keating, Linker and Huffman 1983). In Mundurukú, like in many languages, voicing distinctions in word-initial stops are primarily correlated with salient prevoicing in the voiced series (negative VOT), whereas voiceless stops are produced with no prevoicing (positive VOT), as expected. Another property measured was burst duration in the voiced series, with the exception of /ʤ/ because of the variations [ʤ ~ ɟ ~ dʲ ~ y]. (The results are discussed in detail below.)

Figure 3.4 gives the points tagged in each of the 17 tokens for the stops /b, d/ word-initially: (a) marks the point where there is regular vocal fold vibration, (b) marks the stop burst and (c) the onset of the following vowel. VOT was measured as corresponding to the interval between (a) and (b), and burst duration to (b) and (c). These results will be compared to the results obtained for the voiceless series, discussed in the previous section. The words examined are: for initial /b/, ***bí**o* 'tapir' and ***bek**ítʃát* 'boy, child'; and for initial /d/, ***da**tʃé* 'hawk, sp.' and ***de**kó* 'monkey, sp.'. In most tokens the two speakers were quite consistent in producing initial voiced stops with prevoicing.

Figure 3.4. Waveform of word-initial /d/ in the Mundurukú word *daʧé* 'hawk, sp.'; (a) marks the onset of prevoicing, (b) marks the onset of the burst, and (c) the offset of the burst and beginning of the vowel.



All voiced stops have negative VOT word-initially; for the bilabial stop [b] VOT is only few ms longer than that of the voiced alveolar [d]. The voiced palatal affricate follows the pattern with mean of -107 ms. As previously explained, burst duration could not be measured for /ʤ/ because of the variation in the release.

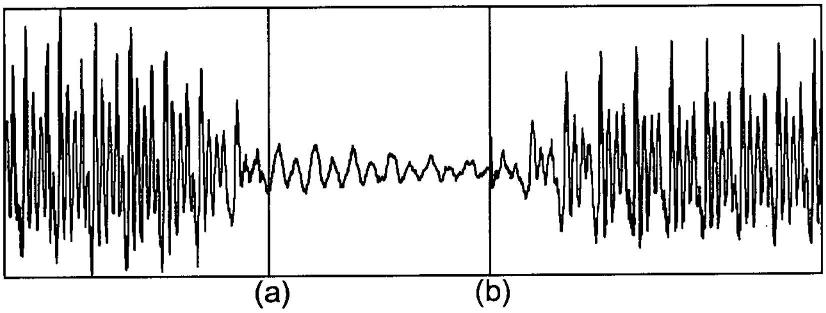
Table 3.10. Duration means (in ms) of VOT and burst for voiced stops word-initially. (17 tokens for each stop, 2 speakers: AK and JT)

		VOT	Burst duration
b		-109 ms	6 ms
	s.d.	22	1.9
d		-105 ms	11 ms
	s.d.	29.3	2.8
ʤ		-107 ms	
	s.d.	25.6	

The primary acoustic correlate of the voiced-voiceless distinction in intervocalic position is duration of the closure. A similar measure of closure duration was conducted for the voiced stops /b, d, ʤ/ in intervocalic (VCV) position, including durations of the preceding vowel. The words examined were *ʧebekít* 'his/her child' for /b/, *ʤededem* 'to talk' and *obadíp* 'my relatives' for /d/, and *ʧoʤóda* 'tucumã fruit' and *aʤóʤót* 'grandmother' for /ʤ/. (The VC sequences underlined correspond to the portion measured; 20 tokens were measured for each stop).

Figure 3.5 illustrates a voiced stop in intervocalic position, characteristically realized with uninterrupted vibration of the vocal cords throughout the closure, and extremely short burst release.

Figure 3.5. Waveform of the Mundurukú word *ʤededem* [ʤɛ̀dɛ̀dɛ̀^{b}m] 'to talk'.



A comparison with the corresponding voiceless stops /p, t, ʧ/ shows that voiceless stops have closure durations that are much greater than the voiced series, as shown in the following table. The means for voiceless stops correspond to their means in VN+CV sequences because these are supposed to reflect the duration of a voiceless stop without the effect of consonant lengthening. (For /ʧ/ and /ʤ/ the means refer to stop + fricative portions.)

Table 3.11. Means for closure durations of voiced stops in VCV sequences and voiceless stops in VN+CV sequences.

		b	p	d	t	ʤ	ʧ
Closure duration		86 ms	156 ms	62 ms	152 ms	83 ms	242 ms
	s.d.	11.0	21.8	12.2	31.2	24.2	16.7

With respect to duration of the preceding vowel, before a voiced stop a vowel patterns with vowels in open syllables, whereas before a voiceless stop, the vowel patterns with vowels in closed syllables.

Table 3.12. Duration means (in ms) of vowels preceding voiced and voiceless stops.

		VbV	VpV	VdV	VtV	VʤV	VʧV
Duration of preceding V	Mean	109	87	141	88	140	99
	s.d.	30.7	8.1	17.6	11.0	18.6	14.3

It follows from this that unlike voiceless stops, voiced stops are not ambisyllabic, but they do have an effect on vowel duration if we consider the difference in place of articulation to be a factor. For example, a vowel is shorter preceding /b/ than preceding /d/: 109 ms versus 141 ms. Despite the influence of place of articulation in the duration of the preceding vowel, it seems reasonable to conclude that vowels are shorter preceding voiceless stops than preceding voiced stops.

To conclude, we saw that voicing distinctions in Mundurukú are characterized by differences in the three parameters examined: (i) VOT in word-initial stops – voiced stops have negative voice onset time, meaning that vocal fold vibration precedes burst release; (ii) closure duration in medial stops – the voiced set is characterized by shorter closure relative to voiceless stops in intervocalic position; and (iii) duration of preceding vowels – vowels are much shorter preceding the voiceless set.

I now proceed to nasal stops and the preoralized versus plain nasal variation.

3.5 Nasal stops

Mundurukú has three nasal stops: /m, n, ŋ/, each of which has at least two variants: plain nasals [m, n, ŋ], and preoralized [^{b}m, ^{d}n, ^{g}ŋ]. The velar nasal /ŋ/ has in addition a third variant: a palatal [ɲ] that occurs only syllable-initially, (8)c; the variant [ŋ] occurs syllable-finally following a nasal vowel, (9)c, and [^{g}ŋ] occurs syllable-finally following an oral vowel, (10)c. The bilabial /m/ and alveolar /n/ are realized as plain nasals [m, n] both syllable-initially, (8)a-b, and syllable-finally following a nasal vowel, (9)a-b, and are partially oralized [^{b}m, ^{d}n] syllable-finally following an oral vowel, (10)a-b.

(8) Syllable-initially: NV and NṼ

(a)	mədí	mə.dí	[mə̀dí]	'rodent, sp.'
	aʃimá	a.ʃi.má	[àʃìmá]	'fish'
	imṍŋ	i.mṍŋ	[ìmṍŋ]	'to put s.t. in…'
(b)	napẽn-pə́	na.pẽn.pə́	[nàpɛ̃̀npə́]	'worm'
	worm-CL			
	nobánṍ	no.bá.nṍ	[nòbã́nṍ]	'gun, rifle'

(c) ŋədə́p ŋə.də́p [ɲə̃̀də́p˺] 'buriti (tree, sp.)'

piŋá pi.ŋá [pĩ̀ɲá] 'fish hook'

(9) Syllable-finally following a nasal vowel: ṼN

(a) ʤe-pírẽ́m ʤe.pí.rẽ́m [ʤɛ̀pĩ́rẽ́m] 'to put a fire out'

CoRef.Poss-put.out

(b) ʤe-kṍn ʤe.kṍn [ʤɛ̀kṍn] 'to eat' (Intr.)

CoRef.Poss-eat

(c) i-ta-bẽŋ i.ta.bẽŋ [ìtàbẽ̀ŋ] 'S/he is alert.'

3-eye-be.alert

(10) Syllable-finally following an oral vowel: VN

(a) t-írem tí.rem [tírɛ̀^{b}m] 'S/he is wet.'

3Su-be.wet

(b) i-kó-n i.kón [ìkó^{d}n] 'to dig something'

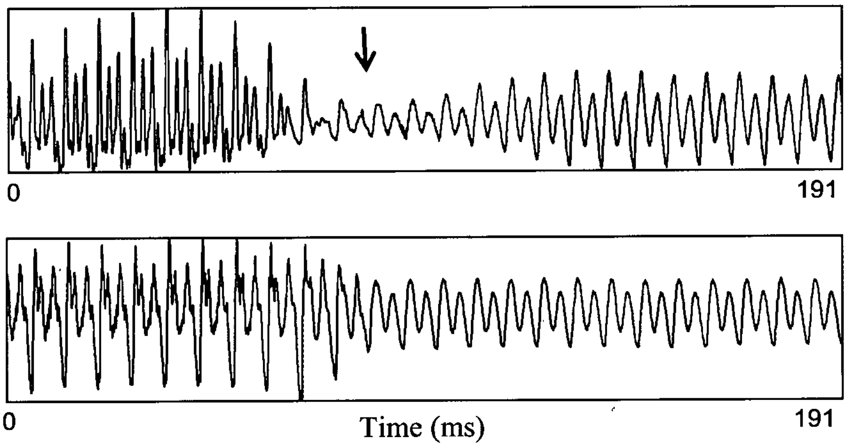
3Ob-dig-IMPRF

(c) i-beŋ-beŋ i.beŋ.beŋ [ìbɛ̀^{g}ŋbɛ̀^{g}ŋ] 'S/he is full.'

3Su-be.full-RED

Relative to the oral closure, lowering of the velum is delayed in preoralized nasals. Compare the waveforms in Figure 3.6, which shows /m/ following oral and nasal vowels. The waveform on top contains part of the preoralized bilabial nasal [^{b}m], and the waveform at the bottom, a plain nasal [m]. Note that the transition from the vowel to the nasal is clearly defined in the sequence VN, whereas in the second case, vowel and nasal overlap, changing gradually from one to the other.

Figure 3.6. Waveforms showing portions of oral and nasal vowels followed by /m/ in the Mundurukú words *tírem* 'It's wet' and *ʤepírẽ́m* 'to put fire out'. The top waveform contains the preoralized variant [^{b}m] after an oral vowel; and in the bottom, the plain nasal [m] after a nasal vowel.



The duration of the oral portion in a preoralized nasal is variable. The oral closure may precede velic lowering or closure and lowering may be more or less simultaneous, but it is never the case that lowering of the velum precedes the closure. Therefore, nasalization never interferes with the articulation of a preceding vowel in a sequence VN.

3.5.1 Preoralization as a coarticulatory effect

The lowering of the velum for a nasal consonant is likely to overlap into the articulatory configuration of preceding vowels (Clumeck 1976; Manuel and Krakow 1984; Farnetani 1986; Manuel 1988; Rochet and Rochet 1991; Solé 1992). The degree of overlap varies across languages; a vowel may be nasalized throughout its duration, as in English, or partially, as in Spanish (Solé 1992). Solé attributes this difference to phonological distinctions. In languages where [nasal] is phonologically distinctive in vowels, coarticulatory effects in VN sequences must be weaker in order to maintain the oral-nasal distinction, especially when adjacent to a nasal consonant. Vowel nasalization caused by coarticulation with a nasal consonant might well be perceived by listeners as an inherent property of the vowel, and this could neutralize a phonological distinction. If, on the other hand, efforts are made to avoid such coarticulatory effects, lowering of the velum for the nasal will be delayed as much as possible so to not interfere with the articulation of the preceding vowel. From the desynchronization of velic lowering with oral closure, preoralization results. In Mundurukú partial oralization is observed only when the nasal closes a syllable, typically indicating a morpheme boundary, that is, in a position where the oral-nasal contrast may be threatened.[3] Nasal onsets are affected neither by the preceding nor by the following vowel. Instead, a nasal onset triggers nasalization on surrounding vowels, completely when a vowel precedes the nasal and partially when follows it. In the latter, nasalization lasts for less than half of the vowel.

For the acoustic investigation of nasals, the targets plain and preoralized variants were analyzed for durational differences. Only the nasals /m, n/ were compared; /ŋ/ was excluded because of its realization as [ɲ] in onset position and [ŋ, ^{g}ŋ] in coda. Durations were measured for the following sequences: word-initial N (#NV), intervocalic N with N as onset (VNV), intervocalic N following an oral vowel (VN+V), intervocalic N following a nasal vowel (ṼN+V), and word-final nasals following both oral and nasal vowels (VN# and ṼN# respectively). The wordlist is provided in (11). For preoralized nasals, duration was measured from the oral closure, therefore including the oral portion, to the onset of the following vowel. As with the case of voiceless stops examined in §3.3 above, morpheme-final nasals followed by a morpheme-initial vowel are released.

(11) List for the acoustic analysis of nasals

(a)	#NV		VNV	
	m̲ədí	‘rodent, sp.’	seŋem̲ṍ	‘lizard’
	n̲apẽnpə́	‘worm’	nobán̲ṍ	‘rifle, gun’
(b)	ṼN#		ṼN+V	
	ʤepíré̃m	‘to put fire out’	ʤepíré̃m=áp	‘s.t. used to put fire out’
	ʤekṍn	‘to eat’	ʤekṍn=áp	‘s.t. used to eat’

---

[3] Stops and nasals not only close the syllable but also the morpheme; there are few exceptions with stops in which case they seem to occur inside the morpheme (e.g. *dáp̲sém* ‘deer’), but I am not aware of any cases with a nasal closing the syllable but not the morpheme. Related to this is the fact that only the rightmost vowel in the morpheme is contrastively oral or nasal, so it may not be a coincidence that coda nasals are preoralized but not onsets. (For further discussion see Chapter 6.)

(c)	VN#		VN+V	
	tírem	'It's wet.'	tírem=át	'one who is wet'
	ikón	'to dig it'	ikón=áp	's.t. used to dig'

The mean durations of nasals in the six environments are given in Table 3.13. Note that a word-final nasal (ṼN# or VN#) tends to have greater duration than a morpheme-final nasal followed by a vowel (ṼN+V and VN+V), and this has greater duration than a nasal in onset position (#NV and V.NV). The difference in duration between VNV and VN+V may reflect the fact that a morpheme-final nasal, like voiceless stops, are lenghthened to provide an onset for the following syllable; thus while VNV is syllabified as V.NV, VN+V is syllabified as VN.NV.

Table 3.13. Duration means (in ms) for the nasals /m, n/. (2 speakers: AK and JT; average of 19 tokens for each sequence).

		#NV	VNV	ṼN+V	VN+V	ṼN#	VN#
m		84.7	102	121	132	153	147
	s.d.	14.8	21.4	21.5	23.6	31.3	18.0
n		79.6	86.7	91.3	111	132	173
	s.d.	25.0	12.8	15.4	27.3	27.7	35.5

Preoralized versus plain nasals seem to behave alike, as the t-test results below show. For /m/, there is a significant difference in ṼN# relative to ṼN+V, and a slight difference in VN# versus VN+V, but no major difference in the other sequences compared. /n/, on the other hand, differs in every pair compared.

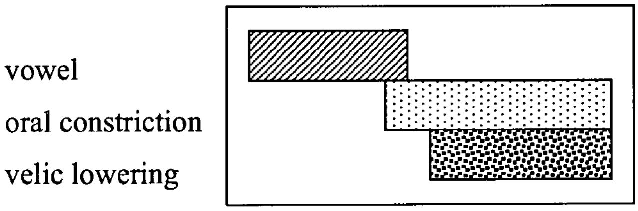
Table 3.14. T-test results for nasals /m, n/ in sequences ṼN#, VN#, ṼN+V, and VN+V.

		ṼN# *vs* VN#	ṼN# *vs* ṼN+V	VN# *vs* VN+V	ṼN+V *vs* VN+V
m	t	0.779	3.83	2.15	-1.67
	s.d.	25.5	26.8	21.0	22.6
	d.f.	38	38	38	38
	p	=0.44	=0.0005	=0.038	=0.10
n	t	-3.90	5.63	5.86	-2.74
	s.d.	31.7	22.4	31.6	22.0
	d.f.	35	36	34	35
	p	=0.0004	<0.0001	<0.0001	=0.0096

The oral portion of word-final nasals have mean durations on the order of 35 ms (s.d. 13.5) for a preoralized bilabial [^{b}m], and 33 ms (s.d. 11.6) for [^{d}n] (10 tokens for each sequence). This durational variation can be indicative of a coarticulatory effect by means of which velic lowering is phased differently relative to the oral closure so as to preserve the oral-nasal contrast on vowels. By delaying lowering of the velum for the nasal, a speaker prevents anticipation of nasality in the preceding vowel, and possibly a perceptual interpretation as an intrinsic feature of the vowel.

A schematic representation of the relative timing of velic and oral gestures is presented Figure 3.7, following a model of articulatory phonology as proposed by Browman and Goldstein (1989, 1992). In this model, articulatory events are gestures, defined in terms of tract variables, and each tract variable is associated with particular articulators. For example, tongue tip constrict location is a tract variable associated with tongue tip, tongue body, and jaw; velic aperture is associated with velum; glottal aperture with glottis, and so on. Since gestures characterize physical events occurring in a given space at a given time, they may interfere with each other; in other words, they overlap.

Figure 3.7. Schematic representation of the relative timing of velic and oral gestures in preoralized nasals.



The articulation of a nasal segment comprises two gestures: velic lowering and oral constriction (Krakow 1989). Krakow observes that word-initial nasals exhibit velic lowering more or less simultaneous with the oral constriction gesture. In word-final nasals, velic lowering gesture precedes oral constriction; this anticipation is perceived as nasalization in a preceding vowel. For the production of a preoralized nasal, the velic lowering gesture is timed relatively late so as to avoid nasality to spread to the preceding vowel. Although this may suggest a phonological process spreading the feature [-nasal] from an oral vowel to a tautosyllabic nasal, phonological evidence is provided in Chapter 6 to demonstrate that oral vowels are also subject to nasal assimilation from a nasal vowel. In other words, the phonology does not treat such vowels as inherently [-nasal]. Preoralization can thus be regarded as a mechanism to avoid a perceptual confusion between inherently nasal vowels and vowels nasalized by coarticulation with a nasal consonant, that is, it is a way of preserving a contrast that would otherwise be neutralized by a coarticulatory effect. I will return to preoralization in Chapter 6 to discuss whether preservation of the contrast in this manner should be phonologically represented.

3.6 Approximants

The set of approximants comprises /r, w, y, ʔ, h/. Their distribution within a syllable varies. /w, y/, may occur both as onset and coda, whereas /r, ʔ, h/ can only be onsets.

(12)	(a)	pá.rát	‘sieve’
	(b)	wi.da̰	‘jaguar’
		kaw.tá	‘salt’
	(c)	yo.boŋ	‘It’s big’
		póy	‘tortoise’

(d) ʔot.pə́ 'worm'

(e) í.hí 'winter'

/r/ has an additional restriction: it does not occur word-initially in native words, but may occur in borrowings (e.g. *rátaʔá* 'can' from Portuguese *lata*, and *rápiʔíp* 'pencil', Portuguese *lápis*), in which case it is preceded by a short, nonsyllabic schwa: [ᵊɾátàʔá] and [ᵊɾápìʔíp˺].[4] (Nonsyllabic [ə] is examined in Chapter 4.) Approximants also have affinities with vowels, especially with respect to their behavior in nasal harmony. These are the consonants that assimilate nasality, thus all have nasalized variants [r̃, w̃, ỹ, ʔ̃, h̃] in the context of nasalization contexts,[5] and are oral otherwise.[6]

(13) (a) ə́rə̃́ [ə̃́r̃ə̃́] 'maracanã (bird, sp.)'

(b) wə̃́y [w̃ə̃́ỹ] 'far, distant'

(c) w-aʔṍ [w̃ã̀ʔ̃ṍ] 'my voice, speech'
1-voice

(d) o-ṍhṍ [õ̀ṍh̃ṍ] 'my domestic animal'
1-domestic.animal

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[4] This was first reported by Braun and Crofts (1965). Young speakers who speak Portuguese fluently pronounce simply [ɾátàʔá] and [ɾápìʔíp˺].

[5] A nasalized [ỹ] may also be realized as [ɲ] syllable-initially, depending on the rate of speech: *y-a-ʔĩ́t=ma* (3-CL-be.small=EMPH) 'It (e.g. house) is small' is phonetically [ỹã̀ʔ̃ĩ́t˺mã] or [ɲã̀ʔ̃ĩ́t˺mã].

[6] Even though the glottal /ʔ/ is transcribed as a full stop in the examples, its realization in intervocalic position is usually as creaky voice on adjacent vowels. See section 3.7 for details.

3.7 Laryngeals: /h/and /ʔ/

Phonologically, the laryngeal approximant /h/ is restricted to medial position but may optionally occur word-initially if the initial syllable is underlyingly onsetless (e.g. *é* 'path' is [ɛ́] ~ [hɛ́], *apát* 'alligator' is [àpát˺] ~ [hàpát˺], and so on). Word-medially /h/ occurs only between identical (reduplicated) vowels,[7] except in reduplication with a fixed vowel /e/ in Have-constructions, which forces /h/ to occur between different vowels. This is illustrated in (14)f. Although /h/ exhibits properties of a default consonant, its status as an independent phoneme is motivated by lexicalization of forms such as those in (14)a-c for which the non-reduplicated forms no longer exist in the language. (The phonology of /h/ is treated in Chapter 4.)

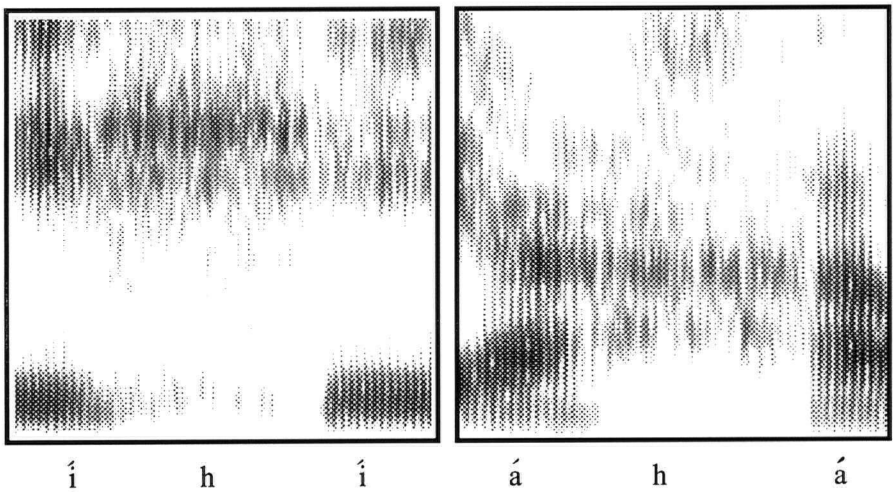
(14)	(a)	íhí	'winter'	*í	
	(b)	o-ő̋hő	'my domestic animal'	*oő	
		1-domestic.animal			
	(c)	y-ao̰ho̰=át	'one who is pale'	*yao̰	
		3Su-be.pale=NOM			
	(d)	ʤe-ə́-hə́-m	'to go up, climb'	o̰-ʤé-ə	'S/he climbed'
		CoRef.Poss-up-RED-IMPRF		3Su-CoRef.Poss-up	
	(e)	i-á-há-m	'to bite s.t.'	o-á	's.t. bit me.'
		3Ob-bite-RED-IMPRF		1sg-bite	
	(f)	t-eí-hé	'It has a price'	t-eí	'its price'
		3-price-RED.Exist		3-price	

---

[7] The reduplicated vowels do not always agree in tonal melody, for example, íhi 'monkey, sp.'

The phonetic aspects of /h/ are acquired from surrounding vowels. As Ladefoged (1971) describes, /h/ is the voiceless counterpart of the following vowel. Compare the two spectrograms below, which show parts of VhV sequences in the Mundurukú words *íhí* 'winter' (on the left) and *iáhám* 'to bite s.t.' (on the right). Note that formant structures for vowels preceding and following the laryngeal remain steady throughout their duration. Note also that the range of frequencies for /h/ varies depending on the vowel. In *íhí*, phonetically [íçí], the peak of energy is centered in the higher frequencies, around F2 and F3. In [áhá], the region with greater energy is located in the lower frequencies, around F1 and F2, with very little energy in the higher frequencies. The phonetic shape of [h] is therefore, as Ladefoged remarked, that of a neighboring vowel, without voicing.

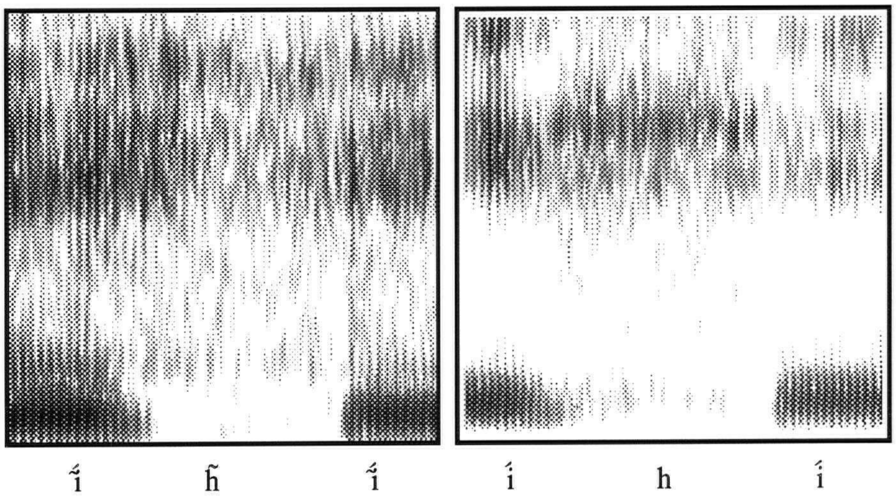
Figure 3.8. Spectrograms of VhV sequences in the Mundurukú words *íhí* 'winter' (left), and *iáhám* 'to go up' (right).



The affinities that the voiceless approximant /h/ has with vowels can also be extended to its compatibility with nasalization, strictly speaking, compatibility with lowered velum, the required configuration for a nasalized sound. Studies (e.g. Ohala 1974; Cohn 1990) have demonstrated that the position of the velum during the production of glottal consonants is largely determined by the context – raised if surrounded by oral sounds, lowered if surrounded by nasal sounds (Ohala 1974). In Cohn's (1990) study of nasalization in Sundanese, the results of airflow traces also confirm that /h/ is heavily nasalized in nasal environments.

In Mundurukú /h/ assimilates nasalization from adjacent nasal vowels. Compare the two spectrograms below containing [h] in both nasal, [ĩ́h̃ĩ́] on the left, and oral contexts, [íhí] on the right. The nasalized sequence exhibits an uninterrupted noise throughout its duration, more evident in the region of F2/F3, which affects not only the vowels but also the laryngeal, suggesting that the velum remains lowered during its production.

Figure 3.9. Spectrograms of [ṽh̃ṽ] and [vhv] sequences in the Mundurukú words *íhí* 'winter' and *aĩ́h̃ĩ́* 'mother, Voc.'.



Another laryngeal that shares some properties with vowels is /ʔ/. Its phonetic realization ranges from complete closure to creaky voice on adjacent vowels. The occurrence of one or the other can be predicted from adjacent segments and tone: segments determine the closure-creakiness realization, and tone determines the target for creakiness. These observations are based on the examination of 120 tokens (2 speakers, AK and JT) of words containing /ʔ/ in the following contexts: (i) word-initially (20 tokens), (ii) preceded by a voiceless stop (40 tokens), (iii) preceded by sonorants, i.e. nasals and glides (10 tokens each), and (iv) in intervocalic position (40 tokens). The results of each context are presented in the following sections.

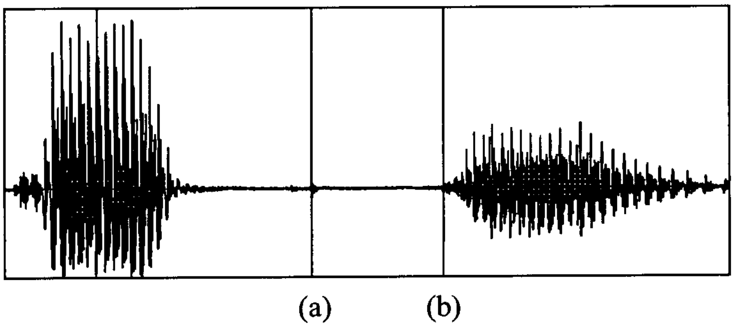
3.7.1 /ʔ/ as a complete closure

The glottal approximant is consistently realized as a complete stop [ʔ] when preceded by another stop, as in (15), which contain sequences Stop-ʔ preceding both High and Low tones.

(15)	VCʔV́		V́C+ʔV	
(a)	ək-ʔá	'house'	kák-ʔao	'rodent, sp.'
	House-CL		fox-?	
(b)	wiap-ʔíp	'stick of a fan'	o-ʃát-ʔa	'my food (e.g. orange)'
	fan-CL		1-food-CL	

Figure 3.10 illustrates the sequence in the word *kák-ʔao*. The release of the voiceless stop [k] is indicated in the waveform by the first point (a), and the silent period that follows it is the closure for the glottal stop. The second point (b) marks the onset of the following vowel.[8]

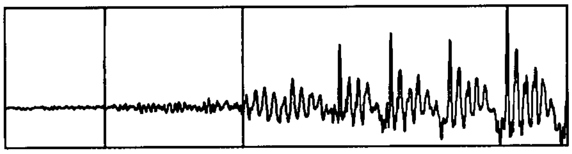
Figure 3.10. Waveform of the Mundurukú word *kákʔao* 'rodent, sp.' to illustrate /ʔ/ as a complete stop.



The glottal was realized as a long and silent closure in 90% of the cases (36 tokens out of 40), but closure durations could be measured only for 25 of these. The others had no clear indication of the point where the glottal closure started as the preceding stop had no visible burst release. In 4 tokens the preceding stop was released as onset of the following vowel, and the glottal realized as creaky voice in the vowel; these are all sequences containing a L-tone vowel,

---

[8] An interesting aspect related to the realization of [ʔ] in C-ʔV sequences, not explored here, is the transition from a silent closure period, the glottal closure, to noisy vibrations in the beginning of the following vowel (the period marked in the figure below by the vertical lines), then to constricted voice, and finally to modal voice. 19 out of 40 tokens examined showed this pattern. The mean duration for these noisy vibrations is 29 ms (s.d. 11).



i.e. sequences V́C-ʔV. Tone of the following vowel is another factor that influences the duration of /ʔ/. Following a stop, it tends to be realized as a complete closure, but is consistently realized as such only when preceding a H-tone vowel. Before a L-tone vowel it may alternate with nonmodal phonation. The results are summarized in Table 3.15.

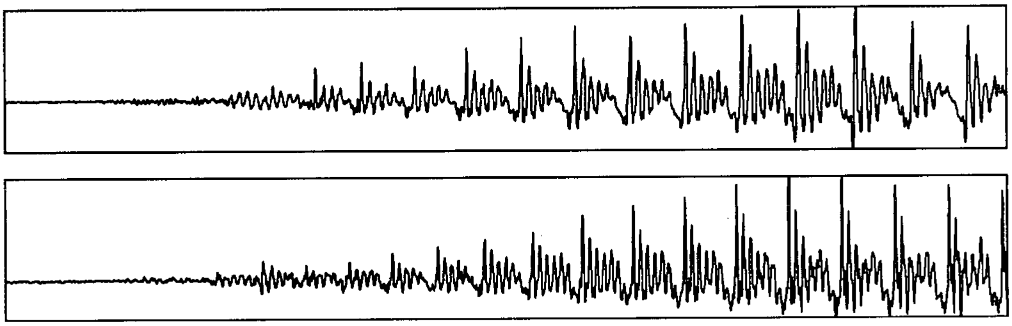
Table 3.15. Results of closure durations for /ʔ/ in VC+ʔV́ and V́C+ʔV sequences.

	/ʔ/ realized as a complete closure	Individual means	Total
VC-ʔV́	20 tokens (100%)	87 ms s.d. 44.8	20 tokens
V́C-ʔV	16 tokens (80%)	61 ms 29.7	20 tokens

A comparison of the means for each sequence shows the influence of tones on the duration of /ʔ/. The glottal approximant has greater duration preceding a H-tone vowel than preceding a L-tone vowel (87 ms versus 61 ms respectively). This is because /ʔ/ is strongly coarticulated with an adjacent, preceding or following, L-tone vowel. This finding is important because it supports a phonological restriction on glottal constriction and tone in the language: only L-tone vowels may surface with constricted voicing.

Figure 3.11 gives a typical example of /ʔ/ preceding both H-tone, waveform on top, and L-tone vowels, waveform in the bottom. Note that /ʔ/ does not exhibit abrupt releases in either case; the transition is from a silent closure period to a period of noisy vibration (not always present as seen in *fn* 8), followed by constricted voicing, and changing gradually to normal.

Figure 3.11. Expanded waveforms comparing the onsets of H-tone vowels, on top, and L-tone vowels, on bottom, following /ʔ/ in the words *əkʔá* ' house' and *ofátʔa* 'my food'.



The effect of constricted voicing is greater, i.e. it lasts longer, in a L-tone vowel (35 ms versus 22 ms respectively). In addition, L-tone vowels are more likely to be affected than H-tone vowels; overall 90% of the 20 tokens for L-tone vowels exhibit constricted voicing, whereas only 65% of the samples with H-tone vowels showed similar effects. The next section provides further details on the ʔ-tone interaction and coarticulatory effects with neighbouring vowels.

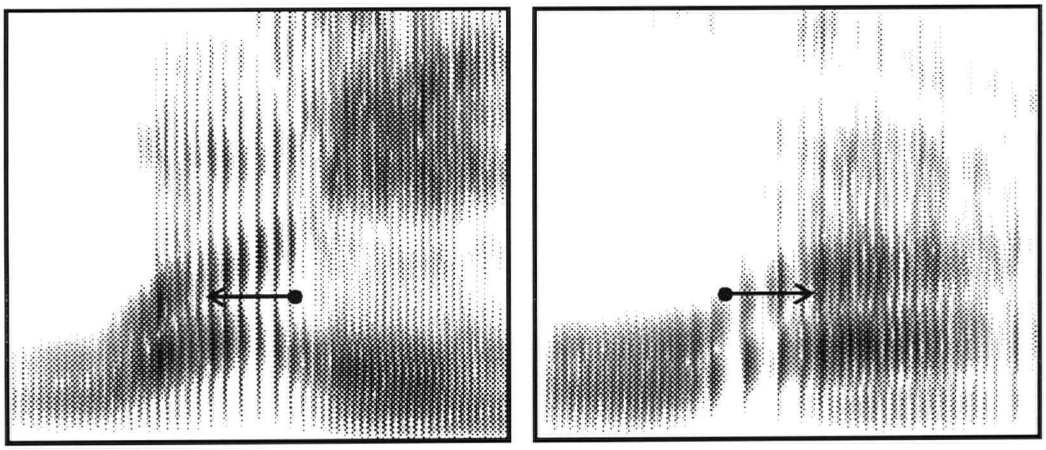
3.7.2 /ʔ/ as constricted voicing

In intervocalic position and following nasals and glides, /ʔ/ tends to be realized as a heavy type of creaky voice. Strictly speaking, its variation as a phonation type occurs between [+sonorant] segments. Illustrations of an intervocalic /ʔ/ preceding both H and L tones are given in the words below.

(16)	VʔV́		V́ʔV	
(a)	waʔé	'bowl'	ó-ʔa	'axe'
			axe-CL	
(b)	o-deʔó	'my scent'	ipádá-ʔa	'macaw's head'
	1-scent		macaw-CL	

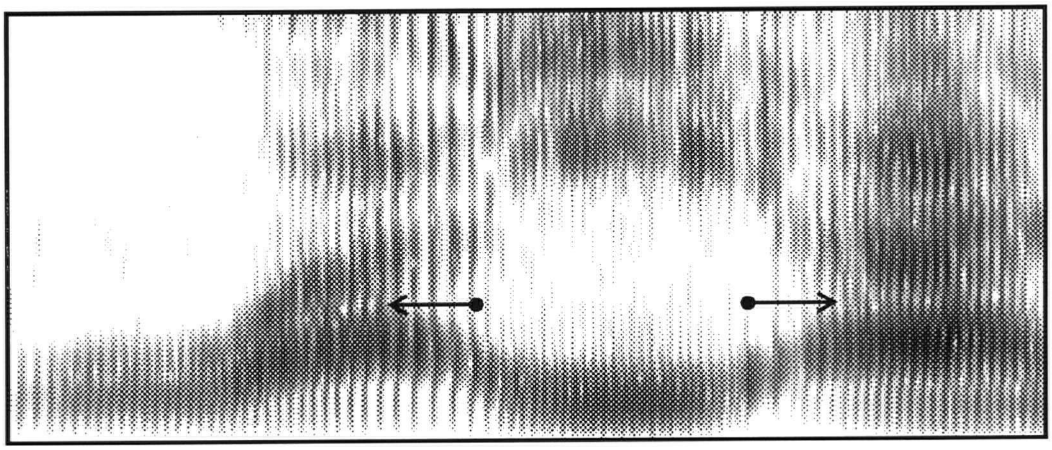
Here tones play a leading role. The spectrograms in Figure 3.12 illustrate the pronunciation of /ʔ/ in intervocalic position, preceding and following H and L tones. The spectrogram on the left represents the sequence VʔV́, and the one on the right the sequence V́ʔV. /ʔ/ is predominantly realized as heavily constricted voicing in both cases; but coarticulation with either vowel, preceding or following the /ʔ/, depends crucially on tone. In the first sequence, VʔV́ (LʔH), the vowel on the left is most affected by creakiness, whereas in the second case, V́ʔV (HʔL), creakiness goes to the right.

Figure 3.12. Spectrograms illustrating the realization of an intervocalic /ʔ/. The spectrogram on the left is a sample of the word *waʔé* 'bowl', and on the right a sample of the word *óʔa* 'axe'.



Another example is given in Figure 3.13. This time a H-tone vowel is intercalated between two glottal approximants; the word is *waʔíʔa* 'gourd'. Similarly, both /ʔ/s surface entirely as creaky phonation, and the vowels affected are the two L-tone vowels. The vowel that is intercalated between them, a H-tone /í/, remains modal.

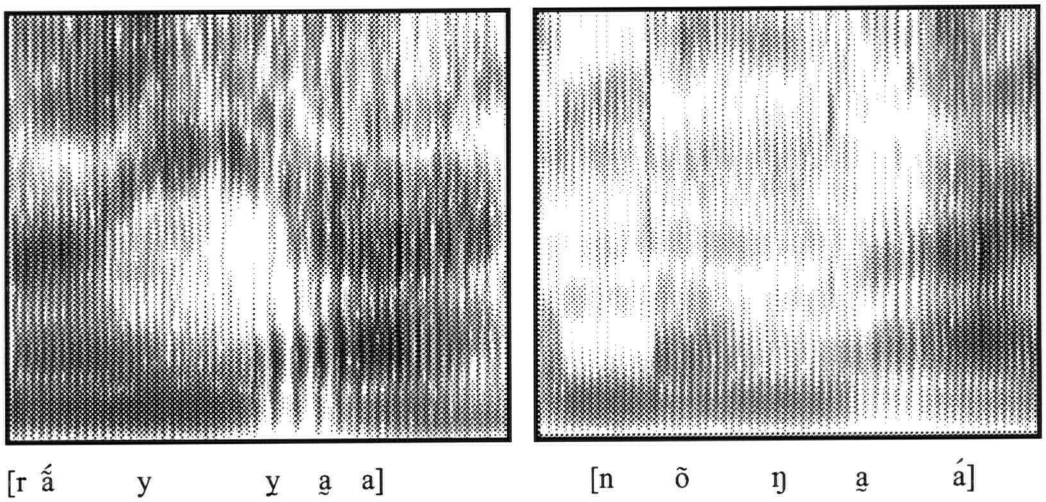
Figure 3.13. Spectrogram of the Mundurukú word *waʔíʔa* 'gourd'.



Note, however, that in all spectrograms above, the region where creakiness is most salient is not in the vowel itself but at the point where the formants change, i.e. during the transition from one vowel into the other. It is this boundary, a syllable boundary in phonology, that is marked by intense glottal activity, suggesting that /ʔ/ is still in syllable-onset position and more or less realized independently of the vowel. Therefore the crucial difference between creaky voice as a contrastive feature of vowels and creakiness triggered by a glottal approximant is timing of constricted voicing. Intensification of glottal activity in the former is synchronized with the vowel itself, not truncated to the transition into the following segment, as discussed in Chapter 2. This distinction is crucial here because, if glottal activity for /ʔ/ during the vowel to vowel transition is salient enough and overrides the perception of creakiness in the vowel, then /ʔ/ can have a phonological status on its own and be perceived by listeners as independent of the vowel. By timing both types of constricted voicing in this manner, the contrast between creaky phonation on vowels and the glottal consonant is maintained.

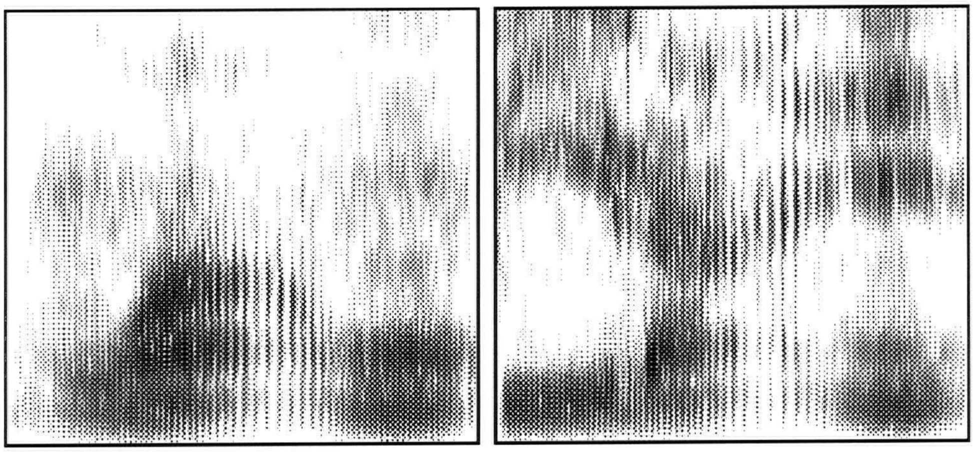
But vowels are not the only sonorants that determine the realization of /ʔ/ as creaky phonation. The following spectrograms illustrate /ʔ/ after a glide /y/ and a nasal /ŋ/ in the words *ʤarã́yʔa* 'orange' and *nõŋʔá* 'flea'. Here too the /ʔ/ is realized with greater glottal activity near the transition to the following vowel. In the first spectrogram, glottal activity overlaps with the articulation of the sequence glide-ʔ-vowel, going from modal to creaky then back to modal – [yy̰a̰a] – and the creaky portion concides with the transition from the glide to the vowel, the point where the syllable boundary is phonologically: *ʤa.rã́y.ʔa*. Interestingly, in *nõŋʔá* only the beginning of the vowel is affected.

Figure 3.14. Spectrograms showing /ʔ/ after a glide and a nasal consonant. The spectrogram in the left shows only the underlined part of the word *ʤarã́yʔa* 'orange', and the second spectrogram shows the entire word *nõŋʔá* 'flea'.



Given these observations, the participation of /ʔ/ in nasal harmony is not problematic for the phonology. Like vowels, nasals and glides, the glottal approximant belongs to the group of [+sonorant], the segments that assimilate nasalization. Two examples of /ʔ/ in nasal contexts are given in the spectrograms in Figure 3.15. Its phonetic realization as a phonation type in these contexts is perfectly compatible with velic lowering, allowing the laryngeal and adjacent vowels to be nasalized altogether.

Figure 3.15. Spectrograms illustrating the sequence [ṽʔ̃ṽ] in the Munduruku words *wa ʔ̃ṍ* 'my voice, language', and *pira ʔ̃ẽ́* 'dry fish'.



Timing of creaky voicing is the core difference between a creaky vowel and /ʔ/ in intervocalic position. In the former, creakiness is timed to the vowel itself, whereas in the latter it is timed to a syllable boundary. Creakiness in a sequence VʔV is heavier near the vowel-to-vowel transition, overriding the creaky effect on adjacent vowels. This leads to an analysis of /ʔ/ as a true consonant.

3.8 Features for consonants

Many of the considerations dealing with the acoustic properties of Munduruku consonants discussed above, along with their phonological behavior (to be discussed in different chapters), lead me to propose six major features to distinguish consonants, and to which I will be referring in the following chapters.

(17) Major features for consonants

	p	b	t	d	ʧ	ʤ	k	s	ʃ	m	n	ŋ	r	ʔ	h	w	y	v	ṽ	y̰	ỹ̰
sonorant	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+
consonantal	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	–	–	–	–	–	–
continuant	–	–	–	–	–	–	–	+	+	–	–	–	+	(±)	+	+	+	+	+	+	+
nasal										+	+	+							+		+
anterior			+	+	–	–		+	–		+		+				–				
voice	–	+	–	+	–	+	–	–	–						–						

[sonorant]. The feature [sonorant] plays a major role in the phonology of Mundurukú. It distinguishes the class of segments that may undergo nasality, [+sonorant], from the class that blocks the process, [-sonorant]. The classification of laryngeals /ʔ, h/ in this class has already been proposed by Chomsky and Halle (1968), but the proposal presented here is primarily supported by the acoustic investigation, which showed that the phonetic realization of laryngeals is largely dependent on the context they occur: /h/ is realized as a voiceless counterpart of adjacent vowels, and /ʔ/ as creaky phonation between [+sonorant] segments, in addition to their compatibility with processes referring to this class (e.g. nasal harmony).

[consonantal]. This feature distinguishes consonantal from vocalic segments (i.e. /w, y/ and vowels). A fundamental difference between a creaky vowel and /ʔ/ is also the feature [consonantal]. Even though /ʔ/ may be realized as creaky phonation on adjacent vowels, timing of creakiness is phased so to coincide with a syllable boundary, more specifically, with an onset position, a position at which [+consonantal] segments occur.

[continuant]. The feature [continuant] distinguishes affricates, [-continuant], from fricatives, [+continuant]. The stop portion in affricates seems to be more salient than the fricative portion, as shown in §§3.4-3.5. In addition, affricates pattern with other stops phonologically, for example, in consonant mutation (to be examined in Chapter 7). The glottal /ʔ/ is ambiguous with respect to this feature: it is [-continuant] following [-sonorant], and [+continuant] following a [+sonorant] segment. This consonant can perhaps be analyzed as unspecified for continuancy, acquiring the feature from adjacent segments.

[nasal]. Nasality is contrastive in the stop series, distinguishing voiced oral stops from nasal ones; and most importantly, it is also contrastive on vowels. Nasal vowels trigger nasal harmony, whereas oral vowels, and other sonorants, undergo the process. Nasal harmony is examined in Chapter 6.

[anterior]. Especially important for coronals, the feature [anterior] distinguishes alveolars, [+anterior] – /t, d, s, n, r/ – from palato-alveolars, [-anterior] – /ʧ, ʤ, ʃ, y/.

[voice]. The feature [voice] is important in the stop series to differentiate /p, t, ʧ/ from /b, d, ʤ/, the only voiced-voiceless set in the language. Voicing contrasts are discussed in greater detail in Chapter 7, which examines a process of voicing alternation and neutralization.

The following chapters present phonological motivations for the classification of consonants according to the features proposed above. Other features may be introduced later as needed.

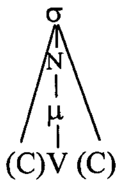
CHAPTER 4

Syllable structure and syllabification

4.1 Preliminaries

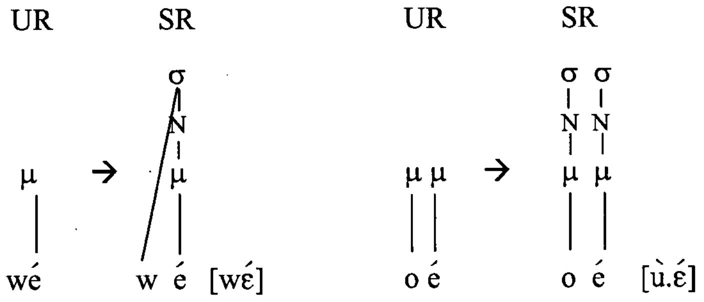
This chapter focuses on the syllable structure and syllabification patterns in Mundurukú. The representation adopted here is as depicted in (1). I follow Kenstowicz (1993: 253; see also Prince and Smolensky 1993) in assuming that "the syllable is a projection of the single primitive category 'nucleus'." I also assume the proposal of Shaw (1992, 1996, 2002) that the nucleus is optimally headed by a mora, i.e. a vowel. Onset and coda are optional, and are occupied by consonants.

(1) A syllable in Mundurukú



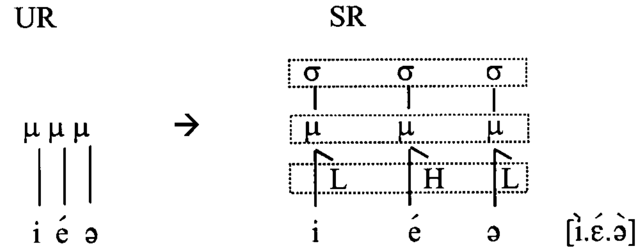
The moraic versus non-moraic value distinction of segments makes a difference in the parsing of a segmental string into syllables. It is this requirement that establishes, for example, the difference between a sequence glide + vowel, (2)a, and a sequence vowel + vowel, (2)b, which are heterosyllabic (V.V).

(2) (a) /wé/ 'rodent, sp.' (b) /o-é/ 'my path'



The mora is also the tone-bearing unit (see Chapter 8), so only vowels bear a tone on the surface. All else being equal, we expect that there will be as many syllables and tones in a word as there are moras. The example below illustrates this pattern.

(3) /i-éə/ 'It's swollen'



Further, the hypothesis that a syllable contains a single mora is consistent with another phonological process that has the syllable as a domain: reduplication. The most pervasive pattern of reduplication in Mundurukú targets the final syllable of a base. Because vowels are parsed into separate syllables, the reduplicative morpheme copies only the second vowel in a VV sequence (call this V-reduplication), and /h/ is epenthesized to provide an onset for the reduplicative morpheme (details in §4.3). (Syllable boundaries are marked by a period.)

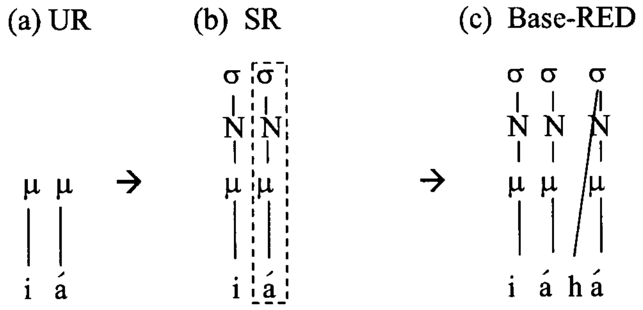
(4) (a) i-á → i.á → i-á-<u>há</u>-m 'bitting s.t.'

3Ob-bite 3Ob-bite-RED-IMPRF

(b) t-aẽ́ → ta.ẽ́ → t-aẽ́-<u>hẽ́</u>-m 'choosing s.t.'

3Ob-choose 3Ob-choose-RED-IMPRF

(5) V-reduplication (RED = σ)

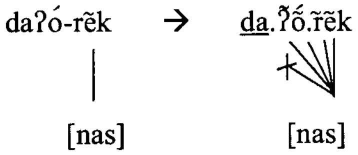


Finally, Mundurukú has a phonotactic restriction on the cooccurrence of /d/ with a nasalized vowel, so that a sequence *dṽ* is never found. (Phonotactic patterns are examined in Chapter 5.) Because of this prohibition, an unusual case of blocking of nasality has arisen in the language.

As we will see in Chapter 6, nasality spreads leftwards from a nasal vowel, affecting all [+sonorant] segments. If /d/ is on the way, as the examples in (6), nasality stops before reaching the syllable containing the stop, and that syllable surfaces oral. Note that (6)b contains a sequence of vowels in which case only the second vowel is nasalized. This pattern provides the last piece of evidence that two or more vowels in sequence are heterosyllabic.

(6) Nasalization and /d/

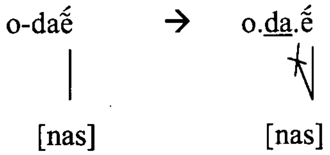
(a)



'lizard, sp.'

lizard-?

(b)



'S.o. picked me'

1Ob-choose

The following sections examine various aspects related to syllable structure and syllabification in the language. I begin by introducing the inventory of syllables and the range of constraints that determine the parsing of segment strings into syllables (Section 4.2). Section 4.3 presents an account of VV sequences and discusses a mismatch between phonetic and phonological syllabification. Section 4.4 takes up some issues on onsets, in particular, issues related to (i) the restriction on word-initial /r/, (ii) ambisyllabic stops, and (iii) syllabification of VCV sequences. Then the analysis proceedes to an investigation of intervocalic clusters, focusing on the coarticulatory effects of some clusters (Section 4.5), and the restriction on a particular sequence of coronal segments (Section 4.5.4). The last section (Section 4.6) examines place assimilation regarding the imperfective suffix {-m}.

4.2 The basics of syllabification

The inventory of syllables in Mundurukú is limited to four types: V, CV, VC, and CVC, all of which may be initial, medial or final in the word, as illustrated in (7).

(7) Syllable types

		Initial	Medial	Final
V	(a)	a.pát	ko.a.tó	dó.á
		‘alligator’	‘crab’	‘spider’
	(b)	i.é.ə	so.é.dəp	bí.o
		‘It’s sore.’	‘fish, sp.’	‘tapir’
CV	(a)	ká.ʃi	pə.ka.só	wi.tṍ
		‘sun, moon’	‘pidgin’	‘bird, sp.’
	(b)	mə.dí	ko.rá.ra	po.ʃo
		‘rodent, sp.’	‘fence’	‘bird, sp.’
CVC	(a)	ʔot.pə́	na.pẽn.pə́	pá.rát
		‘worm’	‘centipede’	‘sieve’
	(b)	kák	ka.sop.ta	po.típ
		‘fox’	‘star’	‘fish, sp.’
VC	(a)	ok.pot	po.át.po.át	co.ót
		‘my son (masc.)’	‘hawk’	‘bird, sp.’
	(b)	a̯y	i.mə.áy.pan	e.it
		‘sloth (moneky, sp.)’	‘to raise (a child)’	‘honey’

I begin the account of syllable structure by looking at the basics of syllabification. The language permits syllables with and without onset or coda, but it is required that these positions are occupied at most by a single consonant. A related prohibition is observed for nuclei; the language disallows more than one vowel in the nuclear position. This requirement can be achieved by *COMPLEX (McCarthy and Prince 1993), for which I adopt a generalized version.

(8) *COMPLEX$_{(\mathrm{Def})}$

Given a string of segments (Cs and Vs), and three positions within a syllable (onset, nucleus and coda), parsing of more than one segment to the same position is prohibited.

The requirement that syllables must have nuclei (Prince and Smolensky 1993) and weight (Shaw 1996) is enforced by the two constraints below. Both constraints are undominated in Mundurukú.

(9) (a) σNUC – Syllables must have nuclei. (Prince and Smolensky 1993)

(b) σMORA – Syllables must have weight (as encoded by the mora). (Shaw 1996)

It is evident from the examples in (7) that the universal preference for CV syllables, encoded by the constraints in (10), is violated in Mundurukú syllables. The presence of V and VC/CVC types of syllable shows that both ONSET and NOCODA are violable in the language.

(10) (a) ONSET – A syllable must have onset.

(b) NOCODA – A syllable must not have coda.

A crucial point for the analysis is the input-output dependence (DEP) relation, the 'anti-epenthesis' constraint. In this study I make use of a related notion of dependence, namely CONTIGUITY (McCarthy and Prince 1994). The use of CONTIGUITY instead of DEP will be motivated in §4.4, which deals with a special case of epenthesis. First, let me introduce how CONTIGUITY will be employed here.

4.2.1 Contiguity

McCarthy and Prince (1994: 123) define CONTIGUITY as in (11).

(11) Contiguity

a. I-CONTIG ("No Skipping")

The portion of S_1 standing in correspondence forms a contiguous string.

Domain ($\mathfrak{R}$) is a single contiguous string in S_1.

b. O-CONTIG ("No Intrusion")

The portion of S_2 standing in correspondence forms a contiguous string.

Range ($\mathfrak{R}$) is a single contiguous string in S_2.

I-CONTIG holds of input strings to guarantee that none of their *internal* elements is deleted in the output. O-CONTIG holds of output strings to avoid *internal* epenthesis. Crucially, CONTIGUITY applies only to internal elements; neither deletion nor epenthesis at the periphery of a string is subject to the constraint. This effect is essential for the analysis of Mundurukú, as we will see later in §4.4. McCarthy and Prince explain,

> "[...] the map $xyz \rightarrow xz$ violates I-CONTIG, because the Range of $\Re$ is {x, z}, and x,z is not a contiguous string in the input. But the map $xyz \rightarrow xy$ does not violate I-CONTIG, because xy is a contiguous string in the input. The constraint O-CONTIG rules out internal epenthesis: the map $xz \rightarrow xyz$ violates O-CONTIG, but $xy \rightarrow xyz$ does not." (p.123)

McCarthy and Prince do not consider reordering of elements in a string as a possible violation of CONTIGUITY; this is attributed to LINEARITY, the 'anti-metathesis' constraint (McCarthy and Prince 1994). However, reordering of elements also creates a different substring, if internal to the morpheme. For example, the map $xyz \rightarrow yxz$ violates CONTIGUITY twice, because y,x and x,z are not contiguous strings in the basic form.

The definition of CONTIGUITY assumed here determines that deletion and epenthesis, as well as reordering, must be marked as violations of the constraint.

(12) CONTIG-IO$_{(\mathrm{Def})}$

The portion of S_1 standing in correspondence forms a contiguous string,
as does the correspondent portion of S_1. (From Kager 1999: 250)
Range ($\Re$) is a single contiguous string in S_1.

It is important to establish the types of structures to which CONTIGUITY applies, and the types of elements that make up a string. Here I distinguish two types of structures. One refers to a string of segments (Cs and Vs) that form a Morpheme, and the other refers to a string of morphemes that form a Word.[1] I refer to the first type as "*intra*-morphemic contiguity," and represent it by M-CONTIGUITY (M=Morpheme); the second type is "*inter*-morphemic contiguity," or W-CONTIGUITY (W=Word).

---

[1] I use the term Word to refer to any morphosyntactic form of a lexical item (Trask 1996); for example, inflected forms of a verb (e.g. go, goes, went, etc.) are, in this sense, different words.

4.2.2 Inter- and Intra-morphemic CONTIGUITY

W-CONTIGUITY and M-CONTIGUITY are defined (13) and (14) respectively. (M-CONTIGUITY is a non-segregated version of McCarthy and Prince's (1994) constraints CONTIGUITY(Root) and CONTIGUITY(Af).)

(13) W-CONTIGUITY

The portions (i.e. morphemes) of W(ord) standing in correspondence form a contiguous string, as do the correspondent portions of W.[2]

(14) M-CONTIGUITY

The portions (i.e. segments) of M(orpheme) standing in correspondence form a contiguous string, as do the correspondent portions of M.

The two constraints make different predictions. M-CONTIGUITY prevents metathesis, epenthesis and deletion of segments inside the morpheme; W-CONTIGUITY, on the other hand, prevents reordering of morphemes and epenthesis, but not deletion, of segments at morpheme boundaries.

W-CONTIGUITY effects. Suppose that {α-β-γ} is an input string of morphemes that form a word. The map α-β-γ → α-*x*-β-γ, where *x* is an epenthetic segment (C or V) not associated with the representation of either α or β, violates W-CONTIGUITY, because epenthesis of *x* creates substrings, {α-*x*} and {*x*-β}, that are not contiguous in the input.

Similarly, the map α-β-γ → α-γ-β violates W-CONTIGUITY, because reordering of β and γ creates substrings, {α-γ} and {γ-β}, that are not contiguous strings in the input.

Suppose now that /*xy*/ are segments that realize a morpheme α. The map $(xy)_{\alpha}$-β → $(x)_{\alpha}$-β does not violate W-CONTIGUITY, because deletion of *y* does not segregate the string of morphemes; the output string is still {α-β}.

---

[2] It is important to clarify that the term "portions of the Word", as I make use of it here, refers specifically to "individual morphemes" that are put together to form a word; therefore W-CONTIGUITY evaluates strings of morphemes. In this sense, a word composed of a single morpheme would be exempted.

The application of W-CONTIGUITY is illustrated below and further discussed in §4.4 which examines V-reduplication.

First of all, since W-CONTIGUITY does not prevent deletion inter-morphemically, the faithfulness constraint MAX must be posited to avoid deletion in general. Other MAX constraints and their ranking relative to each other will be introduced as I examine particular cases.

(15) MAX-IO

Input segments (C and V) must have output correspondents.

The ranking for constraints discussed so far, and others, will be presented in the following sections as I present evidence for their ranking. A case is suggested in Tableau 4.1. *COMPLEX dominates all other constraints to avoid tautosyllabic CC or VV sequences. Below it, we find W-CONTIGUITY (Shorthand: W-CONTIG), which prevents epenthesis of segments between morphemes, and then ONSET; MAX-IO and NOCODA are lower in the ranking. (The position of M-CONTIG in the ranking is discussed in §4.4.)

Tableau 4.1. Syllabification of kasoptá 'star'.

ka-sop-tá thing-flame-CL	*COMPLEX	W-CONTIG	ONSET	MAX-IO	NOCODA
a. ka.so.pta	*!				
b. ☞ ka.sop.ta					*
c. ka.so.pi.tá		*!			
d. ka.so.tá				*!	

The function of W-CONTIG is to avoid epenthesis at morpheme boundaries. Given three morphemes {α=ka, β=sop, γ=ta}, we obtain the following contiguous strings in the input: {ka-sop} and {sop-ta}. Epenthesis of /i/, illustrated by candidate (c), violates inter-morphemic contiguity (W-CONTIG) because the vowel, which is not associated with either *sop* or *ta*, breaks the string {sop-ta} into two substrings, {sop-i} and {i-ta}, and these are not contiguous strings in the input. Conversely, deletion of /p/ in *sop*, illustrated by candidate (d), does not violate W-CONTIG, because the substring {so-ta} still corresponds to the string {β-γ}.

A candidate such as *ka.so.pa.ti* would win according to the ranking proposed in the tableau, because the realization of {γ=ta} as {at} does not violate W-CONTIG, although a violation of M-

CONTIG can be claimed here. The input string /ta/ corresponds to the substring *at*, in which case the segments have been reordered: t-a → a-t. But given that the segments are still "contiguous" in the output, let us assume M-CONTIG is not violated. Despite this, *ka.so.pa.ti* would still be ruled out. We will see later in this chapter that the language has a constraint, ALIGN-R, which determines that the right edge of a morpheme boundary coincide with the right edge of a syllable boundary. The constraint is introduced in §4.4.3 where some issues concerning syllabification of sequences VCV are examined. According to the ranking proposed there (see especially Tableau 4.22), *ka.so.pa.ti* is banned because /p/ in /sop/ must be aligned with the right edge of a syllable, thus *ka.sop.tá* wins.

Let us now turn to the analysis of sequences vowel + vowel, and the difference between phonetic and phonological syllabification.

4.3 Hiatus

The language has five vowel qualities /i, e, ə, a, o/, most of which can be combined to form a sequence VV, syllabified as V.V. (Several arguments for syllabification of VV sequences as V.V were provided in the beginning of this chapter.)

(16) shows that the high front vowel /i/ may be combined with any heterosyllabic vowel.

(16) /i/ + V sequences

(a) i-i i-inə̃́m → i.i.nə̃́m 'to sew s.t.'
3Ob-sew

(b) i-e i-éə → i.é.ə 'It's sore.'
3Su-be.sore

(c) i-ə i-ə → i.ə 'It's light' (weight)
3Su-be.light

(d) i-a ka̰bí-a̰ → ka̰.bí.a̰ 'day'
sky-light/clear

(e) i-o bío → bí.o 'tapir'

Sequences /e/ + vowel are also frequent, but /eə/ and /ea/ in particular are unclear. Combinations of the 2nd person prefix {e-} with a verb or noun beginning with /ə/ or /a/ have different outcomes. In the sequence /e- + a…/, the vowel of the 2nd person prefix is always deleted, as shown in (17)g; but if /e/ belongs to other prefix, for instance {océ-} '1pl.excl.', (17)f, there is an alternation between forms with and without /e/. As for /eə/, it seems that this sequence is permitted in the language, as shown by examples in (17)c-d. The exception is again the 2nd person prefix {e-}, in which case the vowel of the root is deleted, (17)e. This suggests that sequences /eə/ and /ea/ are generally allowed in the language, although there is a prohibition referring specifically to combinations with the person prefix {e-} '2sg', and is, therefore, morphologically conditioned.

(17) /e/ + V sequences

(a) e-i t-eí → te.í 'its price'
3-price

(b) e-e o-ʃeé → o.ʃe.é 'my skin'
1-skin

(c) e-ə i-éə → i.é.ə 'It's swollen.'
3Su-be.swollen

(d) ʤe-ə́ → ʤe.ə́ 'to go up'
CoRef.Poss-up

(e) e-əŋ-ʔá → eŋ-ʔá *eəŋʔá 'your knee'
2-knee-CL

(f) ʔe-a oʧé-a̱ʤẽ́m → o.ʧá.ʤẽ́m ~ oʧéa̱ʤẽm 'We (excl.) arrived.'
1pl.excl-arrive

(g) e-a̰ʤẽ́m → a̰.ʤẽ́m *ea̰ʤẽ́m 'Arrive!'
2Su-arrive

(h) e-o mə́reó → mə́.re.ó 'bat'

As for sequences /ə/ + vowel, these are commonly found; only in the case of /əa/ which may optionally alternate between [əa] or simply [a], as in (18)d.

(18) /ə/ + V sequences

(a) ə-i sə-í → sə.í 'his/her feet'
3-foot

(b) ə-e kobə-é → ko.bə.é 'a tree (sp.) fiber'
tree(sp.)-fiber

(c) ə-ə i-mə-ʤə́-ə-ʤə́-m → i.mə.ʤə́.ə.ʤə́m 'to send s.o.'
3Ob-CAUS-go-RED-IMPRF

(d) ə-a o-bə-a̰-ʃírí → o.bə.a̰.ʃírí ~ o.ba̰.ʃírí 'my thumb'
1-finger-?-AUG

(e) ə-o i-mə-ṍm → i.mə.ṍm 'to put s.t. inside'
3Ob-CAUS-enter

In sequences /a/ + vowel, illustrated in (19), and /o/ + vowel, in (20), no cases of the combinations /aa/ and /oə/ were found. It is not clear at this point whether the language prohibits these sequences or this is simply an accidental gap in the corpus.

(19) /a/ + V sequences

(a) a-i ka-daí → ka.da.í 'plant'
thing-plant

(b)	a-e	t-a-ero̰	→	ta.e.ro̰	'It's soft, tender'
		3-CL-be.soft			
(c)	a-ə	dáə́	→	dá.ə́	'fast, quick'
(d)	a-a	?			
(e)	a-o	t-aó	→	ta.ó	'his/her leg, bone'
		3-leg/bone			

(20) /o/ + V sequences

(a)	o-i	o-í-o	→	o.í.o	'It healed.'
		3Su-?-be.healed			
(b)	o-e	t-a̰bóẽ́	→	ta̰.bó.ẽ́	'ember'
		3-ember			
(c)	o-ə	?			
(d)	o-a	dóá	→	dó.á	'spider'
(e)	o-o	o-ṍhṍ	→	o.ṍ.hṍ	'my domestic animal'
		1-domestic.animal			

Another point to consider concerns the distinction between sequences vowel + vowel and sequences glide + vowel, which are examined next.

4.3.1 Vowels versus glides

Tones are the best phonological indication for syllable breaks, and make a difference in cases such as those in (21).[3] The pairs contrast two syllables versus one, or two moras versus one. Therefore, the opposition is two tones versus one. The first column contains sequences of vowels, each of which belongs to a syllable (V.V) and is thus assigned a tone in phonology. The second column contains sequences glide + vowel (GV/VG), which form a single syllable, thus get a single tone.

(21) V.V versus GV

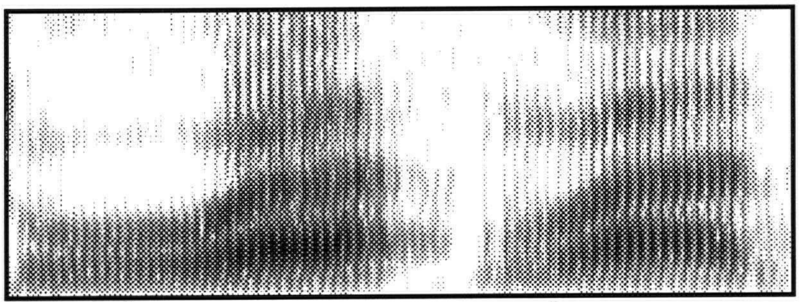
(a) o-é [ùɛ́] 'my path' wé [wɛ́] 'peccary'
1-path

(b) o-á [ùá] 's.t. bit me' wá [wá] 'to cry'
1Ob-bite

(c) sə-í [sə̌í] 'his/her feet' sə́y [sə́y] 'bird, sp.'
3-foot

Phonetically, the duration of a vowel is greater than the duration of a glide, especially in word-initial position. This is illustrated in Figure 4.1, which compares *oá* [ùá] versus *wá* [wá].

Figure 4.1. Spectrogram showing sequences V.V versus GV in the words oá 's.t. bit me.' and wá 'to cry'.



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[3] For the sake of exposition, the vowel /o/ in the examples *oé* 'my path', *oá* 's.t. bit me', etc., is transcribed as the high back vowel [u], but recall from Chapter 2 that /o/ varies freely between [o] and [u].

But durational differences may be obscured by other factors. For example, glides have longer duration in intervocalic position, due to the coarticulation with both preceding and following vowels. The spectrogram below shows an intervocalic [w] in the Mundurukú word *áwá* 'grandmother', which is realized with duration similar to that of [u] in *oá* 's.t. bit me'.

Figure 4.2. Spectrogram showing an intervocalic [w] in the Mundurukú word áwá 'grandmother'.

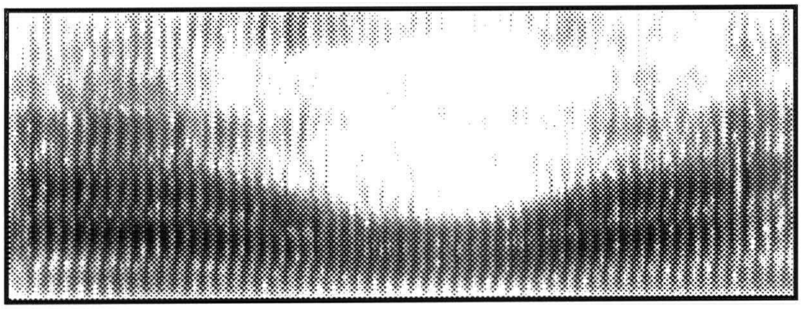
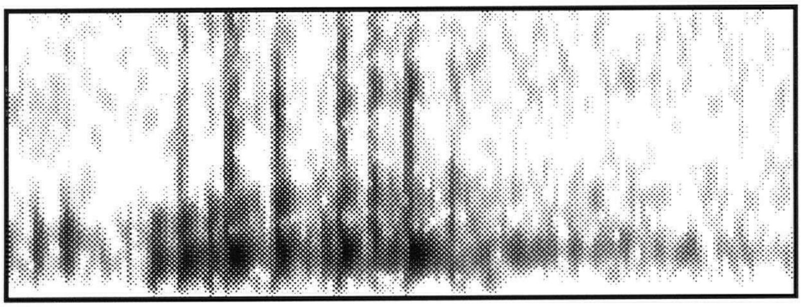


Figure 4.3 gives a slightly different example. The word *k<u>o</u>a̰tó* 'summer' has three tones and therefore three syllables: *ko.a̰.tó*. Phonetically, however, the sequence */ko/* is realized as a labialized consonant [k^w], therefore phonetically two syllables: [k^wà̰.tó].

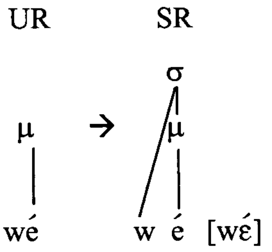
Figure 4.3. Spectrogram of the sequence /koa̰/ [k^wa̰] in the word /koa̰tó/ 'summer'.

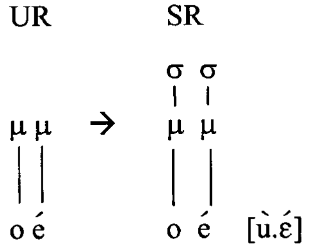


An argument in favor of three as opposed to two syllables, comes from the speakers' intuition about syllabification. Most speakers can whistle the tones of a word: one whistle per tone per mora. In cases like *koa̰tó*, they consistently whistle three tones even though it is phonetically [k^wà̰tó]. This suggests that speakers whistle what is determined by the phonology, not how the word is pronounced (see related discussion in Mohanan 1986).

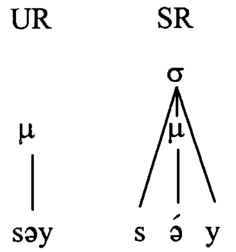
It is evident that phonetics and phonology disagree on the status of vowels and glides, but the findings do not provide evidence to reliably differentiate both. The asymmetry is only resolved in the phonology through the assignment of tones on vowels. In other words, vowels, unlike glides, are tone-bearing units, and since moras are the units that can bear a tone (Pulleyblank 1986; and Chapter 8), the difference between vowels and glides is that vowels are moraic.

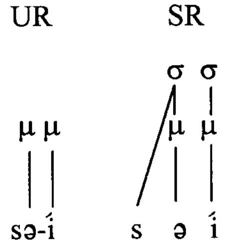
(22) (a) /wé/ 'rodent, sp.' /o-é/ 'my path'





(b) /sə́y/ [sə́y]'bird, sp.' /sə-í/ [sə̀.í] 'his/her feet'





By assuming moras in the underlying representation of vowels, and a constraint demanding faithfulness to an underlying mora, MAX-μ, we can prevent the vowel from changing into a glide and therefore losing its moraic status.

(23) MAX-μ – Input moras must have output correspondents.

Syllabification of VV sequences is illustrated in the following tableau.[4] First, W-CONTIG prevents epenthesis at morpheme boundaries, ruling out candidate (d). Second, glide formation is

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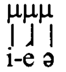
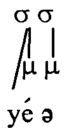
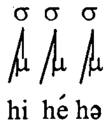
[4] A candidate that would be better than *iéə* in the tableau is *hiéə*, which violates ONSET only twice. I did not include it in the range of candidates because both forms *iéə* and *hiéə* cooccur in the language as free variants. It is desirable here that the ranking predicts the possibility of having an epenthetic element word-initially, because word-initial epenthesis is possible, though optionally. I will return to this point in §4.4.

a fatal violation of the constraint demanding faithfulness to moras (MAX-μ), illustrated by candidate (a). Finally, two vowels parsed to a nucleus position is ruled out by *COMPLEX. This gives us the winner, candidate (b), which violates ONSET three times but retains all of its moras.

Tableau 4.2. Syllabification of VV sequences. (i-éə 'It's swollen.')

	*COMPLEX	MAX-μ	W-CONTIG	ONSET	NOCODA
a. 		*!		*	
b. ☞ 				***	
c. 	*!			**	
d. 			*!		

Under certain conditions, the vowels /o/ and /i/ of the 1st and 3rd person possessive prefixes, {o-} 'my N' and {i-} 'his/her N', have variants that are glides, {w-} and {y-} respectively. These variants occur in inalienable possession before nouns that begin with vowels. The examples in (24) illustrate the variants {o-, i-}, and (25) illustrates the variants {w-, y-}.

(24) 1st and 3rd person markers as plain vowels

(a) o-dóy → o.dóy 'my blood'

1-blood

(b) i-ba̰ → i.ba̰ 'his/her arm'

3-arm

(c) o-a̱ʤḗm → o.a̱.ʤḗm ‘I arrived.’

1Su-arrive

(d) i-ókók → i.ó.kók ‘It’s dirty.’

3Su-be.dirty

(25) 1st and 3rd person markers as glides

(a) w-aʔá → wa.ʔá ‘my head’

1-head

(b) w-e-kisé → we.ki.sé ‘my knife’

1-Poss-knife

(c) y-aʔá → ya.ʔá ‘his/her head’

3-head

(d) y-əʔə́k → yə.ʔə́k ‘his/her belly’

3-belly

The analysis I propose for the alternations o-/w- and i-/y- in possessive constructions is that these possessive prefixes have two allomorphs: one is a full vowel, {o-, i-}, the other is a glide, {w-, y-}, respectively, each of which is selected to a particular context. The tableau illustrates selection of a glide preceding a vowel. MAX-μ is not violated by either candiate because both forms, with and without a mora, are specified in the input; but the selection of {w-} is better because it satisfies ONSET.

Tableau 4.3. Selection of the variant {w-} of the 1st person possessive prefix.

{o-, w-}aʔá 1-head	*COMPLEX	MAX-μ	W-CONTIG	ONSET	NOCODA
a. o.a.ʔá				**!	
b.☞ wa.ʔá					

But not all vowel-initial nouns take the variants {w-, y-}. There are cases that take {o-, i-} instead; for example, *ṍhṍ* 'domestic animal' takes {o-}: *o-ṍhṍ* **w-ṍhṍ* 'my domestic animal'. The selection of {o-, i-} or {w-, y-} also depends on the quality of the initial vowel. This is because the language bans sequences *yi/*iy and *wo/*ow (see Chapter 5 on phonotactic restrictions). As shown in (26), the vowels /o, i/ share many features with /w, y/ respectively, differing only with respect to the feature [vocalic] in which case /w, y/ are [-vocalic].[5]

(26)	o	w	i	y
high	+	+	+	+
back	+	+	-	-
round	+	+	-	-
vocalic	+	-	+	-

The similarity between o/w and i/y counts as a fatal violation of the Obligatory Contour Principle (Leben 1973, Goldsmith 1976, McCarthy 1986; Odden 1986), which prohibits a sequence of identical elements.

(27) Obligatory Contour Principle (OCP)

At the melodic level, two adjacent identical elements are prohibited.

We can recast the prohibitions *wo/*ow and *yi/*iy in Mundurukú in terms of the OCP-constraints in (28). Note that a prohibition on sequences of segments that share more than one feature, here [+high, +round] and [+high, -back], is preferable because it does not exclude other combinations of segments that share only one feature; for example, *wi* or *yo* which share [+high].

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[5] Features for vowels were discussed in Chapter 2.

(28) Sequential prohibitions

(a) *HIBK-HIBK

A sequence [+high, -back]-[+high, -back] is prohibited within a syllable.

(b) *HIRD-HIRD

A sequence [+high, +round]-[+high, +round] is prohibited within a syllable.

An illustration of the restriction *wo is provided in the following tableau. The candidate *wṍhṍ* is ruled out by *HIRD-HIRD despite the fact that it provides an onset for the root-initial vowel.

Tableau 4.4. OCP and selection of {o-, w-}

{o-, w-}ṍhṍ 1-animal	*HIBK-HIBK	* HIRD-HIRD	*COMPLEX	MAX-μ	W-CONTIG	ONSET
a. wṍ.hṍ		*!	▨	▨	▨	▨
b.☞ o.ṍ.hṍ						**

4.4 Onsets

All Mundurukú consonants can be onsets. (29) illustrates the full range of consonants in this position, both word-initially and word-medially. Restrictions exist, however, for /r/ and /h/ which do not occur word-initially, except under specific conditions, as discussed below.

(29)	Word-initially		Word-medially	
/p/	póy	'tortoise'	i.pí	'It hurts.'
/b/	bí.o	'tapir'	ko̰.bé	'canoe'
/t/	ta.wé	'monkey, sp.'	ka.tõ	'village name'
/d/	dó.á	'spider'	ka.diŋ	'dust'
/c/	ʧó.kṍn	'toucan'	da.ʧé	'hawk, sp.'
/j/	ʤa.rã́y.ʔa	'orange'	wa.ʤe.bá	'cocoa'
/k/	kíp	'louse'	á.ko.ba̰	'banana'

/s/	sə́y	'bird, sp.'	ki.sé	'knife'
/ʃ/	ʃík	'mosquito, sp.'	da.ʃá	'fire, firewood'
/m/	mə.dí	'rodent, sp.'	a.ʃi.má	'fish'
/n/	nõŋ.ʔá	'flea'	no.bá.nṍ	'gun'
/ŋ/	ŋá.sə̃́	'now, today'	pi.ŋá	'fish hook'
/r/	---		pá.rát	'sieve'
/w/	wḭ.da̰	'jaguar'	a.wí	'needle'
/y/	ya.ʔá	'his/her head'	a.yá.ʧát	'woman'
/ʔ/	ʔot.pə́	'worm'	wa.ʔé	'bowl'
/h/	---		í.hí	'winter'

4.4.1 Contiguity versus Dependence

The occurrence of /h/ word-initially is not entirely banned (see below), but it seems to be an innovation that has its roots in the function of the consonant in the language. As discussed in Chapter 3, /h/ occurs in between identical (reduplicated) vowels; its status as an independent phoneme is based on reduplicated forms that have been lexicalized as such, and for which the corresponding non-reduplicated forms are no longer used in the language. These are provided in (30). The occurrence of /h/ in non-lexicalized cases is illustrated in (31) below.

(30) (a) o-ṍhṍ 'my domestic animal' *ṍ

1-domestic.animal

(b) y-ao̰ho̰=át 'one who is pale' *ao̰

3Su-CL=NOM

(c) íhí 'winter' *í

(d) íhi 'monkey, sp.' *í

(e) óhó-ʔa 'flute' *ó

flute-CL

In general, the distribution of /h/ is constrained by the phonology to a specific role in reduplication: a default consonant. Its function is to provide an onset for a vowel in V-reduplication, a pattern of reduplication in which the base is a syllable formed by a single vowel, as shown in (31). (See §4.3.3 for another context where [h] surfaces as a default onset.)

(31) Sequences of identical vowels via reduplication

(a) i-á 'to bite s.t.' i-á-há-m 'bitting s.t.'
3Ob-bite 3Ob-bite-RED-IMPRF

(b) ʤe-ə́ 'to go up' ʤe-ə́-hə́-m 'going up, climbing'
CoRef.Poss-up CoRef.Poss-up-RED-IMPRF

(c) t-aẽ́ 'to choose s.t.' t-aẽ́-hẽ́-m 'choosing s.t.'
3Ob-choose 3Ob-choose-RED-IMPRF

(d) ka̰bí-a̰ 'day' ʤe-ka̰bí-a̰-ha̰-m 'dawning'
sky-light CoRef.Poss-sky-light-RED-IMPRF

(e) o-í-o 'S/he got well.' i-mə́y-o-ho-m 'make s.o. get well'
3Su-?-be.well 3Ob-CAUS-be.well-RED-IMPRF

The examples in (32) show that /h/ is prohibited if the sequence of vowels does not result from reduplication.

(32) Non-reduplicated sequences of vowels

(a) i-ísə́ 'It's clean, new' *ihísə́
3Su-be.clean

(b) o-ʃeé 'my skin' *oʃehé
1-skin

(c) ʧoót 'bird, sp.' *ʧohót

The disparity of the distribution of /h/ is then related to its function in language: to separate two adjacent heterosyllabic vowels in V-reduplication. This is the context where it was phonologized and also the context where it mostly occurs synchronically, with some innovations (to be discussed below).

The occurrence of /h/ in reduplication follows from the principles that drive syllabification. The requirement that a vowel-initial syllable in V-reduplication must have an onset is, contradictory as it seems, also a requirement of the ranking that preserves onsetless syllables elsewhere in the language. Here the role of W-CONTIGUITY is crucial, because it treats the reduplicative morpheme as any other morpheme, irrespective of its phonetic realization. This is illustrated in Tableau 4.5.

Tableau 4.5. V-reduplication with epenthetic /h/.

i-á-RED$_\sigma$-m 3Ob-bite-RED-IMPRF	*COMPLEX	MAX-μ	W-CONTIG	ONSET	NOCODA
a. i.á.ám				***!	*
b. yá.hám		*!			*
c. i.á.má			*!*	**	
d. ☞ i.á.hám				**	*

Epenthesis of /h/ does not violate W-CONTIGUITY because the reduplicant (RED) is simply a syllable, with no specific information about the segments that compose it. Thus contiguity is required for the complex BASE-RED, but does not impose restrictions on the segments that realize the reduplicant. For example, candidate (d) obeys W-CONTIGUITY because /h/ belongs to the syllable that realizes the reduplicative morpheme. In this sense, the sequence *hV* is for RED as *i* is for the 3rd person object marker, and *m* for the aspect marker. Therefore, /h/ does not separate the input string {á-RED}.

The constraint is violated only if there is reordering of input morphemes; for example, RED is separated from the base by an intervening segment that is independent of it, such as the suffix {-m} 'Imperfective', illustrated by candidate (c). The output string is {BASE-m-RED}, corresponding to an input {BASE-RED-m}, in which case {BASE, RED} is one contiguous string, and {RED, -m} is another. Reordering breaks the string {BASE, RED} in favor of {BASE, -m}, and cancels {RED, -m}. The presence of /h/ in the reduplicant does not affect any of these.

Therefore, forms with and without /h/ are equally good according to W-CONTIGUITY, but reduplication with the laryngeal is better because of the prohibition on onsetless syllables, enforced by ONSET.

Epenthesis of /h/ is a compelling argument for the use of CONTIGUITY. To demonstrate the importance of this constraint for the analysis of Mundurukú, let us first consider an account using DEP instead. One possibility is to treat V-reduplication as a case of The Emergence of the Unmarked (TETU: McCarthy and Prince 1994). Onsetless syllables are permitted generally, but not in the reduplicant. In an analysis that invokes TETU, two faithfulness constraints must be posited: DEP-IO, to prevent epenthesis elsewhere, and DEP-BR, to prevent epenthesis in the reduplicant.

(33) (a) DEP-IO

Any segment in the output must have a correspondent in the input.

(b) DEP-BR

Any segment in the Reduplicant must have a correspondent in the Base.

Because we want onsetless syllables to surface, DEP-IO must dominate ONSET, and because we want to force /h/-epenthesis in reduplication, ONSET must dominate DEP-BR. Thus the ranking must be DEP-IO >> ONSET >> DEP-BR. The first problem with this ranking is shown in Tableau 4.6, which contains the same candidates examined in Tableau 4.5 above, but this time with DEP instead of CONTIGUITY. Note that the winner candidate is not the one with an epenthetic /h/. To rule out candidate (c), LINEARITY, the anti-metathesis constraint, could be invoked, and if ranked above DEP-BR, candidate (d) would be chosen. But the point I attempt to make here is that the ranking DEP-IO >> ONSET >> DEP-BR still predicts that epenthesis should not be an option.

Tableau 4.6. V-reduplication as TETU.

i-á-RED$_\sigma$-m 3Ob-bite-RED-IMPRF		*COMPLEX	MAX-μ	DEP-IO	ONSET	DEP-BR
a.	i.á.ám				***!	▨
b.	yá.hám		*!	▨	▨	▨ *
c. ☞	i.á.má				**	
d. ☹	i.á.hám				**	*!

The analysis I propose accounts for both marked and unmarked structures, and is therefore more economical. This is also in part because I believe that if a restriction does, or does not, hold for the language in general, then it does, or does not hold for particular aspects of the same language. For example, if onsetless syllables are generally permitted in Mundurukú, then they are permitted in reduplication.

Another argument in favor of CONTIGUITY is illustrated in (34). /h/ begins to extend its function as a default consonant to other environments in the language, and with the same function: to serve as an onset in onsetless syllables. This pattern is mostly found word-initially, where forms with and without /h/ are in free variation.

(34)	(a)	a.pát	~	ha.pát	'alligator'
	(b)	é	~	hé	'path'
	(c)	i.í.sə́	~	hi.í.sə́	'It hurts.'
	(d)	ṍn	~	h̃ṍn	'I'
	(e)	i.é.ə	~	hi.é.ə	'It's swollen.'

The account defended here fails to generate the variation, but the ranking can predict that /h/ in word-initial position is possible. Tableau 4.7 gives an example. Epenthesis of /h/ appears in four contexts: between the person prefix and the verb root, candidate (a); morpheme-internally, candidate (b); word-initially, candidate (c); and both word- and morpheme-initially, candidate (d). Candidates (a) and (d) fail W-CONTIG. Epenthesis of /h/ morpheme-internally violates M-CONTIG, because it segregates the morpheme {éə}. But if /h/ is epenthesized word-initially, both M-CONTIG and W-CONTIG are respected, and the candidate is optimal.

Tableau 4.7. /h/ word-initially but not morpheme-internally

i-éə	M-CONTIG	MAX-μ	W-CONTIG	ONSET	NOCODA
a. i.hé.ə			*!	**	
b. i.é.hə	*!			**	
c. ☞ hi.é.ə				**	
d. hi.hé.ə			*!	*	

Note that candidate (d) would be optimal if ONSET dominated W-CONTIG since it incurs less violations of ONSET relative to (a) and (c). Now, suppose that a change in the ranking takes place, and ONSET is promoted: ONSET >> W-CONTIG. Reranking predicts (d), but not (b), because epenthesis internal to the morpheme is ruled out by M-CONTIG. Therefore, if the phonology of the language decides to avoid onsetless syllables, it is predicted that the change will be at the periphery of morphemes, not morpheme-internally. This prediction is consistent with cross-linguistic observations that epenthesis at the edges of the morpheme or word are preferred over those internal to them (McCarthy and Prince 1994; see also Peterson 2004 for a good discussion of epenthesis and contiguity in Kabardian).

All else being equal, the predictions in terms of language change are as in (35).

(35) Historical change involving epenthesis

M-CONTIG >> W-CONTIG >> ONSET

Effect: Epenthesis at word boundaries possible.

⇓

M-CONTIG >> ONSET >> W-CONTIG

Effect: Epenthesis at word and morpheme boundaries possible.

⇓

ONSET >> M-CONTIG >> W-CONTIG

Effect: No onsetless syllables.

The alternations already observed in Mundurukú suggest that the language may be taking a step further in the change above. This is consistent with the idea that epenthesis first takes place at the edges of morphemes and then internally, and not vice-versa.

The analysis also succeeds in accounting for reduplication with fixed segmental material.

There is a pattern of reduplication in Mundurukú that has a fixed vowel /e/, which derives verbal predicates from nominal constructions; I refer to them as Exist(ential)-predicates, although there are two related interpretations: (i) as predicates of possession, when the noun (N) has an overt possessor – e.g. 'I have a house', or literally 'A house exists in my possession'; and (ii), as existential predicates when N does not have an overt possessor – e.g. 'There is a canoe', or 'A canoe exists'. In this kind of reduplication, the final syllable of the noun is copied but the vowel is always /e/.[6] This is illustrated in the following examples.

(36) Reduplication with fixed vowel /e/

(a)	w-e-ko̰bé (we.ko̰.bé)	w-e-ko̰bé-be
	1-Poss-canoe	1-Poss-canoe-RED.exist
	'my canoe'	'I have a canoe.'
(b)	o-dək-ʔá (o.dək.ʔá)	o-dək-ʔá-ʔe
	1-house-CL:round	1-house-CL:round-RED.exist
	'my house'	'I have a house.'
(c)	áko-ba̰ (á.ko.ba̰)	áko-ba̰-bḛ
	banana-CL:cylindrical.hard	banana-CL:cylindrical.hard-RED.exist
	'banana'	'There are bananas.'
(d)	nobánṍ-nõ̰m (no.bá.nṍ.nõ̰m)	nobánṍ-nõ̰m-nḛ̃m
	rifle.gun-CL:powder	rifle.gun-CL:powder-RED.exist
	'gun powder'	'There is gun powder.'

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[6] Reduplication with /e/ copies features such as nasality and creaky voice, but not tone. The fixed vowel is on a L-tone irrespective of the tone of the base. This can be achieved by the ranking M-CONTIG >> MAX-μ >> W-CONTIG >> ONSET >> MAX-L >> MAX-BR, which preserves L-tone of /e/ while forcing other features to be realized in the reduplicant.

(e)	o-ṍhṍ	(o.ṍ.hṍ)	o-ṍhṍ-hẽ
	1-domestic.animal		1-domestic.animal-RED.exist
	‘my domestic animal’		‘I have a domestic animal.’

As before, if the syllable to be copied is composed of a single vowel, /h/ is inserted as an onset for the reduplicant vowel /e/, as shown in the examples below.

(37) V-reduplication in reduplication with fixed vowel /e/

(a)	t-eí	(te.í)	t-eí-<u>he</u>
	3-price		3-price-RED.exist
	‘its price’		‘It has price.’
(b)	i-ʃeé	(i.ʃe.é)	i-ʃeé-he
	3-skin		3-skin-RED.exist
	‘its skin’		‘It has skin.’

Following a proposal by Kim and Picanço (2003; see also Chapter 9), I assume that the vowel /e/ is underlyingly specified in the representation of the reduplicant, as shown in Tableau 4.8. As a vowel, /e/ is moraic, therefore, it is required by MAX-μ to be realized in the output.[7] And again, epenthesis of /h/ does not violate W-CONTIG because the vowel /e/ does not define RED on its own, only part of it. If we assume that RED is /e/ by itself, then the input morpheme should be {-e}, not RED; in this sense, RED would be either unnecessary or independent of {-e}, and this is not the case here.

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[7] By realizing both /e/ and /h/ in the reduplicant, faithfulness to the base is violated (MAX-BR), but this is not crucial to the point being discussed here; MAX-BR is discussed in Chapter 9.

Tableau 4.8. Epenthesis of /h/ in reduplication with fixed vowel /e/.

t-eí-RED$_{\sigma}$ e	M-CONTIG	MAX-μ	W-CONTIG	ONSET
a. te.í.e				**!
b. ☞ te.í.he				*
c. te.<u>hí</u>.he	*!			
d. te.í.hí		*!		*

As seen in the tableau above, the role of M-CONTIGUITY is to avoid epenthesis morpheme-internally, and this is the reason why candidate (c) is banned. If an epenthetic element is required, epenthesis will first target the edges of morphemes. In this language it is more important to preserve VV sequences morpheme-internally than at morpheme-boundaries.

4.4.2 Word-initial /r/

Another restriction on word-initial onsets is the occurrence of /r/ in this position. This consonant is the second most frequent consonant in onset position in the language (see Chapter 5) even though most consonants have a distribution that include word-initial position. However, the restriction on a word-initial /r/ affects native words, but not borrowings.

The words below are borrowings from Portuguese; they are already consolidated in the lexicon of the language, as it is evident from both phonological and grammatical affinities with native words, in particular, their association with classifiers and adaptation to the native phonology. For example, Portuguese /l/ is replaced by /r/ since /l/ is not a phoneme of the native inventory; also, final /s/ in *lápis* is deleted since /s/ is not a possible coda in Mundurukú; and finally, the Portuguese stressed vowel is reinterpreted as a H-tone vowel.

(38) (a) rápi-ʔíp 'pencil' (Portuguese *lápis*)

pencil-CL

(b) ráta-ʔá 'can' (Portuguese *lata*)

can-CL

(c) papéra-də́p 'paper' (Portuguese *papel*)

paper-CL:flat.flexible

The innovation these borrowings brought to the language is the introduction of a new environment for /r/, previously restricted to medial position. The issue here is that borrowings, but not native words, allow /r/ word-initially.

Suppose the language has a constraint *#r that bans /r/ in this position.[8] The question then is: What forces the phonology to allow borrowings to violate this restriction? First of all, /r/ may not be actually word-initial. As first noticed by Braun and Crofts (1965), a word-initial /r/ is phonetically preceded by a non-syllabic schwa (see §4.5 for more details on this non-syllabic vowel): [ᵊɾ]ápiʔíp 'pencil' and [ᵊɾ]átaʔá 'can'.[9] It may also be pronounced as a plain [ɾ], especially by those more familiar with Brazilian Portuguese. Here I consider the forms with and without a non-syllabic vowel to be phonologically deviant with respect to the prohibition on the occurrence of /r/ word-initally, despite the fact that the variant [ᵊɾ] occurs in the pronunciation of these words. Given this, there seems to be other major requirements that force the phonology to tolerate the introduction of a new pattern in the language, and although these are in conflict with the constraint *#r, they still have priority. I believe that this is related to the fact that, when the borrowings were introduced, /r/ was the best replacement, the 'output' most similar and more faithful to the source, i.e. to /l/, than any other consonant available in the language's inventory.

The phonemic inventory of Mundurukú comprises seventeen consonants (as already seen in Chapter 3). From these only /d/ and /r/ are relatively close to /l/. While the alveolar stop is associated with /l/ in terms of place of articulation and (phonetic) voicing, /r/ shares place of

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[8] Of course, the constraint *#r only describes a prohibition so is not properly formulated, but motivation for it can be based on a similar prohibition in other languages. For example, certain dialects of Brazilian Portuguese, [ɾ] also does not occur word-initially.

[9] Braun and Crofts report that native words are also pronounced this way word-initially, but in all examples used to illustrate the variant, the initial consonant is not underlyingly /r/ as they suppose, but /d/. In later work, Crofts (1985) reports these forms with /d/, and comments that its pronunciation resembles that of [ɾ]. I have witnessed /d/-flapping only intervocalically, and for some of the speakers I have worked with, perhaps suggesting a dialectal variation. Given this, there seems to be a good reason to believe that a word-initial /r/ is in fact an innovation in the language.

articulation, voicing, and most importantly, it is linked to /l/ by the feature [+sonorant]. Therefore /r/ is closer to /l/ than /d/. Such considerations lead to the hypothesis that it is more important to respect sonorancy than a restriction.

The choice for [+sonorant] can be achieved by positing a high-ranking constraint that preserves this feature.

(39) MAX[+sonorant]

Input specifications of the feature [+sonorant] must have output correspondents.

MAX[+son] must dominate the phonotactic restriction on a word-initial /r/, *#r.

Tableau 4.9. From Portuguese lata to Mundurukú ráta.

lata	MAX[+son]	*#r
a. ☞ ráta		*
b. dáta	*!	

The phonology must permit word-initial /r/'s in Mundurukú, otherwise words like *rátaʔá* and *rápiʔíp* would not be possible. What complicates matters is that native words do not reflect the proposed ranking. On the contrary, they suggest an opposite relation between faithfulness and the markedness constraint, one in which *#r dominates MAX[+son]. This is the ranking that bans /r/ word-initially and retains it medially, as shown in the following tableau. (In the tableau '*x*' represents a consonant that is different from /r/.)

Tableau 4.10. Ranking for an underlying /r/ in native words.

ra	*#r_	MAX[+son]
a. ra	*!	
b. ☞ *x*a		*
ara	*#r_	MAX[+son]
c. ☞ ara		
d. a*x*a		*!

This divergence, I believe, is not because the phonology treats native and borrowed items differently. An alternative hypothesis which I would like to defend in the next section is that the language once had a prohibition *#r, but it was lost over time; synchronically, /r/ is 'free' to occur word-initially. The gap in native words reflects the period at which *#r was still active, whereas the borrowings reflect the new pattern.

4.4.2.1 Changing the ranking

Suppose that at an early stage of Mundurukú, shown in (40)a, *#r dominated MAX[+son], and so determined the distribution of /r/ in general. This of course banned all /r/'s from word-initial position and, hypothetically speaking, changed it into *x*.[10] At this stage, forms such as *ráta* and *rápi* were not possible. At a later stage, (40)b, *#r lost its position for MAX[+son]. At this point, the input form of a previous /r/ is no longer /r/, but has been coined (reinterpreted) as /*x*/, the output of the former ranking. This is due to one of the basic principles in OT, Lexicon Optimization (Prince and Smolensky 1993), which asserts that input forms echo outputs. I assume that Lexicon Optimization plays a leading role in language change by coining the output of an early stage as the input of the following. Here is when *ráta* and *rápi* came into the language; the change in the ranking favored a new environment for /r/, but left a gap in the distribution of the consonant. Synchronically, only novel forms have it in word-initial position.

(40) Consequences of changing the ranking

(a) Input: /ra/ /ara/ *#r >> MAX[+son]
Output: [*x*a] [ara]
↓ ↓ ↓ (Lexicon Optimization)
(b) Input: /*x*a/ /ara/ MAX[+son] >> *#r
Output: [*x*a] [ara]

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[10] A word-initial /r/ underlyingly is hypothetical, in respect to one of basics of OT, the Richness of the Base, which says that no constraints hold at the level of underlying representations. There is, however, no language-internal or comparative evidence to support the hypothesis. Amongst Tupi languages, at least Mekens (Galúcio, p.c.) and Mawé (Sérgio Meira, p.c.) show patterns similar to Mundurukú; Karo (Gabas Jr. 1988, 1999), Gavião (Denny Moore, p.c.), and Aweti (Sebastian Drude, p.c.) all exhibit /t/-flapping in which a morpheme-final /t/ is realized as [ɾ] before a morpheme-initial vowel. Thus, the consonant seems to be preferred in intervocalic position in several Tupi languages, and since long ago.

A strong argument in favor of the change in (40) comes again from borrowings. Compare the word *ʤarã́y* 'orange (tree)' to *ráta* 'can', which correspond to Portuguese *laranja* and *lata* respectively. The question here is: Why does Portuguese /l/ correspond to Mundurukú /ʤ/ in *ʤarã́y* but /r/ in *ráta*?

Suppose that *ʤarã́y* came into the language when *#r was still active, i.e. at the stage in (40)a. This prevented /l/ from being introduced into the language as /r/, because *#r banned it. Another option would then be /d/, the most similar consonant after /r/. This implies that *ʤarã́y* entered the language first as *darã́y*, changing later to *ʤarã́y*: laranja → darã́y > ʤarã́y (the notation ">" means 'developed into'). This seems to be correct: not only is the change d > ʤ a real diachronic change in Mundurukú (Chapter 5 discusses it in great detail), but also the correspondences l/ʤ versus l/r in laranja/ʤarã́y versus lata/ráta can be explained in a principled way. The word *ráta* entered the language later; strictly speaking, at the stage in (40)b. Given that *#r could be violated at that period, Portuguese /l/ could then be implemented as /r/. The discrepancies between borrowings and native words can then be considered as the result of a change the constraint *#r underwent. Does this mean that *#r is still active under certain conditions, or that it lost completely its function in the language?

4.4.2.2 Loss of a constraint: systematic versus accidental gaps

A plausible answer, one that follows from OT's basic concepts, is that reranking of constraints took place – grammars differ only in constraint ranking (Prince and Smolensky 1993). If we take different stages of a language to represent a different grammar,[11] then a constraint operating at an early stage may be ranked higher or lower at a following stage.

Suppose that two languages (X and Y) exhibit a restriction on a segment α, and Universal Grammar (UG) has a markedness constraint *α prohibiting α to occur in an environment *z*. Does the restriction on α mean that both languages have the constraint *α operating in their grammars? The idea defended here, and corroborated by the diachronic analysis of Mundurukú

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[11] By "different grammar" I do not mean that two stages of a language are completely unrelated, but that changes that take place at one stage have an effect on the following and, consequently, in the former grammar.

in Chapter 5, is that it is not mandatory that *α be part of the synchronic grammar of a language.

Let us begin by assuming that *α is a constraint in grammar X. In this grammar *α outranks Faith(ulness) to α, so the absence of α in a given context is a systematic gap, accounted for by the ranking *α >> Faith-α banning α in a principled way.

(41) Systematic gap

α...	*α	Faith-α
a. ☞ β...		*
b. α...	*!	

In grammar Y, on the other hand, the gap on the distribution of α is not systematic, meaning that *α does not consistently ban α from context *z*; an example of this can be the difference between borrowed and native items discussed above. This cannot be because of the ranking *α >> Faith-α, since it bans α altogether; for this grammar, *α must be ranked sufficiently lowly such that its effects are not evident. In other words, learners of this language have no indication whatsoever that *α is active in the grammar.

I believe that a child acquiring grammar Y will acquire former borrowings as part of the native vocabulary; for them, α can and does occur in *z*. Therefore, the gap in the distribution of α in this language can be considered as accidental, the consequence of a sound change.

To illustrate the point, assume that at stage I of Mundurukú the ranking was *#r >> MAX[+son]. This banned all /r/s word-initially: hence *laranja* 'orange' entered the language first as *darã́y*, not **rarã́y*. When MAX[+son] gained a higher position in the ranking, it opened a window for a word-initial /r/; hence *lata* 'can' became *ráta*. By Lexicon Optimization, stage II did not have /r/ word-initially in the native vocabulary, but could have it in novel forms. Consequently, children acquiring the language at stage II find /r/ in that position, though not frequently; for them, *ráta* and *rápi* are not borrowings, but lexical items that are part of the native vocabulary. Therefore, *#r has no synchronic motivation, and therefore needs not be acquired.[12] This issue is important because the assumption that a constraint can be completely

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[12] So far I have not found any cases in which a morpheme-initial /r/ may occur both word-initially and word-medially to test whether there is alternation of some sort. If such cases do not exist in the language, then children

demoted from its function makes a difference. Under this view, a diachronic change in one area causes deterioration on another. In the case at stake, promotion of MAX[+son] caused the deterioration of *#r. This hypothesis not only predicts that borrowings may have a word-initial /r/, but also allows for an internal change producing a similar result. For example, a vowel is deleted word-initially leaving /r/ in that position (VrV > rV). But if we assume that *#r and MAX[+son] were simply reranked relative to one another, the prediction is that /r/ will occur word-initially only if it replaces a [+sonorant] segment.

To sum up: the hypothesis is that a gap on the distribution of a segment α may be accidental, meaning that there is no synchronic motivation for the activity of a constraint such as *α. Here I introduced the idea using *#r as an example; other cases will examined in Chapter 5.

4.4.3 Asymmetries in VCV syllabification

In Chapter 3, I compared closure durations for voiceless stops in a number of sequences: (i) after a nasal consonant – VN+CV; (ii) in onset position – VCV; (iii) in morpheme-final position followed by a morpheme-initial vowel – VC+V; and (iv) in combination with an identical stop – VC_1+C_1V. The mean durations, repeated in Table 4.1, showed that voiceless stops are in fact longer (ambisyllabic) in intervocalic position, but the length of individual stops varies according to the stop and the sequence (see below).[13]

Table 4.1. Summary of the duration means (in ms) for voiceless stops.

	VN+CV	VCV	VC+V	VC_1+C_1V
p	156	235	188	265
t	152	239	193	225
k	130	147	169	144

The issue here is the mistmatch between phonetics and phonology. First, morphological operations combining two identical stops (VC_1+C_1V) create geminate-like consonants phonologically, and as such are expected to have greater duration than single stops in sequences

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would in fact have no evidence for *#r.

[13] Ambisyllabicity is also signaled by duration of the preceding vowel. A vowel preceding a voiceless stop is as short as one in a closed syllable.

VCV. The difference was significant for /p/ ($p<0.0001$) but not for /t/ or /k/ ($p=0.11$ and $p=0.27$ respectively).

Similarly, a morpheme-final stop followed by a vowel (VC+V) is lengthened in normal speech (see below on careful speech) to provide an onset for the following vowel. This can be characterized phonologically as gemination; thus sequences VC+V should in principle pattern with sequences VC$_1$+C$_1$V; but they do not. A comparison of the results show a significant difference for /p, t/ ($p<0.0001$ for both stops) but no difference for /k/ ($p=0.21$).

A different result was obtained for nasal stops. As expected, a nasal is longer in ṼN+V or VN+V sequences, where they are lengthened, than in VNV.

Table 4.2. Summary of the duration means (in ms) for nasals.

	VNV	ṼN+V	VN+V
m	102	121	132
n	86.7	91.3	111

Finally, it is well known that the universal parsing of VCV strings is V.CV. However, the two sequences, VCV and VC+V, differ phonologically in Mundurukú. An intervocalic stop or nasal is associated with an onset position only if VCV strings are either monomorphemic (42), or the morphological boundary is V+CV, (43).

(42) VCV

(a) a.pát ‘alligator’

(b) de.kó ‘monkey, sp.’

(c) a.ʃi.má ‘fish’

(d) no.bá.nṍ ‘rifle/gun’

(43) V + CV

(a) i-pák → i.pák ‘It’s red.’
3Su-be.red

(b) e-kop → e.kop ‘You went down.’
2Su-go.down

(c) o-jo-mṍŋ → o.jo.mṍŋ 'I put it.'

1Su-3Ob-put

(d) o-nə̃́y → o.nə̃́y 'my teeth'

1-tooth

Syllabification as V.CV in these examples is determined by ONSET.

Tableau 4.11. VCV → V.CV. Word: *dekó* 'monkey, sp.'

dekó	W-CONTIG	ONSET	MAX-IO	NOCODA
a. ☞ de.kó				
b. dek.ó		*!		*

The constraint also predicts that a morpheme-initial consonant is associated with an onset position.

Tableau 4.12. V+CV → V.CV. Word: *ipák* 'It's red.'

i-pák 3Su-be.red	W-CONTIG	ONSET	MAX-IO	NOCODA
a. ☞ i.pák		*		*
b. ip.ák		**!		**

But the situation is different with nasals and stops in VC+V sequences because the phonology of the language requires their realization as codas. In this position only voiceless stops /p, t, k/, nasals /m, n, ŋ/ and glides /w, y/ occur.[14]

(44)	Word-medially		Word-finally	
/p/	ka.sop.tá	'star'	wi.ap	'fan'
/t/	o.ʃát.ʔa	'my food (e.g. round fruit)'	ʃipat	'to be good'

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[14] The occurrence of /ʔ/ in coda position is discussed in Chapter 8.

/k/	ok.pot	'my son (male speech)'	kák	'fox'
/m/	wa.yõm.pə́	'object for squeezing manioc'	dáp.sém	'deer'
/n/	i.ẽn.mṍŋ	'I put the meat'	ʧó.kṍn	'toucan'
/ŋ/	nõŋ.ʔá	'flea'	yo.boŋ	'It's big.'
/w/	kaw.tá	'salt'	da.ʃéw	'fish, sp.'
/y/	pə̰y.bə́	'snake'	áy	'rodent, sp.'

If the morpheme boundary is VC+V, the universal preference for V.CV is overridden by another that requires syllabic and morphological boundaries to be aligned. That is, oral and nasal stops are obligatorily associated with a coda position, not only in normal but also in careful speech. In normal speech, these consonants close the syllable it is associated with and is released on the following vowel, as illustrated in (45).

(45) Normal speech

(a) i-díp=át → i.díp.^{p}át 'The beautiful one'
3Su-be.beautiful=NOM

(b) w-e-wiap-ep → we.wi.ap.^{p}ep 'I have a fan.'
1-Poss-fan.RED.exist

(c) t-a-ẽn-ẽn → ta.ẽn.^{n}ẽn '(a fruit) with flesh'
3-CL:seed-flesh.meat-RED.exist

(d) ṍm-ṍm (ayáʧá=yə̃)→ ṍm.^{m}ṍm '(The women) are going in.'
enter-RED woman=PL

This distribution of closure and burst events between two different syllables suggests that the consonant is a geminate in the phonology, serving both as coda for the preceding syllable and onset for the following. Gemination is not the resyllabification of a coda consonant: it can be seen as a way of satisfying the alignment of a morpheme boundary with a syllable boundary. Evidence for this requirement comes especially from observations in careful speech: a morpheme-final consonant remains in coda position, and the following onset is either realized by an epenthetic [h] or syllabification is VC.V. (Thus far I have observed this alternation only in reduplication, between base and reduplicant, and at word boundaries.)

(46) Careful speech

(a)	i.díp.át ~ i.díp.[h]át	'The beautiful one'
(b)	we.wi.ap.ep ~ we.wi.ap.[h]ep	'I have a fan.'
(c)	ta.ẽn.ẽn ~ ta.ẽn.[h̃]ẽn	'(a fruit) with flesh'

The alignment of the right edge of a morpheme with the right edge of a syllable is represented here by the constraint below.

(47) ALIGN-R – Align (Morpheme, Right, Syllable, Right)
The right edge of a morpheme must be aligned with the right edge of a syllable.

Here I assume non-crisp edge alignment, following Itô and Mester (1994: 38).

(48) Alignment:
Dfn Align(Cat1, Edge1, Cat2, Edge2)

Let Edge1, Edge2 be either L or R. Let S be any string. Then, for any substring A of S that *is-the-content-of-a* Cat1, there is [a] substring B of S that *is-the-content-of-a* Cat2, such that there is a decomposition D(A) and a decomposition D(B) of B, both sub-decompositions of a decomposition D(S) of S, such that Edge1(D(A))=Edge2(D(B)).

ALIGN-R prevents a morpheme-final consonant to be syllabified exclusively as an onset preceding a morpheme-initial vowel, and if dominated by ONSET, gemination is forced. In the tableau, brackets mark morpheme boundary and periods mark syllabic division.[15]

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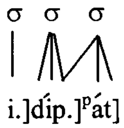
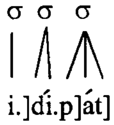
[15] Gemination violates another constraint, CRISPEDGE[σ] (Itô and Mester 1994); this constraint is not discussed because its application does not seem to be crucially required for the facts examined here.

Tableau 4.13. Gemination of coda consonants in normal speech. Input: *idíp át* 'the beautiful one'.

i-díp=át 3Su-be.beautiful=NOM	W-CONTIG	ONSET	ALIGN-R	NOCODA
a.  i.]díp.]át]		**!		**
b. ☞  i.]díp.]^{p}át]		*		**
c.  i.]dí.p]át]		*	*!	*

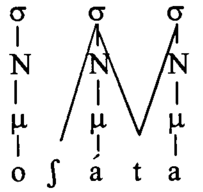
The variation in careful speech cannot be accounted for by the ranking proposed here. Epenthesis of [h] in reduplication (e.g. wiap-ep → wi.ap.hep 'I have a fan') satisfies ONSET but violates W-CONTIG. Likewise, an output without [h] (e.g. wi.ap.ep), satisfies W-CONTIG but violates ONSET. This goes back to the discussion on the possibility of a change promoting ONSET. If W-CONTIG loses its status relative to ONSET, *wi.ap.hep* is predicted; that is, epenthesis at morpheme boundaries may become a regular repair strategy to avoid onsetless syllables in the language. The presence of [h] in careful speech may be an indication that this is on its way.

The analysis of sequences VC_1+C_1V is similar to the one proposed for VC+V. That is, sequences of identical consonants are treated as geminates, as shown in the representations in (49). This analysis is supported by acoustic investigations (see Chapter 3) which show that stops in VC_1+C_1V sequences are realized with single closure and burst events, like a geminate.

(49) (a) o-ʃát-ta → o.ʃát.ta

1-food-CL

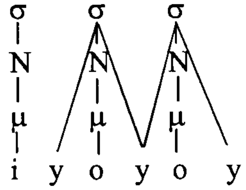
'my food'



(b) i-yoy-yoy → i.yoy.yoy

3Ob-bake-RED

'to bake s.t.'



It is worth noting, however, that sequences VC_1+C_1V and VC+V may differ in closure duration depending on the stop. As previously discussed, this phonetic difference is observed for /p/ and /t/ only; for /k/, sequences Vk+kV and Vk+V are not distinct. Given the discrepancy of the results, I will reserve this issue for future research. For now, let us assume they are phonologically similar.

As a geminate, two identical consonants in a sequence VC_1+C_1V satisfy the right alignment constraint and ONSET. MAX-IO is violated by candidate (a) because it deletes the final consonant of the base, despite the fact that deletion satisfies NOCODA.

Tableau 4.14. Syllabification of a sequence of identical consonants. Word: *-ʃát-ta* 'food-CL'.

ʃát-ta	W-CONTIG	ONSET	ALIGN-R	MAX-IO	NOCODA
a. ʃa.]ta				*!	
b. ☞ ʃat.]ta					*

The next issue to be examined in syllabification in Mundurukú concerns consonant clusters. I begin by looking at some phonetic and phonological aspects of the clusters that are allowed, and then proceed to those that are not, one in particular: sequences coronal + coronal (§4.5.4).

4.5 Consonant clusters

The language allows a large set of medial clusters, all of which are heterosyllabic. We have already seen that this is because of *COMPLEX, which forbids more than one consonant in coda or onset positions. Now we are going to see what clusters are predicted, what are attested, and their phonetic details.

Considering all possible combinations of coda and onset (8 consonants in coda position, /p, t, k, m, n, ŋ, w, y/ and 17 in onset /p, t, ʧ, k, b, d, ʤ, s, ʃ, m, n, ŋ, r, w, y, ʔ, h/), there are 136 possibilities for CC clusters. From these, 8 are excluded because they involve sequences C-/h/ and /h/ does not occur post-consonantally in normal speech, as seen earlier;[16] another 8 clusters – t-ʧ, t-d, t-ʤ, t-s, t-ʃ, t-n, t-r, t-y – do not occur because of a prohibition on sequences /t/ + coronal C (see below in §4.5.4). The others are given in Table 4.3; attested clusters are indicated by '✓',

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[16] It does occur in careful speech though. This was discussed in §4.4.3.

the ones not possible are indicated by '*', and those for which I have found no examples, but also no evidence that they cannot occur, are indicated by '?'. Examples are provided in the following sections.

Table 4.3. Combinations of coda x onset.

	p	t	ʧ	k	b	d	ʤ	s	ʃ	m	n	ŋ	r	w	y	ʔ
p	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	?	?	✓	✓	✓	✓
t	✓	✓	*	✓	✓	*	*	*	*	✓	*	?	*	✓	*	✓
k	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	?	?	✓	✓	✓	✓
m	✓	✓	✓	✓	✓	?	✓	✓	✓	✓	✓	✓	✓	?	?	✓
n	✓	✓	✓	✓	✓	?	?	✓	✓	✓	✓	?	✓	✓	✓	✓
ŋ	✓	✓	✓	✓	✓	✓	?	✓	✓	✓	✓	✓	✓	✓	✓	✓
w	✓	✓	✓	?	✓	✓	?	✓	✓	?	?	?	✓	?	✓	✓
y	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

4.5.1 Clusters I: voiceless stop + C

Consonant clusters in which the first consonant is a voiceless stop are by and large the most suitable clusters for coarticulatory effects in Mundurukú. In almost all combinations, a voiceless stop is phonetically influenced by the following onset. This is interesting because, phonologically, it is an onset consonant that is influenced by a coda consonant in Mundurukú (see especially Chapter 7 on voicing alternation). The distinction between phonetic and phonological processes is important here. Phonetic effects do not involve the manipulation of features and are gradient; phonological processes, on the other hand, involve manipulation of features and are categorical (e.g. Keating 1996). In this section I focus on the coarticulatory effects, relating them to phonological ones.

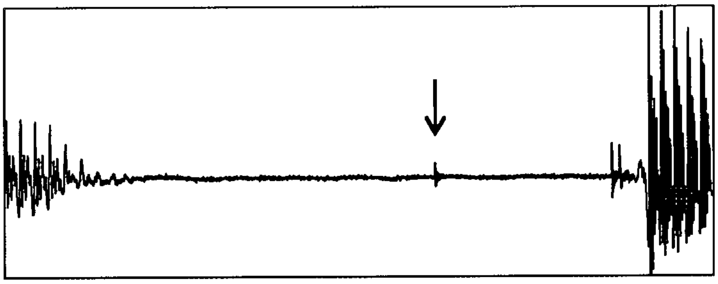
The first CC cluster to be examined consists of a sequence of voiceless stops. (Here and in the rest of the section, clusters in a box are those consisting of a sequence /t/ + coronal, which always result in deletion of /t/. These are examined later in §4.5.4.

(50) Voiceless stop + voiceless stop

	p	t	ʧ	k
p	o.tap.pə́ 'I got the feather.'	ka.sop.tá 'star'	o.təp.ʧó.ʧó 'I saw a leaf.'	i.mə.ʔít.káp.kám 'to help a baby be born'
t	ʔot.pə́ 'worm'	o.ʃát.ta 'my food'	i-mə-ʧoát-ʧoát-m i.mə.ʧó.á.ʧó.án 'make s.o. look'	i.kót.kón 'digging s.t.'
k	ok.pot 'my son'	ok.top 'my husband'	da.jek.ʧó 'rodent, sp.'	i.mə.kí.r̰ik.kí.r̰iŋ 'to tie s.t. up'

Heterorganic clusters (VC_1+C_2V) tend to have greater duration (average of 278 ms, s.d. 34.4), but this result is no different from the result obtained for a sequence /p-p/ ($p=0.24$). They still differ from homorganic clusters in that C_1 is often, though not always, released. Figure 4.4 gives an illustration of a sequence Vp+tV; the arrow marks the burst release for [p].

Figure 4.4. Illustration of the closure phase in the sequence [p-t] in the Mundurukú word kasop-tá 'star'.



It is also possible to have a cluster formed by voiceless stop + voiced stop. Here phonetics and phonology diverge. Phonologically, the language has a process of consonant mutation (see details in Chapter 7) in which voiced stops in onset position agree in [-voice] with a preceding voiceless stop. Voicing alternations are restricted to particular classes of morphemes and subject to certain morphosyntactic conditions; elsewhere, sequences of stops may disagree in voicing, as the examples in (51). In the cluster /p-b/, the verb *-boŋ* 'be big' alternates with *-poŋ* after a voiceless stop, but this is because consonant mutation begins to be generalized in the language.

(51) Voiceless stop + voiced stop

	b	d	ʤ
p	təp.boŋ ~ təp.poŋ ‘the leaf is big’	day.do.dáp.dáp ‘armadillo, sp.’	ʔip.ʤə́k.pə ‘wood louse’
t	ya̰.kó.bə́t.bə́n ‘to hug s.o’	i.do.dot ‘S/he’s tattooed.’	á.ʤó.ʤót ‘grandmother’
k	i.bḭk.bḭk ‘It’s narrow.’	ʤe.dók.dóŋ ‘to swim’	a̰ʤók.ʤóŋ ‘bathing’

Phonetically, however, these sequences may be optionally pronounced as a sequence voiceless + voiced or voiced + voiced, in which the coda stop assimilates voicing from the following onset.

The waveforms in the figures below illustrate three sequences voiceless stop + voiced stop: /p-b/, /k-b/, /k-ʤ/, as produced by two speakers (JT and EM). The sequences in the figures 4.5 and 4.6 below show voiced and voiceless variants of voiceless stops preceding /b/ in -*boŋ* ‘be big’, as produced by the same speaker (JT). He pronounces the sequence /k-b/ as [k-b], maintaining the difference in voicing; this is perhaps facilitated by the difference in place of articulation since the sequence /p-b/ in *təp-boŋ* is produced as a long [b]. (In the waveforms vertical lines mark stop closures.)

Figure 4.5. Waveform illustrating the sequence /p-b/ realized as a long [b]. Word: *təp-boŋ* ‘The leaf is big.’ (JT)

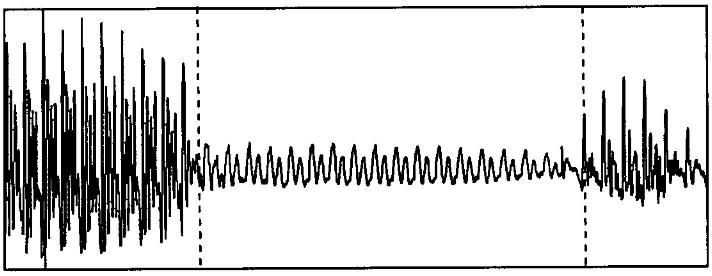
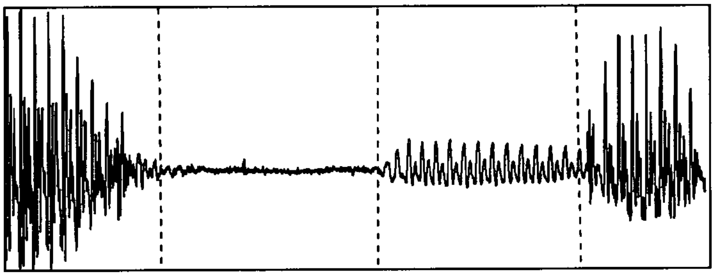
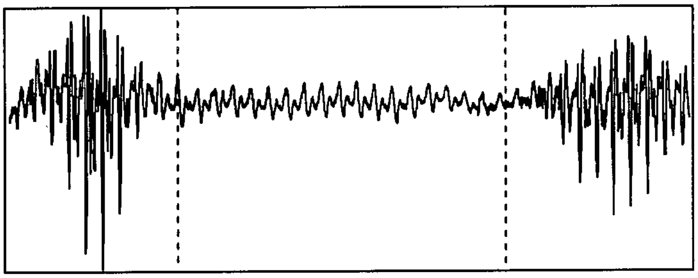


Figure 4.6. Waveform illustrating the sequence /k-b/ realized as [k-b]. Word: *wək-boŋ* ‘My belly is big’ (JT)



For the second speaker (EM), the velar stop /k/ is produced as [g] before /ʤ/.

Figure 4.7. Waveform illustrating the sequence /k-ʤ/ realized as [g-ʤ]. Word: *a̰ʤók-ʤóŋ* ‘bathing’ (EM)



Voicing assimilation varies across speakers. The waveforms below illustrate the voiced-voiceless variation in the same word, *daydodápdáp* ‘armadillo, sp.’, as produced by three speakers. The target is the sequence /p-d/. For both EM and AK, illustrated in the figures in 4.8 and 4.9 respectively, *-dáp-dáp* is pronounced as [dáb-dáp].

Figure 4.8. Waveform illustrating the sequence /p-d/ realized as [b-d]. Word: *daydodápdáp* ‘armadillo, sp.’ (EM)

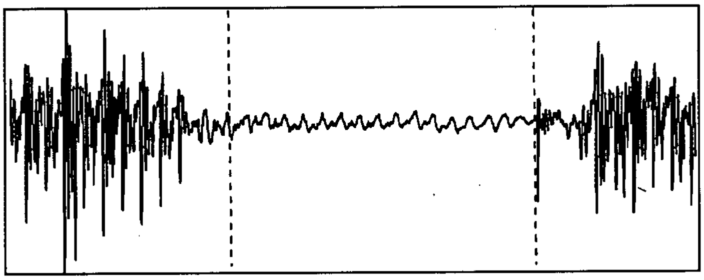
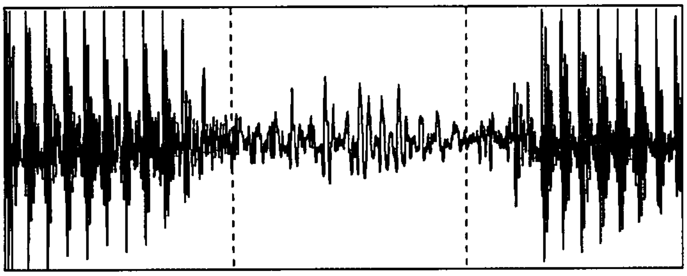
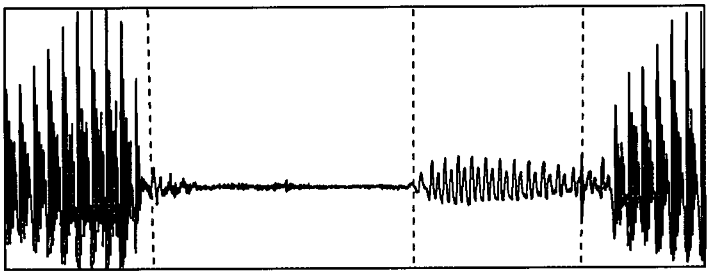


Figure 4.9. Waveform illustrating the sequence /p-d/ realized as [b-d]. Word: *daydodápdáp* 'armadillo, sp.' (AK)



For JT, voicing distinctions were maintained and the sequence surfaces as [p-d].

Figure 4.10. Waveform illustrating the sequence /p-d/ realized as [p-d]. Word: *daydodápdáp* 'armadillo, sp.' (JT)



The variation in voicing assimilation suggests an interpretation in terms of coarticulatory influence of voiced stops, rather than the phonological manipulation of the feature [+voice]. If we assume that [+voice] spreads to a preceding stop, two problems arise for the phonology: (i) the process is optional, and (ii) the language has already a process of voicing alternation, which is obligatory and affects stops in onset position. The differences between the two are outlined in (52). The cooccurrence of both in the same language is unlikely because they have conflicting properties. While progressive assimilation demands that a following voiced stop be realized as voiceless, the other would require the opposite: that a coda stop be realized as [+voice]. In addition, progressive assimilation targets only the stops that contrast phonologically for the feature [voice], thus excluding /k/. Contrary to progressive assimilation, regressive assimilation is not structure-preserving, a property that is typical of coarticulatory effects.

(52) Differences:	Regressive assimilation	Progressive assimilation
	is optional	is obligatory
	is not structure-preserving	is structure-preserving
	targets all voiceless stops	does not include /k/

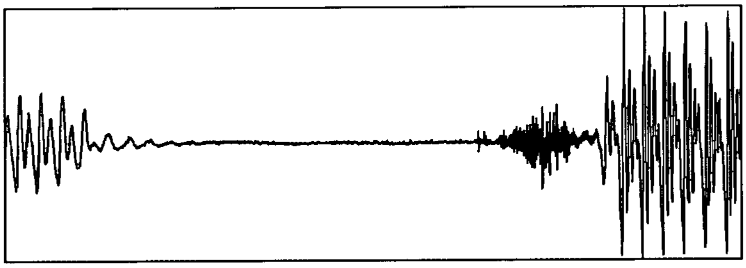
To continue with clusters, a voiceless stop may also be combined with a fricative. There are three reasons to believe that these do not form affricates. First, all stops can be combined with either /s/ or /ʃ/, except for /t/ which deletes because of the prohibition on sequences /t/ + coronal (§4.5.4). Second, the voiceless affricate /ʧ/ contrasts with the sequence t+ʃ in that /t/ is always deleted in the latter. Finally, the same morpheme-initial fricative can be combined with different stops; for example, wək-sa̰ 'my liver' versus yop-sa̰ 'his/her liver'.

(53) Voiceless stop + fricative

	s	ʃ
p	dáp.sém 'deer'	ʃép.ʃép 'two'
t	sə̃́.sə̃t 'monkey, sp.'	o.ʃé.ʃét 'I slept.'
k	wək.sa̰ 'my liver'	wək.ʃa̰.bí 'my back'

Phonetically, the primary difference between affricates and a sequence stop + fricative is that the stop portion in an affricate is much longer than the fricative portion, as seen in Chapter 3, and illustrated in Figure 4.11.

Figure 4.11. Expanded waveform illustrating the affricate /ʧ/. Word: *bekíʧát* 'child, boy' (JT)



Conversely, in stop + fricative sequences, the fricative has a more prolonged period of frication, as shown in the two waveforms below.

Figure 4.12. Expanded waveform illustrating the stop + fricative sequence /k-ʃ/. Word: *wəkʃa̰bí* 'my back' (JT)

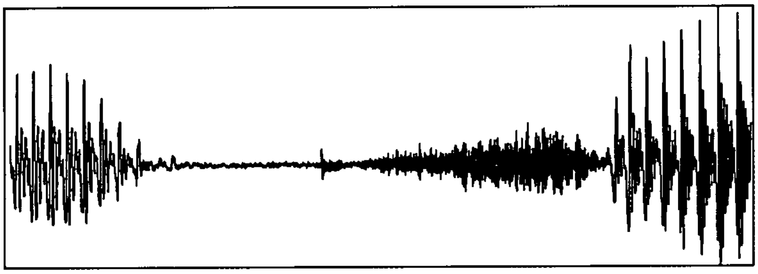
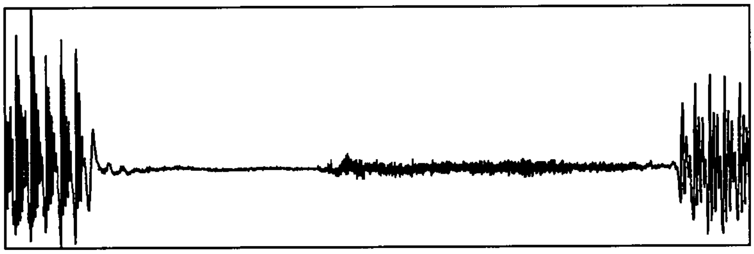


Figure 4.13. Expanded waveform illustrating the stop + fricative sequence /p-s/. Word: *dápsém* 'deer' (JT)



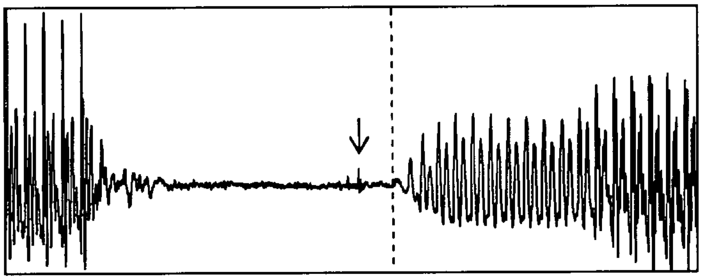
The next cluster to look at is formed by a stop + nasal. For these, I have found no examples of a stop before /n/ or /ŋ/. As for the sequence /t-n/, this is predicted to not be possible because of the prohibition on /t/ + coronal.

(54) Voiceless stop + nasal

	m	n	ŋ
p	o.təp.mṍŋ		
	'I put the leaf…'		
t	o.tit.mṍŋ		
	'I put the flower…'		
k	o.yə̰k.mṍŋ		
	'I put the hollow object…'		

In a sequence stop + nasal, nasalization and stop do no overlap. The waveform below illustrates the sequence /t-m/; after the stop is released (indicated in the waveform by an arrow), voicelessness continues for a short period before nasalization starts.

Figure 4.14. Expanded waveform of the sequence /t-m/. Word: *ototmṍŋ* 'I put the bunch.' (JT)



To conclude the investigation of sequences voiceless stop + C, let us examine those formed by stop + approximant. In this group, the most interesting cluster is the sequence stop + /r/; but before examining it, I want to briefly comment on other sequences.

We have already seen the details of the sequence stop + /ʔ/ in Chapter 3, so I will not examine it here. As for the sequences stop + /w/ and stop + /y/, the effect of the approximant is similar to that of the voiced stops examined above; that is, a glide may also cause a preceding stop to surface voiced. For example, /k/ in the sequence /k-w/ in *iwekwek* 'It's torn' may be produced as [gw].

(55) voiceless stop - approximant

	w	r	y	ʔ
p	ʔip.wéró 'woodpecker'	təp.rət 'The leaf is white.'	o.dop.yə̃́ 'my arrows'	op.ʔə́k 'spear'
t	i.bəy.wát.wán 'to help s.o'	ka.ʔó.ri.rit 'sand, beach'	a.yá.ʧá.yə̃ 'women'	o.ʃát.ʔa 'my food'
k	i.wek.wek 'It's torn.'	yə̰k.réŋ 'She's pregnant'	ʃik.yə̃ 'mosquitoes'	ək.ʔá 'house'

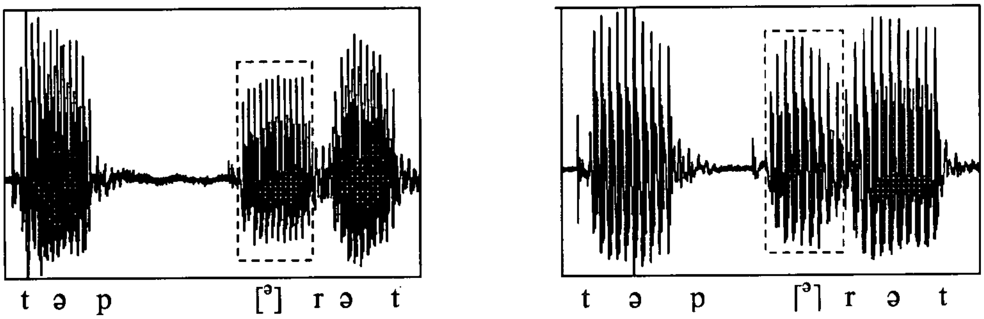
Sequences stop + /r/ are more interesting for the following reasons. First, syllabification of the cluster /p-r/ in *təprət* 'the leaf is white' as /p.r/ (*təprət* → *təp.rət*) offends preference laws for syllable contact (Vennemann 1988), and constitutes a tautosyllabic cluster in many languages. The preferred syllabification would thus be *tə.prət. However, this is not possible in Mundurukú because *COMPLEX, shown in Tableau 4.15, determines that all CC sequences must be heterosyllabic. An alternative, illustrated by candidate (c), would be to insert a vowel and create a new syllable, *tə.pə.rət*, but this is also bad because epenthesis violates W-CONTIG. The optimal candidate is thus *təp.rət*, despite its conflict with the syllable contact law.

Tableau 4.15. Syllabification of the cluster /p-r/.

t-əp-rət	*COMPLEX	W-CONTIG	ONSET	ALIGN-R
a. t]ə.p]rət]	*!			**
b. ☞ t]əp.]rət]				*
c. t]ə.p]ə.rət]		*!		**

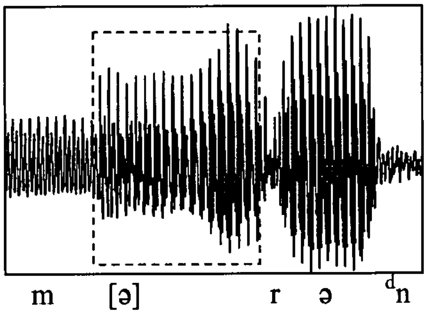
But the phonetic details of clusters such as /pr/ are not so simple. The transition from /p/ to /r/ is not simply [p.ɾ] as the phonology says. The cluster is in fact realized with an epenthetic, non-syllabic vowel: [təp$^{\text{ə}}$ɾət], as shown in the waveforms below. Phonologically this vowel is invisible: speakers recognize only two syllables, *təp.rət*, and therefore two tones, L-L. Another difference between non-syllabic [$^{\text{ə}}$] and a full [ə] is length. In open syllables, vowels tend to be longer than those in closed (see Chapter 3). Compare the two sequences [$^{\text{ə}}$rə] in Figure 4.15 to the sequence [ərə] in Figure 4.16. Figure 4.15 shows waveforms of the word *təprət* [təp$^{\text{ə}}$rət]. Note that [$^{\text{ə}}$] is noticeably shorter (average of 69 ms, s.d. 9.7) than a full [ə] in a closed syllable (mean 79 ms, s.d. 16.2, as seen in Chapter 3).

Figure 4.15. Waveforms illustrating non-syllabic [ə]. Word: *təprət* [tə̀p$^{\text{ə}}$rə̀t] 'The leaf is white'. (AK/JT)



Now compare these to a full vowel [ə] in an open syllable and preceding /r/, shown in Figure 4.16. As a regular vowel, [ə] is clearly longer (mean 180 ms, s.d. 8.2) that a transitional [$^{\text{ə}}$] in a similar context.

Figure 4.16. Waveform illustrating a full vowel [ə]. Word: *imərə́n* [ìmə̀rə̀^{d}n] ‘to make s.t. white’. (JT)



The question here is: ‘Is this a phonetic or a phonological process?’ According to the analysis developed so far, if [^{ə}] is treated as a full vowel in the phonology, two problems arise. First, W-CONTIGUITY does not allow epenthesis at morpheme boundaries. And second, as a full vowel, [^{ə}] would have to be moraic, and as such be assigned a tone on surface, but speakers whistle only two tones, meaning that [^{ə}] in the word *təprət* does not bear a tone for them. Thus, the answer is: a transitional schwa is not phonological. If it is non-syllabic and not a tone-bearing unit, therefore it is not an epenthetic vowel; it serves exclusively to release the stop in order to avoid an ill-formed contact between syllables. This explains why a transitional [^{ə}] is shorter than a full schwa in a similar sequence. But voiceless stop + /r/ is not the only sequence to exhibit a transitional schwa; this effect is also observed in nasal + /r/ sequences, examined next.

4.5.2 Clusters II: nasal + C

In clusters formed by a nasal and another consonant, the sequence nasal + /r/ also exhibits a non-syllabic schwa, as in the case of voiceless stop + /r/. (56) and (57) illustrate combinations nasal + stop, voiceless or voiced; these are produced without influence of either consonant. (There are no examples available for the followings sequences: m-d, n-d, n-ʤ, ŋ-ʤ.)

(56) Nasal + voiceless stop

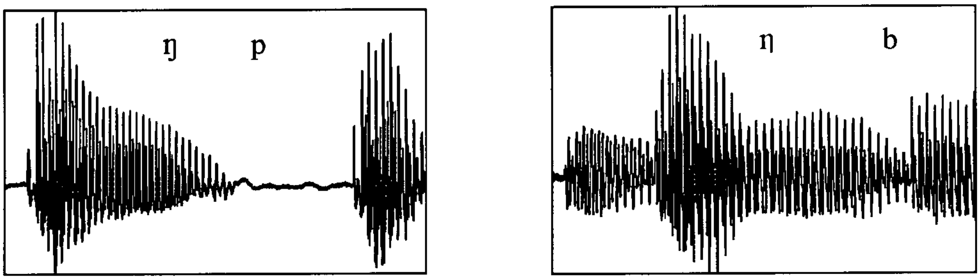
	p	t	ʧ	k
m	wa.yõm.pə́ ‘object for squeezing manioc’	o.kə̃m.tá ‘my nipple’	o.to̰m.ʧó.ʧó ‘I saw the mix’	a̰kṍm.kṍm ‘falling into the water’
n	na.pẽn.pə́ ‘centopede’	ʃin.tṍm ‘porridge mix’	tə̃n.ʧay ‘his/her hips’	i.mẽn.kə́ ‘It’s true, real’
ŋ	pə̃́ŋ.pə ‘one long, flexible object’	ka.ʔṍŋ.tot ‘broom’	ʧoŋ.ʧoŋ áp.ʔip ‘a stick for pounding s.t.’	i.kə̰ŋ.kə̰ŋ ‘It’s tight.’

(57) Nasal + voiced stop

	b	d	ʤ
m	i.e.rə̃m.bóŋ ‘It’s wide.’		a̰.ʤẽ́m.ʤẽ́m ‘to arrive’
n	ʤe.bə́n.bə́n ‘to stumble’		
ŋ	ʤe.ba̰ŋ.ba̰ŋ ‘to crack’	ʤe.dóŋ.dóŋ ‘to swim’	

The waveforms below illustrate sequences nasal + stop. The waveform on the left contains the sequence ŋ-p in the Mundurukú word *pə̃́ŋ-pə* ‘one finger’, and the waveform on the right shows a portion of the the word *bṍŋ-bi(wát)* ‘bracelet’, illustrating the sequence sequence ŋ-b.

Figure 4.17. Waveforms illustrating sequences nasal + stop. Words: *pə̃́ŋpə* ‘one finger’ (on the left) and *bõŋbi(wát)* ‘bracelet’ (on the right). (JT)



The examples in (58) and (59) illustrate the sequences nasal + fricative and nasal + nasal respectively. There are no particular observations to be made about these sequences.

(58) Nasal + fricative

	s	ʃ
m	i.ŋẽm.sə̃́	ta.ʃim.ʃim
	‘It smells a bit.’	‘dog (slang)’
n	tə̃́n.sa.bə́	ʧó.kṍn.ʃí.ʃi
	‘back of the knees’	‘a big toucan’
ŋ	i-ʤõŋ-sə̃́ŋ	ʤe.ʃiŋ.ʃiŋ
	‘S/he’s fat.’	‘to walk around’

(59) Nasal + nasal

	m	n	ŋ
m	ʧə́m.ma	i.i.nə̃́m.nə̃́m	i.mṍŋ.mṍŋ
	‘will go (for sure)’	‘sewing s.t.’	‘putting s.t.’
n	i.mə̃́n.mə̃́n	ti.nə̃́n.nẽn	
	‘to tie s.t.’	‘water mixed with feces’	
ŋ	ʤe.mə̃́ŋ.mə̃́ŋ	ti.bi.nə̃́ŋ.nẽŋ	o.tiŋ.ŋṍn
	‘to lean’	‘porridge mixed with s.t.’	‘I inhaled smoke.’

But for sequences nasal + approximant, (60), one combination in particular deserves attention: the sequence nasal + /r/, examined in detail below.

(60) Nasal + approximant

	w	r	y	ʔ
m		i.rẽm.rə̃́m		o.kə̃m.ʔá
		'It's not so blue.'		'my breast'
n	ka.wẽ́n.wẽ́n	tə̃n.rət	o.sə.ẽn.yóy	kã̰n.ʔí
	'talking'	'Its feces are white'	'I baked the meat.'	'swallow'
ŋ	daŋ.wí	tiŋ.rət		nõŋ.ʔá
	'from'	'The smoke is white.'		'flea'

Like sequences stop + /r/, the sequence nasal + /r/ is also characterized by the presence of a transitional [ᵊ], as shown in the waveforms in Figure 4.18 to Figure 4.20.

Figure 4.18. Waveform illustrating non-syllabic [ə] in nasal + /r/. Word: *tiŋrə́t* 'The smoke is white.' (AK)

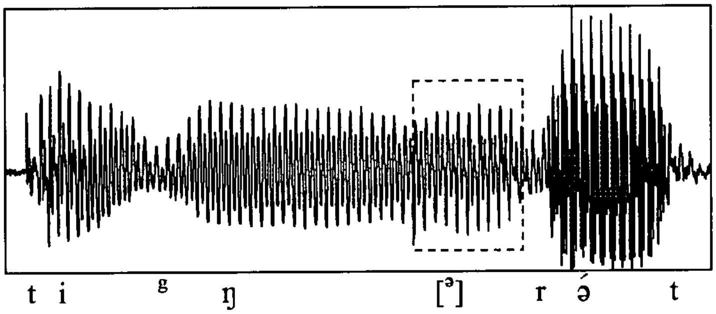


Figure 4.19. Waveform illustrating non-syllabic [ə] in nasal + /r/. Word: *tiŋrə́t* 'The smoke is white.' (JT)

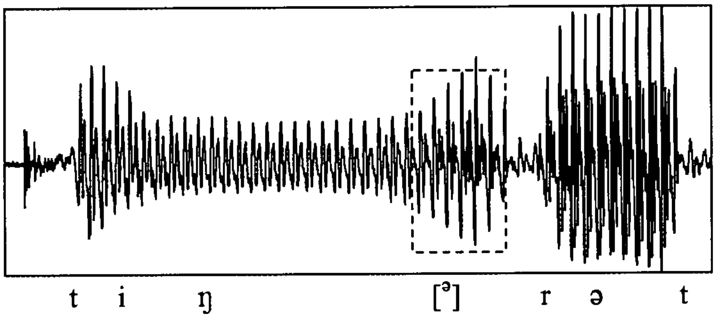
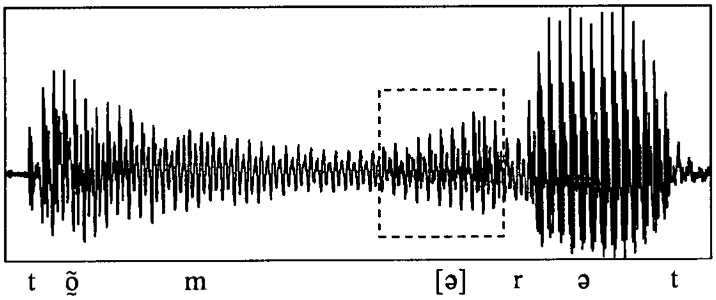


Figure 4.20. Waveform illustrating non-syllabic [ə] in nasal + /r/. Word: *tõ̰mrə́t* 'The flour is white.' (AK)



The sequence ŋ-r in particular shows that a [^{ə}] is in fact non-syllabic. Recall the nasal velar /ŋ/ is realized as a palatal [ɲ] syllable-initially, thus resyllabification would leave /ŋ/ in onset position, preceding [^{ə}]. However, the nasal is still realized as [ŋ] in *tiŋrə́t*: [tì^{g}ŋ^{ə}rə́t], not [tì.ɲə̀.rə́t]. Therefore [^{ə}] does not form a syllable with the preceding stop, oral or nasal. An illustration of syllabification of sequences nasal + /r/ is given in the following tableau.

Tableau 4.16. Syllabification of sequences nasal + /r/.

tiŋ-rət	*COMPLEX	W-CONTIG	ONSET	ALIGN-R
a. ti.ŋ]rə́t]	*!			*
b. ☞ tiŋ.]rə́t]				
c. ti.ŋ]ə.rə́t]		*!		*

4.5.3 Clusters III: approximant + C

There seems to be no coarticulatory effect in sequences approximant + C. The only observation concerns the cluster approximant + /ʔ/ in that the glottal is realized as a heavy type of creaky voicing, as already examined in Chapter 3.

The examples below illustrate all combinations. (61) illustrates the sequence approximant + voiceless stop; (62) the sequence approximant + voiced stop; (63) the sequence approximant + fricative; (64) the sequence approximant + nasal; and finally (65) illustrates the sequence approximant + approximant. Examples for the following sequences were not found in the corpus: w-k, w-ʤ, w-m, w-n, w-ŋ, and w-w.

(61) Approximant + voiceless stop

	p	t	ʧ	k
w	da.pẽ́w.pẽ́w.da	kaw.tá	i.mə.ʧáw.ʧa̰w	
	‘humming-bird’	‘salt’	‘to bite s.t.’	
y	ta̰y.pə́	pəy.tõ.bə́	i.ŋə̰y.ʧə̃́ŋ	ʤe.ko̰y.ko̰y
	‘penis’	‘snake, sp.’	‘S/he is quiet/sad.’	‘to row’

(62) Approximant + voiced stops

	b	d	ʤ
w	ka.káw.ba̰	ya.daw.daw	
	‘cocoa fruit’	‘S/he’s scared.’	
y	pə̰y.bə́	póy.dá	ʤe.kə̃y.ʤó.ʤóm
	‘snake’	‘cassava’	‘to hear’

(63) Approximant + fricative

	s	ʃ
w	séw.sew	kaw.ʃi.ʔá.ʔá
	‘hawk, sp.’	‘fish, sp.’
y	ʤe.sáy.sey	o.tay.ʃi
	‘She has a dress’	‘my wife’

(64) Approximant + nasal

	m	n	ŋ
w			
y	i.mə̃́y.mə̃́y	nay.no.ʔá.bə	a̰.ŋə̰y.ŋə̰y
	‘to nail s.t.’	‘fish, sp.’	‘to think/meditate’

(65) Approximant + approximant

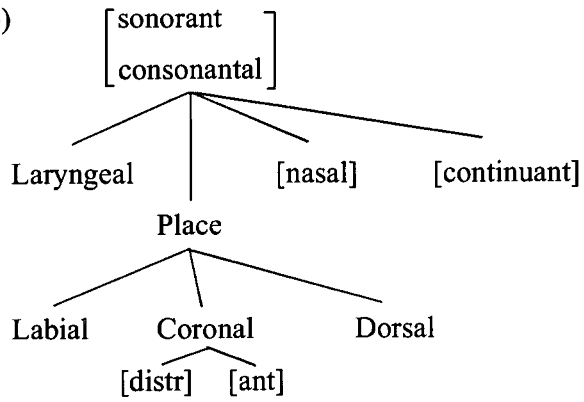
	w	r	y	ʔ
w		dáw.rə́k.ʔa	to.ʃáw.yə̃	pəw.ʔí
		'fish, sp.'	'chiefs'	'to blow'
y	ʤe.wáy.wáy	ya.ro̰y.rə̰y	i.yóy.yóy	ʤa.rã́y.ʔa
	'to laugh'	'It's roundish.'	'It's baked.'	'orange'

I now turn to the one cluster that is phonologically prohibited: sequences /t/ + coronal.

4.5.4 Sequences coronal + coronal

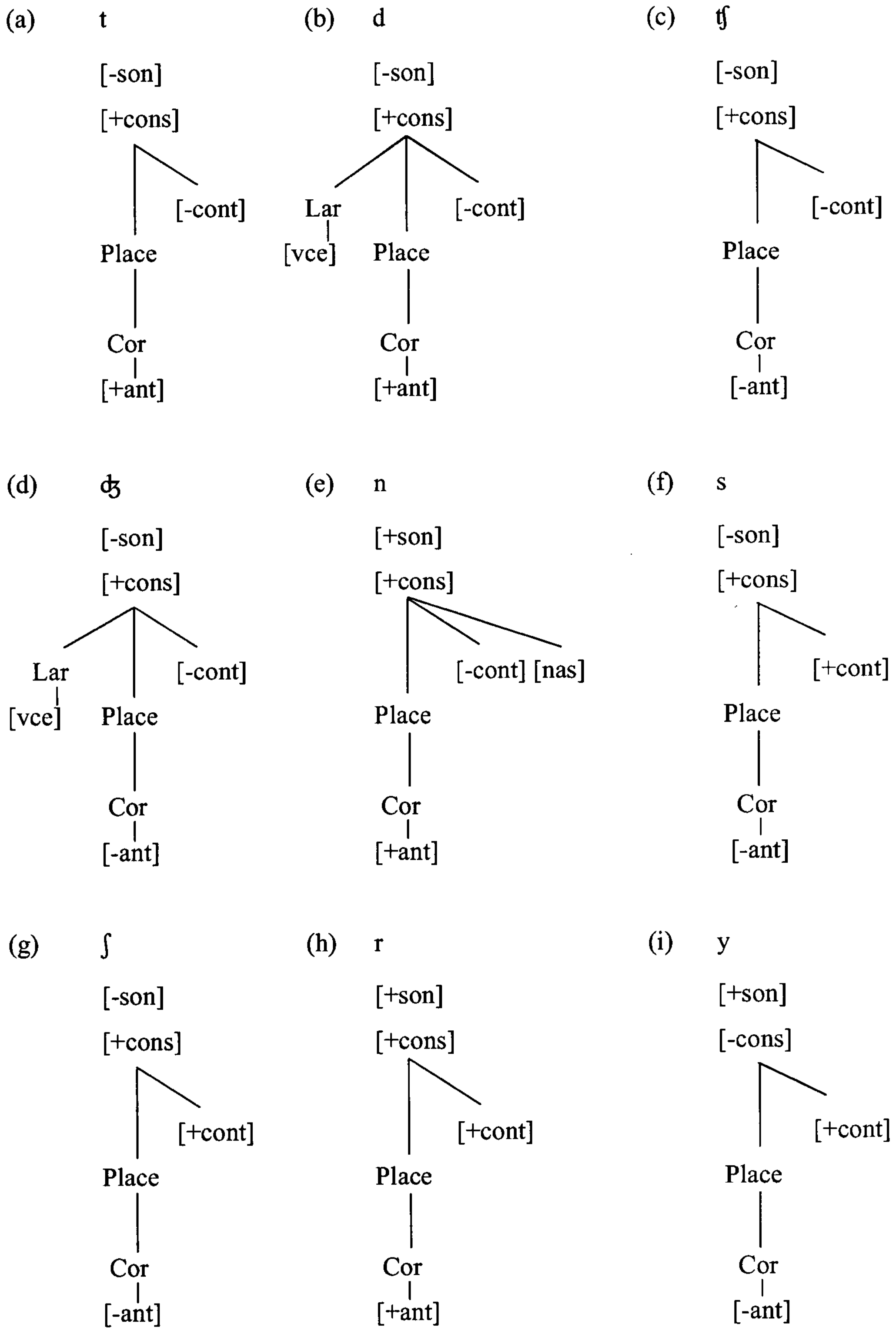
While there seems to be no restrictions on clusters with distinctions in manner of articulation, in the place dimension not all clusters are tolerated; in particular, the sequence /t/ + coronal is prohibited. To explain the facts, assume the representations for coronals in (67) below, following the geometry proposed by McCarthy (1988), which treats [sonorant] and [consonantal] as articulator-free features, located at the root node and necessarily present in the representation of every segment (see Halle 1995).

(66)



There are nine coronal consonants in the consonant inventory of the language: /t, d, ʧ, ʤ, s, ʃ, n, r, y/; these differ in terms of the following features: (i) [sonorant] distinguishes obstruents, [-son], from nasals and approximants [+son]; (ii) [continuant] distinguishes stops, [-cont], from fricatives, [+cont]; (iii) [nasal] distinguishes nasal from oral stops; (iv) [voice] distinguishes voiceless from voiced stops; and (v) [anterior] distinguishes alveolar, [+ant], from palatal segments, [-ant].

(67) Representations for coronals



Combining coronals that may occur in coda position, /t, n, y/, with coronals that occur in onset position, there are 27 possibilities for sequences coronal + coronal. From these, only sequences /t/ + coronal are illicit; the others have no restriction, but there are two for which I have not found examples: n-d and n-ʤ.[17]

(68) Possibilities for sequences coronal-coronal

t-t	*t-d	*t-ʧ	*t-ʤ	*t-s	*t-ʃ	*t-n	*t-r	*t-y
n-t	(?)n-d	n-ʧ	(?)n-ʤ	n-s	n-ʃ	n-n	n-r	n-y
y-t	y-d	y-ʧ	y-ʤ	y-s	y-ʃ	y-n	y-r	y-y

Well-formed coronal + coronal clusters are illustrated in (69) and (70). Despite the two gaps in the corpus (n-d, n-ʤ), I assume that clusters /n/ and /y/ + coronal are all licit in Mundurukú.

(69) Sequences /n/ + coronal

(a) n-t ʃin-tõ̰m → ʃin.tṍm
pancake-flour
'flour for pancake'

(b) n-d ?

(c) n-c t-ə̃n-ʧay → tə̃n.ʧay
3-feces-hips
'his/her hips'

(d) n-ʤ ?

---

[17] Sequences of identical consonants were examined in §4.4.3 above, where I argued that they form geminates. In this case, the sequence t-t is licit as it functions as a geminate phonologically.

(e) n-s i-ẽn-sak → i.ẽn.sák
3-flesh-be.sour
‘The meat is sour.’

(f) n-ʃ ʧókõn-ʃíʃi → ʧó.kṍn.ʃí.ʃi
toucan-AUG
‘a big toucan’

(g) n-r t-ə̃n-rət → tə̃n.rət
3-feces-be.white
‘Its feces are white.’

(h) n-y o-sə-ẽn-yoy → o.sə.ẽn.yóy
1Su-3-flesh-bake
‘I baked the meat.’

(b) y-t wa̱y-tõ-tõ-dá → a.wa̱y.tṍ.tõ.dá
cassava-purple-RED-CL
‘sweet potato, sp.’

(70) Sequences /y/ + coronal
(a) y-d póydá → póy.dá
‘sweet manioc, sp.’

(b) y-c i-ŋəy-ʧə̃́ŋ → i.ŋəy.ʧə̃́ŋ
3Su-thought?-be quiet
‘S/he is quiet, sad.’

(c) y-j i-mə-kə̃y-ʤó-m → i.mə.kə̃y.ʤóm

3Ob-CAUS-?-see-IMPRF

‘to warn someone’

(d) y-s ʧe-sáy-sey → ʧe.sáy.sey

3.Poss-dress-RED.exist

‘She has a dress’

(e) y-ʃ i-tayʃi → i.tay.ʃi

3-wife

‘his wife’

(f) y-n wenə̃́-y-no̰m → we.nə̃́y.no̰m

nut-CL-flour

‘nut flour’

(g) y-r y-a-ro̰y-rḛy → ya.ro̰y.rḛy

3Su-CL-RED.exist

‘It’s (e.g. ball) is round.’

Two coronals in sequence are illicit if the first is /t/. This sequence is repaired with deletion of the alveolar stop.

(71) Ill-formed coronal + coronal sequences

(a) t-d wəy-dot-dot → wəy.do.dot

1pl.incl-be.painted-RED

‘We’re painted.’

(b) t-ʧ i-mə-ʧóát-ʧóát-m → i.mə.ʧó.á.ʧó.án

3-CAUS-look-RED-IMPRF

‘to make s.o. look’

(c) t-ʤ t-i-dóʤot-ʤot-m → ti.dó.ʤo.ʤon
3-CL-CAUS-carry-RED-IMPRF
‘bringing water’

(d) t-s sə̃́t-sə̃t → sə̃́.sə̃t
monkey-RED
‘monkey, sp.’

(e) t-ʃ o-ʃat-ʃet → o.ʃa.ʃet
1-food-RED.exist
‘I have food.’

(f) t-r i-rət-rət=át → i.rə.rət=át
3-be.white-RED=NOM
‘the white moiety’

(g) t-y ayátʃát=yə̃ → a.yá.tʃá=yə̃
woman=PL
‘women’

(h) t-n ?

Coronals have been long argued to have certain properties that other consonants do not have (Paradis and Prunet 1991). Within the markedness theory as proposed by Kean (1975), /t/ is universally unmarked and coronal is the least marked articulation. Many subsequent works support this observation. Kiparsky (1985), for example, emphasized the tendency of coronals to undergo processes of assimilation, to which consonants with other places resist (see also Avery and Rice 1988a-b). Further evidence comes from consonantal harmony which mostly involves coronals (Shaw 1991).

Coronals are also special because they exhibit more contrasts of place and manner of articulation than do other consonants (Keating 1991), and are frequently free to occur in positions in the syllable where other consonants are disallowed (Yip 1991). Because of this, some linguists have assumed that coronals lack Place features (e.g. Avery and Rice 1988a-b; Shaw 1991; Yip 1989, 1991; Rice 1992), or even that they have their own sonority value in the sonority hierarchy (Steriade 1982; Selkirk 1984).

The restriction on coronal clusters in Mundurukú poses a problem for the view that coronal segments are unspecified for place features. Part of the problem is that the phonology restricts cooccurrence of coronals by disallowing the universally unmarked consonant /t/ to be in sequence with another coronal. On the other hand, the process corroborates general observations about the special behavior of coronals, since there is a clear distinction between coronals and non-coronals in the language.

The proposal formulated here accounts for the special behavior of coronals, arguing that deletion results from the interaction of two major principles in phonological theory, the Obligatory Contour Principle (OCP) and the Sonority Sequencing Principle (SSP).

The idea that speech sounds are organized according to their inherent sonority is not new (see Clements 1990 for a good overview). Sonority has played a fundamental role in determining well-formed syllable divisions. An optimal syllable is typically characterized by a string of sounds whose degree of sonority increases towards its peak (e.g. Vennemann 1988). Vowels are the best candidates for these peaks since they possess the highest degree of sonority; consonants vary: liquids are more sonorous than nasals, and these more sonorous than obstruents. In the sonority scale proposed in (72), I follow Clements (1990) in assuming that there is no further division so that coronals and other obstruents are treated alike in terms of relative sonority.

(72) Sonority hierarchy: Vowel > Glide > Liquid > Nasal > Obstruent

One of the ideas defended here is that the phonology of Mundurukú organizes segments based primarily on the feature [sonorant]. Many phonological processes affecting segments refer to this feature. One of them is examined here; another case was presented in §4.4.2 with the discussion of word-initial /r/; and Chapter 6 provides a further piece of evidence from nasal harmony.

The hierarchy of Mundurukú segments proposed here groups together vowels, glides, liquids, and nasals under the group of [+sonorant] segments; and stops and fricatives under the group of [-sonorant]. And still in conformity with the behavior of segments in the language, it is important to distinguish vowels and approximants, [+continuant], from obstruents, [-continuant].

Faithfulness to [+sonorant] dominates faithfulness to [-sonorant], because in many phonological processes to be examined here, [+sonorant] wins over [-sonorant]; and as we will below, these are dominated by faithfulness to [+continuant]. Faithfulness constraints are defined in (73).

(73) (a) MAX[+cont]
Input [+continuant] segments have output correspondents.

(b) MAX[+son]
Input [+sonorant] segments have output correspondents

(c) MAX[-son]
Input [-sonorant] segments have output correspondents.

(d) Ranking: MAX[+cont] >> MAX[+son] >> MAX[-son]

Because the clusters we will be looking at are repaired by deleting one of consonants, we want to avoid another strategy such as changes in Place specifications.[18] The constraint that guaratees this, and which is also important for a process examined in §4.6, is MAXPATHPLACE.

(74) MAXPATH-PLACE (Shorthand: MAXP-PL)
Any input path between Place specifications and an anchor must have
a correspondent path in the output.

Furthermore, it is assumed that the special behavior of coronals can be accounted for without invoking the underspecification of place features, following Smolensky (1993). Restrictions on the coronal place are independently motivated by another constraint in the grammar. I suggest an OCP constraint prohibiting any sequences of coronal plus coronal (see Shaw 1976-1980).

(75) *COR-COR – A sequence coronal-coronal is prohibited.

*COR-COR and MAXPATHPLace join the ranking to determine what coronal + coronal sequences are licit or illicit. The ranking is as in (76).

---

[18] Epenthesis is also banned because it violates either M- or W-CONTIGUITY constraints, which are highly ranked in the language. Thus I will not refer to candidates with epenthetic segments in the tableaux.

(76) *COMPLEX >> MAX[+cont] >> ONSET >> ALIGN-R >> MAX[+son] >> MAXP-PL >>
*COR-COR >> MAX-IO >> MAX[-son]

An example of the ranking in sequences coronal + coronal is given in Tableau 4.17. The sequential prohibition on coronals does not hold of clusters such as nasal + coronal, indicating that MAX[+son] dominates *COR-COR to avoid deletion of a nasal coda. *COR-COR is dominated by ALIGN-R because, as in the case of candidate (d), alignment is crucial in deciding which coronal can be onset, and this cannot be a morpheme-final consonant. Dissimilation of /t/ to [k] passes *CORCOR but fatally violates MAXP-PL.

Tableau 4.17. Well-formed clusters: [+sonorant]-[-sonorant]. Word: *ʃintṍm* 'flour for pancake'

ʃin-tõ̰m		MAX [+cont]	ONSET	ALIGN-R	MAX [+son]	MAXP-PL	*CORCOR	MAX-IO
a. ☞	ʃin.]tṍm]						*	
b.	ʃi.]tṍm]				*!			*
c.	ʃin.]ṍm]		*!					*
d.	ʃi.n]ṍm]			*!				*
e.	ʃin.]kṍm]					*!		

The next tableau illustrates two [+sonorant] coronals. Any attempt to delete one of them is ruled out by the faithfulness constraint preserving this feature.

Tableau 4.18. Well-formed clusters: [+sonorant]-[+sonorant]. Word: *tə̃nrət* 'Its feces are white.'

tə̃n-rət		MAX [+cont]	ONSET	ALIGN-R	MAX [+son]	MAXP-PL	*CORCOR	MAX-IO
a. ☞	tə̃n.]rət]						*	
b.	tə̃.]rət]				*!			*
c.	tə̃.n]ət]	*!		*	*			*

This ranking predicts that whichever [+sonorant] segment forms a cluster with another coronal, it should not be affected by *COR-COR. The following tableau shows a case in which a coronal + coronal sequence emerges in a prefix-root combination.

Tableau 4.19. [+sonorant]-[+sonorant]. Word: *wəy-rət* 'We (incl.) are white.'

wəy-rət		Max [+cont]	Onset	Align-R	Max [+son]	MaxP-Pl	*Cor-Cor	Max-IO
a. ☞	wəy.]rət]						*	
b.	wə.]rət]	*!			*			*
c.	wə.y]ət]	*!		*	*			*

This ranking holds absolutely of /t/ + coronal sequences, as show in Tableau 4.20. Because neither /t/ nor /s/ are sonorants, Max[+son] is irrelevant for this cluster; yet it does not pass the OCP constraint, shown by the failure of candidate (b), therefore the morpheme-final stop is deleted. This decision is made by Align-R which protects a morpheme-final consonant, as in candidate (c).

Tableau 4.20. Ill-formed clusters: *t-s. Word: *sə̃́sə̃t* 'monkey, sp.'

sə̃́t-RED		Max [+cont]	Onset	Align-R	Max [+son]	MaxP-Pl	*Cor-Cor	Max-IO
a. ☞	sə̃́.]sə̃t]							*
b.	sə̃́t.]sə̃t]						*!	
c.	sə̃́.t]ə̃t]			*!				
d.	sə̃́k.]sə̃t					*!		

Another ill-formed cluster is illustrated in Tableau 4.21, this time with a [+sonorant].

Tableau 4.21. Ill-formed clusters: *t-r.Word: *-rə-rət* 'be white'

rət-RED		Max [+cont]	Onset	Align-R	Max [+son]	MaxP-Pl	*CorCor	Max-IO
a. ☞	rə.]rət]							*
b.	rət.]rət]						*!	
c.	rə.t]ət]			*!				

To conclude this section, one additional observation is important here. If we compare the relevance of the low-ranked constraints for the grammar, Max-IO in particular, we see that it is still decisive in picking the optimal candidate. To illustrate the point, consider again the word *kasoptá* 'star' which was introduced in the beginning of this chapter (§4.2). Candidate (b) is as optimal as the winner (a), until it is evaluated by MAX-IO, which preserves input segments.

Tableau 4.22. Syllabification of the word kasoptá 'star'.

ka-sop-tá		*COMP	W-CONT	ONS	ALIGN-R	MAX [+son]	MAXP-PL	*COR -COR	MAX -IO
a. ☞	ka.]sop.]tá]								
b.	ka.]so.]tá]								*!
c.	ka.]so.p]i.tá]		*!		*				
d.	ka.]so.p]tá]	*!			*				
e.	ka.]so.p]a.ti]				*!				

In the following section I present further evidence that faithfulness to input segments conforms to the sonority scale. Vowels and glides are higher than nasals, and these higher than obstruents.

4.6 The imperfective *-m*

The imperfective aspect marker is the labial nasal consonant {-m},[19] which surfaces as /m/ after morpheme-final vowels, (77), and is deleted after glides, (78), and nasals, (79).

(77) {-m} following a morpheme-final V

(a)	ʔó + m	→	ʔóm	'to eat' (Trans)
(b)	ʧə́ + m	→	ʧə́m	'to go'
(c)	aóka + m	→	aókam	'to kill'
(d)	é-ʔə̃ + m	→	éʔə̃m	'to die'

---

[19] There is also the instrumental marker {-m}, as in *kisé-m* 'with a knife', that shows the same pattern.

(78) {-m} following glides

(a)	wáy + m	→	wáy	‘to laugh’
	wə̃́y + m	→	wə̃́y	‘to shoot with an arrow’
(b)	tabidaw + m	→	tabidaw	‘to get lost’
	pə́w + m	→	pə́w	‘to blow’

(79) {-m} following nasals

(a)	ṍm + m	→	ṍm	‘to enter’
	a̰ʤẽ́m + m	→	a̰ʤẽ́m	‘to arrive’
(b)	kṍn + m	→	kṍn	‘to eat’ (Intr)
	nápṍn + m	→	nápṍn	‘to flee, run away’
(c)	mõŋ + m	→	mõŋ	‘to put something down’
	ʔṍŋ + m	→	ʔṍŋ	‘to sweep’

In contrast, after a morpheme-final stop the imperfective fuses with the stop, surfacing with the place of articulation of the stop and nasality of the nasal.

(80) Segment fusion

(a)	kop + m	→	kom	‘to go down’
	kap + m	→	kam	‘to go through, pass’
(b)	dakḁt + m	→	dakḁn	‘to cut’
	kót + m	→	kón	‘to dig’
(c)	ka̰pík + m	→	ka̰píŋ	‘to work’
	a̰ʤók + m	→	a̰ʤóŋ	‘to bathe’

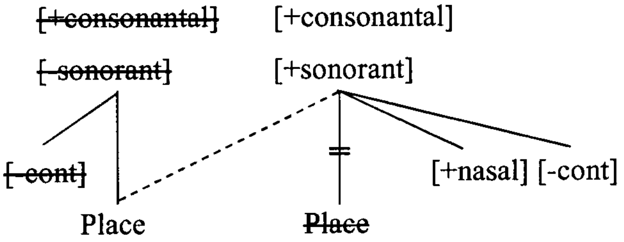
There is a caveat here: the imperfective {-m} must be realized on the surface, but succeeds only if there is a coda position available for it, or the root-final consonant is less sonorous than /m/. In competing with a segment of equal or higher sonority, the affix loses and is deleted. The process shows a root-affix asymmetry, where the realization of the suffix is determined by the degree of sonority of a root-final segment.

(81)

Root-final segment	{-m}
Vowel	realized as coda
Glide	not realized
Nasal	not realized
Stop	realized via fusion with stop

Fusion is schematically represented in (82). This process associates the Place node of a segment with another segment, and deletes the stricture features of the first, [+cons], [-son], and [-cont].

(82) Fusion in Mundurukú



Clearly, fusion violates MAX[-son] and other faithfulness constraints such as MAXPATH-PLACE, discussed earlier. It is also evident that fused forms deviate from their inputs, but can this be characterized as MAX-IO violation?

I follow Kager (1999) in assuming that fusion does not violate MAX-IO, based on the fact that it does not involve the deletion of segments. Kager explains that fusion is "a 'split' correspondence between a pair of input segments and a single output segment." (p.62) In deletion, the input lacks an output correspondent.[20]

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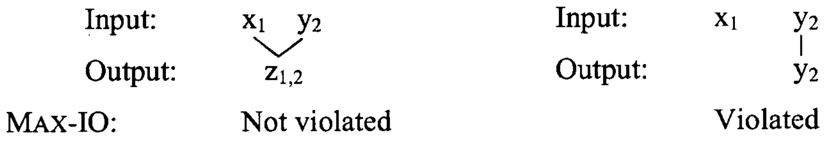
[20] Fusion violates LINEARITY, but this constraint is not discussed here. We can assume that it is ranked low so as to not interfere with highly ranked constraints.

(83) Correspondences diagrams (following Kager 1999)

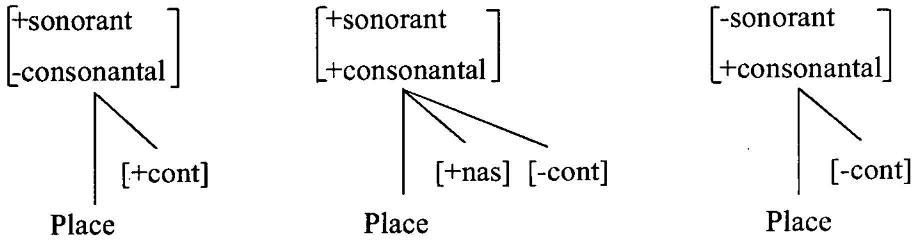
(a) Fusion (b) Deletion



To account for the facts, I propose the following representations for glides, nasals and stops.

(84) Representations for glides, nasals and stops.

(a) Glides (b) Nasals (c) Stops



Given the sonority scale Glide >> Liquid >> Nasal >> Obstruent, the generalization is that the imperfective is deleted in favor a root-final glide, [+continuant], or nasal, [+sonorant], and combines with a root-final stop, [-sonorant]. This is predicted by the ranking Max[+cont] >> Max[+son] >> MaxPath-Place >> Max[-son] as proposed earlier. It is also necessary to prevent the realization of the imperfective as nasalization in a vowel. This effect can be obtained via MaxPath[nasal], following Pulleyblank (1996). (The interaction of DepPath[nasal] with MaxPath[nasal] is discussed in the analysis of nasal harmony in Chapter 6.)

(85) MaxPath[nasal]

Any input path between [+nasal] and an anchor must have a correspondent path in the output.

Tableau 4.23. The imperfective {-m} after vowels. Word: *ʔó-m* ‘to eat’ (Trans.)

ʔó-m		*COMPLEX	MAXPATH [nas]	ALIGN-R	MAX [+son]	MAXP-PLACE	MAX-IO
a. ☞	ʔó]m]			*			
b.	ʔõ]		*!		*		*

Now compare the six candidates in Tableau 4.24. Candidate (e) is fully faithful to the input but is excluded by *COMPLEX. Candidates (c) and (d) fail MAX[+cont]; (d) fails because fusion of /m/ with /y/ yields in loss of the feature [+cont] of /y/. Candidate (b) retains the feature [+nas] of the imperfective but is banned because MAXPATH[nas] does not allow [+nas] to be associated with an anchor other than the one determined underlyingly.

Tableau 4.24. Combination glide + m; word: wáy ‘laugh’.

wáy-m		*COMPLEX	W-CONTIG	MAX [+cont]	MAXPATH [nas]	ALIGN-R	MAX [+son]	MAXP-PLACE
a. ☞	wáy]						*	
b.	wã́y]				*!		*	
c.	wá]m]			*!		*	*	
d.	waɲ]			*!			*	*
e.	wáy]m]	*!				*		
f.	wá.y]əm]		*!			*		

An illustration of the combination nasal + -m is given next. Again, *COMPLEX rules out both nasals as a tautosyllabic cluster in the output, candidate (b), and ALIGN-R favors *nápṍn* over *nápṍm*.

Tableau 4.25. Combination nasal + -m; word: nápṍn 'to flee, run away'.

nápṍn-m		*COMPLEX	W-CONTIG	MAX [+cont]	ALIGN-R	MAX [+son]	MAXP-PLACE
a. ☞	ná.pṍn]					*	
b.	ná.pṍn]m]	*!			*		
c.	ná.pṍ]m]				*!	*	
d.	ná.pṍn.]m]ə				*!		

The fusion of {-m} with a root-final stop is straightforward. As an example, consider the input *taka̰t-m* → *taka̰n* 'to cut' in Tableau 4.26. This ranking shows that it is better to have a split (fused) output than to have only one of the consonants.

Tableau 4.26. Combination of stop+m. Word *taka̰t-m* 'to cut'.

taka̰t-m		*COMPLEX	W-CONTIG	MAXPATH [nas]	ALIGN-R	MAX [+son]	MAXP-PLACE
a. ☞	ta.ka̰n]						*
b.	ta.ka̰]m]				*!		
c.	ta.ka̰t]					*!	
d.	takã̰t]			*!		*	
e.	ta.ka̰t]m]	*!			*		
f.	ta.ka̰.t]əm]		*!		*		

4.7 Conclusion

All the facts examined in this chapter can be generated by the general ranking schematically represented in (86). The lines indicate crucial dominance; constraints in the same row are coranked, meaning that there is no evidence so far to ranking them relative to each other. At the bottom of the ranking we find marginal constraints such as MAX[-son] and NOCODA. Their presence or absence in the ranking makes no difference for the selection of optimal outputs.

(86) Ranking

σMORA
σNUC
M-CONTIG

*COMPLEX
*HIBK-HIBK
*HIRD-HIRD

W-CONTIG, MAX[+cont], MAX-μ

MAXPATH[nas]

ONSET

ALIGN-R

MAX[+son]

MAXPATH-PLACE

*COR-COR

MAX-IO

MAX[-son], NOCODA

Many of the constraints introduced in this chapter are important for other phonological processes, and will be shown as needed in the following chapters.

CHAPTER 5

Phonotactics: Synchrony and Diachrony

5.1 Introduction

Restrictions on the distribution of consonants and vowels are often assigned to synchronic grammars. In this chapter I address the importance of historical information in explaining the nature of phonotactic restrictions. In particular, I pursue the idea that these restrictions accompany the evolution of languages, emerging and changing as the language evolves. This hypothesis finds support in the development of Mundurukú consonants and their phonotactics. The majority of phonotactic patterns observed in the language is accidental, rooted in the various sound changes take took place in the language. These changes left gaps that need not be synchronically motivated, either phonetically or phonologically.

Following Kiparsky (1982), sound change involves (i) innovation – new patterns that come into being, either through borrowings or through changes on one part of the system and which have an effect on others; and (ii) restructuring – the difference between a grammar being acquired by a child and the grammar of those whose grammar is already constructed. It is "the resulting revision in the phonological representations." (p. 3) I hope to show that restructuring takes place in different ways. For example, §5.4 deals with a case of reanalysis of a gap. The language acquired a phonotactic restriction on a sequence /d/ + nasal vowel (*dṽ) as a result of a secondary split caused by a change in nasal harmony. This change affected not only the phonemic inventory but also grammatical structures because of the conflict with consonant mutation (Chapter 7). This conflict resulted in the reanalysis of *dṽ as a language-specific constraint, with a major role in the phonology of the language.

There are also cases of gaps that are repaired later in the grammar. One of these is a gap on the distribution of /ʤ/ (§5.6). This consonant was born in the language with two significant gaps: it did not occur word-initially or before a high front vowel /i/. The first gap has already been repaired by novel forms borrowed from Portuguese, but the second remains.

Conversely, there are gaps that emerge in the history of a segment with a previous regular distribution. This is illustrated by the history of /ʧ/ (§5.6.) and /s/ (§5.7), which synchronically do not occur before a high vowel /i/, a combination that was once possible in the language.

The focal point of the historical analysis is to show that most restrictions on the distribution of segments are not systematic, in the sense that the language does not really prohibit these combinations. Rather, they are accidental gaps caused by sound changes. The distinction between systematic and accidental gaps is established here based, though not strictly, on the presence versus absence of alternations. Forms for which there is no evident variation, but are somehow absent or restricted, are likely to be accidental, and may be rooted in diachronic changes.

5.2 The synchronic patterns

This section is devoted to the set of restrictions on the distribution of consonants and vowels, as manifested synchronically. I hope to show that a purely synchronic analysis of these patterns is not satisfactory, and would require a set of language specific statements that obscure and neglect their diachronic nature. Then I proceed to examining these patterns from a diachronic perspective to show that they result from a series of sound changes, and are better understood this way.

To identify the restrictions on possible combinations of consonants and vowels, a total of 1252 occurrences of consonants were counted in CV(C) syllables, with one instance per variant of each morpheme. For example, morphemes that participate in consonant mutation (see §5.6 and Chapter 7) have voiceless (e.g. *ʧə́* 'to go', *-pa̰* 'arm') and voiced (e.g. *ʤə́*, *-ba̰*) variants; for these, two entries were counted for each consonant: one for /ʧ, p/, and another for /ʤ, b/. Those that do not vary were counted only once. For example, the two words *əkʔá* 'house' and *witáʔa* 'rock' contain the same morpheme *-ʔa* 'round object'; in this case, only one occurrence of /ʔ/ preceding /a/ was counted. Also, reduplicative morphemes were not included, with the exception of /h/ because it mostly occurs in reduplication, as we saw in chapters 3 and 4. Thus the reduplicative morpheme was considered for the distribution of /h/ in *ʤe-ə́-hə́* (from *ʤeə́* 'to go up'), but excluded for the distribution of /w/ in *ʤe-wáy-wáy* 'to laugh'; this form was counted as having only one occurrence of /w/ before /a/. Another case of reduplication included was reduplication with a fixed vowel, as the fixed vowel /e/ examined in Chapter 4. For example, the reduplicative morpheme *-ʔe* in *witáʔaʔe* 'There are rocks' was considered for the distribution of /ʔ/ before /e/.

Table 5.1 gives the relative frequency of consonants in onset position in all CV(C) syllables counted. The last two columns show occurrences before nasal (ṽ) and creaky (v̰) vowels, which are already included in the total of 1252. The numbers in brackets are explained below.

Table 5.1. Relative frequency of Mundurukú consonants in CV(C) syllables.

	_i	_e	_ə	_a	_o	Total	_ṽ	_v̰
p	27	12	33	33	23	128	11	7
b	30	14	20	16	13	93	5	7
t	15	7	11	46	30	109	10	21
d	25	12	6	50	21	114	0	13
k	12	6	20	45	64	147	12	21
ʧ	(1)	11	10	8	15	45	9	2
ʤ	(1)	10	8	6	22	47	5	2
s	(1)	11	35	12	13	72	18	9
ʃ	37	17	0	8	2	64	7	4
m	(1)	2	27	6	5	41	7	2
n	0	7	8	8	7	30	12	4
ŋ [ɲ]	0	15	10	7	9	41	5	3
w	16	21	14	46	0	97	16	7
y	0	3	5	4	11	23	4	5
r	14	40	22	26	31	133	22	9
h	3	3	1	2	3	12	4	1
ʔ	14	8	8	11	15	56	16	0
Total	197	199	238	334	284	1252	163	117

Based on these distributions, the following phonotactic restrictions can be stated.

(1) Phonotactic restrictions

- (a) /w/ does not cooccur with /o/: *wo/*ow
- (b) /y/ does not cooccur with /i/: *yi/*iy
- (c) /ʔ/ does not cooccur with a creaky vowel: *ʔv̰

(d) /d/ does not occur before nasalized vowels: *dṽ

(e) /ʃ/ does not occur before /ə/: *ʃə

(f) /ʧ, ʤ/ do not occur occur before /i/: *ʧi, *ʤi. An exception to these is the alternating morpheme *ʧíʧã́/ʤíʤã́* 'many, much, very'.

(g) /s/ does not occur before /i/: *si. An exception to *si is *pasía* 'to go for a walk', from Portuguese *passear*. There is also *basíaʔá* 'metal basin', also from Portuguese *bacia*. This word seems to be mostly used by those living in the city, and may not be familiar to most speakers, unlike *pasía* 'to go for a walk' which also appears in Crofts (1986).

(h) /m, n, ŋ/ do not occur before /i/: *mi, *ni, *ŋi [ɲi]. /mi/ occurs in *kamiʃá* 'shirt', from Portuguese *camisa*.

In addition to the restrictions in (1), there are also restrictions on word-initial and coda consonants, as seen in Chapter 4. Recall from Chapter 4 that /r, h/ occur word-initially only under specific conditions; and in coda position only the voiceless stops /p, t, k/, nasals /m, n, ŋ, and glides /w, y/ occur. The restrictions *wo, *yi and *ʔy̲ can be attributed to the Obligatory Contour Principle (OCP). (*wo and *yi were already examined in Chapter 4.) The prohibition *ʃə can also be synchronically motivated as a language-specific requirement (see §5.8 for details). But excluding these that are systematic, and for which we can find synchronic motivation from alternations, the rest is better understood from a historical point of view.

First of all, what is striking about the phonotactic restrictions in Mundurukú is the number of consonants that cannot form a syllable with the high front vowel /i/. Similarly, a prohibition such as *dṽ does not appear to have any phonetic or phonological motivation. The language has two voiced stops, /b/ and /d/, and the affricate /ʤ/, but only the alveolar stop is incompatible with a nasalized vowel.

However, as we examine the history of these restrictions, we come to the conclusion that they result from a series of sound changes. In fact, sequences such as *dṽ*, *ʧi*, *ʤi*, *si*, *mi*, *ni* and *ŋi* [ɲi] would have been synchronically possible if the language did not change at earlier periods. This chapter is intended to provide a principled account of these, and show that motivations for them can only be found historically. At the same time, it is argued that while a restriction such as *dṽ must be regarded as a real constraint in the language (§5.4), *ʧi, *ʤi, *ŋi (§5.6), *ni (§5.5), and *si (*§5.7) are merely accidental gaps.

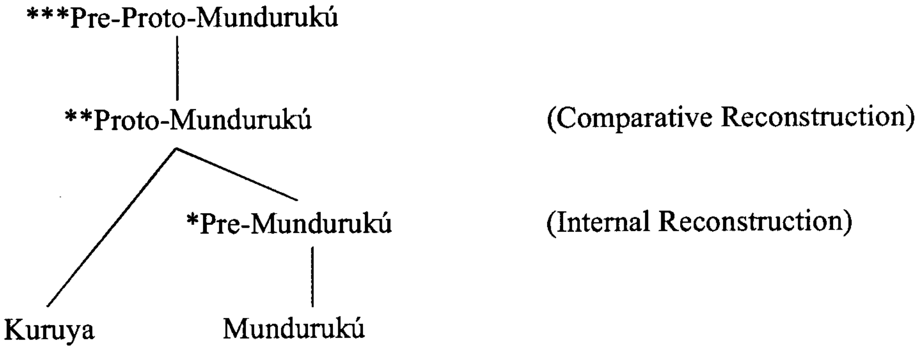
5.3 The development of Mundurukú consonants and phonotactics

5.3.1 Background

The reconstruction of Proto-Mundurukú consonants proposed in this chapter is by means of the Comparative Method, the method that has been most extensively used in historical studies of languages. The primary goal is to demonstrate that the synchronic patterns of Mundurukú directly reflects its history.

As introduced in Chapter 1, this study deals with two levels of reconstruction, schematized in (2) – one at the level of family (Proto-Mundurukú), which compares Mundurukú and its sister language Kuruaya (Comparative Reconstruction), and another language-internally, Pre-Mundurukú (Pre-Mu), which refers to an earlier stage of Mundurukú only (Internal Reconstruction). In some cases a hypothesis must refer to the stage before Proto-Mundurukú, Pre-Proto-Mundurukú (Pre-PMu).

(2)



Mundurukú and Kuruaya are the only languages of the Mundurukú family (Rodrigues 1964, 1970, 1986). Unlike Mundurukú, Kuruaya is nearly extinct; there are only five aged speakers (Costa 1998; Rodrigues 1999), all of whom in their 80's and up. Previous works on Kuruaya were limited to word lists (Snethlage 1910; Nimuendajú 1930) and a preliminary description of its phonology (Costa 1998), with which I disagree on a number of points (see Picanço 2003c). Unless otherwise cited, Kuruaya data is from my own fieldwork, collected in two field trips (2002 and 2004) to Altamira, Pará, Brazil, where I worked with two speakers: Mrs. Maria

Curuaia (82 years old) and Mr. Paulo Curuaia (89 years old). The data on Kuruaya used in this study consists of a word list with approximately 400 lexical items.

The Kuruaya phonemic inventory consists of seventeen consonants (Picanço 2003c; cf. Costa 1998), shown in (3)a, and six oral vowels, with four nasal counterparts, (3)b.

(3) Kuruaya phonemic inventory (Picanço 2003)

(a) Consonants

	Lab	Alv	Pal	Velar	Glottal
Stop	p	t	ʧ	k	
	b	d			
Nasal	m	n		ŋ	
Fricative		s	ʃ		
Lateral		l			
Approximant	w	r	y		ʔ, h

(b) Vowels

Oral			Nasal		
i	ɨ	o	ĩ		õ
e	a	ɔ	ẽ	ã	

As noted by Picanço (2003c), Kuruaya /l/ varies phonetically between an interdental voiced fricative [ð] and a plain lateral [l]. The voiced stop /d/ is produced further back, and is mostly realized as a retroflex [ɖ], except before /i/ where it is a plain palatal affricate [ʤ]. The contrast /b/-/m/ is observed only before oral vowels; there is neutralization to [m] in nasalised contexts. Likewise, /d/ and /n/ are neutralized to [n] in nasalised contexts; they are classified here as independent phonemes, but at this point of the investigation I cannot present strong evidence that they contrast in oral contexts. Like /d/, /n/ also has a palatal allophone [ɲ] before /i/. In nasal contexts, /b, d, l, w, y, r, ʔ, h/ have nasal allophones: [m, n, l̃/ð̃, w̃, ỹ, r̃, ʔ̃, ɦ̃].[1]

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[1] The nasal allophone of /l/ is mostly realized as [l̃], but its realization as [ð̃] or even [n] is also attested.

Other details about the phonology of Kuruaya will be discussed as necessary.

5.3.2 Previous comparative studies on Tupi languages

The reconstruction of Proto-Mundurukú and Pre-Mundurukú developed in this dissertation is the first proposed for the Mundurukú family. A considerable number of historico-comparative studies have been proposed for the Tupi-Guarani family (e.g. Rodrigues 1958a-b, 1985; Lemle 1971; Jensen 1989, 1990, 1998; Dietrich 1990; Mello 1992, 2000; Schleicher 1998; Rodrigues and Cabral 2002; Gildea 2002); and there are a few available for other Tupi families: Gabas Jr. (1991) compares the person-marking systems of Ramarama and Mondé; Moore and Galúcio (1993) propose a reconstruction of Proto-Tupari consonants and vowels; Moore (1994) deals with some syntactic aspects common to several Tupi languages; Storto and Baldi (1994) deal with vowel shift in Karitiana; and Picanço (2003b, 2005b) compares nasal harmony in Mundurukú and Kuruaya. (See also Rodrigues and Fargetti 2005 on the Juruna family, and Moore, Macedo and Lacerda 2005 on the Mondé family.) Other studies have compared languages from different families to show their genetic relationship (e.g. Rodrigues and Dietrich 1997; Rodrigues 1980; Drude and Meira 2005). As for Proto-Tupi, Rodrigues (1995) proposes a preliminary reconstruction of its phonemic inventory.

The historical analysis offered here for the Mundurukú family is innovative in two respects. It is the first reconstruction proposed for a Tupi family that includes a detailed step-by-step analysis of the changes, and it is the first to reconstruct phonological processes such as nasal harmony (Picanço 2005b; also §5.4 and especially Chapter 6), and voicing alternation (§5.6 and especially Chapter 7). This study is not intended to provide a reconstruction of the full phonemic inventory of Proto-Mundurukú; the focus will be on the facts that are crucial for explaining particular synchronic patterns.

5.4 Secondary split: the origin of *dṽ

The sound change which accounts for the restriction *dṽ in Mundurukú is exemplified by the correspondence sets d/l word-initially, in Table 5.2, and word-medially, in Table 5.3; and n/l̃ which appears below in the tables 5.4, word-initially, and 5.5 word-medially. In Kuruaya [l] and [l̃] are allophones of the same phoneme /l/, which correspond systematically to the Mundurukú phonemes /d/ and /n/ respectively. The oral-nasal difference of the context is crucial.

First consider the correspondence in oral environments, word-initially and word-medially.

Table 5.2. Correspondence set I: d/l word-initially.

Mundurukú	Kuruaya	Gloss
dóá	lóa	spider
dárə́k	láik	bow
da̰ʤé	lade(ʔ)	rodent, sp.
da̰ydó	laylɔ(ʔ)	armadillo
dekó	lékɔ	coatá monkey
dokoa̰	lókoa(ʔ)	ant, sp.
daʃá	láʃa	fire, firewood
dat	lat	scorpion
daʔí	laʔi	to dance

Table 5.3. Correspondence set I: d/l word-medially.

Mundurukú	Kuruaya	Gloss
ipádá	sípala	red macaw
akada̰p	akálap	cocoa, sp.
mədí	máli	rodent, sp.
da̰ydó	laylɔ(ʔ)	armadillo
odop	ɔ́lɔp	my arrow
edóti	éloti	your vestments
odaó	oláɔ	my leg, bone
oʤodít	ódolit	my uncle
ka̰wídádá	wílala	clay (Mu), sand (Ku)
tádoʔá	táloʔa	uxi (fruit, sp.)

Now consider the correspondence set n/l̃, which is found in nasal contexts, both word-initially and word-medially. Where Mundurukú has the phoneme /n/, or a dialectal variation between /n/ and /d/ (see §5.4.2 on this dialectal variation), Kuruaya has the nasalized allophone of /l/, [l̃]. Unlike the correspondence set d/l, the set n/l̃ is not completely regular. A gap exists in the context of a high front vowel [ĩ] so that it does not include cases of the sequences ni/l̃i. The reason is that not only Mundurukú lacks *ni*, but the corresponding sequence in this set is also missing in Kuruaya. This gap explains another restriction in Mundurukú, *ni, caused by an independent development that took place in the context /_ĩ and preceded the changes examined here. This will be examined later in §5.5.

Table 5.4. Correspondence set II: n/l word-initially.

Mundurukú		Kuruaya		Gloss
nobánṍ	[nòbã́nṍ]	lobalõ	[l̃õmãl̃õ]	rifle, gun
nõŋʔá	[nõ̀ŋʔá]	lõŋ	[l̃õŋ]	flea
naʔó-rẽk	[nã̀ʔ̃ṍrẽ̀k]	láʔɔ-rénã́n	[l̃ã́ʔ̃õ̀rẽ́nã́n]	lizard
daʔó-rẽk				

Table 5.5. Correspondence set II: n/l word-medially.

Mundurukú		Kuruaya		Gloss
onarẽ́m	[õ̀nãr̃ẽ́m]	olarẽm	[õl̃ãr̃ẽm]	I stink.
odarẽ́m				
nápṍn	[nápṍn]	lápãn	[l̃ã́pã̀n]	to run away/flee
wenə̃́-y	[w̃ẽ̀nə̃́ỹ]	welãĩ	[w̃ẽl̃ãĩ]	Brazil nut
o-bə̰-nə̃́	[òbə̰̃̀nə̃́]	i-i-lã(ʔ)	[ĩĩl̃ã̰]	his/her finger/toe nail
o-nə̃́y	[õ̀nə̃́ỹ]	olãy	[õl̃ãỹ]	my teeth
o-nə̃́n	[õ̀nə̃́n]	olãn	[õl̃ãn]	my feces

The regularity of the correspondence sets d/l and n/l̃, where two distinct phonemes in Mundurukú correspond to an allophonic variation in Kuruaya, suggests a historical change that not only changed the pronunciation of an original segment, but also introduced a new phonological contrast in the language: /d/ versus /n/. This type of differentiation, termed 'secondary split' (Hoenigswald 1960), refers to a process by means of which a change elsewhere in the language causes the allophonic variants of a phoneme to become independent without "...canceling the phonetic difference between the allophones in question" (p. 94). This is the proposal I offer for Mundurukú, and which sheds light on important aspects of its phonology, in particular on the restriction *dṽ.

The hypothesis is that *dṽ originated from a secondary split, caused by a change in nasal harmony. Except for the oral-nasal distinction of the environments, which produced oral /d/ and nasal /n/ outcomes, the change is unconditioned and affected every lexical item containing the proto-phoneme. The details of the change in nasal harmony will be examined in Chapter 6. Here I only summarize the facts that are important for the discussion about the origin of *dṽ.

5.4.1 The change in nasal harmony

To account for the emergence of *dṽ in Mundurukú, we must first understand its relation to nasalization. Nasal harmony is a pervasive phenomenon in both Mundurukú and Kuruaya; the process spreads the feature [+nasal] from a vowel to other segments on the left. In Mundurukú nasality is assimilated by [+sonorant] segments and blocked by [-sonorant]. This is illustrated in (4); (4)a shows assimilation and (4)b blocking.

(4) Nasal harmony in Mundurukú

(a)	ə́rə̃́	→	ə̃́rə̃́	'maracanã bird'
	nobánṍ	→	nobã́nṍ	'gun, rifle'
	i-wə̃́y	→	ĩw̃ə̃́ỹ	'to shoot s.t. (with an arrow)'
	3Ob-shoot			
	e-nə̃́n	→	ẽnə̃́n	'your feces'
	2-feces			
(b)	ʧókṍn	→	ʧókṍn	'toucan'
	ikoérṍ	→	ikõẽ́r̃ṍ	'fly'
	kaʤarã́w-ʔa	→	kaʤãr̃ã́w̃ʔa	'a big pot'
	pot-CL			

w-e-bóró̃-bə	→	webó̃r̃ó̃bə	‘my cotton string’
1-Poss-cotton-CL			

In Kuruaya nasality is not blocked. Both [+sonorant] segments and [+voice] stops assimilate nasality, surfacing with nasal allophones; [-voice] segments are transparent. (5)a shows assimilation of [+sonorant], (5)b assimilation of [+voice], and (5)c transparency.

(5) Nasal harmony in Kuruaya

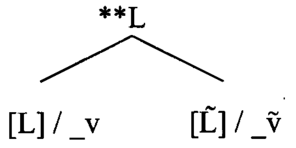
(a)	pawã	→	pãw̃ã	‘banana’
	ar̃it	→	ãr̃it	‘anum (bird, sp.’
	welã-ĩ	→	w̃ẽl̃ãĩ	‘Brazil nut’
	Brazil.nut-CL			
(b)	lobalõ	→	l̃õmãl̃õ	‘gun, rifle’
	de-yã	→	nẽỹã	‘they’
	3-PL			
	o-bi-loã	→	õmĩl̃õã	‘my chin’
	1-mouth-?			
(c)	parawa-tõ	→	pãr̃ãw̃ãtõ	‘macaw, sp.’
	macaw-purple			
	porakã	→	põr̃ãkã	‘two’
	w-e-aikõn	→	w̃ẽãĩkõn	‘my bench’
	1-Poss-bench			

In comparing the two systems we can easily identify their similarities and differences. For similarities, both languages exhibit leftward nasal harmony and in both the trigger is the rightmost nasal vowel in the morpheme. They differ with respect to the number of targets, which in Kuruaya also includes [+voiced] stops, and in the fact that Kuruaya has a system with transparency whereas Mundurukú has one with opacity.

Where both systems are similar, we can reliably suppose that they reflect the system of the proto-language. Thus Proto-Mundurukú had leftward nasal harmony and the trigger was the rightmost vowel in the morpheme. Where they differ, we must then ask which language mostly reflects the proto-system. For reasons that will become clear below, I assume that nasal harmony in Kuruaya mostly reflects nasal harmony in Proto-Mundurukú, where targets were [+sonorant] and [+voice] segments, and [-voice] segments were transparent. Therefore, the development is from a system with assimilation and transparency to a system with assimilation and opacity, and from a system where [+sonorant] and [+voice] were targets to a system where only [+sonorant] is the target. An account of nasal harmony is proposed in Chapter 6; of interest here is the relation between the historical change in the system and *dṽ in Mundurukú.

Assuming that Kuruaya is closer to Proto-Mundurukú than Mundurukú, the hypothesis is that the correspondence sets d/l and n/l̃ discussed above are the reflexes of an allophonic variation determined by nasal harmony. In other words, the Mundurukú phonemes /d/ and /n/ developed out of a single consonant, a consonant with oral and nasal allophones. Let us represent this consonant by **L which stands for 'lateral', probably a voiced lateral fricative [ɮ], given the variation [l] ~ [ð] observed in Kuruaya, as described in §5.3.1. Like Kuruaya /l/, the proto-consonant **L had two allophones: one oral, [L], occurring in oral contexts, and the other nasal, [L̃], occurring in nasal contexts.

(6)

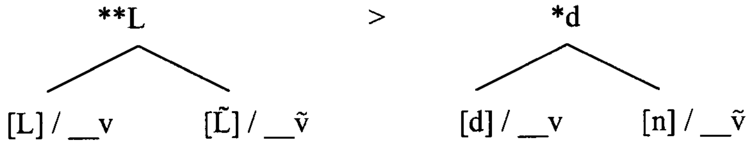


Proto-Mundurukú

Suppose now the sound change in (7). At an intermediate stage of the language, Pre-Mundurukú, **L developed into *d by a process of consonant fortition, and which affected word by word containing **L throughout the entire lexicon. If nasal harmony in Pre-Mundurukú was still characterized by assimilation and transparency, the pre-phoneme *d became of course a target for nasalization. (Recall that [+voice] consonants were amenable to nasalization, surfacing with nasal variants.) Thus *d exhibited an alternation similar to that of the proto-phoneme **L: [d] preceding an oral vowel, and [n] preceding a nasal vowel.

(7) Fortition

(a) Proto-Mundurukú Pre-Mundurukú



Fortition can be said to have been a change in manner, typically attested in changes by lexical diffusion (Labov 1981). If **L was a voiced lateral fricative [ɮ], the change **L > *d then basically involved a change in the stricture feature [continuant], as schematized in (8).

(8)

	**L	>	*d
[sonorant]	–		–
[continuant]	+	>	–
[consonantal]	+		+
[coronal]	+		+
[voice]	+		+

**L > *d is illustrated by the examples below which contain nouns with phonemic oral and nasal vowels, and vowels nasalized via nasal spread. By fortition, all instances of the proto-phoneme **L changed into *d in Pre-Mundurukú, and by nasal spread *d was realized as [n] before a nasal vowel, and [d] otherwise. (For expository reasons, tones are not marked in reconstructed forms.)

(9)

Proto-Mundurukú			Pre-Mundurukú		
**Loa	[Loa]	>	*doa	[doa]	'spider'
**Lõŋ	[L̃õŋ]	>	*dõŋ	[nõŋ]	'flea'
**LobaLõ	[L̃õmãL̃õ]	>	*dobadõ	[nõmãnõ]	'gun, rifle'
**Lapãn	[L̃ãpãn]	>	*dapãn	[nãpãn]	'to run/flee'

Let there now be a change in nasal harmony: the pre-system with assimilation plus transparency developed into another with assimilation plus opacity, thereby causing, in many cases, loss of the environment that conditioned the allophonic variation [d]/[n]. An example of this situation is provided by the Munduruku words *nobánṍ* 'gun, rifle' and *nápṍn* 'to run away/flee' which correspond to Kuruaya *lobalṍ* and *lápãn* respectively. Here Munduruku has /n/ where Kuruaya has the nasal variant [l̃].[2]

(10) Kuruaya (a) l̃ õ m ã l̃ õ (b) l̃ ã́ p ã n

Munduruku n o b ã n õ n á p ṍ n

The conditioning environment for the variant [n] was lost in cases where the vowel was not contrastively nasal but nasalized via assimilation, as in Pre-Mu **dobadṍ* 'rifle/gun' and **dapãn* 'to run/flee'. This created a new environment for [n], which may now occur before oral vowels, and is, therefore, in opposition to [d]. At this point the grammar turned the allophones [d] and [n] into distinct phonemes, without affecting the phonetic differences of both.

But the process of phonologization had an effect on the distribution of the phoneme /d/. While /n/ was phonologized in both oral (e.g. in cases with an intervening voiceless stop) and nasal contexts (where [n] immediately preceded a nasal vowel), the oral stop /d/ was phonologized only in oral contexts, as illustrated in (11). The change *d > d/n did not involve a change in a particular feature. Both [d] and [n] coexisted in the language at the stage nasal spread was altered. The secondary split happened because, since the conditioning environment for the nasal variant was lost in cases such as [nòbấnṍ], speakers had to determine the underlying forms for the former allophones. These were, by Lexicon Optimization, the ones closest to the outputs, namely /d/ and /n/.

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[2] The correspondence set b/m, as in nõmãnõ/nobãnõ, is examined in chapters 6 and 7. To anticipate, it is argued that /b/ and /m/ were already independent phonemes in Proto-Munduruku. By the time the change in nasal harmony took place, the underlying form /b/ was retained, or the outcome would have been similar to the alternation d/n, where the nasal variant was preserved.

(11) From Pre-Mundurukú to Mundurukú (NH=nasal harmony)

Pre-Mundurukú	*doa	*dobadõ	*dõŋ
NH (not blocked)	[doa]	[nõmãnõ]	[nõŋ]
↓			
NH (blocked) + Secondary split	doa	nobãnõ	nõŋ
Mundurukú	dóá	nobánṍ	nõŋ
	[dóá]	[nòbã́nṍ]	[nõ̀ŋ]

This brings us to the synchronic restriction *dṽ, which is nothing but a reflex of the distribution of the oral allophone of the pre-phoneme */d/. In other words, *dṽ emerged from a series of diachronic changes; it is therefore a historical accident.

But how do these changes affect the synchronic grammar of Mundurukú? Is *dṽ a real constraint in the language or is it simply an accidental gap as proposed in Chapter 4 for the absence of word-initial /r/ in the native vocabulary? I argue next that *dṽ is the reanalysis of a gap, and therefore, a language-specific constraint.

5.4.2 The reanalysis of a gap

The diachronic change **L > *d > d/n must be regarded as phonemic because a new contrast between /d/ and /n/ was created. By Lexicon Optimization, the synchronic grammar of the language must assign /d/ and /n/ to the underlying representations of the former allophones of Pre-Mundurukú *d. This left a gap on the distribution of /d/, which is now a restriction on its cooccurrence with a nasalized vowel (*dṽ).

But the change had also an effect on grammatical structure. It created a third variant in an already existing morphophonological alternation: consonant mutation. The process alters voicing in morpheme-initial consonants which may surface voiceless or voiced depending on the preceding segment (see details in Chapter 7). The alternation is between p/b, t/d, and ʧ/ʤ. The voiceless variants surface following consonants, and voiced ones following vowels and glides. Consonant mutation is illustrated in (12).

(12) Consonant mutation

(a)	ayátʃát **pətét**	toʃáw **bətét**
	woman name	chief name
	‘woman’s name’	‘chief’s name’
(b)	tawé **doy**	dápsém **toy**
	monkey blood	deer blood
	‘monkey’s blood’	‘deer’s blood’
(c)	o-t-əp-**tʃó-tʃó**	o-t-a-**dʒó-dʒó**
	1Su-3-CL-see-RED	1Su-3-CL-see-RED
	‘I saw it (e.g. a leaf)’	‘I saw it (e.g. corn seeds)’

Of interest here is the alternation t/d.[3] This is an old phenomenon in the family since a parallel alternation is found in Kuruaya. As expected, the voiced variant /d/ in Mundurukú corresponds to /l/ in Kuruaya.

(13)	Mundurukú	Kuruaya	Gloss
(a)	təp / dəp	tɨp / lɨp	leaf
(b)	ta / da	ta / la	seed
(c)	tap / dap	tap / lap	hair
(d)	ti / di	ti / li	liquid

Before underlying nasal vowels, the alternation is t/n in Mundurukú, corresponding to t/[l̃] in Kuruaya.

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[3] In Chapter 7 I present all the details of these alternations and give a historical explanation of the synchronic patterns (see also §5.6).

(14)	(a)	tawé **nə̃y**	dápsém **tə̃y**	(Kuruaya: tãy / [l̃]ãy)
		monkey tooth	deer tooth	
		‘monkey’s theeth’	‘deer’s teeth’	
	(b)	wenə̃́-y-**nõ̰m**	ʃin-**tṍm**	(Kuruaya: tõ̰m / [l̃]õ̰m)
		nut-CL:nut-CL:powder	pancake-CL:powder	
		‘Brazil nut mix’	‘mix for pancake’	

But where the vowel was nasalized by spreading, in cases similar to *nobánṍ*, both oral and nasal forms are attested in Mundurukú. I believe this is a dialectal variation, as speakers from different villages tend to prefer one form over the other. In one dialect, dialect B, the nasal variant prevailed, including in forms that were involved in consonant mutation. In the other dialect, the oral variant was retained if the vowel was not underlyingly nasal, probably by analogy to the alternation t/d illustrated in (13) above, that is far more frequent.

(15)		Dialect A	Dialect B	
	(a)	waje **dákə̃́**	waje **nákə̃́**	‘cocoa tree branch’
		cocoa branch		
	(b)	daʃá **da̰bóẽ́**	daʃá **na̰bóẽ́**	‘burning coal’
		firewood ember		

The major effect that the change *d > d/n had on consonant mutation was the conflict in the choice between /d/ and /n/ in representing the voiced variant in contexts where nasality was lost. In the context of an underlyingly nasal vowel, the voiced variant is unambiguously /n/. This provides a valuable argument for the assumption that the gap left on the distribution of /d/ has been reanalyzed as real constraint, *dṽ, defined in (16).

(16) *dṽ – The sequence dṽ is prohibited.

Consider the following examples from dialect A. Nasal harmony spreads to the left, nasalizing all [+sonorant] segments it encounters. In (17), nasalization should reach /d/ but nasalization is blocked right before a syllable containing /d/, and that syllable surfaces oral.

(17)	(a)	y-a̰bí-dawə̃́n 3-tip-sharpen	→ ya̰.bí.d̲a̲.̲w̃ə̃́n	'to sharpen a tip of s.t.'
	(b)	o-darẽ́m 1Su-be.fetid	→ o.d̲a̲.̲r̃ẽ́m	'I stink'
	(c)	daʔó-r̃ẽk lizard-?	→ d̲a̲.̲ʔ̃ṍ.r̃ẽk	'lizard'
	(d)	o-daẽ́ 1Ob-choose	→ o.d̲a̲.̲ẽ́	'S.o. picked me.'

In dialect B, the corresponding forms are fully nasalized.

(18) (a) ya̰bĩ́n̲ãw̃ə̃́n
(b) õn̲ãr̃ẽ́m
(c) n̲ãʔ̃ṍr̃ẽk
(d) õn̲ãẽ́.

We can summarize the patterns as in (19). The dialects differ only with respect to the environment where a vowel was a target in nasal spread; before an oral vowel the variant is invariably /d/, and before an underlyingly nasal vowel the variant is always /n/.

(19) Summary of the patterns

	_v	_ṽ	_v...ṽ
Dialect A	d	n	d
Dialect B	d	n	n

These patterns are complex because they involve the interaction of three processes: (i) the change *d > d/n and change in nasal harmony, (ii) nasal harmony as it is synchronically, and (iii) consonant mutation. This chapter deals with (i), and attempts to show that *dṽ must be regarded as a language-specific constraint, not an accidental gap. The accounts of nasal harmony and consonant mutation are proposed in chapters 6 and 7 respectively. This means that the alternations in (19) will be explained step-by-step as all processes involved are examined.

The constraint *dṽ is crucial for the analysis, and the reason why it must be posited for Mundurukú is as follows. Consider the proto- and pre-forms of alternating morphemes in (20); (20)a illustrates a morpheme with an oral vowel (_v); (20)b illustrates **L followed by an underlying nasal vowel (_ṽ); and (20)c and (20)d show cases of a nasal vowel somewhere in the morpheme but not immediately adjacent to **L (_v...ṽ). In the examples, only the voiced variants are provided, but recall that **L and *d had a voiceless variant [t] postconsonantally. Also, recall that nasalization in Proto-Mundurukú was not blocked, thus **L was realized as [L̃] in the morphemes in (20)b-d. In Pre-Mundurukú, every instance of **L changed into *d by fortition, as discussed earlier. Since nasalization did not change until after Pre-Mundurukú, *d also had a variation [d]/[n], similar to the alternation [L]/[L̃].

(20)	Proto-Mundurukú			Pre-Mundurukú		
(a)	**Lao	[Lao]	>	*dao	[dao]	'leg/bone'
(b)	**Lãỹ	[L̃ãỹ]	>	*dãy	[nãỹ]	'tooth'
(c)	**Lakə	[L̃ãkə̃]	>	*dakə̃	[nãkə̃]	'branch'
(d)	**Laẽ	[L̃ãẽ]	>	*daẽ	[nãẽ]	'to choose'

Between Pre-Mundurukú and the modern period, nasal harmony underwent changes. At this point, obstruents became opaque, blocking nasalization in cases such as (20)c. As a consequence, the oral and nasal allophones of *d became independent.

However, a complication arose in consonant mutation. This initial alveolar in alternating morphemes, **L in PMu and *d in Pre-Mu, had three variants, [t, d, n], regularly distributed according to adjacent segments: [t] after consonants, [d] before oral vowels and [n] before nasal vowels. Differentiation of [d] and [n] brought about a conflict in consonant mutation, especially in cases where there was an intervening obstruent (e.g. Pre-Mu *dakə̃ 'branch'), since this was the context that established the contrast between /d/ and /n/. But did phonologization of [d] and [n] also apply to the morphemes involved in consonant mutation? At first glance, this seems to be the case in dialect B where the form is realized on the surface as *nakə̃*, contrary to dialect A where we find *dakə̃*. I will save the discussion of this controversy for Chapter 7, after we examine nasal harmony (Chapter 6), and the details of consonant mutation.

Aside from these dialectal differences, there is a good reason to argue for the constraint *dṽ in the synchronic grammar of Mundurukú. First of all, by positing *dṽ, the chances that the oral variant in words such as *daẽ́* 'to choose' will surface as **dãẽ́* are excluded.[4]

Tableau 5.1. The effect of *dṽ

daẽ́	*dṽ	Faith
a. dãẽ́	*!	
b. ☞ daẽ́		

Secondly, no other choice exists in cases where the vowel is underlying nasal (e.g. *də̃y* versus *nə̃y*), so that the output will always be *nə̃y*. This is the pattern that figures in both dialects, and despite the differences in the selection of oral and nasal variants, neither A nor B have outputs such as **dãẽ́* and **də̃y*.

Tableau 5.2. dṽ again

də̃y	*dṽ	Faith
a. ☞ nə̃y		(*)
b. də̃y	*!	

Finally, the constraint *dṽ also captures the fact that neither dialect has yet acquired sequences *dṽ*, either via borrowing or nasal spread. Prior to the change in nasal harmony, *dṽ was not required because the realization of Pre-Mundurukú *d as [n] was entirely predictable from nasalization. After the change, the choice between [d] and [n] came to be in conflict with

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[4] An output in which nasalization spreads all the way to /d/ (i.e. *nãẽ́*) also satisfies *dṽ, and this is the situation in dialect B. For further details, see Chapter 7.

nasalization, especially because [n] is no longer an allophone of /d/, it has a phonemic status on its own. The patterns in consonant mutation are a good example of this conflict. When speakers produce *daẽ́* 'to choose' or *darẽ́m* 'to be fetid' as [dà.ẽ́] and [dà.ɾ̃ẽ́m], they violate the requirements demanding nasalization to spread to as many eligible targets as possible, but they do so in order to satisfy a more important requirement in the language, namely *dṽ. The gap left on the distribution of /d/ after phonologization of /d/ and /n/ is now a real constraint, and a crucial one.

In addition to the change **L > *d > d/n, which explains the restriction on the cooccurrence of the voiced alveolar stop and a nasalized vowel (*dṽ), several sound changes took place in the language, giving rise to other patterns observed synchronically. I now turn to the restriction *ni and the historical change that gave rise to it.

5.5 The origin of *ni

In the previous section I called the reader's attention to a gap in the correspondence set n/[l̃]: there were no cases of the correspondence before /ĩ/. This can be attributed to the fact that the change **L > *d > d/n did not include the sequence **[L̃ĩ], otherwise *ni* would have been developed in the language, as did the sequence *di*: **Li > *di > di. Synchronically, **ni*, or **nĩ*, is another phonotactic restriction in Mundurukú. In this section I tentatively examine the origin of **ni* in the language. Very few vestiges exist that can reliably explain it, but a few words may shed light on a possible historical explanation.

I believe that **Lĩ disappeared from the family before Proto-Mundurukú. The primary reason is because Kuruaya lacks the sequence *l̃ĩ*, although it has *li*, as in *-li* 'liquid', and *nĩ*, in which case /n/ is phonetically realized as nasal palatal [ɲ], as in *ínĩ* [ĩ́ɲĩ̀] 'hammock'. Three related words allows us to establish the correspondence set given in Table 5.6. However, this set is found to occur only intervocalically, a restriction for which I offer no explanation here.

Table 5.6. Correspondence set III: r/n intervocalically

Mundurukú	Kuruaya	Gloss
wareta̯y	wañĩta̯y [w̃ãɲĩta̯y]	najá palm
warẽm-áp-ʔa	wíñĩ-paʔ [w̃íɲĩpa̯]	genipa
	weñĩpaʔ	
ə̯rə̃́	íñĩ [íɲĩ]	hammock

The hypothesis is that the proto-sequence **Lĩ underwent a sound change independent of other Proto-Mundurukú **L's, and before the change **L > *d > n took place; this is the reason why it did not include sequences **Lĩ.

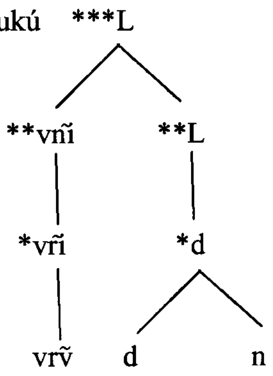
Let us suppose that **L was phonetically realized as [n] before the nasal high vowel /ĩ/. (See Clements and Sonaiya (1990) on a similar realization of sequences /lṽ/ in Yoruba.) Abstracting away from other changes – e.g. changes in vowel quality and the absence of nasalization in the Mundurukú word *wareta̯y*, I hypothesize that the proto-sequence **Lĩ, realized as [ñĩ], developed into Pre-Mundurukú /r/, which in turn merged with other /r/'s in the language. The change is shown below.

(21) **Lĩ [ñĩ] > *rṽ: Proto-Mundurukú **iLĩ [ĩñĩ]
Pre-Mundurukú *irĩ [ĩr̃ĩ]
Mundurukú ə̯rə̃́ [ə̯̃̀r̃ə̃́]

It may be that *ñĩ* was not simply the phonetic realization of **Lĩ, but it had already been phonologized in Proto-Mundurukú, suggesting that the change **Lĩ > **ñĩ took place in Pre-Proto-Mundurukú, the stage before Proto-Mundurukú. There are two reasons for this assumption. One is the fact that Kuruaya lacks the sequence /l̃ĩ/, although it has /ñĩ/. Another is that, if **L > *d took place between Proto- and Pre-Mundurukú and did not include the sequence **Lĩ, then these forms had already been phonologized as **ñĩ, and therefore were no longer associated with **L. Chronologically, Pre-Proto-Mundurukú ***L occurred before all vowels, including /ĩ/. Between Pre-Proto-Mundurukú and Proto-Mundurukú, ***Lĩ changed into **ñĩ.

Between Proto-Mundurukú and Pre-Mundurukú, **nĩ developed into *r̃i, whereas **L developed into *d.

(22) Relative chronology



Pre-Proto-Mundurukú	***iLĩ	***Loa	***Lõŋ
Proto-Mundurukú	**iñi	**Loa	**Lõŋ
Pre-Mundurukú	*ir̃i	*doa	*dõŋ
Mundurukú	ə̰rə̃́	dóá	nõŋ
	'hammock'	'spider'	'flea'

But a problem arises when we look at the word "hammock" in other Tupi languages, shown in Table 5.7. Rodrigues and Dietrich (1980) reconstruct the form **inĩ* 'hammock' for Proto-Tupi-Guarani (PTG), and Moore and Galúcio (1993) reconstruct **ẽ/ĩnĩ* for Proto-Tupari (PTu). Karitiana is the only language to have /r/, like Mundurukú, whereas most Tupian languages have /n/. (The word in Mekens was provided by A. Galúcio, in Gavião by D. Moore, in Karitiana by L. Storto, in Mawé by S. Meira, and in Awetí by S. Drude.)

Table 5.7. The word "hammock" in Tupi.

PTG	PTu	Mekens	Gavião	Karitiana	Mawé	Awetí	Mund	Kuruaya
*inĩ	*ẽnĩ/ĩnĩ	eni	ini	ẽrẽ-mɨ	ɨni	ʔinĩ	ə̰rə̃́	ínĩ

Given this, there is little comparative evidence for the change ***L > **n before /i/, but the correspondences in Table 5.7 do show that **nĩ > *r̃i > rṽ is a plausible route. Furthermore, we cannot ignore the fact that Kuruaya does not have the sequence *lĩ*, and that there are vestiges of the correspondence rṽ/nĩ in the Mundurukú family. The question as to whether it developed from the pre-proto-sequence ***Lĩ can only be answered if the majority of Tupian languages are considered, and a comparison of this sort is beyond the scope of this study.

5.6 The origin of *ʧi, *ʤi, and *ŋi

The change **L > *d > d/n was not the only change in the phonemic inventory of the language. There was another, much more complex series of changes by means of which a single consonant developed into four others. These changes are diagrammatically represented in (23). A step-by-step reconstruction will be provided below, but the reader should keep in mind that we are going to look at changes that took place at three different stages: (i) between Pre-Proto- and Proto-Mundurukú (§5.6.1), (ii) between Proto- and Pre-Mundurukú (§5.6.2), and (iii) between Pre-Mundurukú and the present (§5.6.3). These changes explain the following phonotactic restrictions: *ʧi, *ʤi, and *ŋi [ɲi].

Four Mundurukú sounds – three are phonemes, /ʃ, ʧ, ʤ/, and the other, [ɲ], is an allophone of the nasal velar /ŋ/ syllable-initially – are all historically linked to a single consonant: Pre-Proto-Mundurukú ***C, which stands for a postalveolar stop, probably the (IPA) palatal stop /c/.[5] ***C had two surface realizations: [ʧ] preceding the high front vowel, and [C] elsewhere. Between Pre-Proto-Mundurukú and Proto-Mundurukú the allophone [C] became voiced intervocalically, hence [D], and an affricate [ʧ] in other contexts (i.e. word-initially and following a consonant); these in turn merged with other ***ʧ's (§5.6.2). Because of nasal harmony, [D] probably had a nasal realization [N] in nasal contexts. This is corroborated by the fact that in Kuruya the contrast between the voiced stops /b, d/ and nasals /m, n/ is neutralized to [m, n] in nasal contexts.

Between Proto-Mundurukú and Pre-Mundurukú (§5.6.2), proto-**D changed into a voiced affricate *ʤ, carrying along the allophony determined by nasal assimilation: [ʤ] preceding oral vowels, and [ɲ] preceding nasal vowels, except in consonant mutation (§5.6.3). At this stage the change in nasal harmony took place (as explained in section 5.4.1 above). This also had an

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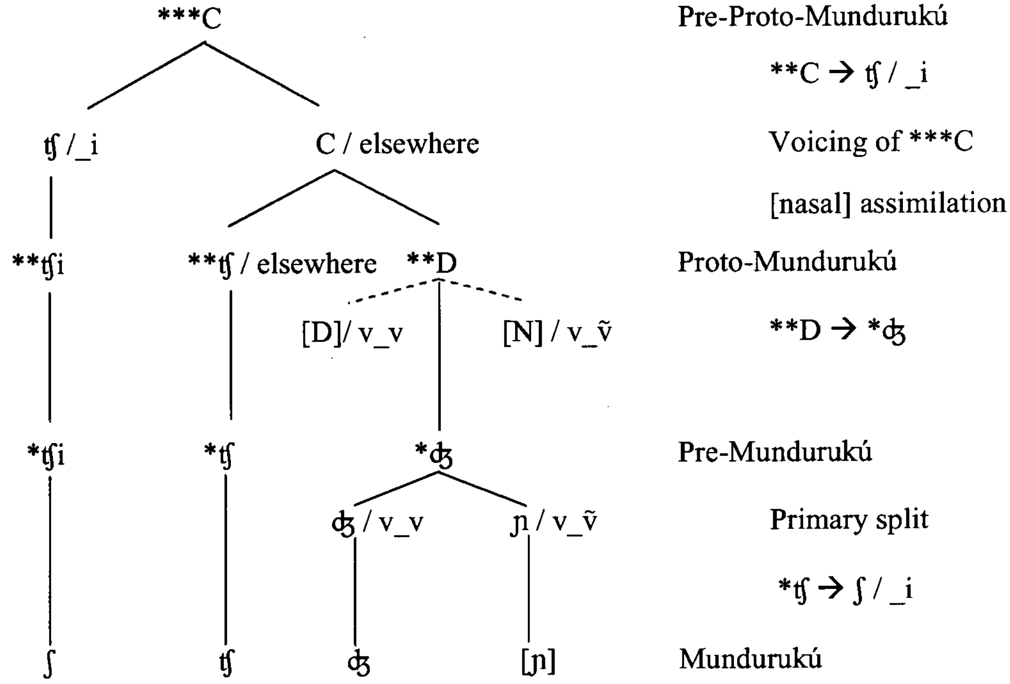
[5] I must clarify that even though /ʃ, ʧ, ʤ/ and [ɲ] are historically linked to ***C, they all have other sources as well. For example, there are at least three sources for /ʃ/: ***Ci and Proto-Mundurukú **k^{j}V and **ʃ (see §5.8). Likewise, not all /ʤ/'s come from ***C; some of them were introduced in borrowings, e.g. *ʤóromó* 'pumpkin', from Portuguese *jerimum*.

impact here, propelling the split of *ʤ into two, and the merger of its nasal allophone [ɲ] with the nasal velar /ŋ/ (i.e. a primary split).

(23) From Pre-Proto-Mundurukú ***C to Mundurukú /ʃ/, /ʧ/, /ʤ/, [ɲ]. (Changes that took place between stages may not be chronologically parallel.)



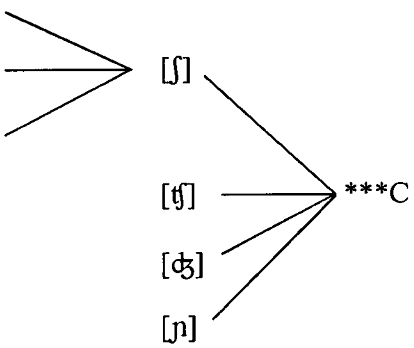
It is precisely the allophonic alternation [ʧi]/[C] in the pre-proto-stage which has given rise to the synchronic prohibitions *ʧi, *ʤi, and *ŋi [ɲi]. At each stage in the history of ***C, the resulting forms underwent changes independently. In Proto-Mundurukú ***C had already been split into **ʧ and **D; later in Pre-Mundurukú, it was split into *ʧ and *ʤ, and finally into /ʃ, ʧ, ʤ/ and [ɲ] in the modern stage. As it can be noted in the diagram, the phoneme /ʤ/ was born in the language with two gaps in its distribution: (i) it never occurred before /i/, and (ii) it was restricted to intervocalic position. The latter restriction has already changed because of some borrowings that came into the language (§5.6.1).

As for /tʃ/, the restriction *tʃi is more recent, and was caused by the sound change *tʃ > ʃ / _i. Clearly, then, only if we consider the development of ***C, can we provide a satisfactory explanation for the patterns.

5.6.1 Between Pre-Proto-Mundurukú and Proto-Mundurukú

The Mundurukú words below have an ancestor in common, the voiceless palatal stop ***C, in the pre-proto-language.

(24)	(a)	ʃík	'mosquito'
	(b)	i̠ʃí	'his/her mother'
	(c)	otayʃi	'my wife'
	(d)	tʃə́	'to go'
	(e)	da̠dʒé	'peccary'
	(f)	táɲe	'mouse'



In (24)a-c two changes took place: first, ***C becomes an affricate [tʃ] before a high front vowel in Pre-Proto-Mundurukú; and second, the stop component of [tʃ] is lost, and [tʃ] becomes simply a fricative [ʃ] in Mundurukú. Only the evidence of Kuruaya allow us to reconstruct this route. If we compare the sequence *ʃi* in Mundurukú with related forms from Kuruaya, we obtain the correspondence set of Table 5.8. Before the high front vowel /i/, where Mundurukú has [ʃ] Kuruaya has the palatal affricate [dʒ], which is an allophone of /d/ in this context.

Table 5.8. Correspondence set IV: ʃ/d before /i/.

Mundurukú	Kuruaya		Gloss
ḭ-ʃí	í-di(ʔ)	[íʤiʔ]	his/her mother
ʃík	dik	[ʤik]	mosquito
weʃík	wedik	[weʤik]	potato
bə́ʃiʃim	bɨydim	[bɨyʤim]	fear of s.t.
daydo̰-ʃíʃí	laylo-diʔ	[layloʤiʔ]	armadillo, sp.
iʃí-bə	ídí-bɨʔ	[íʤí-bɨʔ]	tropical creeper

This provides evidence for the reflex of the affricate [ʧ] before the high vowel, but does not provide evidence for ***C itself. For that we must establish another correspondence set ʤ/d, given in Table 5.9: Mundurukú /ʤ/ corresponds to Kuruaya /d/, phonetically a retroflex [ɖ]. This set has three important restrictions: (i) it is found to occur only between vowels; (ii) it is never found in the context of nasalization; and (iii) it is in complementary distribution with the set ʃ/d, i.e. it does not occur before a high front vowel /i/.

Table 5.9. Correspondence set V: ʤ/d intervocalically in oral contexts

Mundurukú	Kuruaya	Gloss
ʃiʤáp	ki**d**ap	shelter
a**ʤó**ré	a**d**oreʔ	to be old
a**ʤó** / áʤo	**ádo**	what
da̰**ʤé**	la**d**eʔ	peccary
a̰ʤók	a**d**ok	to bathe
kəyá**ʤe**	kɨya**de**	yesterday
o-ʧe-**ʤ**a̰ʤa̰ 1Su-CoRef.Poss-defecate	o-ʧe-**d**adaʔ	I defecated.
o̰-**ʤé**-po 3Su-CoRef.Poss-lye	o-**de**-pɔ́	S/he is lying.
i-**ʤo**ʧé 3-be.there	i-**dó**ʧe	It's there
o-**ʤo**-dá 1Su-3Ob-cook	o-**do**-la	I cooked it
o-**ʤo**dít 1-uncle	ó-**do**lit	my uncle
e-we-**ʤə́** 2-Refl-together	e-we-**dɨ**	with you

In the context of nasalization we find the third correspondence set in this group, which is in complementary distribution to both ʃ/d and ʤ/d. The palatal allophone of Mundurukú /ŋ/ [ɲ], corresponds to Kuruaya /n/. Like the correspondence ʤ/d, the set [ɲ]/n is also restricted to intervocalic position, and does not occur before the high vowel /i/. (Recall from §5.5 that the Kuruaya sequence ñĩ [ɲĩ] corresponds to the sequence rṽ in Mundurukú; see Table 5.6 above.)

Table 5.10. Correspondence set VI: [ɲ]/n intervocalically in nasal contexts

Mundurukú		Kuruaya	Gloss
táŋe	tá[**ɲ**]e	ta**n**ẽ	mouse
piŋá	pi[**ɲ**]á	pi**n**ã	fish-hook
akóŋe	akó[**ɲ**]e	okpɨ́**n**ẽʔ	Mu: necklace; Ku: belt
oŋḛbí	o[**ɲ**]ḛbí	o**n**ẽbiʔ	my armpit
ya̰ŋóbə	ya̰[**ɲ**]óbə	ya**n**õbɨʔ	his neck
oŋebít	o[**ɲ**]ḛbít	o**n**ẽbit	my grandson/daugther
aŋóka̰	a[**ɲ**]óka̰	a**n**õka	place
owaŋó	owa[**ɲ**]ó	owa**n**õ	my brother/sister

This gives three sounds in correspondence;

(25)	Kuruya	[ʤ]ik	i[ʤ]iʔ	la[ɖ]eʔ	ta[n]ẽ
	Mundurukú	[ʃ]ík	ḭ[ʃ]í	da̰[ʤ]é	tá[ɲ]e
		'mosquito'	3-mother	'peccary'	'mouse'

and three sets in complementary distribution:

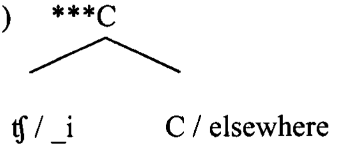
(26) Summary of the correspondence sets

_i	v_v	v_ṽ
ʃ/d	ʤ/d	ɲ/n

These sounds have in common the property of being realized in the postalveolar region, except for [n] which is, impressionistically, alveolar. This suggests that the original sound out of which they developed was also postalveolar; hence ***C is [+coronal, -anterior].

Before a high front vowel, both Mundurukú and Kuruaya exhibit a plain palatal – [ʤ] in Kuruaya and [ʃ] in Mundurukú – but these diverge in manner and voicing. Before examining a solution to this problem, let us first suppose that ***C was realized as a voiceless affricate [ʧ] before a high front vowel, and [C] elsewhere.

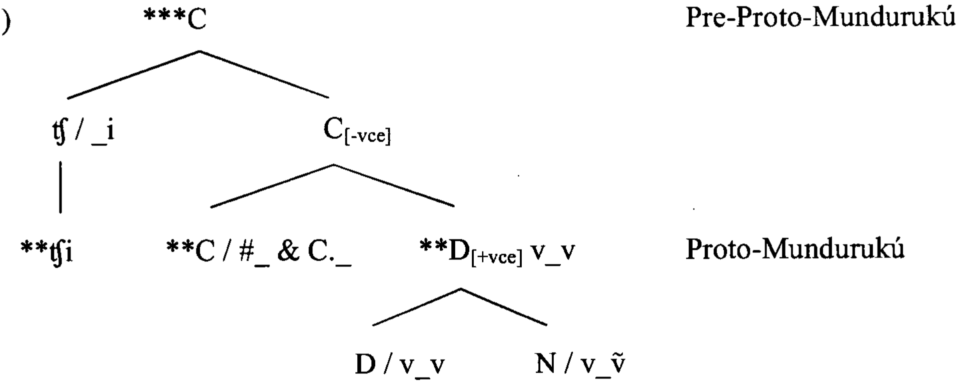
(27) Pre-Proto-Mundurukú



In Mundurukú the voiced reflexes [ʤ] and [ɲ] are only found intervocalically, and do not include the high front vowel /i/. Synchronically, both /ʤ/ and /ŋ/ are rare word-initially. For example, there are only four nouns in the corpus that begin with /ʤ/: *ʤarấy* 'orange (tree)', *ʤóromó* 'pumpkin', *kaʤarấwʔa* ' a big pot', and *ʤoráwi* 'a table for domestic use', all of which are borrowings from Portuguese: *laranja*, *jerimum*, *caldeirão* and *jirau*, respectively. Kuruaya has /d/ in the phonemic inventory, which occurs freely word-initially: *dá* 'one', *doridoy* 'rabbit', etc. However, I have not found any cases of the correpondence ʤ/d in any other position than intervocalically, suggesting that not all /d/'s of Kuruaya originate from ***C. In Mundurukú, on the other hand, the primary source for /ʤ/ is the allophone of ***C that became [+voice] intervocalically. Thus the distribution of /ʤ/ reflects the distribution of this allophone; that is, it is restricted to intervocalic position in the native vocabulary; its occurrence in word-initial is due to borrowings.

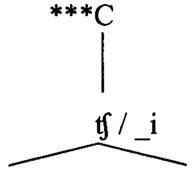
The restriction on the correspondence ʤ/d and ɲ/n to intervocalic position suggests that ***C was originally voiceless, hence [+coronal, -anterior, -voice], and became [+voice] intervocalically. But this change did not affect all of its allophones. Recall that the voiced variant did not occur before the vowel /i/, where ***C was realized as [ʧ], in addition to word-initially and following a consonant, where ***C was realized as [C]. (Word-initial and postconsonantal [C] are examined in §5.6.2.) This is schematically represented in (28). Here we also find the influence of nasalization. Since [D] was [+voice], it was also a target for nasal harmony, which affected all [+sonorant] and [+voice] segments at that stage; thus D had two allophones, [D] in oral contexts, and [N] in nasal contexts.

(28)



It is important to note that Kuruaya has [ʤ] as the reflex of Proto-Mundurukú **ʧ before the vowel /i/, and [ɖ, n] as reflexes of [D, N] respectively. Mundurukú has [ʃ] and [ʤ, ɲ]. The problem is Kuruaya [ʤ] versus Mundurukú [ʃ]; i.e. voiced vs. voiceless, and affricate vs. fricative. Schematically we have the following.

(29)



Kuruaya	Mundurukú		
[ʤ]ik	[ʃ]ík	'mosquito'	(word-initially)
i[ʤ]iʔ	i̯[ʃ]í	'his/her mother'	(intervocalically)

It is unlikely that the change [-voice] > [+voice] also affected the sequence **ʧi, since the pair [ʤ] / [ʃ] in the word for 'mosquito' occurs word-initially, and only intervocalic consonants were affected. One hypothesis is that there was an initial vowel in the pre-proto-language, ****vCik* 'mosquito', which was lost after the change [-voice] > [+voice] took place: ***vCik > **vʧik > *vʤik > ʤik (> ʃik). Comparative evidence suggests that this was not the case as most Tupian languages do not have a initial vowel in this word – e.g. Suruí: *ník*; Gavião: *dik*; Karo: *tik*; and Karitiana: *tik*. Therefore, voicing in the Kuruaya words /dik/ and /idiʔ/ was independently motivated, perhaps by influence of other /d/'s that came into the language.

Another piece of evidence comes from the reflex of the voiceless allophone ***ʧ in the following words.

(30)		Mundurukú	Kuruaya	Gloss	Correspondences
	(a)	tay-ʃi	tai-ʧi	'wife'	ʃ / ʧ
	(b)	potíp-ʃíʃí	pótip-ʧi	'fish, sp.'	ʃ / ʧ

The morpheme *-ʃi* in the words *tayʃi / potípʃíʃí*, and *-ʧi* in the corresponding words in Kuruaya, are historically derived from the word *-ʃi* and *-di* 'mother' respectively, and therefore reflect ***C. This morpheme is no longer reanalyzable in the word for 'wife', (30)a, in either language, and is semantically interpreted as an 'augmentative' in (30)b. Thus we can say that, synchronically, they have no connection with each other, except that historically they are derived from the same root. These examples show that in Mundurukú the change ***C > **ʧ > ʃ /_i applied regularly, but in Kuruaya we find *-di* [ʤ] in 'mother' and *-ʧi* in 'wife' and 'fish', in which case the change ***C > **ʧ > ʤ did not apply. In (30)b it may be because *-ʧi* follows a consonant, but in (30)a, the root *tai-* ends in a vowel. This example shows that the change in the feature [-voice] of the reflexes of sequences ***ʧi in Kuruaya (e.g. dik 'mosquito', ídi? 'his/her mother') took place at a later stage, say, between Proto-Mundurukú and Pre-Kuruaya. This leads us to the conclusion that voicing did not affect ***[ʧ]. This is a plausible hypothesis because a route such as ***Ci > **ʧi > ʃi in Mundurukú, where [-voice] is maintained along the way, seems to be more natural than another that changes [voice] twice, and without motivation.

5.6.2 Between Proto-Mundurukú and Pre-Mundurukú

Having established the allophones of ***C and the change ***C > D, we find in Proto-Mundurukú two reflexes of ***C: **ʧ and **D, with its allophones [D] and [N], and a phonotactic restriction: **D and **N did not occur before the high front vowel /i/. There was also a third reflex that occurred word-initially and postconsonantally, and whose phonetic realization has not yet been determined. This is found in the followings roots, which because of the change [-voice] > [+voice] ended up exhibiting a morphophonological alternation between voiced and voiceless forms, and which now participate in the process of consonant mutation. (Consonant mutation was introduced in §5.4, but see especially Chapter 7.)[6]

(31) Alternating morphemes

	Mundurukú	Kuruaya	Gloss
(a)	ʧə́ / ʤə́	ʧɨ / dɨ	'to go'
(b)	ʧə̰k /ka-ʤə̰k	ʧɨk / kádɨ̰k	'be cold'/ 'cold (weather)'
(c)	ʧẽ́m / ʤẽ́m	ʧẽm / nẽm	'to go/come out'

In Mundurukú the alternation is always ʧ/ʤ, whereas in Kuruaya we find ʧ/d or ʧ/n, depending on the oral versus nasal quality of the following vowel. From these pairs we obtain the correspondences given in Table 5.11.

Table 5.11. Correspondences in consonant mutation.

Voiceless form before v/ṽ	Voiced form in v_v	Voiced form in v_ṽ
ʧ / ʧ	ʤ / d	ʤ / n

The correspondence ʧ/ʧ as the voiceless variants of alternating morphemes prompts us to also reconstruct **ʧ in Proto-Mundurukú for ***C word-initially and postconsonantally. Thus in Proto-Mundurukú ***C was split into two: **ʧ and **D, which in turn had two variants, oral and nasal, because of nasal harmony.

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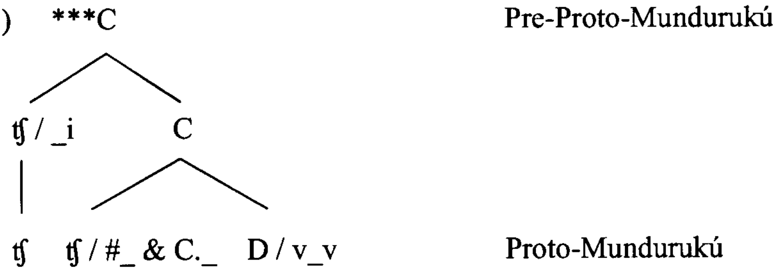
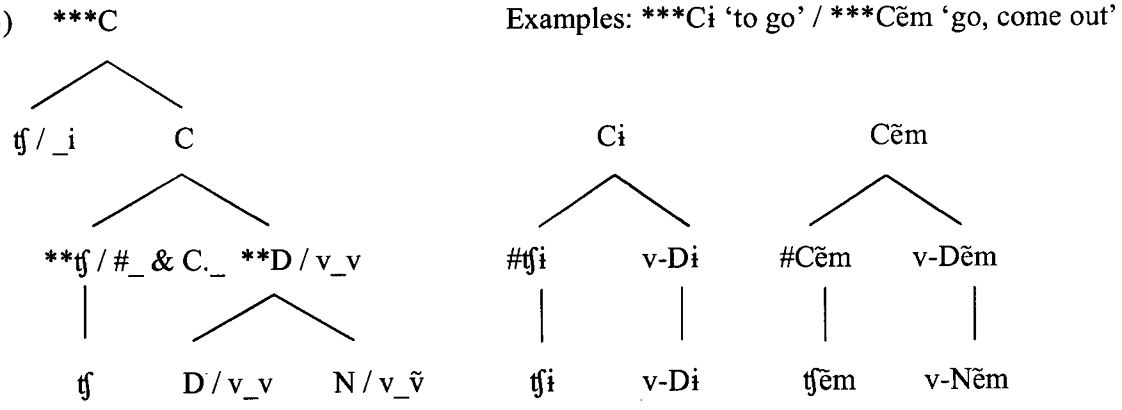
[6] Recall that the voiced forms surface after vowels and glides (e.g. o̰ʤə́ 'S/he went'), and the voiceless forms after consonants or when isolated (e.g. oyóptʃẽm 'The stick came off' and ʧə́m ṍn 'I will go').

(32)



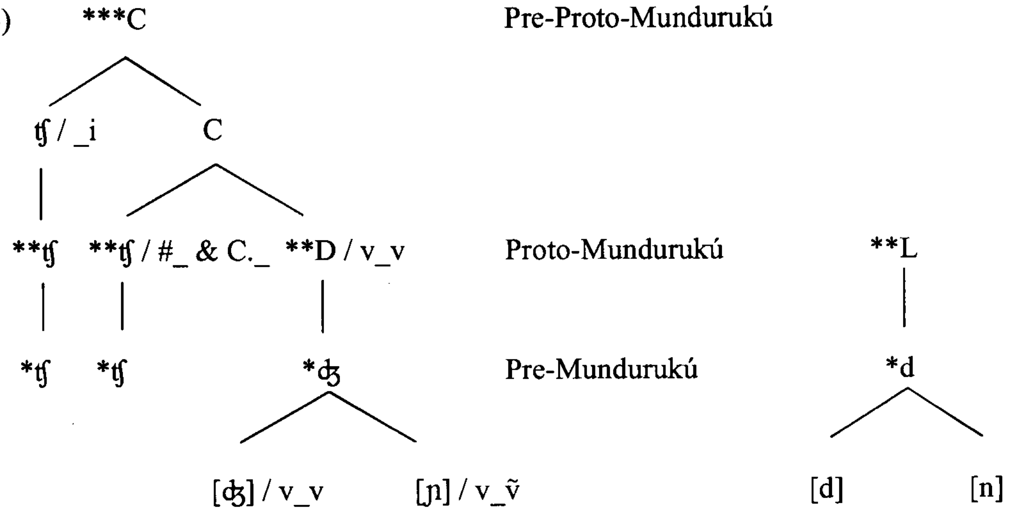
In (33) I give examples of the development of consonant mutation in the reflexes of ***C in a number of morphemes. All of these have a distribution that may or may not involve a preceding morpheme. For example, intransitive verbs can occur with or without a person marker (e.g. tʃə́m ṍn 'I will go' versus o̰dʒə́ 'S/he went.'). When preceded by a morpheme-final vowel, as in *o̰dʒə́*, they had the environment that favored [-voice] > [+voice], and were therefore affected: **v-tʃɨ → v-Dɨ, in oral contexts, and **v-tʃẽm → v-Nẽm, in nasal contexts. But when isolated or preceded by a morpheme-final consonant, the environment blocked voicing, so they remained voiceless in those contexts: #**tʃɨ → tʃɨ and #**tʃẽm → tʃẽm.

(33)



Mundurukú had another step, Pre-Mundurukú, diagrammatically represented in (34). At this stage **D developed into *dʒ. Because of nasal harmony, *dʒ had two allophones, [dʒ] and [ɲ], a pattern similar to that of the proto-language. Recall that it was at his stage that **L > *d took place, so the change **D > *dʒ may be regarded as a readjustment of the inventory, caused perhaps by the phonetic similarity between *D and *d, and similarity of allophonic variations.

(34)



Because *tʃ and *ʤ entered into opposition relative to each other, the change *D > *ʤ created a new contrast in the language. But this opposition emerged in the language with a phonotactic restriction. The change **tʃ > ʃ eliminated all sequences *tʃi* in the language, emerging then the restriction *tʃi, in addition to the other two, *ʤi and *ŋi [ɲi], which resulted from the split of ***C between Pre-Proto- and Proto-Mundurukú. There is one exception to *tʃi/*ʤi: the alternating morpheme *tʃítʃã́* / *ʤíʤã́* 'many, much, very', which either came later or was preserved, perhaps because of its frequent use as an intensifier. This suggests that the language does not prohibit sequences *tʃi* or *ʤi*, their absence is simply a gap left behind by a series of sound changes.

There are nevertheless other issues to consider. According to the diagram in (34), the distributions of the reflexes of *tʃ and *ʤ should exhibit enormous gaps in modern Mundurukú. In Pre-Mundurukú *tʃ was preserved only word-initially, postconsonantally, and before /i/, and *ʤ intervocalically. This is, however, not the case synchronically. The distribution of /ʤ/ is examined in the next section, here I will focus on the distribution of /tʃ/. In addition to word-initially and postconsonantally, /tʃ/ may also occur intervocalically, preceding all vowels but /i/.

(35) Intervocalic /ʧ/

(a) pəʧa ‘animal game’

(b) daʧé ‘hawk, sp.’

(c) oʧṍoʧṍ ‘cough’

(d) o-í-ʧək ‘It broke’

3Su-?-be.broken

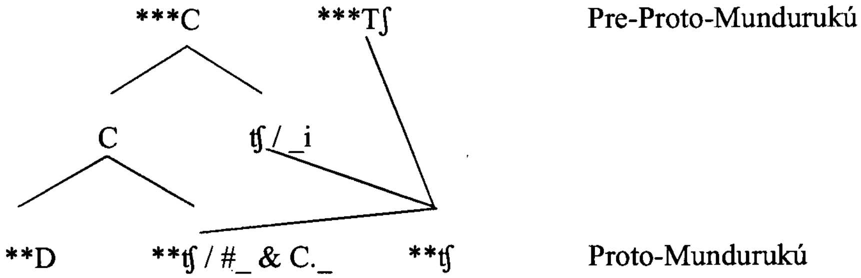
This is interesting because it reflects another diachronic process in Proto-Mundurukú, namely the merger of **ʧ, reflex of ***C, with other **ʧ’s. Related forms in Kuruaya reveal that the proto-language had another **ʧ, which had a distribution similar to the synchronic distribution of /ʧ/ in the language.

Table 5.12. Correspondence set VII: ʧ/ʧ word-initially, intervocalically and postconsonantally.

Mundurukú	Kuruaya	Gloss
ʧókṍn	ʧokãn	toucan
ʧə̃ŋʔí	ʧã́ŋʔi	to stand still
ʧoʔá	ʧóʔa	hill
iʤoʧé	idóʧe	It’s there
taʧə́pʧə́p	taʧɨpʧɨp	S/he’s miserly
oʧeʧó	oʧeʧo	I bit.
oʧṍoʧṍ	ɔʧɔɔʧɔm	cough / to cough
ʤeʧə̃́ŋ-ʧə̃ŋ	oʧeʧãŋʧãŋ	I walked around
ekʧó	ekʧɔ/o	your basket
yopʧə̃ŋ	yɨkʧãŋ	The stick is straight
ʤeʧə̃́ŋʧə̃́ŋ	oʧeʧãŋʧãŋ	I walked around

The proto-phoneme for the correspondence ʧ/ʧ can without problems be identified as **ʧ, which is the reflex of the pre-proto-phoneme represented here by ***Tʃ. In Pre-Proto-Mundurukú, ***C and ***Tʃ were distinct phonemes, but merged in the period between Pre-Proto- and Proto-Mundurukú. Therefore, the change **ʧ > ʃ /_i also affected the reflex of the sequence ***Tʃi, the reason why we now find /ʧ/ preceding all vowels but /i/. This case illustrates a situation in which a phoneme with a regular distribution has acquired a gap.

(36) Merger in Proto-Mundurukú



A similar explanation cannot be proposed for /ʃ/, which is found word-initially, medially, and preceding all vowels but /ə/.

(37) Examples of /ʃ/ in Mundurukú

(a)	ʃaʔíp	'piquiá' (tree, sp.)
(b)	daʃéw	'fish, sp.'
(c)	ʃẽ́	'bird, sp.'
(d)	poʃo	'bird, sp.'

Contrary to Mundurukú, Kuruaya exhibits two significant gaps in the distribution of /ʃ/. It does not occur before /i/ and /ɨ/. This permits us to reconstruct a proto-phoneme **ʃ and the addition of a new environment for /ʃ/ in Mundurukú: the change **ʧi > ʃi, which filled in the gap of the consonant before a high front vowel. But it does not permit us to recover the gap before the central vowel, /ə/ in Mundurukú and /ɨ/ in Kuruaya. The absence of this sequence in both languages means that there was a gap in this context in the proto-language. The restriction remains in modern Mundurukú since we do not find the sequence *ʃə* (see discussion in §5.8).

A hypothesis by Rodrigues (1995; see also Rodrigues and Dietrich 1997) is that Proto-Tupi did not have any fricatives in the phonemic inventory. His explanation for the languages that have them synchronically is that they were acquired by means of sound changes, similar to the change **ʧ > ʃ in Mundurukú. This is a hypothesis that requires a larger comparative investigation, beyond the Mundurukú family, and will not be explored here. For our purposes, it suffices to know that Proto-Mundurukú also had **ʃ in the phonemic inventory.

5.6.3 Between Pre-Mundurukú and Mundurukú

We have established that in the Pre-Mundurukú ***C had already been split into two phonemes, *ʤ, and *ʧ; *ʤ developed from **D, *ʧ from the merger of a reflex of ***C with a reflex of ***Tʃ. Between Pre-Mundurukú and Mundurukú, *ʧ > ʃ / _i, which eliminated all sequences *ʧi's in the language.

(38) *ʧ / _i Pre-Mundurukú
|
ʃi Mundurukú

Consider now a case of primary split. That is, the split of a phoneme and the merger of one of its allophones with another phoneme in the language. Pre-Mundurukú *ʤ had an allophonic variation determined by nasal harmony: [ʤ] preceding oral vowels, and [ɲ] preceding nasal vowels. The oral allophone became an independent phoneme, /ʤ/, but the nasal allophone [ɲ] merged with /ŋ/, and is now its allophone in onset position.

Consider different explanations for this split. First, the change in nasal harmony caused the split, an effect similar to the split of *d into /d/ and /n/ examined in §5.4.1. Second, /ŋ/ had already a palatal [ɲ] as an allophone, and because of its phonetic similarity with the nasal allophone of *ʤ, also [ɲ], these merged naturally. And third, their phonemic allegiance is still as it was, meaning that [ʤ] and [ɲ] are still related by allophony. This possibility can be excluded because the distribution of /ʤ/ no longer reflects the distribution of [ʤ] in the pre-language; it occurs before nasal vowels synchronically (e.g. oʤẽ́m 'I went out.'), and word-initially in borrowings (e.g. ʤarã́yʔa 'orange'). Similarly, [ɲ] also occurs word-initially (e.g. *[ɲ]ədə́p* 'tree, sp.'). Thus, these gaps in the distribution of /ʤ/ and [ɲ] have already been repaired by the grammar.

The second possibility, that [ɲ] merged with /ŋ/ independently, is unclear at this point of the investigation, because /ŋ/ is restricted to coda position in Kuruaya, and probably in Proto-Mundurukú. But the data indicate that the proto-allophone [ɲ] may not be the only source for the nasal velar syllable-initially; Mundurukú has some native words with [ɲ] for which I have not found cognates in Kuruaya; for example, *a[ɲ]əpé* 'fish, sp.' and *se[ɲ]emṍ* 'chameleon', and others were introduced through borrowing from Portuguese; for example, *piʃá[ɲ]a* 'cat' (Portuguese: *bicha[n]o*), *ká[ɲ]a* 'sugar-cane' (Portuguese: *ca[n]a*). Note that in the borrowings [ɲ] replaces Portuguese [n]; there is also nasalization in the pronunciation of the words in Portuguese, roughly: [biˈʃãnu ~ biˈʃãnũ] and [ˈkãna ~ ˈkãnã] respectively. This suggests that the borrowings were adapted according to the distribution of *[ɲ] in Pre-Mundurukú prior to the change in nasal harmony, and therefore preceded it. After this change, /n/ became an independent phoneme, which leads us to the conclusion that *bichano* and *cana* would have been introduced as *piʃána* and *kána* if they were acquired after the change in nasal harmony.

The hypothesis that nasal harmony caused the split is plausible, but it is suggested here that the phonemic differentiation of *[ʤ] and *[ɲ] was already in progress when the change in nasalization took place.

Consider again the change *D > *ʤ in conjunction with consonant mutation, shown in (39). Between Pre-Proto- and Proto-Mundurukú, the change ***C > **D caused a morphophological process of voicing alternation morpheme-initially, ʧ/D in oral contexts and ʧ/N in nasal contexts.

(39) Pre-Proto-Mundurukú Cɨ 'to go' Cẽm 'to go/come out'
***C > **D / v_v
Proto-Mundurukú ʧɨ / v-Dɨ ʧẽm / v-Dẽm [v-Nẽm]

Between Proto- and Pre-Mundurukú, **D changed into *ʤ. The allophonic variation is then reflected in the new period as a variation between [ʤ] and [ɲ], as previously explained. But this variation was simplified in consonant mutation to a variation ʧ/ʤ, even in nasal contexts. This is illustrated by the Pre-Mundurukú pair **ʧẽm/v-ʤẽm*, which corresponds to Proto-Mundurukú ***ʧẽm/v-Nẽm*. As a consequence, a new environment emerged in the distribution of *[ʤ], which can at this stage precede a nasal vowel.

(40)	Proto-Mundurukú	**ʧɨ / v-Dɨ	**ʧẽm / v-Dẽm [v-Nẽm]
	**D > *ʤ		
	Pre-Mundurukú	*ʧə / v-ʤə	*ʧẽm / v-ʤẽm
	Mundurukú	ʧə́ / v-ʤə́	ʧẽ́m / v-ʤẽ́m
		'to go'	'to go/come out'

After the change **D > *ʤ, and the new environment for *ʤ, the environment that determined a variation between [ʤ] and [ɲ] can no longer be identified. Thus the grammar must at this point restructure its phonemic inventory, in Kiparsky's (1982) sense. [ʤ] became independent and [ɲ] was then phonologically associated with the nasal velar /ŋ/, which was previously restricted to coda position. Its association with [ɲ] in onset-position thus filled in a gap in its distribution. A piece of evidence that this may have been the case comes from the word *nə̃ɲáp* [nə̃ɲáp] 'bench', which is the lexicalized form of *nə̃ŋ+áp* (sit(?)+NOM) 'thing for sitting'. In *nə̃ɲáp* the morpheme-final /ŋ/ appears as an onset preceding the nominalizer *áp*, and is realized as [ɲ].

5.6.4 Summary of the changes

To conclude this section, I provide below illustrations of the evolution of ***C, and the different changes that culminated in its division into four consonants.

Table 5.13. Summary and illustrations of the evolution of ***C in Mundurukú.

	***C > **ʧ > *ʃ		***C > **ʧ/D > *ʧ/ʤ		***C > **D > *ʤ/ɲ	
Pre-PMu	Cik	i-Ciʔ	Cẽm	Cɨ	LaCeʔ	taCẽ
PMu	ʧik	i-ʧiʔ	ʧẽm/v-Dẽm	ʧɨ/v-Dɨ	LaDeʔ	tãDẽ
Pre-Mu	ʧik	i-ʧiʔ	ʧẽm/v-ʤẽm	ʧɨ/v-ʤɨ	daʤeʔ	tãɲẽ
Mu	ʃík [ʃík˺]	ḭ-ʃí [ḭ̀ʃí]	ʧẽ́m/v-ʤẽ́m [ʧẽ́m/v-ʤẽ́m]	ʧə́/v-ʤə́ [ʧə́/v-ʤə́]	da̰ʤé [dà̰ʤé]	táŋe [tã́ɲẽ̀]
Gloss	mosquito	3-mother	go/come out	to go	peccary	mouse

And the relative chronology, including the change **L > *d > d/n, is as shown in (41). (Changes in vowels are not dealt with here; the symbol ⊂ stands for 'merges with'.)

(41) Relative chronology

(a) Pre-Proto-Mundurukú

	***iLĩ	***Lapãn	***Loa	***Cik	***LaCeʔ	***taCẽ
***Ci > **tʃi	---	---	---	ʧik	---	---
***vCv > **vDv	---	---	---	---	La[D]eʔ	ta[N]ẽ
***vLĩ > **vnĩ	inĩ	---	---	---	---	---
Surface:	˜inĩ	L̃ãpãn	Loa	ʧik	LaDeʔ	taNẽ

(b) Proto-Mundurukú

	**iñĩ	**Lapãn	**Loa	**ʧik	**LaDeʔ	**taDẽ
**vñĩ > *vr̃ṽ	ir̃ĩ	---	---	---	---	---
**L > *d	---	[n]apãn	[d]oa	---	[d]aDeʔ	---
**D > *dʒ	---	---	---	---	da[ʤ]eʔ	ta[ɲ]ẽ
*[ɲ] ⊂ /ŋ/	---	---	---	---	---	taŋe
Surface:	ĩr̃i	nãpãn	doa	ʧik	daʤeʔ	tãɲẽ

(c) Pre-Mundurukú

	*ə̰rə̃	*dapõn	*doa	*ʧik	*da̠ʤe	*taŋe
Change in NH plus						
*d > d / n	---	napõn	doa	---	da̠ʤe	---
Surface:	ə̰̃r̃ə	napõn	doa	ʧik	da̠ʤé	tãɲẽ

(d) Mundurukú

*tʃ > ʃ / _i	---	---	---	ʃík	---	---
	ə̰rə̃́	nápṍn	dóá	ʃík	da̠ʤé	táŋe
Surface:	ə̰̃r̃ə̃́	nápṍn	dóá	ʃík	da̠dʒé	tã́ɲẽ

5.7 The origin of *si

If we look back at Table 5.1 and compare the number of occurrences of the sequence *ʃi* (=37) to the number of the sequence *si* (=0), the first hypothesis is that /s/ is realized as [ʃ] before a high front vowel: s → ʃ /_i. Here I reject this hypothesis, and show that *si is another accidental gap caused by historical changes.

5.7.1 Native versus borrowed vocabulary

One way to approach the restriction *si is to say that /s/ is realized on the surface as a palatal fricative [ʃ] in the context /_i. This is of course plausible since palatalization s → ʃ /_i is commonly attested cross-linguistically. An additional observation that could support this analysis is the fact that /ʃ/ is the most frequent consonant in the context / _i, with 18% of the total number of combinations consonant + /i/, given in Table 5.1. The problem with this analysis is that there is no evidence, synchronic or diachronic, to assert that /s/ is or was neutralized to [ʃ] before the high front vowel, or even that the sequence *si* is prohibited in the language.

Synchronically, there is no case which could reveal an alternation s/ʃ. On the contrary, the sequence *si* does occur in the language, though not in native words. For example, in the words *pasía* 'to go for a walk', borrowed from Portuguese *pa[si]ar* ~ *pa[se]ar*, and for some speakers, *basíaʔá* 'a metal basin', from Portuguese *ba[si]a*. The distribution of /s/ parallels that of a word-initial /r/ in that it exhibits a controversy between native versus borrowed words. There are no cases of the sequence *si* in the native vocabulary, but there are in borrowings. The explanation proposed for this controversy is similar to that proposed for *#r: there is no such a restriction **si* in the synchronic grammar of Mundurukú; the absence of sequences *si* in the native vocabulary is an accidental gap, originated from historical processes of deletion and change in vowel quality (§5.7.2). The historical investigation also provides evidence for arguing against a palatalization process such as s → ʃ /_i in the history of /s/ in the Mundurukú family, as we see next. Synchronically, borrowings prove this assumption to be correct as the Portuguese words introduced in the language retained the sequence *si*, otherwise we would expect them to realized as **paʃía* and **baʃía* instead of *pasía* and *basía*, respectively.

5.7.2 The history of /s/ in Mundurukú

Consider the correspondence set VIII in Table 5.14. It shows that sequences *si* were eliminated via a process of deletion of /s/ before the high vowel /i/, both word-initially and word-medially.

Table 5.14. Correspondence set VIII: Øi/-si

Mundurukú	Kuruaya	Gloss
iporó	síporɔ	wild cat
ipádá	sípala	macaw, sp.
o-í-pik 3Su-?-be.burned	o-sí-pik	It burned.

This set corresponds to a proto-sequence that can be identified as Proto-Mundurukú **si, and to a process of deletion of **s before /i/.

(42)		Proto-Mundurukú		Mundurukú	
	(a)	**sipɔrɔ	>	iporó	'wild cat'
	(b)	**sipaLa	>	ípádá	'macaw, sp.'
	(c)	**o-si-pik	>	o-í-pik	'It burned.'

Now consider the correspondence set IX. Here /s/ was preserved but Mundurukú and Kuruaya exhibit a difference in the quality of the following vowel: /i/ in Kuruaya and mostly /ə/ in Mundurukú.

Table 5.15. Correspondence set IX: sv/si

Mundurukú	Kuruaya	Gloss
wásə̃	osĩ	bird
soé-dəp	ísíe	fish, sp.
mə-səré-bə	lo-síre	electric fish
məsək-tá	másik	manioc
kosə́-da	kósi-la	babaçu (plant, sp.)

The reconstructed form for the correspondence sə/si is **sɨ. As a working hypothesis, the proto-vowel **ɨ was fronted in Kuruaya, **sɨ > si, but lowered to /ə/ in Mundurukú, **sɨ > sə, as illustrated in (43).

(43)	Proto-Mundurukú	Mundurukú	Kuraya	Gloss
(a)	**oasɨ̃	wásə̃	osĩ	'bird'
(b)	**masɨk	məsə́k	másik	'manioc'
(c)	**kosɨ	kosə́	kósi	'babaçu'

There is an apparent exception to this set, namely the pair soé-dəp / ísíe 'fish, sp.'. Here Kuruaya /si/ corresponds to Mundurukú /so/. I suggest that Proto-Mundurukú **isɨe first developed into Pre-Mundurukú *isəe, and then into *soé* in Mundurukú, where ə > o and the initial vowel /i/ was deleted.

(44)	Proto-Mundurukú	Pre-Mundurukú	Mundurukú	
	**isɨe	*isəe	soé-dəp	'fish, sp.'

Another interpretation of the correspondence set IX is that the proto-vowel is **/i/ but changed its quality to /ə/ in modern Mundurukú (see Picanço 2004). In this case the proto-forms in (43) would be: ***oasĩ,* ***masik,* and ***kosi*, respectively. However, there is considerable evidence that the proto-vowel **ɨ, not **i, lowered to /ə/ in Mundurukú, irrespective of this environment. In this sense, the change **ɨ > ə is independent of any prohibition on the sequence *si*. Table 5.16 gives the correspondence ə/ɨ, which is reconstructed as **ɨ.

Table 5.16. Correspondence set X: ə/ɨ

Mundurukú	Kuruaya	Proto-Mundurukú	Gloss
pə̰y-bə́	pɨy	**pɨy	snake
təp / dəp	tɨp / lɨp	**tɨp / **Lɨp	leaf
to̰bə́y / do̰bə́y	tobɨy / lobɨy	**tobɨy / **Lobɨy	sling
o-kə̰	o-kɨʔ	**o-kɨʔ	my cultivated garden
abə́t	abɨt	**abɨt	an old lady
kəyáʤe	kɨyade	**kɨyaCe	the day after tomorrow
ʧə́ / ʤə́	ʧɨ / dɨ	**Cɨ / Dɨ	to go
o-bətét	o-bɨ́tet	**o-bɨtet	my name
i-ʧə̰k	i-ʧɨk	**i-Cɨk	It's cold.
ábə / abə́	abɨ	**abɨ	Who?
o̰-bə́	o-bɨʔ	**o-bɨʔ	my finger/hand
i-pərə́k	í-pɨrɨk	**i-pɨrɨk	It's smoked.

There is another historical source for /s/ in Mundurukú. Compare now the examples in the correspondence set XI in Table 5.17. Here Mundurukú has the sequence *psV* where Kuruaya has *biV*. Contrary to the cases examined above, this set cannot be reconstructed as Proto-Mundurukú **s.

Table 5.17. Correspondence set XI: psv/biv

Mundurukú	Kuruaya	Gloss
ipsóy	ibioy	duck
y-opsa	i-bia	his/her liver
kópsə̃́	kóbĩa [kṍmĩ-a̰]	insect, sp.

Following a proposal by Rodrigues (1995), these sequences are reconstructed as shown in (45), in which Mundurukú *psV* and Kuruaya *biV* are the reflexes of Proto-Mundurukú **piV.[7]

(45) Proto-Mundurukú **piV

Mu: psV Ku: biV

The reconstructed form **piV did not change much in Kuruaya, where it simply underwent voicing: **piV > biV. This may be because the three cases with this correspondence are all intervocalic; so far I have not found any cases word-initially. Thus voicing in Kuruaya may be attributed to the position where the sequence **piV occurred, i.e. intervocalically.

Conversely, **piV did not undergo voicing in Mundurukú. Here the changes are more complex, as shown in (46), and involve (i) the realization of /ʔ/ as creaky voice on the vowel: ***piʔV > piV̰; (ii) the realization of the sequence /pi/ as palatalization on the labial stop (p^j): **piV > p^jV; (iii) the change from a palatalized p^j to an affricate p^s: p^jV > p^sV; and (iv) finally, the reinterpretation of the affricate p^s as a sequence *p-s*: *p^s > p-s. (The difference between a sequence stop + fricative and an affricate was discussed in Chapter 4.)

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[7] Evidence for **piV comes from other Tupi languages (Rodrigues 1995). For example, the word for 'egg' corresponds to Aweti -upiʔa, Juruna ubiʔá, Mekens -upia, and Wayoro -ipia. In Mundurukú /ʔ/ was lost, leaving creaky voice on the vowel.

(46)	Pre-Proto-Mundurukú	***kopĩ-ʔa	***ipioy	***opi-ʔa
		insect-CL	duck	liver-CL
	ʔV → V̰	kopĩã̰	---	opia̰
	Proto-Mundurukú	**kopĩã̰	**ipioy	**opia̰
	Palatalization	kop^{j}ã̰	ip^{j}oy	op^{j}a̰
	Frication	kop^{s}ã̰	ip^{s}oy	op^{s}a̰
	Pre-Mundurukú	*kopsã̰	*ipsoy	*opsa̰
	Mundurukú	kóp.sə̃́	ip.sóy	op.sa̰
		'insect, sp.'	'duck'	'liver'

The historical facts thus show that s → ʃ /_i was never part of the grammar of Mundurukú. Consequently, there is no reason to assume a process such as s → ʃ /_i based solely on distributional patterns, i.e. the absence of *si* in native words versus the high number of sequences *ʃi* in the language. If sequences *si* were eliminated by deleting **s before /i/, or by changing the quality of the vowel, why should the absence of *si* in the native vocabulary be accounted for differently?

Let us assume for a moment that the language had a constraint prohibiting the sequence *si*, call it *si (i.e. a combination /s/ + /i/ is prohibited). To satisfy *si, deletion of /s/ was used as a strategy, not a palatalization process such as s → ʃ / _i. Therefore, if the language never invoked the process, why should we now say it does? Borrowings like *pasía* and *basíaʔá* are a good argument against this assumption, and are also an argument against the existence of a constraint *si. In this sense, deletion of /s/ may have been motivated by other factors, and the absence of *si* in native words may thus be regarded as an accidental gap.

5.8 On the history of /ʃ/

We have already seen in §5.6 that one of the historical sources for /ʃi/ in Mundurukú was the change *ʧi > ʃi. This section examines another change that also resulted in the sequence /ʃi/, namely **k^{j}V > ʧi > ʃi. The proto-sequence is represented here as **k^{j}V because the data does not suffice to determine the exact quality of the vowel that triggered palatalization of Proto-Mundurukú **k (but see below).

It is important to note that Kuruaya lacks the sequences *ʃi* and *ʃɨ*, and Mundurukú lacks the sequence *ʃə*. In Mundurukú, *ʃi* developed out of Pre-Mundurukú *ʧi and **k^{j}V. As for **ʃə*, this restriction will be discussed shortly.

First, let us consider the correspondence ʃ/ʃ for which the proto-phoneme *ʃ is reconstructed.

Table 5.18. Correspondence set XII: ʃ/ʃ

Mundurukú	Kuruaya	Proto-Mundurukú	Gloss
ʃaʔíp	ʃaʔíp	**ʃaʔip	piquiá tree
daʃá	láʃa	**Laʃa	fire/firewood
oʃét	óʃetkɨʔ	**oʃet	I slept.
wḭʃa̰	wíʃaʔ	**wiʃaʔ	ant, sp.
daʃéw	láʃoy	**Laʃew/oy	fish, sp.
toʃáw	tóʃaw	**toʃaw	chief

Now consider the second set. Mundurukú has *ʃi* where Kuruaya has *ki*.

Table 5.19. Correspondence set XIII: ʃi/ki

Mundurukú	Kuruaya	Gloss
ʃirí	kíri	‘a little parrot’
taʃíp	tákip	‘It’s hot.’
ʃĩn	kĩn	‘pancake’
ʃiʤáp	kídap	‘shelter’
iʃeé	ikíe	‘his/her skin’
oda̰ʃḭt	olakit	‘my daughter (male speech)’

In Table 5.19 we find that the palatal fricative /ʃ/ corresponds to Kuruaya /k/ before the high vowel /i/. At first glance, this correspondence suggests that the Proto-Mundurukú sequence **ki underwent a process of palatalization, followed by loss of the stop component: **ki > *ʧi > ʃi. However, the existence of forms whose sequences /ki/ were not affected shows that palatalization may not have been triggered by **/i/. A change such as **ki > *ʧi > ʃi should have left a gap in the distribution of /k/, because it would have eliminated sequences *ki* altogether. However, this is not the synchronic pattern, and sequences *ki* are found in Mundurukú, as (47) illustrates.

(47)	(a)	akíriʧé	'dog'	
	(b)	kíp	'louse'	
	(c)	tabəkĩ	'fish, sp.'	(from Portuguese *tambaqui*)
	(d)	kisé	'knife'	
	(e)	bekít	'child'	
	(f)	akiʤə́	'yard'	
	(g)	ikítpit	'younger brother of a man'	
	(h)	ikibḭt	'younger sister of a woman'	
	(i)	okipít	'my younger brother (female speech)'	
	(j)	iba̰íkíbi	'his/her shoulder'	
	(k)	ikit	'It's unripe, green'	
	(l)	saríkíta	'manioc flour'	

For some of these we find corresponding words in Kuruaya, a fact that give us basis to reconstruct sequences /ki/ as **ki in Proto-Mundurukú.

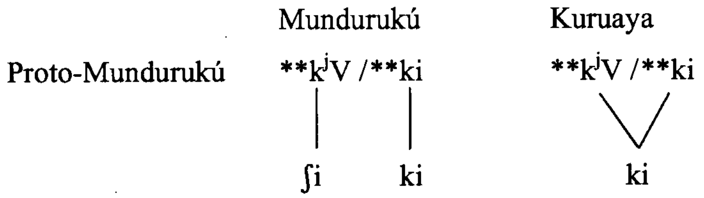
(48)	Mundurukú	Kuruaya	Proto-Mundurukú	Gloss
(a)	kíp	kíp	**kip	'louse'
(b)	bekít	bɨ́kit	**bɨkit	'child'

The issue here is that Kuruaya has a sequence /ki/ corresponding to two sequences in Mundurukú, /ki/ versus /ʃi/. We cannot reconstruct both as **ki because palatalization, if it applied regularly, should have affected all proto-sequences **ki.

An alternative hypothesis then is that the difference between the correspondences ʃi/ki and ki/ki is due to a difference in the quality of the vowels that followed the proto-phoneme **k. For the correspondence ʃi/ki, I propose the pre-proto-sequence ***kV, which was already in the process of palatalization in Proto-Mundurukú, thus **k^jV. The exact quality of this vowel is not clear at this point, but there are some indications. For example, the word for 'hot' – *taʃíp* in Mundurukú and *takip* in Kuruaya – corresponds to *okɨ* in Karitiana, *-akup* in Aweti, *-akup* in Mawé, *akop* in Tupari, and is reconstructed as **-akup for Proto-Tupi (Rodrigues 1995). This suggests that the pre-proto-sequence might have been ***ku, which was realized as **k^ju in Proto-Mundurukú. However, given that this is the only case found thus far, I will make use of the notation ***kV/**k^jV.

As for the correspondence ki/ki, we can reconstruct it as **ki for Proto-Mundurukú. Thus **k^jV and **ki were kept distinct in Mundurukú; their reflexes are the sequences /ʃi/ and /ki/ respectively; but in Kuruaya, **k^jV and **ki merged, and we now find only the sequence /ki/. Although it is proposed that **k^j and **ki coexisted in Proto-Mundurukú, I do not mean to imply that they were independent phonemes; they might have been allophones of **k.

(49)



These changes are illustrated below. The hypothesis is that between Proto-Mundurukú and Pre-Mundurukú, **k^j was realized as a plain affricate *ʧ and, consequently, merged with *ʧ that originated from ***Ci, examined in §5.6. This explains why Mundurukú has only /ʃi/ as the reflex of both ***Ci and ***kV. If ***kV became *ʧi in Pre-Mundurukú, then the change *ʧi > ʃi included not only the reflexes of ***Ci but also those of ***kV.

(50)	Pre-Proto-Mundurukú	***Cik	***takVp	***kip
	Proto-Mundurukú	**ʧik	**takʲVp	**kip
	Pre-Mundurukú	*ʧik	*taʧip	*kip
	Mundurukú	ʃík	taʃíp	kíp
		‘mosquito’	‘be hot’	‘louse’

Turning now to the absence of /ʃ/ before /ə/, neither Mundurukú nor Kuruaya have this sequence; precisely, the restrictions are *ʃɨ in Kuruaya and *ʃə in Mundurukú. There is synchronic evidence from alternations that the sequence /ʃə/ is in fact prohibited in Mundurukú. Consider now a pattern of reduplication with a fixed vowel /ə́/ ‘not so’, illustrated below.

(51) (a) i-pak-pə́k ‘It’s not so red.’

3Su-be.red-RED

(b) y-apĩ́n-pə̃́n ‘It’s not so short.’

3Su-be.short-RED

If the base contains /ʃ/, as in the following examples, this consonant is not copied because a sequence *ʃə* would emerge in the reduplicant. Instead, /ʃ/ is replaced by /s/.

(52) (a) i-poʃí-sə́ ‘It’s not so heavy.’ *ipoʃíʃə́

3Su-be.heavy-RED

(b) t-aʃíp-sə́p ‘It’s not so hot.’ *taʃípʃə́p

3Su-be.hot-RED

We must thus assume that the language prohibits a combination /ʃ/ + /ə/, which is here represented by the constraint *ʃə.

(53) *ʃə – A sequence *ʃə* is prohibited.

An analysis of the prohibition *ʃə in reduplication is offered in Chapter 9, where reduplication with fixed vowels are examined.

5.9 Conclusion

To sum up, from the eleven restrictions identified in the beginning of this chapter (*wo, *yi, *ʔy̰, *dṽ, *ʧi, *ʤi, *si, *ʃə, *mi, *ni, *ŋi), five are accidental (*ʧi, *ʤi, *si, *ni, *ŋi), as the result of various sound changes; and five are systematic (*dṽ, *wo, *yi, *ʔy̰, *ʃə), in the sense that there is synchronic evidence that the grammar disallows these sequences. There is one, *mi, for which I have not found a diachronic explanation; but it is worth noting that the sequence [mi] does occur in borrowings: *kamiʃá* 'shirt', from Portuguese *camisa*. Thus, this too may be considered as accidental. For these, I assume that they are not prohibitions, but simply gaps in the distribution of the respective consonants.

All the changes and their consequences for the grammar can be summarized as follows.

*Change **L > *d.* In Mundurukú /d/ and /n/ developed out of the proto-phoneme **L. This consonant underwent fortition in Pre-Mundurukú, where it was realized as *d, and had two allophones: [d] in oral environments and [n] in nasal environments.

*Change in nasal harmony and the split *d > d/n.* Between Pre-Mundurukú and the modern period, nasal harmony changed into a system with opaque segments. This change caused the allophones [d] and [n] of the pre-phoneme *d to be phonologized as /d/ and /n/, respectively, according to the environments they occurred. This change affected the phonemic inventory because a new contrast between /d/ and /n/ emerged. The most significant consequence was a gap left in the distribution of /d/, which ended up restricted to oral contexts. This explains the emergence of the phonotactic restriction *dṽ in the language.

Conflict with consonant mutation. The change *d > d/n had also an effect on grammatical structure because it came to be in conflict with a morphophological alternation: voicing alternation. After the change, speakers had to choose either the oral or nasal variant to represent the voiced variant of some morphemes. The change *d > d/n determined that all /n/'s should be preserved where they occurred previously, regardless whether the following vowel was underlyingly nasal or nasalized via spreading, but consonant mutation determined that the oral variant was generally /d/ unless the following vowel was nasal. This confict caused the re-interpretation of the gap in the distribution of /d/ as a language-specific constraint: *dṽ.

The change ***L > **n > r / _i. The absence of the sequence *ni* in Mundurukú was explained by another sound change in which **L was realized as Proto-Mundurukú **n before the high vowel. This **n later developed into /r/ in Mundurukú.

The restrictions *ci, *ji, *and* *ɲi [ɲi] are all explained by the change ***C > **ʧ, **D > *ʧ/*ʤ > ʧ, ʃ, ʤ, [ɲ]. The change ***C > **ʧ, **D, eliminated the sequence **Di already in Proto-Mundurukú; subsequent changes turned **D into Mundurukú /ʤ/ and [ɲ], but these never included the vowel /i/. Between Pre-Mundurukú and the modern period, *ʧ > ʃ / _i, eliminating all sequences *ʧi* in the language and filling in the gap on the distribution of /ʃ/ which did not occur before /i/. Another source for /ʃi/ was the change ***kV > **k^{j}V > *ʧi > ʃi which overlapped with the change ***Ci > **ʧi > ʃi.

Deletion of **s. The proto-phoneme **s was deleted before the high vowel, causing another gap in the language: the absence of sequences *si* in the native vocabulary. The fact that the language has acquired borrowings with sequences *si* shows that synchronically there is no such a restriction on these sequences.

CHAPTER 6

Nasal Harmony

6.1 Introduction

In examining the history of the phonotactic restrictions in Mundurukú, I pointed out several times the importance of nasalization in the language. In this chapter, I provide an OT analysis of the synchronic nasalization systems of Mundurukú (§6.4) and Kuruaya (§6.5), in addition to an OT account of the historical changes that gave rise to the system found presently in Mundurukú (§6.6). Several issues are addressed here. First, I argue for an approach in terms of the OCP-subsidiary feature effects (Padgett 1991), proposing that two features must be considered in nasal harmony phenomena: [sonorant] and [voice] (§6.3.3). Second, it is proposed that transparency and opacity in nasal harmony are very similar, and do not require a reranking of constraints. I demonstrate this with the analyses of Mundurukú, a system with opacity, and Kuruaya, a system with transparency. These languages have the same ranking of constraints, but with one crucial difference: the sequential prohibition *ORAL NASAL (Pulleyblank 2002) is defined locally for Mundurukú and non-locally for Kuruaya, but in both languages the ranking is *ORAL NASAL >> DEPPATH. Third, in §6.4.2 I speculate about the relation trigger-target, suggesting that there is a correlation between triggers and targets; languages tend to include a greater number of segments in the process if the trigger is a nasal vowel, than if the trigger is a nasal consonant. I conclude the chapter by comparing Mundurukú and Kuruaya, and providing an OT account of the relative chronology of the changes in nasal harmony.

I begin by presenting the data relevant to the analysis of Mundurukú.

6.2 Nasal harmony: general aspects

Mundurukú does not only exhibit a contrast between oral and nasal vowels, discussed in Chapter 2, but nasal vowels exhibit the property of spreading nasality to adjacent segments. The pair in (1) illustrates the oral-nasal opposition and nasal spread.

(1) (a) o-é-ʔə̃ → õẽ́ʔ̃ə̃ 'S/he died.'
3Su-Poss-not.exist

(b) i-éə → iéə 'It's swollen.'
3Su-be.swollen

On descriptive grounds, nasal harmony has the following properties.

(i) Nasalization is triggered by a nasal vowel.

(ii) It targets the class of [+sonorant] segments: vowels, nasals and approximants (w, y, r, ʔ, h). A justification for the classification of the laryngeals /ʔ, h/ as [+sonorant] is provided in §6.4.1.

(iii) It is blocked by the class of [-sonorant] segments: stops and fricatives.

(iv) Nasalization is regressive.

Nasal harmony is illustrated in the following data. They show the participation of the liquid /r/, in (2)a-c, glides /w, y/, in (2)d-f, and nasals, in (2)g-h.

(2) (a)	/ə́rə̃́/	→	ə̃́r̃ə̃́	'maracanã bird'
(b)	/kororṍŋ-ta/	→	kõr̃õr̃ṍŋta	'cicada'
	cicada-CL			
(c)	/bórṍ-bə/	→	bṍr̃ṍbə	'cotton string'
	cotton-CL			
(d)	/waẽn/	→	w̃ãẽn	'oven'
(e)	/káwẽ́-di/	→	kã́w̃ẽ́di	'beverage'
	beverage-CL			
(f)	/wayõm-pə́/	→	w̃ãỹõmpə́	'tipiti' (artifact for squeezing manioc)
	tipiti-CL			
(g)	/wenə̃-ʔíp/	→	w̃ẽnə̃ʔíp	'Brazil nut tree'
	nut-CL			
(h)	/e-nə̃́y/	→	ẽnə̃́ỹ	'your teeth'[1]
	2-tooth			

---

[1] A glide in coda position also assimilates nasality from a nasal vowel, but here I will not deal with rightward spread.

The following examples illustrate the participation of the laryngeals /ʔ, h/. A justification for assuming that they are phonologically nasalized in nasal harmony is presented in §6.4.1.

(3)	(a)	/e-ṍhṍ/	→	ẽṍh̃ṍ	'your domestic animal'
		2-domestic.animal			
	(b)	/ã́ihĩ́/	→	ã́ĩh̃ĩ́	'mother' (Vocative)
	(c)	/w-aʔṍ/	→	w̃ãʔ̃ṍ	'my speech, language'
		1-voice			
	(d)	/ka-ʔṍŋ-tot/	→	kãʔ̃ṍŋtot	'broom'
		thing-sweep-CL			
	(e)	/w-e-ʔẽ/	→	w̃ẽʔ̃ẽ	'my mortar'
		1-Poss-mortar			
	(f)	/pira-ʔẽ́/	→	pĩr̃ãʔ̃ẽ́	'cured fish'
		fish-cured			

Nasality spreads throughtout an entire word, unless it encounters an obstruent (a stop or fricative) which interrupts the process. This is shown by the examples below; (4)a-c show blocking by voiceless stops, (4)d-e by voiced stops, and (4)f-g by fricatives.

(4)	(a)	/ʧókṍn/	→	ʧókṍn	'toucan'
	(b)	/wapərə̃m/	→	wapə̃r̃ə̃m	'açaí palm'
	(c)	/ikoérṍ/	→	ikõẽ́r̃ṍ	'fly'
	(d)	/kaʤarã́w-ʔa/	→	kaʤãr̃ã́w̃ʔa	'a big pot'
		pot-CL			

(e) /w-e-bórṍ-bə/ → webṍrṍbə ‘my cotton string’
1-Poss-cotton-CL

(f) /pósə̃́ŋ/ → pósə̃́ŋ ‘medicine’

(g) /iʃíwã́-ʔa/ → iʃĩ́wã́ʔa ‘fish, sp.’
fish-CL

All these aspects will be examined in the following sections. §6.3 deals with theoretical assumptions necessary for the analysis, including the issue on locality conditions (§6.3.1), (in)compatibility with features (§6.3.2) and harmony as the result of the OCP constraint (§6.3.3). OT accounts of nasal harmony in Mundurukú and Kuruaya are proposed in §6.4 and §6.5, respectively. The participation of laryngeals in nasalization is examined separately in §6.4.1 where I defend the idea that the phonetic realization of /ʔ, h/ in the language permits us to assume that they are compatible with nasalization. In §6.4.2 I explore the nature of the relation triggers versus targets in nasal harmony, suggesting that languages tend to include more targets in the process if the trigger is a nasal vowel, whereas the number of targets is smaller if the trigger is a nasal consonant. This observation is based on Walker's (1998) nasal harmony database. I then turn to the diachronic aspects of nasal harmony and provide an OT account of the relative chronology that gave rise to the modern system of Mundurukú. In addition, I discuss the consequences of this change for the synchronic grammar, and how it explains the irregularities of the process.

First let me introduce some theoretical points that will be relevant for the analysis. Here I make use of two fundamentals: one is locality on nasal harmony, the other is grounding conditions, in the spirit of Archangeli and Pulleyblank (1994).

6.3 Theoretical assumptions

6.3.1 Locality

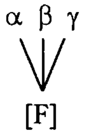
A major obstacle linguists face in analyzing harmony phenomena is the local versus non-local character of a harmonic feature [F]. In one view (e.g. Goldsmith 1976), skipping a segment β is tolerated if β lacks specifications required for [F].

(5)

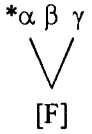
Where α, β, γ are any segments, and F is any feature

Others (e.g. Archangeli and Pulleyblank 1994; McCarthy 1994; Flemming 1995; Gafos 1996; Ní Chiosáin and Padgett 1997; Walker 1998) argue for strict segmental locality in the sense that every segment within the domain of [F] is participant, (6)a; gapped configurations, as in (6)b, are in this view considered to be universally ill-formed.

(6) (a)

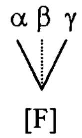


(b)



For cases of harmony with transparent segments, the configuration in (6)a relies on the assumption that that β still realizes (is coarticulated with) [F], but because coarticulation is weak, it is invisible to the phonology (Ní Chiosáin and Padgett 1997). (7) shows schematically how strict locality is satisfied. The dashed line indicates that β realizes [F] but only at the phonetic level.

(7)



Phonetic level: α, β, γ realize [F].

Phonological level: only α, γ are legitimate targets for [F].

In the analysis of nasal harmony in Mundurukú (§6.4) and Kuruaya (§6.5), I also argue for strict segmental locality, i.e. nasality must spread from segment to segment. I am, however, careful in adopting strict adjacency as advocated by Ní Chiosáin and Padgett. In their view, locality is a phonological principle that must be respected at the phonetic level. [F] overlaps the articulatory configuration for β (locality is phonetically respected), but the effect is *not enough* to be phonologically relevant. In a view that tries to integrate phonetics and phonology, the question is: How much must a feature affect a segment so to be regarded as 'phonologically relevant'?

Mundurukú and Kuruaya exhibit an important difference. Mundurukú has a system in which sonorants undergo nasalization and voiced and voiceless obstruents block the process; Kuruaya, on the other hand, has a system in which sonorants and voiced obstruents undergo nasalization and voiceless obstruents are transparent (see details in §6.5). The problem here is transparency. According to Ní Chiosáin and Padgett, to validate [nasal] on both vowels in a sequence such as *áporĩm* → *ã́põr̃ĩm* 'açaí palm', nasalization must also be phonetically realized in the stop. This implies that the language realizes [p] with a lowered velum if surrounded by nasalized vowels. From the point of view of the phonology, however, nasality on [p] is *not enough* to be relevant. Here 'not enough' may be interpreted in two ways. One is that the velum remains lowered until shortly after the oral closure for [p], prenasalizing the stop: [ã^{m}põ…]. Another interpretation is that the velum remains *slightly* open during the production of [p], while it is fully open for the vowels: [ã̃p̃õ̃…]. (A double tilde is to indicate that nasalization on vowels is heavier than nasalization on [p].)

In the first case, [ã^{m}põ…], nasalization overlaps articulation for [p], but lowering of the velum is not a continuous gesture; it lowers for the first vowel, then closes for most part of [p], and lowers again for the following vowel. This is not consistent with the configuration in (7), which treats harmonic features as a continous, uninterrupted gesture.

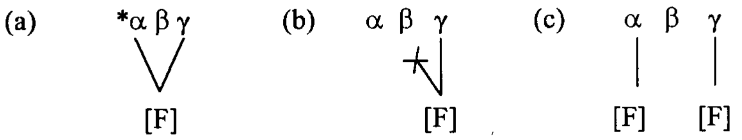
In the second case, nasality is a continous gesture, that is, the velum remains lowered throughout the entire sequence, but the velic gesture must be synchronized so that nasalization on [p] must not be equivalent to nasalization on the vowels, otherwise it would be phonologically relevant. Even though this is consistent with the configuration in (7), a nasalized [p̃] is not articulatorily plausible since buccal segments and velum lowering are incompatible. As Ohala and Ohala (1993: 227) explain, "the velic valve must be closed (i.e. the soft palate must be elevated) for an obstruent articulated further forward than the point where the velic valve joins the nasal cavity and the oral cavity."

Another problem in generalizing the coarticulatory effects of harmonic features at an abstract level is the conflict it creates between phonetic and phonological effects. A general assumption about coarticulatory effects is that they do not involve manipulation of feature values (Keating 1995). On the contrary, coarticulatory effects are governed by phonological distinctions – the more contrasts need be maintained, the weaker the coarticulatory effects (Solé 1992). Consider again the case of transparent obstruents. Nasality targets a different set of segments, but in Ní Chiosáin and Padgett's approach, all segments must realize the feature in order to satisfy locality. To achieve this, the realization of [+nasal] must be manipulated in such a way that the outcome cannot be interpreted by the phonology as a legitimate target. In other words, the amount of nasalization in a non-target must be controlled so to avoid a conflict with the phonology. This can no longer be considered as a coarticulatory effect, but a phonological property that would define certain segments as being specifically 'non-targets'.

Furthermore, (7) discards the generalization of featural compatibility by treating any segment as compatible with [F]. In assuming that [F] is coarticulated with β, we must also assume that β does not resist [F], and it is well known that interpolation due to coarticulation depends mostly on the segment's coarticulatory resistance (Blandon and Nolan 1977). Lindblom (1983) makes use of the notion *coarticulatory propensity* to say that coarticulatory effects may be minimized to resolve conflicts related to incompatiblity of feature combinations. The more β resists [F], the less coarticulatory effects there will be between [F] and β. While this may not be the case for a number of harmonic features (see Ní Chiosáin and Padgett for some examples), a similar generalization does not hold for the feature [+nasal], and there is evidence showing that transparent oral obstruents in nasal harmony phenomena remain oral (e.g. Walker 1998).

From all this it follows that it is difficult to quantify the different degrees of featural overlapping to obtain substantial evidence for the universal validity of the structure in (7) as a way of satisfying locality in harmony phenomena. Here I pursue a hypothesis that recognizes a gapped configuration as universally ill-formed, (8)a. β is, in principle, a potential target within the domain of a harmonic feature [F], but the realization of [F] in β depends crucially on one factor: β must be compatible with [F] (see next in §6.3.2 for details in what features are compatible with [nasal]). If β is not compatible with [F] and intercalates two legitimate targets, [F] is interrupted, as in (8)b. The 'transparency' effect arises if a requirement demanding [F] to be manifested in all compatible segments overrides the incompatibility of β with [F], forcing the phonology to 'repeat' the gesture after it has been interrupted, (8)c.

(8)



In this approach the feature [+nasal] can be a continuous gesture, but only if all segments in the domain are compatible with it; incompatibility causes interruption (blocking) or discontinuity (transparency) of the gesture.

6.3.2 Grounding conditions

Archangeli and Pulleyblank (1994) brought forth, among other things, the core aspects of the relation between phonetics and phonology: grounding conditions, defined in (9). They argue for a model in which statements governing cooccurrence of features (path conditions) are phonetically motivated.

(9) Grounding Conditions (Archangeli and Pulleyblank 1994: 177)

- I. Path conditions invoked by languages must be phonetically motivated.
- II. The stronger the motivation for a path condition Φ,
  - a. the greater the likelihood of invoking Φ,
  - b. the greater the likelihood of assigning a wide scope to Φ within a grammar; and vice versa.

In all surveys of nasal harmony (e.g. Piggott 1992; Cohn 1993; Walker 1998; see also Pulleyblank 1989), the general observation is that vowels exhibit the strongest interaction with nasalization, whereas voiceless obstruents are typically neutral. Following vowels, we find glides and then liquids. In the other extreme we find obstruents, i.e. stops and fricatives, which often resist nasalization. But if obstruents are targets in nasal harmony, it is the class of [+voiced] obstruents that is more likely to be affected. Thus, vowels, glides and liquids compose a class of segments that is most compatible with nasality, the class of [+sonorant]; obstruents form the class of least compatibility with [+nasal]. The interplay of nasality and certain types of segments is schematized in (10).

(10) Compatiblity with [nasal]

Vowels Glides Liquids Voiced obstruents Voiceless obtruents
Stronger ←——————————————→ Weaker
[+sonorant] [-sonorant]

The feature [sonorant] can be used to distinguish two classes of segments that are (in)compatible with the feature [+nasal]: [+sonorant] is the most compatible, and [-sonorant] is the least compatible. This permits us to invoke a feature cooccurrence condition as defined below, following Archangeli and Pulleyblank (1994).

(11) Grounding condition:

- (i) If [+nasal], then [+sonorant]; or
- (ii) If [+nasal], then not [-sonorant].

The grounding condition is implemented here as a markedness constraint, NAS/SON.

(12) NAS/SON – If [+nasal], then [+sonorant].

An important prediction of Nas/Son is shown below. The constraint is satisfied as long as the output is [+sonorant], as in the case of an obstruent (e.g. /t/) that is realized as a plain nasal ([n]), but is violated if the output is either partially nasalized ([^{n}t]).

(13) Effects of Nas/Son.

Input	Output	Nas/Son
vtv | [nas]	a. ṽnṽ ↘ [n]	✓
	b. ṽ^{n}tṽ ↘ [n]	*

In addition to [+sonorant], another feature that is compatible with [+nasal] is [+voice]. In systems where nasality is not blocked, voiceless obstruents behave transparent, and voiced obstruents typically participate in the process by assimilating the feature completely. There is an interesting relation here: like glides and liquids, voiced obstruents may undergo or block nasalization, but rarely behave transparent. Voiceless obstruents, on the other hand, are either transparent or blockers, but not targets. Thus, while any segment can block nasality, only some undergo the process (see also Walker 1998). Based on this observation, I suggest that in addition to [+sonorant], the feature [+voice] is what brings obstruents closer to the group of targets in nasal harmony. The interaction between [+nasal] and sonorants is expected to be the strongest, but voiced segments are also likely to be associated with the feature. Conversely, little interaction is expected with segments that are neither sonorants nor voiced, i.e. voiceless obstruents.

I propose that the relation between voicing and nasality is based on phonetic similarity; voiced obstruents and nasal segments have in common the property of being phonetically voiced, and this similarity makes a difference in nasal harmony where the more similar elements are, the stronger the interaction (see further discussion next in §6.3.3). In general, harmony is based on (i) the segment's compatibility with the feature [+nasal], and (ii) its similarity to the source for [+nasal].

6.3.3 Harmony via no-disagreement (Pulleyblank 2002)

Pulleyblank (2002, following Smolensky 1993) proposes deriving harmony by prohibiting feature disharmony (*F G). Pulleyblank's proposal unifies harmony with the Obligatory Contour Principle (OCP). In the same way the OCP disallows sequences of identical elements, it also disallows featural disagreement.

(14) Sequential prohibition (Pulleyblank 2002)

*X...Y: A sequence of X, Y on a tier is prohibited.

Sequential prohibitions enforce adjacent segments to share the same value of a given feature. In the context of our discussion, the prohibition is on a sequence oral + nasal. The constraint proposed is *ORAL NASAL (Pulleyblank 2002), which evaluates segment-to-segment, irrespective of their compatibility with the feature [+nasal].

(15) *ORAL NASAL (*OR NAS)

A [+nasal] segment may not be preceded by a [-nasal] segment.

To bring the hypothesis of harmony via no-disagreement even closer to the OCP-effects, in the accounts of nasal harmony in Mundurukú and Kuruaya, *ORAL NASAL is instantiated as a constraint that holds more strongly between segments sharing some additional feature(s), also known as the OCP-subsidiary features effects (Suzuki 1998; Padgett 1991; McCarthy 1986, 1994; Mester 1986; Selkirk 1988, 1993; Yip 1989; Pierrehumbert 1993). The idea is that *ORAL NASAL enforces assimilation if adjacent segments share subsidiary features that are most compatible with [+nasal]. These features are, according to the scale in (10) above, [+sonorant] and [+voiced]. The feature [+voiced] is used here to describe any sound that involves vibration of the vocal folds; it is redundant in sonorants but still relevant in nasal harmony, as discussed earlier (see also §6.5.)

Given these two features, [+sonorant] and [+voiced], languages may invoke one or both. For example, the set of targets in Mundurukú includes [+sonorant] segments, as shown in (16). They also share [+voiced], but this feature cannot be invoked because voiced stops are non-targets. Kuruaya, on the other hand, makes use of both features, as we will see in §6.5. (The laryngeals /ʔ, h/ also belong to the group of targets, but these are examined separately in §6.4.1.)

(16) Features for vowels, glides, liquid, obstruents in Mundurukú

	Source	Targets				Non-targets	
	Ṽ	V	w/y	r	N	Stops	Frics
sonorant	+	+	+	+	+	-	-
voiced	(+)	(+)	(+)	(+)	(+)	+/-	-

The OCP-subsidiary feature effect states that two segments must agree for [+nasal] if they already share [+sonorant]. The revised version of the sequential prohibition *ORAL NASAL is provided in (17).

(17) *ORAL NASAL

A [+nasal] segment may not be preceded by a [-nasal] segment if they share the feature [+sonorant].

(18) illustrates the effect of *ORAL NASAL. Given three sequences, stop + Ṽ (e.g. bṼ), glide + Ṽ (e.g. wṼ), and nasal + Ṽ (e.g. mṼ), *ORAL NASAL is violated in the sequence wṼ because glides and vowels share the feature [+sonorant], and this feature is compatible with [+nasal]; therefore both must share [+nasal].

(18)	(a)	b	Ṽ	(b)	*w	Ṽ	(c)	m	Ṽ
[son]		-	+		+	+		+	+
[nas]		-	+		-	+		+	+
*OR NAS		Respected			Violated			Respected	

Let us now consider the issue of adjacency. Here I adopt a two-way distinction of proximity between trigger and target: (i) local – i.e. segment-to-segment: * ORAL-NASAL; and (ii) non-local – i.e. one or more segments intervene between trigger and target: *ORAL...NASAL. This scale is in the spirit of Suzuki (1998; see also Pulleyblank 2002) in that proximity is seen as a harmonic scale, as in (19). However, a two-way distinction between local and non-local suffices for the analyses of Mundurukú and Kuruaya.

(19) Proximity hierarchy (Suzuki 1998: 82)

$*X...X = \{*XX >> *X\text{-}C_0\text{-}X >> *X\text{-}\mu\text{-}X >> *X\text{-}\mu\mu\text{-}X >> \ldots >> *X\text{-}\infty\text{-}X\}$

The local version of *ORAL NASAL is as follows.

(20) *ORAL-NASAL (to be revised)

A [+nasal] segment may not be *immediately* preceded by a [-nasal] segment if they share the feature [+sonorant].

Contrary to Kuruaya (to be examined in §6.5), Mundurukú [+nasal] propagation is from segment to segment, regarding that all segments are specified for the relevant feature.

6.4 Nasal harmony in Mundurukú

The advantage of enforcing harmony based on subsidiary features helps resolve the issue concerning blocking. The hypothesis proposed in the account of nasal harmony in the Mundurukú family is that nasality targets specific groups of segments. Once this requirement is satisfied, any extra association of the feature with a non-target is penalized. The constraint that penalizes associations that deviate from the input is DEPPATH (Pulleyblank 1996), here formulated as DEPPATH[nasal]. Conversely, the constraint that prevents loss of [+nasal] associations is MAXPATH[nasal], introduced in Chapter 4, and reproduced below; if [+nasal] is in the underlying representation of a segment, then it must also be present on the surface.

(21) (a) MAXPATH[nasal]
Any input path between [+nasal] and an anchor must have a correspondent path in the input.

(b) DEPPATH[nasal]
Any output path between [+nasal] and an anchor must have a correspondent path in the input.

In the general case, segments that are targets to the harmonic feature necessarily violate DEPPATH[nasal]; but once this requirement has been satisfied, any other association will be fatal. The ranking is given in (22). Recall that NAS/SON is an alternative to distinguish a class of segments that is most compatible with nasality, as discussed earlier in §6.3.2.

(22) Mundurukú ranking
MAXPATH[nas], NAS/SON >> *OR-NAS >> DEPPATH[nas]

With this ranking, vowels that are underlyingly oral remain oral. A path between [nasal] and an anchor cannot surface in the output, unless it is already associated with a vowel in the input. Interestingly, the ranking makes it unnecessary to posit a highly-ranked constraint against featural insertion, namely DEP[nasal].

Tableau 6.1. Input: *aró* 'parrot'.

aró	MaxPath[nas]	Nas/Son	*Or-Nas	DepPath[nas]
a. ãr̃ṍ \/ [n]				*!**
b. arṍ | [n]			*!	*
c. ☞ aró				

When [+nasal] is underlyingly assigned to a vowel, harmony is obligatory if the adjacent segments are also [+sonorant]. The following tableau illustrates propagation of nasality. In a sequence formed only by sonorants, the ranking MaxPath[nas], Nas/Son, *Or-Nas >> DepPath[nas] determines that nasality be shared by all sonorants in the sequence.

Tableau 6.2. Nasal propagation in a sequence of sonorants: *ə́rə̃́* → *ə̃́r̃ə̃́* 'maracanã (bird, sp.)'.

ə́rə̃́ | [nas]	MaxPath[nas]	Nas/Son	*Or-Nas	DepPath[nas]
a. ☞ ə̃́r̃ə̃́ \/ [n]				**
b. ə́rə̃́ | [n]			*!	
c. ə́rə́	*!			

Tableau 6.3 illustrates opacity. Once all sonorants in a sequence have been associated with the feature [+nasal], *Or-Nas is satisfied. From this point on, any association of the harmonic feature counts as a fatal violation of DepPath[nas]. This constraint is necessarily violated, but violations are tolerated only to satisfy the high-ranking status of *Or-Nas. When a [+nasal] feature reaches a non-target, propagation of nasality must be interrupted. This is the reason why candidate (b) loses, and (c) wins. Note also that DepPath[nas] treats multiply linked features and insertion of features similarly. Even if we assume that the feature [+nasal] skips the stop in a form such as *ĩkõẽ́r̃ṍ*, this candidate would be also excluded by DepPath[nas].

Tableau 6.3. Opacity with voiceless obstruents: *ikoérṍ* → *ikõẽ́r̃ṍ* 'fly'.

ikoérṍ [nas]	MAX PATH[nas]	NAS/SON	*OR-NAS	DEP PATH[nas]
a. ĩ^{ŋ}kõẽ́r̃ṍ [n]		*!		*****
b. ĩkõẽ́r̃ṍ [n] [n]				****!
c. ☞ ikõẽ́r̃ṍ [n]				***
d. ikoérṍ [n]			*!	
e. ikoéró	*!			

Amongst obstruents, voiced stops are also compatible with nasality, as discussed earlier in §6.3.2 (see also §6.5). But in Mundurukú they block nasal spread.

Tableau 6.4. Opacity with voiced obstruents: *bórṍ* → *bṍr̃ṍ* 'cotton plant'.

bórṍ [nas]	MAX PATH[nas]	NAS/SON	*OR-NAS	DEP PATH[nas]
a. ☞ bṍr̃ṍ [n]				**
b. mṍr̃ṍ [n]				***!
c. bórṍ [n]			*!	

6.4.1 *The behavior of laryngeals*

In nasal harmony, the laryngeals /ʔ, h/ are also targets of nasality. Nasal propagation through /ʔ/ is illustrated in (23), and through /h/ in (24).

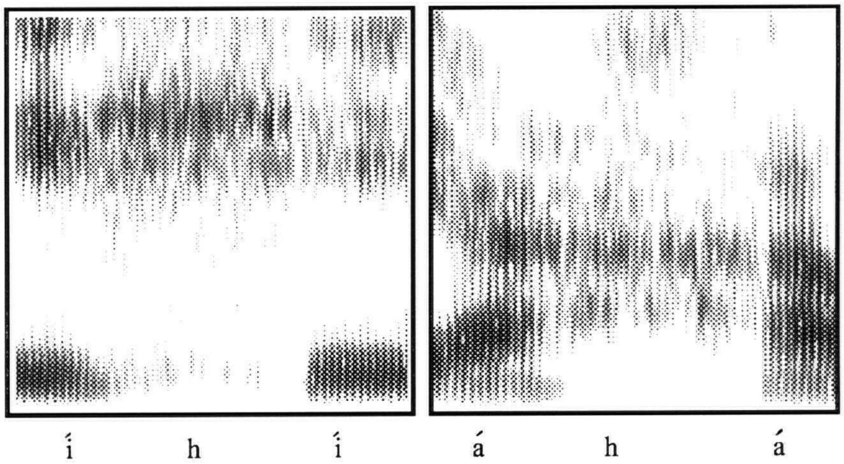
(23) (a) w-aʔõ → w̃ãʔ̃ṍ 'my speech, language'

1-voice

	(b)	ka-ʔṍŋ-tot	→	kãʔ̃ṍŋtot	‘broom’
		thing-sweep-CL			
	(c)	w-e-ʔẽ	→	w̃ẽʔ̃ẽ	‘my mortar’
		1-Poss-mortar			
	(d)	pira-ʔẽ́	→	pĩr̃ãʔ̃ẽ́	‘cured fish’
		fish-cured			
(24)	(a)	e-ṍhṍ	→	ẽṍh̃ṍ	‘your domestic animal’
		2-domestic.animal			
	(b)	t-aẽ́-hẽ́-m	→	tãẽ́h̃ẽ́m	‘to choose s.t.’
		3Ob-choose-RED-IMPRF			
	(c)	ã́ihĩ́	→	ã́ih̃ĩ́	‘mother’ (Voc.)

The analysis of nasal spread in Mundurukú is crucially one of featural compatibility, in which [+sonorant] plays a central role. Laryngeals do not pose a problem because they fall into this group, as proposed in Chapter 3. (See also Chomsky and Halle 1968 who treat them as [+sonorant].) The acoustic investigation of /h/ and /ʔ/ showed that their phonetic realizations depend largely on the context. For example, the two spectrograms below show that there is no change in the formant structures for the vowels preceding and following /h/, and the range of frequencies for the laryngeal varies depending on the vowel. In *íhí* ‘winter’ the peak of energy is centered in the higher frequencies; whereas in *áhám* ‘to bite s.t.’, the region with greater energy is located in the lower frequencies.

Figure 6.1. Spectrograms of VhV sequences in the Mundurukú words *íhí* 'winter' and *iáhám* 'to bite s.t.'.



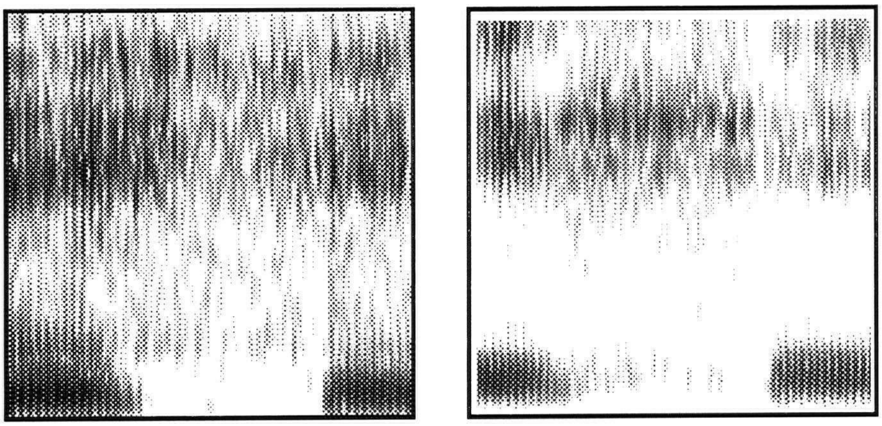
If the phonetic shape of /h/ is determined by the context, its seems plausible to assume that it is also compatible with nasalization. In fact, Ohala (1974: 364) observes that in nasalized contexts the velum remains lowered for laryngeals such as [h] and [ʔ]: "the position of the velum during glottal and pharyngeal consonants must be largely contextually determined." Similarly, Cohn (1990) finds that Sundanese [h] shows nasalization in nasalized environments, but no nasal airflow traces were detected for [ʔ]. However, it is not indicative that [ʔ] is produced with a raised velum; as Cohn remarks, "the lack of nasal airflow for glottal stop is due to the behavior of the glottis." (p.67) Closure at the glottis blocks both oral and nasal airflow, but this interruption provides no indication about the position of the velum, whether it is lowered or elevated. If we define segments amenable to nasalization as those articulatorily compatible with a lowered velum, laryngeals offer no counter-evidence to this hypothesis.

Overall, Mundurukú laryngeals can without problems be assumed to be compatible with a lowered velum, especially because they are largely dependent on the contexts at which they occur. The oral realization of /h/ was already illustrated above in Figure 6.1 (see also Chapter 3). Similarly, the acoustic analysis of /ʔ/, discussed in Chapter 3, also showed that this consonant is realized according to the context: as a heavy type of creaky voicing between [+sonorant] segments, and as a complete closure following an oral obstruent. This creaky effect is comparable to creaky voice on vowels, which can also be nasal (e.g. *tõ̰m* 'powder' and *ʤepã̰* 'to beat').

However, there is one fundamental difference between creaky voice as a contrastive property of vowels and the creaky effect that results from the realization of /ʔ/: timing of creakiness. In the former case, creaky voice is synchronized with the vowel itself, whereas in the latter, it coincides with a syllable boundary, as shown below in Figure 6.3 (and in Chapter 3).

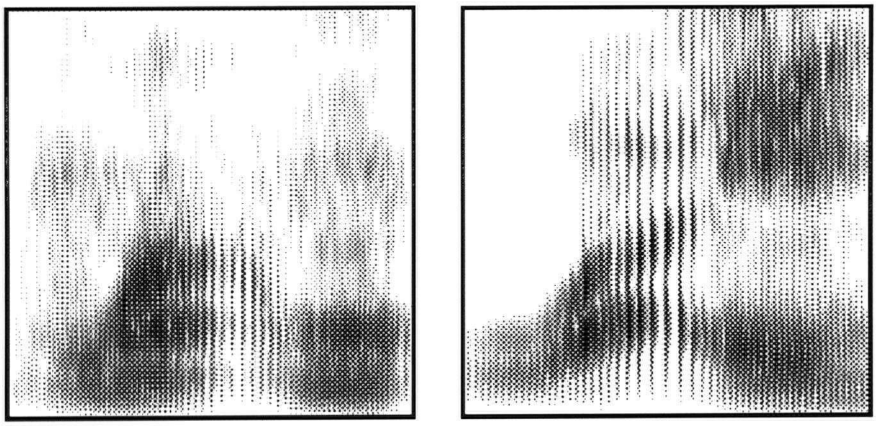
The spectrograms in Figure 6.2 and Figure 6.3 compare /h/ and /ʔ/, respectively, in oral and nasal contexts. For /h/, Figure 6.2, the nasalized sequence [ĩh̃ĩ] exhibits an uninterrupted noise throughout the entire sequence, suggesting that [h] is fully nasalized in a nasal context, and oral otherwise.

Figure 6.2. Spectrograms of VhV sequences in the Mundurukú words *aĩhĩ́* 'mother' (left) and *íhí* 'winter' (right).



Illustrations of /ʔ/ in oral and nasal contexts are given in Figure 6.3. As in the case of /h/, its phonetic realization also reflects the context. Note, however, that although the glottal is not realized as a complete closure, creakiness is heavier near the transition from one segment to the other, coinciding phonologically with a syllable boundary. In Chapter 3 I hypothesized that timing of creakiness was determined phonologically because the glottal still maintains its consonantal status.

Figure 6.3. Spectrograms of VʔV sequences in Mundurukú. Words: *waʔṍ* 'my voice, speech' (left), and *waʔé* 'bowl' (right).



The observations above lead to the conclusion that in Mundurukú laryngeals are perfectly compatible with velic lowering. Therefore, the participation of /ʔ, h/ in nasal harmony is not surprising. To account for nasalization through laryngeals in the language, I assume that glottals have only a laryngeal node, following Clements (1985; see also Cohn 1990, 1993). I also assume that they are specified for the features [+consonantal, +sonorant]. The distinction [+consonantal] is important because they always occupy the edge of a syllable, in particular an onset position. (For further discussion on /ʔ/, see Chapter 8.)

(25) (a) h

[+cons]
[+son]
|
Laryngeal
|
[+spread glottis]

(b) ʔ

[+cons]
[+son]
|
Laryngeal
|
[+constricted glottis]

Phonologically, /ʔ, h/ can be seen as the voiceless and creaky reflexes of neighboring vowels, sharing with these features such as [place], [nasal], etc. Their articulatory configuration is thus an extension of the articulatory configuration of adjacent segments, except for laryngeal features. From a phonetic point of view, sequences VhV and VʔV represent extreme cases of coarticulatory effects. The gestures for the vowels are carried over the laryngeals, with only a gradual change in laryngeal gestures. In sequences VhV, the laryngeal gestures go from voiced to voiceless to voiced again, i.e. [VV̥V]; and in sequences VʔV, they go from modal to creaky to modal, i.e. [VV̰V].

The tableau below illustrates nasality in a sequence VʔṼ. The output *w̃ãʔ̃ố* follows from the ranking if we assume that, phonologically, laryngeals are [+sonorant], and as such also targets to nasal propagation.

Tableau 6.5. Nasal propagation through laryngeals.

waʔố [nas]	MAXPATH [nas]	NAS/SON	*OR-NAS	DEPPATH [nas]
a. ☞ w̃ãʔ̃ố				***
b. waʔố			*!	

The facts discussed so far have dealt with the feature [+nasal] as a property of vowels, which is characterized phonologically as a harmonic feature. There is, however, a difference between [+nasal] as a property of vowels and [+nasal] as a property of nasal consonants. Mundurukú makes a clear distinction between the nature of the source for nasal harmony. This is an important issue to address because, in languages where a nasal vowel triggers harmony, more segments tend to be involved in the process than languages where harmony is triggered by a nasal consonant, as I discuss next.

6.4.2 Nasal vowels versus nasal consonants in harmony systems

There seems to be a correlation between the source for nasal harmony and the classes of segments that undergo the process. In Mundurukú, for example, there is a condition on nasal harmony: the feature [+nasal] spreads only from a nasal vowel, and never from a nasal stop, as the following examples show.

(26) (a) i-ʔó-m → iʔóm *ĩʔ̃ốm 'to eat s.t.'
3Ob-eat-IMPRF

(b) i-ʔə̃́-m → ĩʔ̃ə̃́m 'S/he will die.'
3Su-die-IMPRF

One possible explanation is that the language contrasts [-nasal] and [+nasal] vowels underlyingly; thus in (26)a, the vowel is not affected because it is underlyingly [-nasal]. In fact, the language has a phenomenon that seems to support this hypothesis. In the transition from an oral vowel to a tautosyllabic nasal consonant, orality of the vowel is maintained until after the oral closure for the nasal consonant, resulting in preoralized nasals, (27). After nasal vowels, only plain nasals surface, (28).

(27) (a) i-ʔó-m → iʔó[^{b}m] 'to eat s.t.'
3Ob-eat-IMPRF

(b) i-kót-m → ikó[^{d}n] 'to dig s.t.'
3Ob-dig-IMPRF

(c) ka-diŋ → ka-di[^{g}ŋ] 'dust'
thing-smoke

(28) (a) o-ṍm → õṍ[m] 'I went in, entered.'
1Su-enter

(b) ʤe-kṍn → ʤekṍ[n] 'to eat (Intr.)'
CoRef.Poss-eat

(c) (i)tĩ́ŋ-ʔa → (i)tĩ́[ŋ]ʔa 'pot'
pot-CL

An acoustic analysis of preoralized nasals was provided in Chapter 3, where I suggested that the phenomenon is not a phonological process involving the feature [-nasal], but a coarticulatory effect to avoid perceptual confusion. It is well known that lowering of the velum for a nasal consonant overlaps with the articulatory configuration of preceding vowels (Clumeck 1976; Manuel and Krakow 1984; Farnetani 1986; Manuel 1988; Rochet and Rochet 1991; Solé 1992). Vowel nasalization caused by coarticulation with a nasal consonant might well be perceived by listeners as an inherent property of the vowel, thus neutralizing a phonological distinction between oral and inherently nasal vowels in that context. As Clumeck (1976) pointed out, coarticulatory effects may affect phonological distinctions by generating perceptual confusion between distinctive and coarticulated features.

The hypothesis offered here is that preoralization of a nasal consonant in Mundurukú is not a phonological process that spreads the feature [-nasal] from an oral vowel. The reason is as follows: the process applies only to a sequence vowel + (tautosyllabic) nasal at a morpheme boundary. Heterosyllabic nasals are never affected by an adjacent oral vowel. On the contrary, a nasal consonant is likely to nasalize surrounding vowels when contrasts need not be maintained. In this case, nasalization never affects any other segment but the vowel immediately preceding or following the nasal.

(29) (a) karimá → kar̃imã́ ~ kar̃imá ~ karimã́ 'monkey, sp.'
*kãr̃imá

(b) koməpí → kõmə̃pí ~ kõməpí ~ komə̃pí 'timbó' (poisonous plant)

Preoralization thus occurs only where the oral-nasal contrast must be maintained: the right edge of a morpheme. I hypothesize that preoralized nasals are the result of a coarticulatory effect in which oral constriction and velic lowering are phased differently. It differs from other phonological processes in not being automatic. The speaker produces preoralized nasals in order to avoid the anticipation of the velic lowering gesture being perceived as nasalization on preceding vowels, and consequently, neutralizing the contrast between oral and nasal at the edge of a morpheme. If, in the transition from an oral vowel to a nasal consonant, lowering of the velum for the nasal is delayed, desynchronized with respect to the preceding vowel, speakers prevent nasalization effects in VN sequences from being perceptually interpreted as an intrinsic feature of the vowel. This hypothesis is corroborated by the fact that vowels that trigger preoralization in a nasal consonant are as amenable to nasalization as any other vowel. Compare (30) to (31): morpheme-final oral vowels that assimilate nasality from a nasal vowel also trigger preoralization of a nasal consonant. If these vowels were specified for [-nasal], we would expect them to not be affected by nasal harmony.

(30) (a) t-eí-ʔít → tẽ́ĩʔ̃́it 'It's cheap.'
3.price-be.small

(b) w-e-ktʃṍ-ã́ĩ → wektʃõã́ĩ 'strap of my basket'
1-Poss-basket-rope

(31) (a) pebə́rə̃́ <u>deí-m</u> → deí[^{b}m] ‘How much does it cost?’

how.much price-IMPRF

(b) w-e-<u>ktʃó-m</u> → wektʃó[^{b}m] ‘my (future) basket’

1-Poss-basket-IMPRF

The point here is that propagation of nasality from a nasal vowel is phonological in character. In fact, the analysis predicts that the vowel should assimilate nasalization from another vowel, whether or not a morpheme-final vowel is specified for the feature [-nasal] underlyingly. These two possibilities are illustrated in the following tableau.

Tableau 6.6. Input: *teí-ʔĩ́t* ‘It’s cheap’.

teí- ʔĩ́t | | [-n][+n]	MAXPATH [nas]	NAS/SON	*OR-NAS	DEPPATH [nas]
a.☞ tẽ́ĩʔĩ́t				***
b. teíʔĩ́t			*!	
teí- ʔĩ́t | [+n]				
a.☞ tẽ́ĩʔĩ́t				***
b. teíʔĩ́t			*!	

The preoralization effect observed in nasal consonants, on the other hand, follows from the differences in coordination of individual gestures to weaken the effect a nasal consonant may have on adjacent vowels. It is not feature spreading as in (32)a. Phonologically, the output is simply a sequence vowel + nasal, (32)b. This viewpoint is satisfactory because it treats the phenomenon as the result of coarticulatory effects, independent of feature specifications.

(32)

There is another issue to consider. If a vowel can only assimilate nasalization from another vowel, and not from a nasal consonant, it is because a nasal consonant cannot function as the source for nasal harmony. That is, the feature [+nasal] of a nasal stop is inert in the language. The question then is: Given two possible sources for nasal harmony in the language – nasal vowels and nasal consonants – why do [+nasal] vowels trigger harmony, but not [+nasal] consonants?

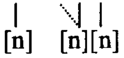
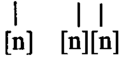
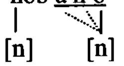
The phonological analysis proposed here does not capture the fact that a nasal consonant cannot spread nasality to preceding segments. In a VN sequence, nasality must spread from the consonant since it agrees with the vowel in terms of the subsidiary feature [+sonorant].

Tableau 6.7. Wrong prediction: nasalization in a sequence vowel + nasal consonant. Input: *ʔóm* 'to eat'

ʔó-m	MAXPATH [nas]	NAS/SON	*OR-NAS	DEPPATH [nas]
a. ☞ ʔ̃ṍm				**
b. ☹ ʔóm			*!	▨

The ranking predicts that in a harmonic context, a vowel preceding a nasal consonant must surface [+nasal], as illustrated in Tableau 6.8. However, this is not because a nasal vowel spreads its feature;

Tableau 6.8. Nasality spreads from a nasal consonant. Input: *nobánṍ* 'rifle, gun'

nobánṍ	MAX PATH [nas]	NAS/SON	*OR-NAS	DEPPATH [nas]
a. ☞ nob ã́ n ṍ 				*
b. nob á n ṍ 			*!	▨
c. nob ã́ n ṍ 				**!

it is because *ORAL-NASAL does not distinguish between nasal consonants and nasal vowels in terms of which one bears the harmonic feature, as shown in the following tableau.

Tableau 6.9. Nasality spreads from a nasal consonant. Input: *karimá* 'monkey, sp.'

karimá	MAX PATH [nas]	NAS/SON	*OR-NAS	DEPPATH [nas]
a.☞ kãr̃ĩmá [n]				***
b.☹ karimá | [n]			*!	

The problem here is: an attempt to prevent nasalization in a sequence vowel + nasal consonant also prevents assimilation in a harmonic context, and an attempt to enforce harmony also enforces harmony where it is not expected. If we assume that harmony is triggered by any [+nasal] segment, both nasal vowels and nasal consonants are predicted to trigger the process. However, in languages that have both nasal vowels and nasal consonants in their inventories, and nasal harmony, the tendency is to chose only one source for the process.

Walker (1998) provides a nasal harmony database with more than ninety systems classified in terms of the classes of segments that undergo nasalization in nasal harmony: vowels, glides, liquids, fricatives and stops. She also provides information about the triggers of the process in those languages, but her study focuses essentially on the nature of targets. Here I will focus on the nature of triggers relative to that of targets. The discussion is based on Walker's condensed version of the nasal harmony database, provided in her dissertation.

The purpose of this study is to compare triggers versus targets in nasal harmony. I counted the number of languages in which nasal harmony is triggered by (i) a nasal vowel, (ii) a nasal stop, or (iii) both. The results are given in Table 6.1. Languages in which the harmonic feature is not attributed to a segment in particular, that is, nasality is a property of the syllable, foot, or morpheme, were identified separately. The numbers refer only to languages for which the triggers were clearly identified. For example, in Dayak (Kendayan dialect; Indonesian Borneo) the trigger is apparently a nasal stop, but this appeared with a question mark (?) in Walker's database. Cases like this were excluded. In Acehnese (Hesperonesian; Indonesia), on the other hand, harmony is triggered by a nasal stop, and possibly by a vowel nasal, but again, the latter was marked with (?). In this case, I included the language in the study but for cases in which nasal harmony is triggered by a nasal stop. Finally, cases in which nasality is triggered by other segments, or functions as an independent morpheme in the language were not included. The results presented in Table 6.1 thus refer to the 78 languages for which the triggers were clearly identified. As for targets, I use the same classification Walker suggests in the database. (Notation: V=vowel; G=glide; L=liquid; F=fricative; S=stop.)

Table 6.1. Cross-linguistic distribution of triggers and targets in nasal harmony.

Trigger \ Target	V	V-G	V-G-L	V-G-L-F	V-G-L-F-S	Total
nasal V	2	4	7	3	11	27
nasal C	3	16	3			22
nasal V + nasal C	4	6	1		2	13
Property of syllable, foot, morpheme			3		13	16
Total	49 languages			29 languages		78

The numbers suggest that systems in which a nasal vowel triggers nasal harmony tend to involve more segments in the process. If the trigger is a nasal consonant, the targets seem to be limited to the class of [+sonorant] segments: mostly vowels and glides and less frequently, liquids. These cases represent 44.89% of the 49 languages; 26.53% are triggered by a nasal vowel, and 22.44% by either one. Surprisingly, systems where the targets include all classes of segments (29 languages), the trigger is typically a nasal vowel (48.27%), or nasality is not a property of the segment (44.82%). In addition, nasal harmony is typically triggered by either a vowel or a consonant, and less frequently by both. The results are unexpected considering the fact that nasal stops are more frequent than nasal vowels cross-linguistically.

These numbers are significant, but more data is necessary. For example, it would be important to investigate how many languages make a contrast between nasal vowel and nasal consonant, and how they behave in nasal harmony. Information for all languages is not available in Walker's dissertation, but the numbers do show that triggers and targets are interrelated in the sense that the number of segments affected by the process tends to be higher if the trigger is a nasal vowel. If the trigger is a nasal consonant, only [+sonorant] segments, mostly vowels and glides, tend to be involved.

In Mundurukú, nasality targets [+sonorant] segments as well, and we will see in §6.5 that the system has developed from another in which voiced obstruents were also targets. This is consistent with the observation that nasal vowels may affect a higher number of segments. This is an issue that deserves further research, and it is not the purpose of this study to pursue a cross-linguistic investigation.

Let us now turn to the problem this analysis faces. Recall that it predicts that a nasal consonant triggers harmony. The point here is source versus target. A nasal consonant must be treated as a target, whereas a nasal vowel must be treated as a source. This suggests that a constraint enforcing harmony must refer to both source and target. I offer here an alternative, but with the awareness that it may need to be refined.

Nasality is triggered by a vowel in Mundurukú, not by a consonant. Thus, the constraint *ORAL NASAL must not only enforce harmony between segments sharing the feature [+sonorant], but also restrict this effect to a sequence in which a nasal *vowel* is the [+sonorant] segment that bears the harmonic feature. This information is crucial for the analysis. According to the features [nasal] and [sonorant], the two sequences VN and VṼ are identical: [+sonorant, -nasal]-[+sonorant, +nasal]. While VN is allowed in Mundurukú, VṼ must be realized as [ṼṼ]. Given this, I suggest the following re-formulation of the constraint *ORAL NASAL.[2]

(33) *ORAL-NASAL (revised version)

In a string of segments $s_n \ldots s_2$, s_1, if

- (i) s_2 immediately precedes s_1, s_n immediately precedes s_2, and
- (ii) s_2, s_n are [+sonorant, ±syllabic], but
- (iii) s_1 is [+sonorant, +syllabic, +nasal],

then s_2, s_n must also be [+nasal].

(33) differs from Pulleyblank's (2002) proposal in that it evaluates a string of segments sharing the subsidiary feature [+sonorant], and includes the information about the source; condition (i) requires strict adjacency between segments in a string, and can be adapted if assimilation is non-local (see §6.5 for an example); condition (ii) refers to the subsidiary feature that all segments must share, in this case [+sonorant]; and condition (iii) makes reference to the source: [+syllabic, +nasal], i.e. a nasal vowel. The constraint thus determines that in a string of [+sonorant] segments, if the last segment is a nasal vowel, then all preceding segments must agree in nasality. The restriction does not apply if the last segment is a nasal consonant. For example, in the word *nobánṍ* 'gun/rifle', the sequence …*ánṍ* is formed by three sonorants and the last sonorant is a nasal vowel, satisfying thus the three requirements of *ORAL-NASAL that they must agree in nasality.

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[2] The reformulation proposed for the constraint *ORAL-NASAL in this section does not affect the cases examined so far. The feature [±syllabic] is to clearly differentiate vowels from glides and other consonants.

(34) n–o–b–a–n–õ ‘gun/rifle’

	s_6	s_5	s_4	s_3	s_2	s_1
[son]	+	+	-	+	+	+
[syll]	-	+	-	+	-	+
[nas]	+	-	-	-	+	+

The sequence …*anṍ* in (34) can be assessed as follows:

(i) [a] (s_3) immediately precedes [n] (s_2), [n] immediately precedes [õ] (s_1);

(ii) [a] and [n] are [+sonorant, ±syllabic];

(iii) [õ] is [+sonorant, +syllabic, + nasal]; then

[a] and [n] must also be [+nasal]

Tableau 6.10 shows the effect.

Tableau 6.10. Input: *nobánṍ* ‘rifle, gun’

nobánṍ | [n]	MAXPATH [nas]	NAS/SON	*OR-NAS	DEPPATH [nas]
a. ☞ nobã́nṍ				*
b. nobánṍ			*!	
c. nõbã́nṍ				**!

If the feature [+nasal] is not associated with a vowel, then it must not be harmonic.

Tableau 6.11. Input: *karimá* ‘monkey, sp.’

karimá | [n]	MAXPATH [nas]	NAS/SON	*OR-NAS	DEPPATH [nas]
a. ☞ karimá				
b. kãr̃imá				*!**

Yet, why is the definition of the constraint *ORAL-NASAL given in (33) important for the analysis?

Traditionally, Optimality Theory establishes that opacity involves a difference in the ranking of DEP relative to the harmony constraint. In our discussion these would be DEP[nas] and *ORAL NASAL. For the present purposes, let us assume a non-local version of the constraint, making reference to the trigger, defined in (35).

(35) *ORAL…NASALV

A segment [+sonorant, +syllabic, +nasal] must not be preceded by a segment [+sonorant, -nasal].

For there to be opacity, DEP[nas] must outrank *ORAL…NASALV.

(36) Ranking: DEP[nas] >> *ORAL…NASALV

DEP[nas] is successful in avoiding insertion of [+nasal] if a blocking segment intervenes, as /k/ in candidate (c). Recall that gapped configurations are universally ill-formed so that an output with a 'skipped' segment is considered to be insertion of [+nasal].

Tableau 6.12. Input: *ikoérṍ* 'fly'

ikoérṍ	MAXPATH [nas]	NAS/SON	DEP[nas]	*OR…NASV
a. ☞ ikõẽ́rṍ				*
b. ikoérṍ				**!**
c. ĩkõẽ́rṍ			*!	

A problem again arises if a morpheme contains a nasal consonant. The standard OT analysis predicts that the nasal should serve as the source for harmony to satisfy *ORAL…NASALV.

Tableau 6.13. Input: *nobánṍ* 'rifle, gun'

nobánṍ	MAXPATH [nas]	NAS/SON	DEP[nas]	*OR…NASV
a. ☞ nõb ã́ n ṍ |/ \/ | [n] [n] [n]				
b. ☹ nobã́nṍ				*!
c. nobánṍ				*!*

I hope to have shown that an standard OT analysis does not account for the requirements of nasal harmony in the language. In the analysis proposed here, the generalizations about the process are, to a certain extent, well captured.

First, nasal harmony is seen as a sub-case of the OCP-subsidiary features effects in that the more similar trigger and target are, the stronger their interaction. I proposed that harmony is enforced in a string of segments if they all share the subsidiary feature [+sonorant].

Second, opacity is seen as the association of the harmonic feature in a segment-to-segment basis, regarding they are all compatible with it. Incompatibility results in interruption of the process. Once the harmony constraint is satisfied, every new association is fatal. This is what the ranking *ORAL-NASAL >> DEPPATH[nas] predicts, contrary to the standard analysis which states that opacity results from ranking DEP[nas] higher than the harmony constraint.

Finally, I pointed out that the reference to the source of the harmonic feature is important because the language allows only a nasal vowel to spread nasality; nasal consonants are in this respect inert. The hypothesis is corroborated by the fact that, cross-linguistically, nasal harmony is more frequently triggered by either a nasal vowel or a nasal consonant, and rarely by both. Furthermore, there seems to be a correlation between the source for the harmonic feature and the classes of segments involved; the generalization is that the number of segments affected in the process is greater in systems where a nasal vowel is the source.

6.5 Nasal harmony in Kuruaya

Comparative evidence suggests that nasal harmony in Mundurukú has developed out of a system where segments were either transparent or targets. This system is found in Kuruaya (Picanço 2003c). Like Mundurukú, Kuruaya exhibits regressive nasalization within the word, and the trigger is a nasal vowel. Unlike Mundurukú, nasalization targets [+sonorant] segments and [+voiced] obstruents;[3] voiceless obstruents are transparent to nasal spread. (37) illustrates assimilation by [+sonorant] segments; (38) illustrates assimilation by [+voiced] stops, in which case they surface as plain nasal consonants; and (39) illustrates transparency.

(37) (a) arĩt → ãr̃ĩt 'anum (bird, sp.)'

(b) pawã → pãw̃ã 'banana'

(c) welấ-ĩ → w̃ẽl̃ấĩ 'Brazil nut'
nut-CL

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[3] Kuruaya does not have a voiced fricative in the inventory, only [ð] which is an allophone of /l/; this too assimilates nasality, [ð̃], but in nasal contexts /l/ is mostly realized as [l̃].

	(d)	lá?ɔ-re-nãn	→	l̃ã́õ-r̃ẽ-nãn	‘lizard, sp.’
		lizard-?-Comp			
(38)	(a)	pobeʔ-yã	→	põmẽ́ỹã	‘canoes’
		canoe-PL			
	(b)	o-bi-loã	→	õm̃ĩl̃õã	‘my chin’
		1-mouth-?			
	(c)	dé-yã	→	nẽ́ỹã	‘they’
		3Dem-PL			
	(d)	kabiʔ-sãy	→	kãm̃ĩ́sãỹ	‘darkness/night’
		sky-dark			
(39)	(a)	w-e-aikõn	→	w̃ẽãĩkõn	‘my bench’
		1-Poss-bench			
	(b)	porakã	→	põr̃ãkã	‘two’
	(c)	parawa-tõ	→	pãr̃ãw̃ãtõ	‘macaw, sp.’
		macaw-purple			
	(d)	pasiã	→	pãs̃ĩã	‘parrot, sp.’
	(e)	warisõ	→	w̃ãr̃ĩsõ	‘bird, sp.’

Comparing Mundurukú and Kuruaya, we obtain the following similarities and differences:

(40)

	Mundurukú	Kuruaya
Trigger:	rightmost nasal vowel	rightmost nasal vowel
Direction:	right-to-left	right-to-left
Segments affected:	sonorants	sonorants, voiced obstruents
Opaque segments:	obstruents	none
Transparent segments:	none	voiceless obstruents

The two systems are alike with respect to trigger and direction of nasal harmony. They differ with respect to the participation of the various classes of segments, and the local versus non-local nature of assimilation. In Kuruaya nasal harmony is not blocked; segments are either targets or behave transparent. In Mundurukú, on the other hand, segments are targets or block the process. Kuruaya is also interesting because nasality affects segments that block the process in Mundurukú: the class of [+voice] obstruents. This suggests that the OCP-subsidiary feature cannot be [+sonorant] alone, as suggested for Mundurukú. (41) compares some features for targets, non-targets, and source.

(41) Features for vowels, glides, liquid, obstruents

	Source	Targets				Non-targets	
	Ṽ	V	w/y	r	Oral/Nas Stops	Stops	Frics
sonorant	+	+	+	+	-/+	-	-
voice	(+)	(+)	(+)	(+)	+	-	-

Vowels, glides, and liquids share [+sonorant, +voice], but vowels, glides, liquids and voiced stops share [+voice]. Thus two subsidiary features can be stipulated for Kuruaya: [+sonorant] and [+voice]. The feature [+voice] is defined phonetically here; sonorants are [+voice] because they involve vibration of the vocal folds, but the feature is phonologically redundant for this class. It makes a difference for the class of obstruents in that voiced segments undergo the process and voiceless segments resist it.

Two sequential prohibitions are proposed below. One for the [+sonorant], (42), the other for [+voice], (43). Stipulation of these two features as two separate subsidiary features accounts for the change in nasal harmony, to be examined below. Another alternative would be to invoke only [+voice], and assume that the change in nasal harmony also involved a change from the subsidiary feature [+voice] to [+sonorant]. For present purposes, I will represent these two classes of segments separately. Also, nasal harmony in Kuruaya is not blocked as voiceless obstruents behave transparent. Thus *ORAL NASAL is crucially non-local.

(42) *ORAL...NASAL$_{SON}$ (non-local version)

In a string of segments $s_n \ldots s_2$, s_1, if

(i) s_2 precedes s_1, s_n precedes s_2, and

(ii) s_2, s_n are [+sonorant, ±syllabic], but

(iii) s_1 is [+sonorant, +syllabic, +nasal],

then s_2, s_n must also be [+nasal].

(43) *ORAL...NASAL$_{VCE}$ (non-local version)

In a string of segments $s_n \ldots s_2$, s_1, if

(iv) s_2 precedes s_1, s_n precedes s_2, and

(v) s_2, s_n are [+voice, ±syllabic], but

(vi) s_1 is [+voice, +syllabic, +nasal],

then s_2, s_n must also be [+nasal].

The tableau below shows assimilation in a sequence of sonorants. Note that the ranking proposed for Kuruaya is similar to that proposed for Mundurukú, except for the constraint *ORAL...NASAL$_{VCE}$ which is absent in Mundurukú. This difference can be explained by the historical change in nasal harmony (see §6.6).

Tableau 6.14. Assimilation by sonorants: *pawã* → *pãw̃ã* 'banana'.

pawã	MAX PATH[nas]	NAS/SON	*OR...NAS$_{SON}$	*OR...NAS$_{VCE}$	DEPPATH[nas]
a. ☞ pãw̃ã					**
b. pawã			*!*	**	
c. mãw̃ã					***!

Another interesting prediction concerns opacity versus transparency. As previously discussed, standard OT accounts for opacity cases by ranking faithfulness constraints, DEP in particular, higher than the harmony constraint; transparency, on the other hand, requires DEP to be low ranked (e.g. Pulleyblank 2002). It is necessary that DEP be ranked lower in Kuruaya, the transparency case. However, in the proposal offered here, opacity and transparency follow from the same principle, namely that associations with the harmonic feature are tolerated only in order to satisfy the harmony constraint; this satisfaction is local in Mundurukú and non-local in Kuruaya. Tableau 6.15 provides an example. Voiceless obstruents are not targets as they are neither [+sonorant] nor [+voice], but nothing prevents them from assimilating nasality and surfacing as plain nasal stops, e.g. candidate (d).

However, the only associations that may violate DEPPATH[nas] are the ones required by the high-ranking sequential prohibitions, which favor candidate (a).

Tableau 6.15. Transparency of voiceless segments: *parawa-tõ* → *pãr̃ãw̃ãtõ* 'macaw, sp.'

parawa-tõ	MAXPATH[nas]	NAS/SON	*OR...NAS$_{\text{SON}}$	*OR...NAS$_{\text{VCE}}$	DEPPATH[nas]
a. ☞ pãr̃ãw̃ãtõ					*****
b. parawatõ			*!****	*****	
c. pãr̃ãw̃ãt̃õ		*!			
d. pãr̃ãw̃ãnõ					******!

The next tableau shows assimilation of voiced stops. *OR…NAS$_{\text{VOI}}$ demands that in a sequence of segments, if they all agree for [+voice], than they all must agree for [+nasal]. Even though an output such as *põbẽỹã*, candidate (a), satisfies *OR…NAS$_{\text{SON}}$, it violates *OR…NAS$_{\text{VOI}}$ because /b/ is [+voice].

Tableau 6.16. Assimilation with voiced stops: *pobeʔ-yã* → *põmẽỹã* 'canoes'.

pobeʔ-yã	MAX PATH[nas]	NAS/SON	*OR...NAS$_{\text{SON}}$	*OR...NAS$_{\text{VCE}}$	DEPPATH[nas]
a. põbẽỹã				*!	***
b. ☞ põmẽỹã					****
c. pobẽỹã			*!	*	**

Having proposed the analyses of the synchronic patterns of nasal harmony in Mundurukú and Kuruaya, I turn now to a historical approach to the phenomenon. In the next section, I propose an OT account of the changes that Mundurukú underwent, and demonstrate how the language acquired the present system.

6.6 An OT account of a historical change in nasal harmony

In Chapter 5 I approached nasal harmony from a historical point of view. I showed that the proto-system, Proto-Mundurukú, had properties similar to those observed in Kuruaya. In particular, (i) the targets were voiced stops and sonorants, and (ii) voiceless obstruents were transparent. On descriptive grounds, the historical changes can be stated as follows:

(44) Historical changes

- (i) Harmony changed from non-local to local; consequently
- (ii) The system changed from one with transparent segments to another with opaque segments.
- (iii) The set of targets was reduced to sonorants; consequently,
- (iv) Voiced stops became non-targets.

The changes (i) and (ii) can be explained by the following historical change in the sequential prohibition: *OR...NAS > *OR-NAS. In other words, nasal harmony became more restricted; the non-local requirement became strictly local. And (iii) and (iv) can be explained by a change in the ranking: *OR...NAS$_{\text{VOI}}$ » DEPPATH[nas] > DEPPATH[nas] » *OR...NAS$_{\text{VOI}}$.

Consider, for example, the proto-Mundurukú word **LobaLõ 'rifle, gun', shown in Tableau 6.17. (See Chapter 5 for a reconstruction of the word **LobaLõ in Proto-Mundurukú.) The (non-local) sequential prohibitions required all [+sonorant] and [+voice] segments to also be [+nasal] if the last vowel was [+nasal]; thus candidate (b) was the optimal output at that stage.

Tableau 6.17. Proto-Mundurukú: **LobaLõ 'rifle, gun'

**LobaLõ	MAX PATH[nas]	NAS/SON	*OR...NAS$_{\text{SON}}$	*OR...NAS$_{\text{VCI}}$	DEP PATH[nas]
a. L̃õbãL̃õ				*!	****
b.☞ L̃õmãL̃õ					*****
c. LobãL̃õ			*!*	***	**

As seen in Chapter 5, between Proto-Mundurukú and Pre-Mundurukú, the proto-phoneme **L developed into the pre-phoneme *d: **LobaLõ > *dobadõ; since nasal harmony remained as in the proto-language, *d had two allophones, [d] in oral contexts and [n] in nasal contexts. The nasal variant is shown in the following tableau. The optimal output in the pre-language was [nõmãnõ] in which all sonorants and voiced stops surfaced nasal.

Tableau 6.18. Pre-Mundurukú: *dobadõ 'rifle, gun'

*dobadõ	MAX PATH[nas]	NAS/SON	*OR...NAS$_{SON}$	*OR...NAS$_{VCE}$	DEPPATH[nas]
a. dõbãdõ				*!**	**
b.☞ nõmãnõ					*****
c. dobãnõ			*!	**	**
d. dobadõ			*!*	***	
e. nobãnõ			*!	*	**

Between Pre-Mundurukú and the modern stage, several changes took place. These are schematized in (45), with reference to the constraints proposed so far. First, harmony became strictly local; this can be interpreted as a change in the constraint itself: *OR...NAS > *OR-NAS (i.e. non-local > local). Second, the allophones of *d, [d]/[n] became independent (secondary split): *d > d/n; in OT, phonologization can be achieved by faithfulness to allophones – e.g. MAX-[d] and MAX-[n]. Finally, voiced stops developed into opaque segments; this suggests that *OR-NAS$_{VOI}$ lost its importance in the language, and consequently its position for DEPPATH[nas]: *OR-NAS$_{VOI}$ » DEPPATH[nas] > DEPPATH[nas] » *OR-NAS$_{VOI}$. For reasons to be clarified later, *OR-NAS$_{VOI}$ did not simply lose its position for DEPPATH[nas]; I will suggest that this constraint was completely lost, and this was independent of DEPPATH[nas].

(45) From Pre-Mundurukú to Mundurukú (NH=nasal harmony)

Pre-Mundurukú *OR...NAS$_{SON}$ » *OR...NAS$_{VOI}$ » DEPPATH[nas]
NH (not blocked) ↓ ↓

NH (blocked) *OR-NAS$_{SON}$» *OR-NAS$_{VOI}$» DEPPATH[nas]
Secondary split MAX-[n], MAX-[d] ↓

*OR-NAS$_{SON}$» DEPPATH[nas] »...» *OR-NAS$_{VOI}$

Mundurukú *OR-NAS$_{SON}$» DEPPATH[nas]
Contrast between /d/ and /n/

As complex as these changes may seem, an OT analysis can be proposed. To begin with, recall from Tableau 6.18 above that the output for the word *dobadõ in Pre-Mundurukú was [nõmãnõ], in which [nasal] was associated with every segment in the word. Take this output to be our "input" for the next stage (modern Mundurukú), as shown in Tableau 6.19 below. Note that this proposal differs from the OT assumption that changes involve constraint reranking. Here I also allow for constraints to become more restrictive, without changing their position in the ranking. In addition, the tableau does not represent a synchronic stage in particular, but the historical changes that gave rise to the modern system. It is meant to provide the relative chronology of the historical changes schematized in (45), including some immediate consequences for the grammar. Each column represents the order of these developments, and columns separated by dotted lines indicate simultaneous developments. Finally, in the "input" [nõmãnõ], the feature [nasal] appears linked to every segment, but this is because [nõmãnõ] was the surface form prior to the changes, and not because they were all specified for this feature. The source is the last vowel in the morpheme; preceding segments are targets. (See below for further comments on this tableau.)

Tableau 6.19. An OT relative chronology for the changes in nasal harmony.

*[nõmãnõ] [nas]	MAX-/b/ MAX-/m/	*OR...NAS$_{\text{SON}}$ > *OR-NAS$_{\text{SON}}$	*OR...NAS$_{\text{VCE}}$ > *OR-NAS$_{\text{VCE}}$	MAX-[n] MAX-[d]	DEP PATH[nas]
a. nõmãnõ [nas]	*!				*****
b.☞ nobãnõ [n] [n]			*(b)		***
c. nõbãnõ [n] [n]			*(b)		****!
d. dobãnõ [n]			*(b)	*!	**

When the system changed from transparency to opacity (i.e. *OR...NAS > *OR-NAS), the phonemic inventory had to be restructured with respect to the values to be assigned for the nasal allophones since the change caused loss of the environment that conditioned the allophonic variations [b]/[m] and [d]/[n]. I claim that at this stage, /b/ and /m/, but not [d] and [n], were contrastive in the language. This hypothesis finds support in the fact that they contrast in oral environment in Kuruaya, though are neutralized to [m] in nasal contexts (as seen in Chapter 5). In Mundurukú they contrast in both oral and nasal contexts, as shown in Chapter 3. If there is a contrast in both Kuruaya and Mundurukú, then we can suppose that they were independent phonemes in Proto-Mundurukú, with an alternation similar to that found in Kuruaya: /b/ and /m/ were neutralized to [m] in the context of nasalization. The role of the faithfulness constraints MAX-/b/ and MAX-/m/ is to preserve this contrast in the following stage, and this is the reason it is ranked above the change. It follows from this that, when the change in nasal harmony took place, the "output" could no longer assign [m] to the underlying representation of [nõmãnõ]; the nasal variant [m] had already been associated with the phoneme /b/. This is why candidate (a) is ruled out.

As for [d] and [n], it was established earlier (and in Chapter 5) that they were allophones of Pre-Mundurukú *d, and developed out of the change **L > *d; they only became independent later as a result of a change in the non-local character of nasal harmony: *OR...NAS > *OR-NAS. This change had a consequence in the inventory. By restricting nasal harmony to a locality requirement, the conditioning environment for the alternation [d]/[n] was lost in many cases, and the inventory needed be restructured with respect to the underlying representations for these allophones. By Lexicon Optimization, represented in the tableau by the faithfulness constraints MAX-[d] and MAX-[n], inputs should mirror their outputs. For example, candidate (d) is excluded because the phoneme /d/ is assigned to the allophone [n] in the context where nasality was lost. However, the "input" has the allophone [n], so the form /d/ in that context fatally violates MAX-[n].

At this point, two candidates remain. Candidate (b) spreads the harmonic feature locally, as now demanded by the sequential prohibition *OR-NAS; and candidate (c) spreads the feature from both a nasal vowel and a nasal consonant, fatally violating DEPPATH[nas].

The change in the ranking, *OR-NAS$_{\text{VOI}}$ » DEPPATH[nas] > DEPPATH[nas] » *OR-NAS$_{\text{VOI}}$, took place after these changes, as a consequence of the preservation of the contrast between /b/ and /m/ everywhere, and phonologization of [d] and [n], which militated against the requirement that voiced obstruents should be nasal in nasal contexts. In other words, the sequential prohibition *OR-NAS$_{\text{VOI}}$ became unnecessary, and lost completely its importance in the language. This is why Mundurukú only needs the ranking: *OR-NAS$_{\text{SON}}$ » DEPPATH[nas].

This gives us the 'optimal system': nasality spreads locally to [+sonorant] segments, and is blocked by [-sonorant].

CHAPTER 7

Consonant Mutation

7.1 Introduction

Another pervasive phonological process in Mundurukú is consonant mutation. The process affects specific groups of morphemes, as we will see in §7.2, and is characterized by voiced-voiceless alternations of morpheme-initial stops; voiced variants occur after vowels and glides, and voiceless variants occur after stop and nasal consonants. The alternations are p/b, t/d, and ʧ/ʤ, as illustrated by the morphemes *pa̰/ba̰* 'arm', *ta/da* 'seed', and *ʧó/ʤó* 'to see', respectively. Note in (1)c that mutation is first determined in the stem and then copied in the reduplicative morpheme, despite the fact that the initial consonant is intervocalic (see Chapter 9 on the interaction between reduplication and consonant mutation).

(1) Consonant mutation

(a)	ayáʧát **pa̰**	i-tayʃi **bá**
	woman arm	3-wife arm
	'woman's arm'	'his wife's arm'
(b)	ka-sop-**tá**	mərá-**da**
	thing-flame-CL	corn-CL
	'star'	'corn'
(c)	o-t-əp-**ʧó-ʧó**	o-t-a-**ʤó-ʤó**
	1Su-3-leaf-see-RED	1Su-3-CL-see-RED
	'I saw a leaf.'	'I saw it (e.g. corn seeds)'

The t/d alternation has another variant, t/n, which occurs in nasal contexts, to be examined in §7.3.3.

(2)	(a)	o-**nə̃́y**	(b)	dápsém **tə̃y**
		1-tooth		deer tooth
		'my teeth'		'deer's teeth'

The majority of morphemes that participate in the t/d-n alternation refer to a class that has been analyzed as containing the relator prefix {d-} (Rodrigues 1990, Gomes 2000). Gomes claims that this initial consonant was historically a prefix that marked the 'contiguity' of a dependent before a head, a function similar to what consonant mutation does synchronically (see below). It is important, however, to keep in mind that the t/d alternation is not restricted to morphemes that take Gomes' contiguity marker. In other words, this alternation is not a synchronic property of the 'relator prefix' in particular. This is illustrated by the transitive verbs below. The verbs *daka̰t* 'to cut', (3)a, and *dá* 'to cook', (3)b, both participate in consonant mutation, but only *daka̰t* supposedly takes the relator prefix; formally, this verb is, according to Gomes, {d- + aka̰t}. The verb *dá* 'to cook', on the other hand, belongs to another class, meaning that the initial stop is not a prefix; hence {da}. The primary difference between these two classes is 3rd person agreement: object agreement, for example, is marked as {t-} in *daka̰t*, but {ʤo-} in *dá*. Significant, again, is the fact that both verbs show identical behavior in the t/d alternation, independent of what class they belong to.

(3) Participation in consonant mutation

(a)	o-t-daka̰t → otaka̰t	o-y-op-táka̰t	o-t-a-dáka̰t
	1Su-3Ob-cut	1Su-3-CL-cut	1Su-3-CL-cut
	'I cut it.'	'I cut the stick.'	'I cut it (e.g. seeds)'
(b)	o-ʤo-dá	o-t-õ̰m-tá	o-t-a-dá
	1Su-3Ob-cook	1Su-3-CL-cook	1Su-3-CL-cook
	'I cooked it.'	'I cooked the flour.'	'I cooked it (e.g. seeds)'

Therefore, it does not seem to be relevant whether or not the initial consonant was historically an affix. For one thing, as Gomes has already pointed out, this 'relator prefix' is not synchronically independent of the root. In addition, and contrary to Gomes, there are also other reasons to doubt that its function is to grammatically mark contiguity of a dependent before a head; whether or not it had this function, the fact is that, synchronically, this is not the case. Good examples showing this are provided in (4). The verb *doyʤẽmʤẽm* 'to bleed' is a compound formed by two roots: the inalienable noun *doy* 'blood' + the unaccusative verb *ʤẽm* ‘to go out’, both of which are subject to consonant mutation (see §7.2). The noun belongs to the class of morphemes that, according to Gomes, take the contiguity marker; hence {d- + oy} in his analysis. But note that in *doyʤẽ́mʤẽ́m* the dependent of *doy*, in this case *ṍn* ‘1sg’, is not contiguous to the derived verb, but the relator prefix {d-} is still selected. Similarly, in the second example, *nə̃yʔə́kʔə́k=ʔək=át*, the initial consonant /n/ in *nə̃́y* ‘tooth’ is the nasal variant of the contiguity marker; its presence in this nominalized form should serve to indicate the presence of a dependent (i.e. a possessor), but in this example, the interpretation the nominalized form has is “An *x* such that *x* takes *teeth* out”, in which case *nə̃y* ‘teeth’ is used generically. These cases suggest that, if contiguity marking was once the primary function of these initial alveolar stops, this function has already been neutralized in the grammar.

(4) (a) doy-ʤẽ́m-ʤẽ́m ṍn ‘I’m bleeding.’
blood-go.out-RED 1sg

(b) nə̃y-ʔə́k-ʔə́k=ʔək=át ‘dentist’
tooth-take.out-RED=HAB=NOM
(Lit.: One who habitually takes teeth out)

Given these facts, I will treat morphemes such as *daka̠t* ‘to cut’, *doy* ‘blood’ and *nə̃y* ‘tooth’ as single morphemes, not as {d-/n- + Root}. As for those involved in the alternations p/b and ʧ/ʤ, there is no synchronic or historical evidence that these initial stops are/were independent of the root.

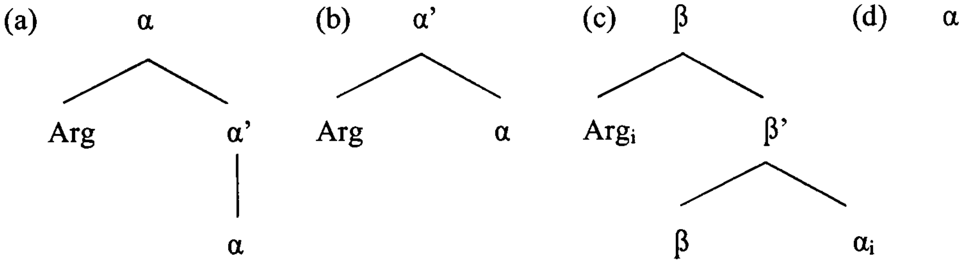
The phenomenon of consonant mutation in Mundurukú has never been called into question, though it is often cited because of its morphosyntactic importance (e.g. Crofts 1973, 1985; Gomes 2000, 2002; and especially section 7.2). Moreover, there exists no formal proposal of the process, especially in terms of the underlying forms of the alternating consonants (voiceless or voiced), and consequently, the kind of phenomenon involved: fortition, if voiced segments change to voiceless, or lenition, if the reverse; or perhaps both.

In this chapter I examine the morphosyntactic (§7.2), phonological (§7.3), and historical (§7.4) aspects of consonant mutation in Mundurukú, hoping to demonstrate that mutation is the interaction of two phenomena: fortition and lenition. The first devoices an initial /d/, and the other voices /p/ and /ʧ/ in the same position. I conclude the discussion by presenting some preliminary observations about the emergence of the process in the language (§7.4).

7.2 Morphosyntactic aspects

Consonant mutation is subject to morphological and syntactic requirements. Morphologically, it applies to sub-groups of major classes. For instance, in the nominal class, it pervades inalienable nouns only, and in the verbal class, unaccusative, transitive and some stative verbs. I examined a considerable amount of data from each group, and the observations are presented separately in the following sub-sections. In general, the process applies to any head that takes an internal argument. In the nominal class, the process affects inalienable nouns (§7.2.1); in the verbal class, we find the alternation in transitive and unaccusative verbs (§7.2.2); and in other classes, we find the alternation in postpositions and other argument taking morphemes (7.2.3). The generalizations are: (i) if an item is lexically associated with an argument, it participates in consonant mutation; and (ii) if an alternating morpheme is locally associated with its argument, it manifests the alternation. By 'locally' I mean that there must not be any other morpheme intervening between a head and its argument. Tentatively, this can be syntactically defined in terms of a Specifier-Head or Complement-Head relations, as in (5)a-b; α is the head, and Specifier and Complement refer to the head's internal argument. We do not expect to find the alternation if there is an intervening element between them, as in (5)c, or if the head itself does not take an argument, (5)d. In general, consonant mutation is not just a phonological process, it serves to mark a dependency relation between two elements. For expository reasons, I will refer to these relations as Dependent/Head relations.

(5) Alternation expected No alternation expected



I begin the investigation of consonant mutation by showing the classes of morphemes that are involved in the process, and then proceed to an examination of its phonological aspects. I offer a formal OT account in §7.3, discussing a number of problems the analysis encounters, particularly challenging to the theoretical model adopted here. Ultimately, the analysis is forced to appeal to language-specific devices.

7.2.1 Nouns

Mundurukú nouns can be divided into two classes (Picanço 2003a): possessable and non-possessable.[1] Semantically, possessable nouns can be of two types: alienable, nouns that do not require a possessor but may have one; and inalienable, nouns that are obligatorily possessed (Crofts 1973, 1985; Picanço 2003a).

(6) Noun classes in Mundurukú (Picanço 2003a)

Nouns
- Possessable
  - Inalienable: obligatory possession
  - Alienable: optional possession
- Non-possessable

Alienable possession is morphologically marked by the possessive prefix {é-, e-} attached to the head noun, as illustrated in (7).[2]

(7) Alienable possession: [Possessor – Possessive prefix – Possessee]

(a)
ayátʃát é-ko̰bé | w-e-ko̰bé
woman Poss-canoe | 1-Poss-canoe
'woman's canoe' | 'my canoe'

(b)
aŋókátkát é-nobánṍ | wəy-e-nobánṍ
man Poss-rifle | 1pl.inc.-Poss-rifle
'man's rifle' | 'our rifle'

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[1] Non-possessable items are: animals in general, and elements such as sun/moon, stars, sky, rain, hills, etc. Possession of domestic animals can be expressed syntactically by means of the inalienable noun *-ṍhṍ* 'domestic animal', as in *o-ṍhṍ akíritʃé* 'my dog' (Lit.: 'My domestic animal (is) a dog.')

[2] The high-tone variant of the possessive prefix occurs word-initially, e.g. *ayátʃát é-ko̰bé* 'woman's canoe'; and the low-tone variant occurs word-internally, e.g. *w-e-ko̰bé* 'my canoe'.

Inalienable possession is zero-marked; the Possessor, an independent noun or a pronominal element, is simply juxtaposed to the possessee.[3]

(8) Inalienable possession: [Possessor – Possessee]

(a)	ayáʧát pa̰	o-ba̰
	woman arm	1-arm
	'woman's arm'	'my arm'
(b)	tawé doy	e-dóy
	monkey blood	2-blood
	'monkey's blood'	'your blood'
(c)	ayáʧat ʔit	i-ʔít
	woman child	3-child
	'woman's child'	'my child'

Among nouns, consonant mutation is found to occur only in the inalienable class. More than a phonological process, it indicates that the element immediately preceding an inalienable noun is the grammatical possessor. (9) contains possessive noun phrases in which the two elements stand in a possessor-possessee relation. In these cases consonant mutation is obligatory; the head noun surfaces with the voiced variant if the preceding noun ends in a vowel or glide, as in (9)a, and voiceless following a consonant, as in (9)b. Note that nasal consonants pattern with voiceless stops in consonant mutation, despite the fact that they are phonetically voiced.

(9)	(a)	tawé doy	'monkey's blood'
		monkey blood	
	(b)	dápsém toy	'deer's blood'
		deer blood	

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[3] See Picanço (2003a) for the semantic classes of inalienable nouns.

Now compare (9) with (10), which contains cases in which the preceding element is not the grammatical possessor. In (10)a, the noun *tawé* 'monkey' is semantically the possessor and precedes the head noun *doy* 'blood', but it is not the grammatical possessor. The noun appears incorporated into the verb and forms a unit with the latter; hence, the head noun takes the 3rd person prefix {t-} to indicate that the possessor is not in the same phrase. (It is important to distinguish /t/ that results from the t/d alternation, and /t/ that marks '3rd person'. The example in (9)b above illustrates the voiceless variant in consonant mutation, and the examples in (10)a-b below refer to the 3rd person prefix {t-}, which is always voiceless. See Chapter 9 for an account of the third person {t-}.) In (10)b the prefix marker *o-* '1st person' is neither the grammatical nor the semantic possessor of *doy*. Even though this prefix precedes the noun and ends in a vowel, consonant mutation does not apply because *o-* and *-doy* do not form a syntactic unit. Conversely, in (10)c, the prefix *o-* refers to possessor, thus the noun surfaces with the voiced variant.

(10) (a) [tawé [**t-oy**-daʃíp]] 'The monkey's blood is hot.'
monkey 3-blood-be.hot (Lit.: 'The monkey his blood is hot.')

(b) [o-[**t-oy**-ʤó-ʤó]] 'I saw his/her blood.'
1Su-3-blood-see-RED

(c) [[**o-doy**]-ʤó-ʤó] 'S.o. saw my blood.'
1-blood-see-RED

Table 7.1 gives the distribution of morpheme-initial consonants in the inalienable class. Consonant mutation applies regularly to the entire class. If a noun can surface with an initial voiced stop, [b, d/n, ʤ], it can also have a voiceless variant, [p, t, ʧ]. There are two non-alternating inalienable nouns in the corpus: *p̲í* 'ache, be painful, poisonous', as in *w-a̠-pí* 'I have a headache' and *komə-pí* 'timbó' (a poisonous plant); and *t̲ayʃi* 'wife', as in *ọ-tayʃi* 'my wife'.

Table 7.1. Distribution of consonants morpheme-initially in inalienable nouns (Total = 154 inalienable nouns)

	p	b	p/b	t	d	t/d-n	ʧ	ʤ	ʧ/ʤ	k	ʔ	m	n	ŋ	s	ʃ	r	w	y	V
Inalienable	1	0	14	1	0	47	0	0	1	22	8	0	0	4	2	4	0	2	1	47

(11)-(13) provide examples of inalienable nouns that participate in consonant mutation. (The glottal stop in brackets [ʔ] indicates that the morpheme triggers creaky voice on the preceding vowel, to be examined in Chapter 8.)

(11) Examples of the p/b alternation

(a)	pa̰ / ba̰	'arm'
(b)	pi[ʔ] / bi[ʔ]	'mouth'
(c)	pə[ʔ] / bə[ʔ]	'finger, hand'
(d)	pəre / bəre	'friend, companion'
(e)	pído / bído	'air, breath'
(f)	pətét / bətét	'name'
(g)	padip / badip	'relative'
(h)	pə̰nẽ́ / bə̰nẽ́	'branch'
(i)	põŋbí / bõŋbí	'wrist'

(12) Examples of the t/d, n alternation

(a)	tit / dit	'flower'
(b)	təp / dəp	'leaf'
(c)	tap / dap	'hair'
(d)	toy / doy	'blood'
(e)	tot / dot	'bunch'
(f)	tə̃y / nə̃y	'tooth'
(g)	tõ̰m / nõ̰m	'powder'
(h)	tə̃n / nə̃n	'feces'
(i)	tõ̰ / nõ̰	'sprout'
(j)	takə̃́ / dakə̃́, nakə̃́	'branch'
(k)	taŋṍpa / daŋṍpa, naŋṍpa	'shin'

(13) Example of the ʧ/ʤ alternation

(a)	ʧodít / ʤodít	'uncle'

Consonant mutation is therefore a regular process in the class of inalienable nouns; without exception, if a noun has [b, d/n, ʤ] morpheme-initially, it can also have [p, t, ʧ]. As for verbs, the process has some irregularities.

7.2.2 Verbs

There are five surface classes of verbs in Mundurukú: unergative, unaccusative, stative, transitive, and derived transitive, following a classification proposed in Picanço (2004a; but see Crofts 1973, 1985, and Gomes 2000). These classes are illustrated in (14).

(14) (a) o-ʧe-ka̰pík (Unergative)

1Su-CoRef.Poss-work

'I worked.'

kaʤarã́w-ʔa o̰-ʤé-a-é-bók

pan-CL 3Su-Co.Ref-CL-Poss-float

'The pan floated.'

(b) o-ʔat (Unaccusative)

1Su-fall

'I fell.'

kaʤarã́w-ʔa o-y-á-ʔat

pan-CL 3Su-3-CL-fall

'The pan fell.'

(c) o-díp (Stative)

1Su-be.beautiful

'I'm beautiful.'

ək-ʔá y-a̰-díp

house-CL 3-CL-be.beautiful

'The house is beautiful.'

(d) o-ʤo-ʔó (Transitive)

1Su-3Ob-eat

‘I ate it.’

ayáʧát ʤarã́y-ʔa o-y-á-ʔo

woman orange-CL 3Su-3-CL-eat

‘The woman ate an orange.’

(e) o-ŋə-pík (Derived transitive)

1Su-3Ob.CAUS-be.burned

‘I burned it.’

o-t-əp-mə-pík

1Su-3-CL-CAUS-be.burned

‘I burned it (e.g. leaves).’

Consonant mutation is not as frequent in verbs as it is in nouns. Table 7.2 gives the distribution of morpheme-initial consonants in the different classes of verbs. Two verb classes participate regularly in the process: unaccusative and transitive; and another is systematically immune: unergative. In the group of stative verbs, consonant mutation is irregular; there are few cases of the alternations p/b and t/d-n, and no cases of the alternation ʧ/ʤ; all cases of /ʧ/ and /ʤ/ morpheme-initially in this group do not alter, or if they do, the alternation is optional (see §7.3.1). In general, about 10% of verbs exhibit a regular pattern of alternation.

Table 7.2. Distribution of consonants morpheme-initially in stative, unaccusative, transitive, and unergative verbs. (Total = 217 verbs.)

	p	b	p/b	t	d	t/d,n	ʧ	ʤ	ʧ/ʤ	k	ʔ	m	n	ŋ	s	ʃ	r	w	y	V
Stative (111 verbs)	14	7	4	4	5	3	7	1		13	3	3	1	2	6	1	6	8	2	22
Unaccusative (19 verbs)				1		1			2	2	3				1	3				6
Transitive (46 verbs)			2			9			1	10	4	3		1	1	1		3		11
Unergative (40 verbs)	6	4		2	4		1	1		7		1	1	2	1	2		4		4

In derivations by means of the causative *mə-* (derived transitives), if a verb root undergoes the process, it surfaces with the voiced variant in the derived verb. This is illustrated in (15). These derivations are the only exceptions to the generalization that the preceding element must be the head's argument. In these cases, the alternating head functions as the argument of the verbal head *mə-*.

(15) (a) i-mə-**ʤẽ́m** 'make *x* go out, leave'
3Ob-CAUS-go.out

ʧẽ́m ṍn 'I will go out.'
go.out 1sg

(b) i-mə-**dáʃi**-m 'make *x* hot'
3Ob-CAUS-be.hot-IMPRF

y-op-**táʃip** 'The stick is hot.'
3-CL-be.hot

Consonant mutation is obligatory in a verb if it is associated with an internal argument. The examples below illustrate consonant mutation between an unaccusative verb and its subject, (16)a, and a transitive verb and its object, (16)b; and (16)c gives an example of the alternation with a stative verb.

(16)	Voiceless	Voiced
(a)	**ʧẽ́m** ṍn	o-**ʤẽ́m**
	go.out.IMPRF 1sg	1Su-go.out
	'I will go out.'	'I went out.'
(b)	o-y-op-**táka̰t**	daʃá **dáka̰t**-ka̰-n ṍn
	1Su-3-CL-cut	firewood cut-RED-IMPRF 1sg
	'I cut the stick.'	'I'm cutting firewood.'
(c)	ayáʧát tap t-ap-**pérén**	piŋá-bə i-bə-**bérén**
	woman hair 3-hair-be.long	hook-CL 3-CL-be.long
	'The woman's hair is long.'	'The fishing line is long.'

A list of verbs that have a regular pattern of alternation is given below. (17) provides examples of stative verbs that participate in consonant mutation; (18) and (19) illustrate unaccusative and transitive verbs respectively.

(17) Stative verbs

(a)	pérén / bérén	'be long'
	párárák / bárárák	'be written, marked'
	paʔóre / baʔóre	'be difficult'
	paʔárẽ́m / baʔárẽ́m	'be invisible'
(b)	taʃíp / daʃíp	'be warm, hot'
	tarẽ́m / darẽ́m , narẽ́m	'be fetid'
	tot / dot	'be painted, tattooed'

(18) Unaccusative verbs

(a)	ʧə́ / ʤə́	‘go’
	ʧẽ́m / ʤẽ́m	‘go out/leave’
(b)	tot / dot	‘come’

(19) Transitive verbs

(a)	pə / bə	‘catch, carry’
	pəywát / bəywát	‘help, advise’
(b)	taka̰t / daka̰t	‘cut’
	tá / dá	‘cook’
	tḛ / dḛ	‘grate’
	tobə́ʃik / dobə́ʃik	‘find’
	toʤóat / doʤóat	‘bring s.t. to s.o.’
	tawə̃́n / dawə̃́n, nawə̃́n	‘sharpen’
	taẽ́ / daẽ́, naẽ́	‘choose’
(c)	ʧó / ʤó	‘see’

The following verbs are classified as non-alternating. (20) illustrates non-alternating stative verbs, and (21) non-alternating unergative verbs.

(20) Stative verbs

(a)	i-poʃí	‘It’s heavy.’
	i-pík	‘It’s burned.’
	i-paʔí	‘S/he’s feverish.’
	i-parara	‘S/he’s afraid, scared.’
	i-pərə́k	‘It’s dry.’
	i-pók	‘S/he’s beaten (with a stick).’

(b)	i-beŋbeŋ	‘S/he’s full.’
	i-ba̰kba̰k	‘It’s cracked.’
	i-bík	‘S/he’s lying.’
	yo-boŋ	‘It’s big.’
(c)	i-tok	‘It’s perforated.’
	i-tórṍŋ	‘It’s crooked.’
	tóró-ʔí	‘It’s hanging.’
(d)	i-díp	‘It’s beautiful.’
	i-déŋ	‘It’s be stabbed.’
	i-də	‘It’s loose.’
(e)	i-ʧə́p	‘It’s sour.’
	i-ʧókʧók	‘S/he’s happy.’
	i-ʧə̃ŋ	‘It’s straight.’
	i-ʧa̰	‘It’s hard.’
	i-ʧa̰kʧa̰k	‘It’s squeezed.’
(f)	i-ʤõŋsə̃́ŋ	‘It’s fat.’

(21) Unergative verbs

(a)	ʤe-pirḛฺ	‘blink’
	ʤe-pit	‘go away’
	ʤe-pírín	‘sink’

(b)	ʤe-baw	‘burp’
	ʤe-bók	‘float in the water’
(c)	ʤe-tip	‘dive’
	ʤe-títít	‘suck’
(d)	ʤe-dok	‘swim’
	ʤe-dede	‘talk, answer’
	ʤe-dáə	‘run, go fast’
(e)	ʤe-ʧə̃́	‘stop’
(f)	ʤe-ʤóró	‘jump’

7.2.3 Other cases

Consonant mutation also pervades other classes, including postpositions (22), several particles (23),[4] and the verbalizer suffix (24). In these groups as well, voicing of the morpheme-initial stop is determined by the preceding segment.

(22) Postpositions

(a)	waẽn **pádí**		əkʔá	**bádí**
	oven inside		house-CL:round	inside
	‘inside the oven’		‘inside the house’	
(b)	ayáʧát=**pe**		ək-ʔá=**be**	
	woman=in/to		house-CL=in/to	
	‘to the woman’		‘in the house’	

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[4] Here I use the term ‘particle’ for expository reasons; a proper classification is still necessary.

(c)	waẽn	**tʃedʒé**	ək-ʔá	**dʒedʒé**
	oven	on	house-CL	on
	‘on the oven’		‘over the house’	
(d)	áko-ʔíp	**tiót**=pe	ko̰bé	**diót**=pe
	banana-CL	under=in/to	canoe	under=in/to
	‘under the banana tree’		‘under the canoe’	

(23) Particles

(a)	ka̰pík-pí-ŋ	**pimá**...	ádé	**bimá**...
	work-RED-IMPRF	when	many	when
	‘While working...’		‘When there are many...’	
(b)	ố̃n	**pit**...	í-té	**bit**...
	1sg	contrast	?-DEM	contrast
	‘as for me...’		‘as for him...’	
(c)	a̰dʒók	**pək**	tʃə̃ŋ-ʔí	**bək**
	2.bathe	Imminent	stand.up-?	Imminent
	‘Go bathe!’		‘Stand up!’	
(d)	w-e-ka̰pík	**pət**	ey-e-ə́	**bət**
	1-Poss-work	ability	2pl-Poss-go.up	ability
	‘I can work.’		‘I can go up.’	
(e)	i-tʃók-tʃók	**pəyé**...	i-poʃí	**bəyé**...
	3Su-be.happy-RED	because	3Su-be.heavy	because
	‘Because s/he’s happy...’		‘Because it’s heavy...’	

(f)	i-díp	**ʧíʧá**		i-pí	**ʤíʤá**	
	3Su-be.beautiful	Intensifier		3Su-hurt	Intensifier	
	'S/he's is very beautiful.'			'It hurts a lot.'		
(g)	ṍn	**tak**		o̰-ʃí	**dak**	
	1sg	too		1-mother	too	
	'me too'			'my mother too'		
(h)	o-ktop	**tə́**	o-ʔát?	bío	**də́**	o-y-áóká?
	1-husband	Q	3Su-fall	tapir	Q	3Su-3Ob-kill
	'Was it my husband who fell?'			Was it a tapir that he killed?'		

(24)	o-sə-itop-**tá**	o-sə-tayʃi-**dá**
	1Su-3Ob-husband-Vzr	1Su-3Ob-wife-Vzr
	'I arranged her marriage.'	'I arranged his marriage.'

The process also applies to compounds formed with an alternating morpheme, whether it is a verb, (25), or a noun, (26).

(25) Compounds: verbs

(a)	**pa̰**-ʧá / ba̰-ʧá	'be strong'
	arm-be.hard	
(b)	**pi**-pərə́k / bi-pərə́k	'be thirsty'
	mouth-be.dry	
(c)	**tao̰**-bə́k / dao̰-bə́k	'be slim, thin'
	leg-?	
(d)	**tao**-apĩ́n / dao-apĩ́n	'be short'
	leg-be.short	

(e) **tao-bérén** / dao-bérén 'be tall'
leg-be.long

(f) **tao**-bíre / dao-bíre 'be tired'
leg-be.tired

(g) **tópa**-pə̰̃n / dópa-pə̰̃n, nópapə̰̃n 'be full'
face-be.full

(h) **toy-ʤẽ́m** / doy-ʤẽ́m 'bleed'
blood-go.out

(26) Compounds: nouns

(a) daydo-**dáp**-dáp 'armadillo, sp.'
armadillo-hair-RED

(b) ka-**diŋ** 'dust'
thing-smoke

(c) ka-ʔṍŋ-**tot** 'broom'
thing-sweep-CL

To sum up: consonant mutation is a regular and obligatory alternation of a head in the presence of its argument. Grammatically, it serves to express the local dependency relation that holds between, for example, possessor-possessee, subject-unaccusative verb, object-transitive verb, object-postposition, etc. If these syntactic conditions are not met, consonant mutation does not apply. In the next section we will see some of these cases, which lead to the conclusion that there are two processes involved: lenition and fortition.

7.3 Phonological aspects

We saw earlier that certain classes of morphemes (e.g. inalienable nouns, unaccusative verbs, transitive verbs, postpositions, etc.) participate regurlarly in the process of consonant mutation, in that morpheme-initial consonants surface voiced after vowels and glides, and voiceless after other consonants. Mundurukú has 7 oral stops, /p, b, t, d, ʧ, ʤ, k/, but mutation applies only to those that contrast for the feature [voice]; thus the alternation k/g is never found. Examples are provided below; the p/b alternation is illustrated in (27), t/d in (28), and ʧ/ʤ in (29).

(27)	(a)	ayáʧát pa̰	i-tayʃi bá
		woman arm	3-wife arm
		‘woman’s arm’	‘his wife’s arm’
	(b)	t-ə̃n-pə́	piŋá-bə
		3-feces-CL	fishhook-CL
		‘his/her intestines’	‘fishing string’
	(c)	ayáʧát pətét	toʃáw bətét
		woman name	chief name
		‘woman’s name’	‘chief’s name’
(28)	(a)	ka-sop-tá	mərá-da
		thing-flame-CL	corn-CL
		‘star’	‘corn (seeds)’
	(b)	tawé daó	dápsém taó
		monkey leg/bone	deer leg/bone
		‘monkey’s leg/bone’	‘deer’s leg/bone’
	(c)	tawé doy	dápsém toy
		monkey blood	deer blood
		‘monkey’s blood’	‘deer’s blood’

(29)	(a)	o-t-əp-ʧó-ʧó		o-t-a-ʤó-ʤó	
		1Su-3-CL-see		1Su-3-CL-see-RED	
		‘I saw it (e.g. leaf)’		‘I saw it (e.g. corn seeds)’	
	(b)	o-ʃét	ʧíʧấ	i-pí	ʤíʤấ
		1Su-sleep	Intensifier	3Su-be.painful	Intensifier
		‘I slept in.’		‘It hurts a lot.’	

The interaction between consonant mutation and nasal harmony (examined in Chapter 6), has developed another pattern, t/n, which is the nasal version of the t/d alternation (see §7.3.3). Before a nasalized vowel, (30), the alternation is obligatorily t/n.

(30)	(a)	dápsém	tə̃y	mədí	nə̃y / *də̃y
		deer	tooth	cotia	tooth
		‘deer’s tooth’		‘rodent’s (sp.) tooth’	
	(b)	ʃin-tṍm		wenə̃́-y-nõ̰m / *dõ̰m	
		pancake-CL		nut-CL-CL	
		‘flour for pancake’		‘nut flour’	
	(c)	o-ktop	tə̃́n	o-nə̃́n / *də̃́n	
		1-husband	feces	1-feces	
		‘my husband’s feces’		‘my feces’	

There is no interaction with nasality in the alternations p/b and ʧ/ʤ.

(31)	(a)	ayáʧát	põ̰ŋbí	o-bõ̰ŋbí	
		woman	wrist	wrist	
		‘woman’s wrist’		‘my wrist’	

(b) ʧẽ́m ṍn
go.IMPRF 1sg
'I will go.'

o-ʤẽ́m
1Su-go
'I went.'

There are some irregularities that resulted from the interaction between consonant mutation and nasality, but I will save these for §7.3.3.

Consonant mutation is structure-preserving; it does not generate phonemes that are not already members of the phonemic inventory. Only consonants with voiced-voiceless pairs in the inventory may alter; that is, p/b, t/d and ʧ/ʤ, but not k/g, as shown in (32).

(32) (a) o̰-ʔít-**kap**
3Su-child-pass
'The child was born.'

o̰-**káp**
3Su-pass
'S/he passed by.'

(b) kák **kədá**-m o̰-ʤə́
fox look.for-IMPRF 3Su-go
'S/he went look for a fox.'

bío **kədá**-m o̰-ʤə́
tapir look.for-IMPRF 3Su-go
'S/he went look for a tapir.'

The prohibition on a voiced velar [g] can be accounted for by the phonologization of an aerodynamic constraint on voicing in obstruents (Ohala 1983), as discussed in Chapter 3. To vibrate, the vocal folds require sufficient airflow passing through the glottis. This requirement enters in conflict with the complete closure required in the production of a stop, because the closure causes the air to accumulate more rapidly in the oral cavity, and consequently, inhibit vibration of the vocal folds. In this sense, voicing is threatened for obstruents in general, but the anterior versus posterior sites of constriction also make a difference: the further back an obstruent is articulated, the more difficult it is to maintain voicing since air accumulates more rapidly in back articulated stops, like [g], than in front articulated stops, like [b].

In conformity with the aerodynamic constraint on voicing in obstruents, I propose the following constraints on the cooccurrence between obstruents and voicing, given in (33)a-c. Their harmonic ranking is as shown in (33)e, which determines that voiced labials are less marked than coronals, and these are less marked than velars.

(33) (a) *VOIVEL

A velar [-sonorant] must not be voiced.

(b) *VOICOR

A coronal [-sonorant] must not be voiced.

(c) *VOILAB

A labial [-sonorant] must not be voiced.

(d) MAX[±voice]

Input [±voice] segments have output correspondents.

(e) Harmonic ranking

*VOIVEL >> *VOICOR >> *VOILAB

The interaction between faithfulness and markedness constraints will then allow or disallow voicing contrasts on particular segments. Crucially, *VOIVEL, which bans voiced velar obstruents, must outrank faithfulness to voicing, MAX[±voice], in order to guarantee that /g/ will never surface, and /k/ will never undergo voicing in Mundurukú.

Tableau 7.1. Prohibition on [g]: *bío kədám* 'to look for a tapir'.

bío kədá-m or gədá-m	*VOIVEL	MAX[±voi]
a. bío gədám	*!	▨
b. ☞ bío **k**ədám		(*)

As for other stops, the contrast between voiceless /p, t, ʧ/ and voiced /b, d, ʤ/, must be preserved, as shown by the examples in (34).

(34) (a)	i-**pík**	*ibík	i-**bík**
	3Su-be.burned		3Su-be.closed
	'It's burned.'		'It's closed.'

(b)	i-mə-**tók** 3Ob-CAUS-be.perforated ‘to perforate s.t.’	*imədók	**ʤe-dók** CoRef.Poss-swim ‘to swim’
(c)	**i-ʧa̰k-ʧa̰k** 3Su-be.squeezed-RED ‘It’s squeezed.’	*oʤa̰kʤa̰k	o-**ʤat** 1Su-catch ‘I caught.’

We must therefore guarantee voicing distinctions in other places of articulation. This can be obtained if faithfulness to voicing outranks the markedness constraints on voicing in labials and coronal obstruents, as shown in the following tableau.

Tableau 7.2. Contrast between voiceless and voiced stops maintained.

i-pík ‘be burned’ i-bík ‘be closed’	*VoiVel	Max[±voi]	*VoiCor	*VoiLab
a. ipík ipík		*!	▨	▨
b. ☞ ipík ibík				*

But the situation is different in consonant mutation where labials and coronals may surface voiceless or voiced. Here it is important to establish whether the process involves the loss of the feature [+voice], or the opposite, i.e. addition of [+voice]; or perhaps both.

7.3.1 Lenition versus fortition; lenition and fortition

The criteria for deciding the direction in voicing alternation are variable. Mutation may be a case of ‘lenition’, which refers a change of a consonant considered ‘strong’ into one considered ‘weak’; for instance, voiceless stops (*fortis*) change into voiced stops or fricatives (*lenis*). Or it may be the reverse, ‘fortition’, in that a weak consonant changes into a strong consonant; thus, voiced stops change into voiceless stops.

One way of establishing the direction is to place alternating morphemes in a context that does not favor alternation. This may be utterance-initially or within a sentence in which the element preceding the alternating morpheme does not form a morphological or syntactic unit with it. Examples of the first kind are better to obtain for all three alternations in Mundurukú, allowing us to draw a good parallel between them. The first two colums below illustrate the alternation; the third column contains the same morphemes utterance-initially, without alternation. Note that the variants that surface are voiceless in the case of p/b and ʧ/ʤ.

(35)	Voiced	Voiceless	No alternation: voiceless /p/
(a)	o-tayʃi **bĩ́**	ayáʧát **pi**	**pi**-dap-ʔə́k-ʔə́k=ʔək=át
	1-wife mouth	woman mouth	mouth-hair-take-RED=HAB=NOM
	‘my wife’s mouth’	‘woman’s mouth’	‘barber’
(b)	piŋá-**bə**	t-ə̃n-**pə́**	**pə**-mə̃́n
	fishhook-CL	3-feces-CL	finger-enclosure
	‘fishing line’	his/her intestines’	‘ring’

(36)	Voiced	Voiceless	No alternation: voiceless /ʧ/
(a)	doy-**ʤẽ́m-ʤẽ́m**	o̰-y-ákoóp-**ʧẽ́m**	**ʧẽ́m-ʧẽ́m**=ʔək o̰-ʃí
	3Su-go.out-RED	3Su-3-pus-go.out	go.out-RED=HAB 1-mother
	‘to bleed’	‘The pus came off.’	‘My mother always goes out.’
(b)	o̰-**ʤə́** Belém be	---------	**ʧə́-m** ṍn
	3Su-go Belém LOC		go-IMPRF 1sg
	‘S/he went to Belém.’		‘I will go.’

Surprisingly, the situation is different with the alternation t/d-n. Here we obtain the voiced variant.

(37)	Voiced	Voiceless	No alternation : /d/ or /n/
(a)	tawé **doy**	dápsém **toy**	**doy**-ʤẽ́m-ʤẽ́m
	monkey blood	deer blood	blood-go.out-RED
	‘monkey blood’	‘deer blood’	‘to bleed’

(b)	y-a-**dírem**	t-ap-**tírem**	ṍn **dírem** o-ʤə́y
	3-CL-be.wet	3-hair-be.wet	1sg be.wet 1-MOD
	‘It (e.g. fruit) is wet’	‘His/her hair is wet’	‘I wanted to be wet.’
(c)	o-**nə̃́y**	ayáʧát **tə̃y**	**nə̃y**-ʔə́k-ʔə́k=ʔək=át
	1-tooth	woman tooth	tooth-take-RED=HAB=NOM
	‘my teeth’	‘woman’s teeth’	‘dentist’

We have thus identified two opposite effects of consonant mutation in Mundurukú: voiceless stops /p, ʧ/ undergo voicing (lenition), and /d/ undergoes devoicing (fortition).

Further support is given in (38), which contains unergative verbs (on the left) derived from stems that participate in the p/b alternation (on the right). Consonant mutation does not apply to unergatives because the relation between a head and its dependent is intermediated by two other elements, the possessive prefix {é-, e-} and the prefix {ʧe-}, which marks coreferentiality (where *ʧe-+e-* → *ʧe-*); thus unergatives are morphologically complex: <u>Dependent</u>-Coreferential-Possessive-<u>Head</u> (see Picanço 2004 for details), and therefore do not satisfy the morphosyntactic conditions on the process, which determines that head and dependent must be in a local dependency relation: Dependent-Head. Therefore, unergatives provide another good argument for the lenition/fortition controversy. As shown in (38), the fact that the derived verbs surface with a voiceless stop confirms the lenition hypothesis for the p/b alternation.

(38) Derived unergative verbs

(a)	o-ʧe-**pído**-wát	Compare:	o̰-**bído**
	1Su-CoRef.Poss-breath-?		1-breath
	‘I breathed.’		‘my breath’
(b)	o-ʧe-**paʔárẽ́m**		o-**baʔárẽ́m**
	1Su-CoRef.Poss-be.invisible		3Su-be.invisible
	‘I disappeared.’		‘I’m invisible.’

Now let us look at the examples in (39). The stative root *ʧə̰k* 'be cold' exhibits an irregular pattern of consonant mutation; the voiced variant only occurs in the compound *kaʤə̰k*, (39)c, but not in the stative and transitive-causative forms, (39)a-b. This case is exceptional, but also suggests that the root-initial consonant was originally voiceless; thus in the case of the alternation ʧ/ʤ, the process is also lenition.

(39) (a) **i-ʧə̰k** 'It's cold.'
3Su-be.cold

(b) **i-mə-ʧə̰k** 'make *x* be cold'
3Ob-CAUS-be.cold

(c) ṍn **ka-ʤə̰k** 'I'm cold (weather).'[5]
1sg thing-be.cold

A parallel argument can be offered for the fortition hypothesis. The noun *daʃá* 'fire/firewood', historically an inalienable noun, is synchronically used without a possessor, as other nouns designating basic cultural products; for example, *e* 'tobbaco', *op* 'arrow', and *əkʔá* 'house'. However, while the free form contains a voiced stop /d/, this initial consonant still alternates when the noun is possessed; for instance, *ayáʧát taʃá* 'woman's firewood' versus *odaʃá* 'my firewood'. Supposing that the free form of the noun retained the underlying consonant, then the t/d alternation in fact refers to a process in which a voiced stop is devoiced after consonants, i.e. fortition.

Putting all the considerations above together, consonant mutation in Mundurukú is thus the result of the interaction of two processes: lenition, which assigns the feature [+voice] to an initial /p/ or /ʧ/, and fortition, which deletes [+voice] from an initial /d/. There is, however, a minor objection to the lenition/fortition distinction in consonant mutation: distribution. Recall from

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[5] Voicing is not due to the morpheme ka-. Compare ka-ʤə̰k 'cold' and ka-tõ (thing-purple) 'a Mundurukú village'.

Table 7.1 and Table 7.2 that consonant mutation applies regularly to three major classes: (i) inalienable nouns, (ii) transitive verbs, and (iii) unaccusative verbs. The generalization for these classes is that if a head surfaces with a voiced stop initially, it can also have a voiceless variant; but not conversely. The number of counter-examples is significantly low, but this statement implies that there is only one process involved, namely fortition. In support of this we find that fortition begins to be generalized in the language; i.e. non-alternating voiced stops begin to be affected in similar contexts, as shown in (40)a-b, which may now have voiced and voiceless variants when preceded by voiceless stops. Voiceless stops remain unaffected, (40)c.

(40) (a) boŋ 'be big' t-əp-**boŋ** Also: təp-**poŋ**
3-leaf-be.big
'The leaf is big.'

(b) díp 'be beautiful' t-ap-**díp** Also: tap-**típ**
3-hair-be.beautiful
'His/her hair is beautiful.'

(c) pík 'be burned' o-ba̰-pík *oba̰**bík**
1-arm-be.burned
'My arm is burned.'

I suggest that the examples in (40) are innovations, which have not yet been consolidated in the grammar. This is perhaps an attempt the grammar is making to resolve the conflict between fortition and lenition, by having only one process. Given this, it remains for us to account for the following observations.

(41) Summary of the facts

(a) The language contrasts /p/ vs. /b/, /t/ vs. /d/, /ʧ/ vs. /ʤ/, but /k/ vs. */g/.

(b) Neutralization of contrasts I: voiceless stops /p/ and /ʧ/ become voiced (lenition).

(c) Neutralization of contrasts II: voiced /d/ becomes voiceless (fortition).

(d) Triggers: vowels and glides trigger lenition; obstruents (stops and nasals) trigger fortition.

(e) Direction: assimilation is progressive.

(f) Structure preservation: consonant mutation does not generate phonemes that are not already members of the inventory.

(g) Generalization: non-alternating voiced stops begin to be affected in similar contexts; thus, the tendency is to generalize fortition, not lenition.

(h) Interaction with nasality: t/d alternation in oral contexts, t/n in nasal contexts.

(i) Dialectal variation: the result of a historical change in nasal harmony (see §7.3.3).

7.3.2 Discussion and analysis

The particulars of Mundurukú consonant mutation brings about broader perspectives for featural phonology and OT in general. First, consonant mutation shows the possibility of having two phenomena, so to speak, in complementary distribution relative to each other; this is in the sense that they do not overlap the segments affected.

Second, in consonant mutation the features of a coda segment prevail over those of an onset. This has some implications for claims about positional faithfulness (Beckman 1998; Lombardi 1996, 1999), which, in the case of voicing assimilation, deals better with regressive assimilation (e.g. Lombardi 1996). Mundurukú voicing alternation is more restricted, and crucially requires morphosyntactic information; for instance, morpheme-specific properties and appropriate morphological or syntactic configurations.

Finally, these alternations do not conflict with general requirements that maintain voicing contrasts elsewhere in the grammar. For example, the language contrasts /p/ versus /b/, but this contrast may be neutralized under specific conditions, and /p/ can be realized as [b].

In classic OT, a feature F is contrastive in a language if faithfulness to F outranks some markedness constraint on F, e.g. *F.

(42)	(a)	Faith-F >> Markedness-F	F is contrastive
	(b)	Markedness-F >> Faith-F	F is neutralized

In Mundurukú, [voice] is constrastive in the stop series, except for the velar stop /k/. This implies that the language requires the ranking in (42)a, in that faithfulness to [voice] outranks markedness constraints on voicing, with the exception of *VOIVEL, as shown in Tableau 7.1 and Tableau 7.2 above. But under specific conditions, contrasts may be neutralized: voiceless obstruents may be voiced in onset position, and voiced obstruents may be voiceless. Thus, the language also makes use of the ranking in (42)b.

The relevant observation is: "To indicate a dependency relation between a head and its internal argument, a morpheme-initial stop must agree with the preceding segment in the following way: if the segment is [-consonantal], the stop is [+voice]; if it is [+consonantal], then the stop is [-voice]. Elsewhere, voicing contrasts are maintained."

Consonant mutation is clearly a language-specific device. First, mutation is mainly determined by the feature [consonantal]: the voiceless forms occur following segments that are [+consonantal], which include not only voiceless obstruents but also sonorants like nasal stops; in addition, these must be distinguished from [-consonantal] segments (i.e. vowels and glides), which trigger voicing.

Another reason is that mutation serves to a specific morphosyntactic function: to mark a dependency relation between a head and its argument.

These particular aspects of the process require that the constraint demanding the alternation be specific to Mundurukú. Alternatively, one could account for the patterns by means of allomorphy, as in (43). Every alternating morpheme has two underlying forms: voiced and voiceless, which must be selected to their appropriate environments.

(43) Alternating morphemes as allomorphs

(a)	pído	'breath'	Elsewhere
	bído		Selected after [-consonantal] segments
(b)	toy	'blood'	Selected after [+consonantal] segments
	doy		Elsewhere
(c)	ʧə́	'to go'	Elsewhere
	ʤə́		Select after [-consonantal] segments

A disadvantage of the allomorphy approach concerns the selection of allomorphs to the 'appropriate contexts'. Under this view, this is done by the phonology. In the case of the variants p/b and ʧ/ʤ, voiced forms are selected following a [-consonantal] segment, and voiceless forms elsewhere; but in the alternation t/d, /d/ is the elsewhere case. The allomorphy approach misses the generalization that voicing alternation takes place only if there is a dependency relation between two elements; elsewhere voicing contrasts are maintained. To demonstrate this, suppose the following sequential prohibitions, which will be used to select the allomorphs to their appropriate contexts. (44)a selects the voiced variant following a vocalic segment; and (44)b selects the voiceless variant.

(44) (a) *[-cons] – [-son, +cons, -cont, -voi] (Shorthand: *Voi-Vls)
A sequence [-cons, +cont] – [+cons, -cont, -voi] is prohibited.

(b) *[+cons] – [-son, +cons, -cont, +voi] (Shorthand: *Vls-Voi)
A sequence [+cons, -cont] – [+cons, -cont, +voi] is prohibited.

*Voi-Vls says that a voiceless stop, i.e. [-son, +cons, -cont, -voi], can be in sequence with a glide or vowel, and *Vls-Voi that a voiced stop cannot be in sequence with another consonant. The sequential prohibitions pick voiced and voiceless allomorphs according to the contexts. The following tableau demonstrates the selection of voiced forms if the morpheme follows a vowel. Note that selection of either allomorph satisfies Max[±voice] because both forms are available in the input.

Tableau 7.3. Selection of voiced variants.

V-{pído/bído}	*VoiVel	Max[±voi]	*Voi-Vls	*Vls-Voi	*VoiCor	*VoiLab
a. V-pído			*!		*	
b.☞ V-bído					*	*
V-{toy/doy}						
a. V-toy			*!			
b.☞ V-doy					*	

Tableau 7.4 shows that the ranking also selects the voiceless forms following a [+consonantal] segment.

Tableau 7.4. Selection of voiceless variants.

C-{pído/bído}	*VoiVel	Max[±voi]	*Voi-Vls	*Vls-Voi	*VoiCor	*VoiLab
a.☞ C-pído					*	
b. C-bído				*!	*	*
C-{toy/doy}	*VoiVel	Max[±voi]	*Voi-Vls	*Vls-Voi	*VoiCor	*VoiLab
a. C-toy						
b. C-doy				*!	*	

The ranking also predicts that, word-initially, the voiceless allomorph must be selected, as illustrated in the following tableau. This is satisfactory for the alternations p/b and ʧ/ʤ;

Tableau 7.5. Selection of voiceless variants.

{pído/bído}	*VoiVel	Max[±voi]	*Voi-Vls	*Vls-Voi	*VoiCor	*VoiLab
a. ☞ pído					*	
b. bído					*	*!

but not for the t/d alternation, where the ranking picks the voiceless allomorph in these contexts, but the actual forms must be voiced.[6]

Tableau 7.6. Wrong prediction: selection of voiceless variant.

{toy/doy}	*VoiVel	Max[±voi]	*Voi-Vls	*Vls-Voi	*VoiCor	*VoiLab
a. ☞ toy						
b. ☹ doy					*!	

In addition, by treating alternating morphemes as subject to phonological requirements only, the analysis generates patterns that are not attested in the language. For example, the unergative verb *ʤe-pído* 'to breathe' is derived from an alternating root, as we saw above in (38); although the prefix *ʤe-* ends in a vowel, the initial consonant /p/ must be voiceless because *ʤe-* is not the

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[6] One could argue that coronals, as opposed to labials and velars, are required to voiced. A constraint demanding this (e.g. VoiCor: If [coronal] then [+voice]) would correctly select the voiced form in Tableau 7.6, but it would also predict that the ʧ/ʤ alternation, which also involves coronals, should pattern the same way.

dependent argument of *pído*. However, the sequential prohibitions are context-free, i.e. they do not refer to the morphosyntactic conditions to which the process is subject. The ranking thus predicts that the voiced variant must be selected whenever there is a preceding vowel.

Tableau 7.7. Wrong prediction: selection of voiced variant.

ʤe-{pído/bído}	*VoiVel	Max[±voi]	*Voi-Vls	*Vls-Voi	*VoiCor	*VoiLab
a.☹ ʤe-pído			*!		*	
b.☞ ʤe-bído					*	*

These problems arise because consonant mutation does not follow from phonological requirements only. Whether we posit one or both forms underlyingly, the constraint must refer to the syntactic configuration in which mutation is required. In other words, it needs to make reference to (a) the morphosyntactic conditions that determine the alternation, (b) triggers and targets, and (c) the effects; that is, lenition in one case, fortition in the other, as the language exhibits both.

A constraint is proposed in (45). Condition (i) refers to previous *Voi-Vls and (ii) refers to *Vls-Voi, which have been incorporated into a single constraint with reference to the morphosyntactic environment where they apply. Each of these could be proposed independently, but for present purposes, I will refer to them as DHR[voi].

(45) Dependent-Head-Relation[voice] (DHR[voi])

In a Dependent-Head relation, α is a segment of Dependent, and β a segment of Head.

Let α and β be adjacent,

(i) if β is [-son, +cons, -cont], but α is [-cons], then β is [+voiced]; but

(ii) if α is [+cons], then β is [-voice].

With DHR[voice], alternation is achieved. This is shown in the tableau below, which illustrated lenition. DHR[voice] must dominate faithfulness to [voice] in order to allow loss or addition of the feature [voice], without fatal violations of Max[±voice]. Epenthesis of a vowel in the cluster C-p satisfies DHR[voi] as long as the stop surfaces voiced, but fatally violates W-Contiguity, which forbids epenthesis.

Tableau 7.8. Lenition. Input: *pído* 'breath'.

V-pído	*VOIVEL	W-CONTIG	DHR[voi]	MAX[±voi]	*VOICOR	*VOILAB
a. V-pído			*!		*	
b.☞ V-bído				*	*	*
C-pído	*VOIVEL	W-CONTIG	DHR[voi]	MAX[±voi]	*VOICOR	*VOILAB
a. C-pído						
b. C-bído			*!	*	*	*
c. Cə-bído		*!		*	*	*

Because DHR[voice] applies only if two elements stand in a dependent-head relation, it does not require the alternation in derivations in which the Head is not preceded by the Dependent, as in the case of the unergative verb *ʤepído* 'to breathe', derived from the alternating root *pído*. Here, the preceding vowel is not a segment of the Dependent, so the initial /p/ is not required to undergo voicing. Alternation in these cases fatally violate MAX[±voi].

Tableau 7.9. No alternation. Input: *ʤe-pído* 'to breathe'.

ʤe-e-pído CoRef-Poss-breath	*VOIVEL	DHR[voi]	MAX[±voi]	*VOICOR	*VOILAB
a. ʤe-bído			*!	**	*
b.☞ ʤe-pído				**	

The ranking can also account for fortition, as shown in Tableau 7.10;

Tableau 7.10. Fortition. Input: *doy* 'blood'.

C-doy	*VOIVEL	W-CONTIG	DHR[voi]	MAX[±voi]	*VOICOR	*VOILAB
a. ☞ C-toy				*		
b. Cə-doy		*!			*	
c. C-doy			*!		*	

and retention of /d/ if it does not occur in the context that requires alternation. The example in the next tableau is interesting because the verb is a compound, formed by two alternating morphemes: *doy* 'blood' and *ʧẽ́m* 'to go out', in which *doy* functions as the Dependent of the verb root. Thus alternation is required for the root but not for the noun. This is why candidate (c) is ruled out and (b) wins.

Tableau 7.11. Input: *doy-ʧẽ́m* 'to bleed'

doy-ʧẽ́m blood-go.out	*VOIVEL	DHR[voi]	MAX[±voi]	*VOICOR	*VOILAB
a. toy-ʤẽ́m			**!	*	
b.☞ doy-ʤẽ́m			*	**	
c. doy-ʧẽ́m		*!(ʧ)		*	

The problem is the class of stative verbs, which have both alternating and non-alternating roots, as seen above in §7.2.2. It is not possible, for example, to generate the contrast between the two cases in (46) based on the assumption that they are lexically similar; (46)a illustrates the p/b alternation, and (46)b illustrates a non-alternating /p/.

(46) (a) i-párárák → ibárárák 'It's marked.'
3Su-be.marked

t-əp-párárák → təppárárák 'to write'
3-leaf-be.marked

(b) i-parara → iparara 'S/he's afraid.'
3Su-be.afraid

For the class of stative verbs, it is necessary to lexically distinguish two sub-classes: alternating roots take an internal argument (e.g. *párárák* 'to be marked'), non-alternating roots do not (e.g. *parara* 'to be afraid'). Thus, the roots that take an argument are subject to DHR[voi], and as such must undergo voicing alternation.

This is obviously a speculation; except for the fact that these roots participate in consonant mutation, I cannot offer other arguments to explain their properties as a class distinct from the one that does not alternate. This is an issue I will set aside for future research.

7.3.3 The t/d alternation and nasality

The history of nasal harmony in Mundurukú came up several times in this study. The system evolved from another where nasality was not blocked, like in Kuruaya. The change in nasal harmony had an effect in the inventory because a contrast between /d/ and /n/ was established. In Pre-Mundurukú, */d/ had oral and nasal allophones, determined by context: [d] preceding an oral vowel, and [n] preceding a nasal vowel. The change in nasal harmony caused a secondary split, that is, the allophones became independent phonemes. However, phonologization left a gap in the distribution of /d/ before a nasalized vowel, which is now the constraint *dṽ, as discussed in detail in Chapter 5.

(47) *dṽ – The sequence dṽ is prohibited.

The changes involving nasal harmony affected the t/d alternation because the voiced variant was also realized as [n] in the context of nasalization. The secondary split determined that the nasal allophone [n] should be retained in the former environments, but consonant mutation demanded [d]. The immediate consequence of this conflict was a dialectal difference, summarized in (48). For both dialects, the voiced variant of alternating morphemes is [d] before an oral vowel, and [n] before an underlying nasal vowel. The difference arises in contexts where the vowel was nasalized by spreading in the earlier system; where one dialect has [d], the other has [n].

(48) Summary of the patterns in consonant mutation

	_v	_ṽ	_v...ṽ	voiceless variant
Dialect A	d	n	d	t
Dialect B	d	n	n	t

The /d/-variant before an oral vowel was discussed previously in this chapter. In this section I deal with the nasal variant and the dialectal difference.

First of all, in both dialects the alternation is t/n before an underlying nasal vowel.

(49) t/n alternation before an underlying nasal vowel

(a)	dápsém tə̃y	mədí nə̃y / *də̃y
	deer tooth	cotia tooth
	‘deer’s tooth’	‘rodent’s (sp.) tooth’
(b)	ʃin-tṍm	wenə̃́-y-nõ̰m / *dõ̰m
	pancake-CL	nut-CL-CL
	‘flour for pancake’	‘nut flour’
(c)	o-ktop tə̃́n	o-nə̃́n / *də̃́n
	1-husband feces	1-feces
	‘my husband’s feces’	‘my feces’

Let us assume for the moment that the underlying form in morphemes that participate in the t/n alternation is generally /d/, and that this consonant changes to [n] in the output because of the highly-ranked constraint *dṽ against the sequence [dṽ].

Recall that the ranking that determines nasal harmony, examined in Chapter 6, is as in (50).

(50) MaxPath[nas], Nas/Son >> *Oral-Nasal >> DepPath[nas]

Since the language prohibits a sequence *dṽ*, the constraint *dṽ must be ranked higher than the constraints on nasal harmony. Let us suppose that the general ranking is as in (51), which combines consonant mutation with nasal harmony.

(51) General ranking

*dṽ >> DHR[voi] >> MaxPath[nas], Nas/Son >> Max[±voi] >> *Oral-Nasal >> DepPath[nas]

Before looking at the details of this interaction, we must account for the fact that both dialects make a contrast between /t, d, n/, but /d/ and /n/ never contrast before a nasal vowel; in this context we find only [n]. For that, I propose a constraint prohibiting the change /d/ → [n], here encoded by Dep[+son].

(52) Dep[+son]

A [+sonorant] segment in the output must have a correspondent in the input.

Consider first an input /t/. Max[±voi] guarantees its realization in the output as [t].

Tableau 7.12. /t/ preserved in the output.

tv		*dṽ	Max [±voi]	Dep [+son]
a. ☞	tv			
b.	dv		*!	
c.	nv		*!	*

Now consider /d/ before an underlying nasal vowel. Because the language prohibits the sequence d-ṽ, the output cannot be faithfulness to its input. The vowel cannot lose its nasality, candidate (b), because of MaxPath[nas], neither can /d/ be rrealized as [t], candidate (c), because [+voice] must be preserved; a better solution is then [n], which maintains voicing and does not violate highly ranked constraints.

Tableau 7.13. No contrast between /d/ and /n/ before a nasal vowel.

dṽ		*dṽ	MaxPath [nas]	Max [±voi]	Dep [+son]	Dep Path [nas]
a.	dṽ	*!				
b.	dv		*!			
c.	tṽ			*!		
d.☞	nṽ				*	*

But if the input is /n/, it is time for MaxPath[nas] to take action and ensure that this feature will not be lost, as shown in the following tableau.

Tableau 7.14. Contrast between /d/ and /n/ preserved.

nv		*dṽ	MAXPATH [nas]	MAX [±voi]	DEP [+son]	DEPPATH [nas]
a.	tv		*!	▨	▨	▨
b.	dv		*!	▨	▨	▨
c.☞	nv					

The ranking should also be capable of producing the same results in the interaction between voicing alternation and nasal harmony. But can it account for the dialectal difference seen in (48) above?

Let us begin with the cases that do not show a discrepancy: both dialects have [n] as the voiced variant of /d/ preceding an underlying nasal vowel.

(53) t/n alternation before an underlying nasal vowel

(a) dápsém tə̃y — mədí nə̃y / *də̃y
deer tooth — cotia tooth
'deer's tooth' — 'rodent's (sp.) tooth'

(b) ʃin-tə̃́m — wenə̃́-y-nə̰̃m / *də̰̃m
pancake-CL — nut-CL-CL
'flour for pancake' — 'nut flour'

(c) o-ktop tə̃́n — o-nə̃́n / *də̃́n
1-husband feces — 1-feces
'my husband's feces' — 'my feces'

Tableau 7.15 gives an illustration of how the ranking produces the nasal variant if an input contains the sequence /dṽ/. Because *dṽ is ranked higher than DHR[voi], which determines the alternation, the output cannot contain [d], ruling out the form *də̃́n*, candidate (a). Another possibility is to change /d/ into [t], candidates (b) and (c), since the language does not prohibit the sequence [tṽ]. However, (c) fatally violates DHR[voice], which requires a voiced variant after a vowel, and (b) violates W-CONTIG, which forbids inter-morphemic epenthesis. The choice is then [n], which satisfies both DHR[voice] and MAX[±voice], since [n] is (phonetically) voiced.

Tableau 7.15. Dialects A and B. Input: *v-də̃́n → ṽnə̃́n* 'feces'

v-də̃́y		*dṽ	W-CONTIG	DHR [voi]	MAXPATH [nas]	MAX [±voi]	DEP [+son]	DEPPATH [nas]
a.	v-də̃́ỹ	*!						*
b.	vC-tə̃́ỹ		*!			*		*
c.	v-tə̃́ỹ			*!		*		
d.	v-də́y				*!			
e. ☞	ṽ-nə̃́ỹ						*	***

The voiceless variant is illustrated in the next tableau.

Tableau 7.16. Dialects A and B: voiceless variant.

vC-də̃́y		*dṽ	W-CONTIG	DHR [voi]	MAXPATH [nas]	MAX [±voi]	DEP [+son]	DEPPATH [nas]
a.	vC-də̃́ỹ	*!						*
b.	vCə̃-nə̃́ỹ		*!					*
c.	vC-nə̃́ỹ			*!			*	***
d.☞	vC-tə̃́ỹ					*		*

The dialectal difference refers specifically to cases where /d/ does not immediately precede a nasal vowel (i.e. dv…ṽ). The relevant examples are given below; (54) illustrates cases in which an intervening stop blocks nasalization, and (55) illustrates cases with no blocking segments. In dialect A, we find /d/ and an unusual case of blocking: nasality is blocked right before a syllable containing /d/, and that syllable surfaces oral. In dialect B, we find /n/ only, including cases where nasalization is blocked by an obstruent; if there is no blocker, nasality spreads normally.

(54)	UR	Dialect A	Dialect B	Gloss
(a)	dakə̃́	[dakə̃́]	[nakə̃́]	'branch'
(b)	da̰bóẽ́	[da̰bṍẽ́]	[na̰bṍẽ́]	'ember'

(55)	UR	Dialect A	Dialect B	Gloss
(a)	daẽ́	[da.ẽ́]	[nãẽ́]	‘choose s.t.’
(b)	darẽ́m	[da.r̃ẽ́m]	[nãr̃ẽ́m]	‘be fetid’
(c)	dawə̃́n	[da.w̃ə̃́n]	[nãw̃ə̃́n]	‘sharpen s.t.’

Let us begin by inspecting Dialect A.

7.3.3.1 Dialect A

In dialect A, /d/ is typically realized as [d], except before an underlying nasal vowel.

(56) Dialect A

_v	_ṽ	_v…ṽ
d	n	d

The function of DEP[+son] is crucial. This constraint must be dominated by DHR[voi] because mutation is priority, but it must dominate the constraint that determines spreading, i.e. *OR-NAS, because this dialect does not want to have [n] unless no other possibility exists. However, there is another possibility in a context /dv…ṽ/; namely, to stop nasality before it reaches the syllable containing /d/, as in candidate (a). Although this violates the condition on nasal harmony, it does so in order to satisfy DEP[+son].

Tableau 7.17. Dialect A. Input: *v-darẽ́m* → *v-dar̃ẽ́m* ‘to be fetid’

v-darẽ́m		*dṽ	W-CONTIG	DHR [voi]	MAXPATH [nas]	MAX [±voi]	DEP [+son]	*OR-NAS	DEPPATH [nas]
a. ☞	v.da.r̃ẽ́m							*	*
b.	v.dã.r̃ẽ́m	*!							**
c.	v.tã.r̃ẽ́m			*!		*			**
d.	ṽ.nã.r̃ẽ́m						*!		****

Any other possible scenarios should produce the same results for this dialect, even if consonant mutation is not involved. For example, the noun below is not an alternating morpheme, but also exhibits spontaneous blocking because a sequence [dṽ] could emerge.

(57)

UR	Dialect A	Dialect B	
daʔó-rẽk	da.ʔ̃ṍ.r̃ẽk	nã.ʔ̃ṍ.r̃ẽk	'lizard, sp.'
lizard-?			

Spreading nasality as much as possible minimally violates *OR-NAS. Thus, it is better to block nasality spontaneously, candidate (f), than to not spread this feature at all, candidate (e).

Tableau 7.18. Dialect A. Input: *daʔórẽk → daʔ̃ṍr̃ẽk* 'lizard, sp.'

daʔó-rẽk		*dṽ	W-CONTIG	DHR [voi]	MAXPATH [nas]	MAX [±voi]	DEP [+son]	*OR-NAS	DEPPATH [nas]
a.	dãʔ̃ṍr̃ẽk	*!							****
b.	daʔórek				*!				
c.	tãʔ̃ṍr̃ẽk					*!			****
d.	nãʔ̃ṍr̃ẽk						*!		*****
e.	daʔórẽk							**!**	
f. ☞	daʔ̃ṍr̃ẽk							*	***

This takes care of Dialect A. Let us turn to Dialect B, which has [n] in a context /dv…ṽ/.

(58) Dialect B

_v	_ṽ	_v…ṽ
d	n	n

7.3.3.2 Dialect B

Obviously the same ranking cannot generate the patterns in Dialect B, since it has a preference for [n] in a context of nasalization. Whether or not a nasal vowel is adjacent to /d/, the output is always [n]. (Here we are still assuming that the underlying representations of these morphemes contain /d/.) This preference suggests that *OR-NAS dominates DEP[+son] in this dialect. With this reranking, the chances that /darẽ́m/ 'to be fetid' or /daʔórẽk/ 'lizard, sp.' will surface as [dar̃ẽm] or [daʔ̃ṍr̃ẽk] are excluded, as illustrated in the following tableaux.

Tableau 7.19. Dialect B. Input: *v-darẽ́m* → *v-nãr̃ẽ́m* 'to be fetid'

v-darẽ́m		*dṽ	W-Contig	DHR [voi]	MaxPath [nas]	Max [±voi]	*Or-Nas	Dep [+son]	DepPath [nas]
a.	v.da.r̃ẽ́m						*!		*
b.	v.dã.r̃ẽ́m	*!							**
c.	v.tã.r̃ẽ́m			*!		*			**
d. ☞	ṽ.nã.r̃ẽ́m							*	****

Tableau 7.20. Dialect B. Input: *daʔórẽk* → *nãʔ̃ṍr̃ẽk* 'lizard, sp.'

daʔó-rẽk		*dṽ	W-Contig	DHR [voi]	MaxPath [nas]	Max [±voi]	*Or-Nas	Dep [+son]	DepPath [nas]
a.	dãʔ̃ṍr̃ẽk	*!							****
b.	daʔórek				*!				
c.	tãʔ̃ṍr̃ẽk					*!			****
d. ☞	nãʔ̃ṍr̃ẽk							*	*****
e.	daʔórẽk						*!***		
f.	daʔ̃ṍr̃ẽk						*!		***

But is reranking sufficient to account for the dialectal difference? The answer is "no". If the reranking Dep[+son] >> *Or-Nas → *Or-Nas >> Dep[+son] can generate *nãr̃ẽ́m* from /darẽ́m/, it is not possible to generate *nakə̃́* from /dakə̃́/ 'branch'. The ranking wrongly predicts that the output for this dialect should also be *dakə̃́*, as it is in Dialect A.

Tableau 7.21. Dialect B. Wrong result: *v-dakə̃́* → **v-dakə̃́*

v-dakə̃́	*dṽ	W-Contig	DHR [voi]	MaxPath [nas]	Max [±voi]	*Or-Nas	Dep [+son]	DepPath [nas]
a. ☞ v-dakə̃́								
b. ☹ v-na.kə̃́							*!	

One possibility is to invoke *VoiCor, as shown in the following tableau. Because this constraint prohibits voiced coronals, it must dominate Dep[+son] to exclude an output such as *dakə̃́*, and select *nakə̃́* instead.

Tableau 7.22. Dialect B. Input: *v-dakə̃́ → v-nakə̃́*

v-dakə̃́	*dṽ	W- Contig	DHR [voi]	MaxPath [nas]	Max [±voi]	*VoiCor	*Or-Nas	Dep [+son]	DepPath [nas]
a. v-dakə̃́						*!			
b. ☞ v-na.kə̃́								*	*

However, it is crucial that Dep[+son] be ranked higher than *VoiCor in order to guarantee the contrast between /d/ and /n/. With the ranking *VoiCor >> Dep[+son], the prediction is that an input /d/ should be realized as [n] everywhere.

Tableau 7.23. Dialect B. Contrast between /d/ and /n/.

dv	*dṽ	W- Contig	DHR [voi]	MaxPath [nas]	Max [±voi]	*VoiCor	*Or-Nas	Dep [+son]	DepPath [nas]
a. ☹ dv						*!			*
b. ☞ nv								*	
c. tv					*!				

It seems thus that this dialectal difference does not straightforwardly results from constraint reranking.

I suggest instead that the difference between Dialect A and B is a difference in the underlying representations of these morphemes, not in the ranking. Both dialects have the ranking in (59), which (i) implements the necessary contrasts, not only between voiceless and voiced stops but also between oral and nasal stops, as well as the absence of a contrast /d/ versus /n/ before a nasal vowel; (ii) determines voicing alternation and nasal harmony; and (iii) accounts for the interaction between consonant mutation and nasality.

(59) Ranking for both dialects

*dṽ >> W-Contig >> DHR[voi] >> MaxPath[nas], Nas/Son >> Max[±voi] >>

Dep[+son] >> *Or-Nas >> DepPath[nas]

I assume that the difference between the two dialects is associated with the fact that Dialect B has both /d/ and /n/ in the underlying representations of alternating morphemes (e.g. /doy/ 'blood' versus /nakə̃́/ 'branch'), whereas Dialect A has only /d/ (e.g. /doy/ versus /dakə̃́/). This difference can be explained by the change in nasal harmony (examined in Chapter 5), as follows.

For Dialect B, phonologization of oral and nasal allophones of Pre-Mundurukú *d applied regularly throughout the entire grammar, and included morphemes that participated in consonant mutation. Take, for example, the four cases below. The development *d > d/n in consonant mutation parallels the development of non-alternating morphemes such as *dobadõ > nobanõ, in which the allophone [n] was phonologized in the former contexts. This is consistent with the history of *d in the language and the change in nasal harmony.

(60)	_v	_ṽ	_v…ṽ	
Pre-Mundurukú	*doy	*də̃n	*dakə̃	*dobadõ
↓	[doy]	[nə̃n]	[nãkə̃]	[nõmãnõ]
Change in NH (blocked)				
+ Secondary split	doy	nə̃n	nakə̃	nobanõ
Dialect B	doy	nə̃n	nakə̃́	nobánṍ
	'blood'	'feces'	'branch'	'rifle/gun'

For Dialect A, the change *d > d/n was overridden by the analogy to the t/d alternation in oral contexts. Consonant mutation was then generalized as involving an alternation between [t] and [d], except if /d/ immediately precedes a nasal vowel, in which case the prohibition *dṽ requires [n]. This did not affect *nobánṍ* because it is a non-alternating morpheme.[7]

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[7] In the case of *daʔórẽk* 'lizard, sp.', Dialect A retained /d/ despite the fact that it is a non-alternating morpheme. This is probably because the nasal vowel belongs to the second morpheme: /rẽk/; the root itself is oral: /daʔó/.

(61)	_v	_ṽ	_v…ṽ	
Pre-Mundurukú	*doy	*də̃n	*dakə̃	*dobadõ
↓	[doy]	[nə̃n]	[nãkə̃]	[nõmãnõ]
Change in NH (blocked)				
+ Secondary split	doy	nə̃n	nakə̃	nobanõ
↓				
Analogy to t/d	doy	də̃n	dakə̃́	--
Dialect A	/doy/	/də̃n/	/dakə̃́/	/nobánṍ/
*dṽ	[doy]	[nə̃n]	[dakə̃́]	[nobã́nṍ]
	'blood'	'feces'	'branch'	'rifle/gun'

If we assume that there is only one ranking, but different underlying representations, outputs such as *dakə̃́* in Dialect A versus *nakə̃́* in B can be accounted for without problems, as shown in Tableau 7.24.

Tableau 7.24. Dialects A and B.

A: v-dakə̃́	*dṽ	W-CONTIG	DHR [voi]	MAXPATH [nas]	MAX [±voi]	DEP [+son]	*OR-NAS	DEPPATH [nas]
a. ☞ v-dakə̃́								
b. v-nakə̃́						*!		*
c. v-takə̃́			*!		*		*	

B: v-nakə̃́	*dṽ	W-CONTIG	DHR [voi]	MAXPATH [nas]	MAX [±voi]	DEP [+son]	*OR-NAS	DEPPATH [nas]
a. v-dakə̃́				*!				
b. ☞ v-nakə̃́								
c. v-takə̃́			*!		*			

This concludes the account of consonant mutation in Mundurukú. The phenomenon affects groups of morphemes and respects particular morphosyntactic requirements, and as such cannot follow from universal patterns. It shows that a language may have two opposite processes, fortition and lenition, in addition to a requirement that preserves phonological contrasts. In particular, consonant mutation shows that contrasts versus neutralization of features may not be a simple matter. But most importantly, the ranking proposed here accounts for the interaction of two phonological processes: consonant mutation and nasal harmony, and the dialectal difference in consonant mutation.

In the following section I examine some historical facts, focusing on the history of lenition.

7.4 On the history of the alternations ʧ/ʤ and p/b

Consonant mutation is a common phenomenon in the Mundurukú family. Kuruaya exhibits patterns similar to those found in Mundurukú: voiced following vowels and glides, and voiceless following consonants. (62) compares these alternations. While Mundurukú exhibits only a voiceless-voiced alternation, the situation is more complex in Kuruaya; the alternations are t/l and ʧ/d, a difference not only in voicing but also in manner – /l/ is phonetically realized as [l, ð] and /d/ as [ɖ, ʤ]; the voiceless variants are as in Mundurukú, [t] and [ʧ] respectively. The nasal variant in Mundurukú corresponds to the nasal allophone [l̃] in Kuruaya. This was discussed extensively in Chapter 5.

(62) Correspondences in consonant mutation

Kuruaya	p / b	t / l-[l̃]	ʧ / d
Mundurukú	p / b	t / d-n	ʧ / ʤ

Examples of the alternations in Kuruaya are provided in (63). As seen in Chapter 6, nasality in Kuruaya targets voiced obstruents, so the voiced variants of alternating morphemes surface with their respective nasal allophones in nasal contexts; these are illustrated in the third column.

(63) Consonant mutation in Kuruaya

	Voiceless	Voiced	Nasal
(a)	o-ʔɨk-**pɨʔ**-nẽ	o-**bɨʔ**	o-**bi**ʔ-wẽ [õ**mĩ**w̃ẽ]
	1-belly-finger-string	1-finger	1-mouth-?
	‘my belt’	‘my finger/hand’	‘my chin’

(b)	arek-ʔíp-**ti**	márađí-**li**	ó-**lãy** [ṍl̃ãỹ]
	caucho-tree-liquid	sugar.cane-liquid	1-tooth
	'sap of a caucho tree'	'sugar cane juice'	'my teeth'

(c)	í-tim	**ʧin**	í-sãy	**din**	ó-**dẽm** [ṍnẽm]
	3Su-be.good	very	3Su-be.dark	very	3Su-go.out
	'It's very good.'		'It's very dark.'		'S/he went out.'

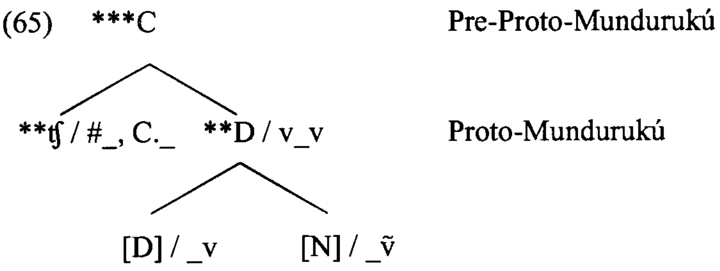
The data on consonant mutation in Kuruaya is still scarce and not much can be said about the realizations of these morphemes outside the environments that condition the alternation. There is, however, some indication that the alternations are essentially the same in both languages. Like Mundurukú, the variant that surfaces utterance-initially in the alternation ʧ/d is also voiceless in Kuruaya.

(64)		Mundurukú		Kuruaya	
	(a)	**ʧə́**-m ṍn		**ʧɨ**-m ṍn	'I will go.'
		go-IMPRF 1sg			
	(b)	o̰-**ʤə́**		ó-**dɨ**	'S/he went.'
		3Su-go			

There is considerable evidence that permits an account of the history of the alternation ʧ/ʤ in Mundurukú; although there is still lack of comparative data, a similar hypothesis can be proposed for p/b.

In Chapter 5, I discussed the origin of the phonotactic restrictions *ʧi, *ʤi and *ŋi, and established that the pre-proto-phoneme ***C had already developed into **ʧ and **D in Proto-Mundurukú, as in (65). **ʧ was retained word-initially and postconsonantally; **D was restricted to intervocalic position, and had oral and nasal allophones, [D] and [N], determined by the oral versus nasal quality of the following vowel.

(65)



Essentially, the distribution of the reflexes of ***C in Proto-Mundurukú resemble the ʧ/d alternation in Kuruaya: *ʧ* word-initially and post-consonantally, and *d* or *n* intervocalically, which in turn is similar to the ʧ/ʤ alternation in Mundurukú. A comparison of these patterns is given in (66).

(66) Comparing the patterns

Voiceless form in #_, C_	Voiced form in v_v	Voiced form in v_ṽ
ʧ / ʧ	ʤ / d	ʤ / n
ʧə́ / ʧɨ 'go'	v-ʤə́ / v-dɨ	
ʧẽ́m / ʧẽm 'go out'		v-ʤẽ́m / v-nẽm

The relevant observations are these. In (65) above, the sound change ***C > **ʧ/D affected all lexical items containing ***C, but it failed to apply regularly to some morphemes. Where ***C occurred intervocalically only, it became invariably **D, as shown in the following examples.

(67) Reconstructions for ***C. (Pre-PM=Pre-Proto-Mundurukú; PM=Proto-Mundurukú)

Mundurukú	Kuruaya	Pre-PM	PM	Gloss
da̱ʤe	ladeʔ	***LaCeʔ	**LaDeʔ	peccary
ʃiʤáp	kidap	***kiCap	**kiDap	shelter
aʤóré	adoreʔ	***aCore(ʔ)	**aDore(ʔ)	be old
aʤó / áʤo	ádo	***aCo	**aDo	what

But where ***C occurred word-initially or after a consonant, it became **ʧ. Examples of this set are difficult to assess because **ʧ merged with ***Tʃ in Proto-Mundurukú, as shown in Chapter 5. To recover these cases, a comparison with other Tupian languages is necessary, as the one given in (68) below. (The data were provided by Sérgio Meira (SM), Ana Galúcio (AG), Denny Moore (DM), Sebastian Drude (SM), and Luciana Storto (LS).)

I tentatively suggest in (68) that the word *ʧoʔá* 'hill' is a case of ***C word-initially, whereas *ʧókṍn* 'toucan' reflects ***Tʃ in the same position. Compare the occurrences of Mundurukú *ʧ*, *ʤ* or the alternation *ʧ/ʤ* to the corresponding words in other Tupi languages. In addition, compare these to the forms reconstructed for Pre-Proto-Mundurukú and Proto-Mundurukú. Note that ***C corresponds to /t/ in Mawé, Awetí and Karitiana, /s, ts/ in Mekens, and /d, t/ in Gavião; ***Tʃ, on the other hand, corresponds to a glide /j/ in Mawé, Gavião and Tupari, and /ɲ/ in Karitiana, perhaps by influence of nasalization. This suggests that, historically, Mundurukú /ʧ/ may have developed out of at least two different sources.

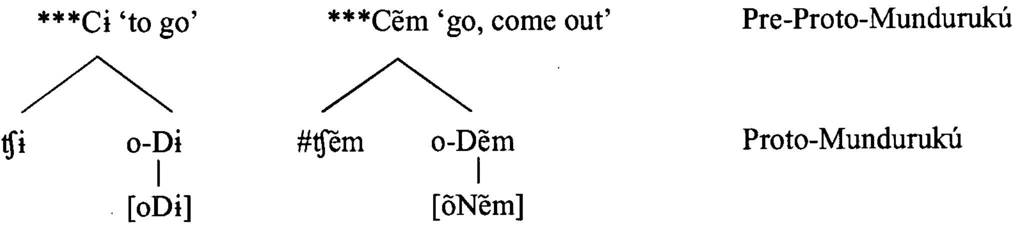
(68) Reconstructions for **C. (Mund=Mundurukú; Ku=Kuruaya; Maw=Mawé; Mek=Mekens; Gav=Gavião; Aw=Awetí; Kar=Karitiana; Tup=Tupari)

Mund	Ku	Maw (SM)	Mek (AG)	Gav (DM)	Aw (SD)	Kar (LS)	Pre-PM	PM	Gloss
ʧo-ʔá	ʧó-ʔa	ɨi-tɨ-ʔok	soo	do			***Co	**ʧo	hill
a̰ʤók	ádok		atsu		atuk	otɨ	***aCok	**aDok	bathe
ʧó ʤó	ʧo do	wanẽ-tup	sop	ma-tóó	tup	tɨp	***Co	**ʧo/Do	see
ʧə́ ʤə́	ʧɨ dɨ	are-to	set	tẽẽ	a-to	tat	***Cɨ	**ʧɨ/Dɨ	go
ʧókṍn	ʧókãn	jũkaŋ	jokãt (Tup)	jókããt	?tukan	ɲeokõn	***Tʃokãn	**ʧokãn	toucan

The data are consistent with the hypotheses that (i) the alternating palatal affricate was originally voiceless, and (ii) that it underwent voicing intervocalically. Chronologically, Pre-Proto-Mundurukú had only ***C in all environments. By lenition, ***C was voiced intervocalically and remained voiceless in other environments. In Proto-Mundurukú ***C had already developed into **D and **ʧ. The reflexes of **D in modern Mundurukú are /ʤ/ and [ɲ], as explained in Chapter 5; and the reflexes of **ʧ are /ʃ/ before a high front vowel (see Chapter 5, §5.6.2), and /ʧ/. There are also cases that alternate between [ʧ] and [ʤ], because the change ***C > **ʧ/D failed to apply regurlarly to some instances of ***C morpheme-initially. These cases refer to morphemes that occurred in the environments that favor both **ʧ and **D. As a consequence, the grammar acquired a new morphophonological alternation.

By occurring morpheme-initially, and by referring to classes that may or may not involve a preceding morpheme, ***C had two realizations: **D and **ʧ. Consider, for example, the unaccusative verbs ***Cɨ 'go' and ***Cẽm 'go out' in (69). Assume that these verbs occurred with or without a person marker, as they do in Kuruaya and Mundurukú (e.g. *ʧə́m ṍn* 'I will go' versus *o̰ʤə́* 'S/he went'). When preceded by a morpheme-final vowel, as in *o̰ʤə́*, the initial consonant was placed in the environment that favored voicing, and was therefore affected; here the voiced variant is **vDv in oral contexts, and **ṽNṽ in nasal contexts. Word-initially or preceded by a morpheme-final consonant, we find the voiceless variant: **ʧv and **ʧṽ.

(69)



I believe that the alternations ʧ/ʤ in Mundurukú, and ʧ/d in Kuruaya, reflect the sound change ***C > **ʧ/**D, which took place between Pre-Proto and Proto-Mundurukú. Because the distribution of these morphemes permitted them to occur in different environments, the initial consonant assimilated the change accordingly.

At a later stage, (70), Proto-Mundurukú **ʧ and **D developed into Pre-Mundurukú, *ʧ and *ʤ respectively, and these into Mundurukú /ʧ, ʃ, ʤ/, and [ɲ].[8] The alternation ʧ/ʤ, which was caused by the change ***C > **ʧ/**D, thus continued through the following generations as a regular phonological process.

(70)	**ʧ / #_, C_	**D / v_v	Proto-Mundurukú	**ʧɨ/ʧẽm	**Dɨ/Nẽm
	*ʧ	*ʤ	Pre-Mundurukú	*ʧɨ/ʧẽm	*ʤɨ/ʤẽm
	ʧ ʃ	ʤ ɲ	Mundurukú	ʧə́/ʧẽ́m	ʧə́/ʤẽ́m

The history of the p/b alternation is unclear, but a similar hypothesis could also be proposed here. There is some comparative evidence showing that many instances of alternating morphemes in Mundurukú have developed out of a voiceless stop, as the examples in (71).

(71) Data from Rodrigues (1995); except Mundurukú and Kuruaya.
(PTG=Proto-Tupi-Guarani)

Mund	Kuruaya	Awetí	Karitiana	Mawé	Mekens	PTG	Gloss
pəʔ/bəʔ	pɨʔ/bɨʔ	po	pɨ	po	po	*po/mo	hand
pído/bído	ka-bílɔlɔ 'wind'			pɨhu	pito	*pɨtu	breath(e)
pe/be	pe/be			-pe		*-pe	locative

There is also evidence that /b/ originated from a voiceless stop that underwent voicing intervocalically, especially if we compare Mundurukú and Kuruaya to Tupinambá in (72).

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[8] As seen in Chapter 5, Pre-Mundurukú *ʧ developed later into /ʃ/ before a high front vowel, and the nasal allophone of **D developed into /ʤ/ and [ɲ], but the latter merged with the allophone of /ŋ/ syllable-initially.

(72) Data from Rodrigues (1980, 1995); except Mundurukú and Kuruaya

Mund	Kuruaya	Awetí	Mawé	Tupari	PTG	Tupinambá	Gloss
a̰bík		apɨk	apɨk	epsik	*apɨk	apɨk	sit down
iʃíbə	idíbɨ					ɨsɨpo	vine
ibə́t	ibɨt				*pɨpor	pɨpor	footprints
to̰bə́y do̰bə́y	tobɨy lobɨy					tɨpoy	sling

Beyond the Mundurukú family, lenition is a common phenomenon; but contrary to Mundurukú, it is a morpheme-final stop that is affected by a morpheme-initial vowel. The process is found in Gavião (Moore 1984), Karo (Gabas Jr. 1988), languages of the Tupari family (Ayuru, Makurap, Mekens and Tupari) (Moore and Galúcio 1993), Awetí (S. Drude, p.c.), Mawé (Meira, p.c.), and several languages of the Tupi-Guarani family (Mello 2000 and references cited in there).

Mundurukú also had sporadic morpheme-final lenition. There are vestiges of the process in the word *nobã́nṍ* 'gun/rifle', (73), which comes from *dop* 'arrow' + *ã́nṍ* 'other', literally 'the other arrow'.[9] In Kuruya, *ã́lõ* is still found in cases like *tek ã́lõ* 'the other house'; thus "rifle" is *lobalõ* which comes from *lɔp* + *alõ*. Of course, *nobã́nṍ* has already been lexicalized, probably since Proto-Mundurukú, and can no longer be reanalyzed as *dop* + *ã́nṍ*; i.e. synchronically, it is a single morpheme.

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[9] I am grateful to Eduardo Ribeiro, Sebastian Drude, Pedro Viegas Barros, and Hein van der Voort for replying to me in the Etnolinguistica list, pointing out this possibility.

(73)	Pre-Proto-Mundurukú	***Lɔp + aLõ	‘arrow + other’
	p → b / v_+v	Lɔb+aLõ	
	Lexicalization	LɔbaLõ	
	Output	[L̃õmãL̃õ]	

An argument in favor of lexicalization is that *dop* ‘arrow’ in this word has undergone the changes that ***L underwent in the context of nasalization: **L > *d > n; in oral contexts the change was: **L > *d > d (see chapters 5 and 6). For example, *odop* ‘my arrow’ comes from ***ɔLɔp*.

(74)	Proto-Mundurukú	**LɔbaLõ	**ɔ-Lɔp
	**L > d	dobadõ	ɔdɔp
	Pre-Mundurukú	*dobadõ	*o-dop
	Change in nasal harmony		
	Secondary split: *d > d/n		

If *dop* and *ánṍ* were still separate morphemes at the time the change in nasal harmony and secondary split took place, we would expect the word for “rifle” to be *dobanõ*, because *dop* developed out of **Lɔp, but in *nobánṍ*, the reflex of **L is /n/, as all reflexes of the allophone of **L in nasal contexts.

(75)	Mundurukú	nobánṍ	odop
	Output	[nobã́nṍ]	[odop]
		‘rifle/gun’	‘my arrow’

A great deal of work would be necessary to recover lenition processes before Proto-Mundurukú, but there are reasons to believe that, at the proto-stage, there was already a contrast /p/ versus /b/ and /ʧ/ versus /D/, in that the voiced stops were acquired by means of a lenition process in intervocalic position. As a working hypothesis, Pre-Mundurukú distinguished two sets of voiceless stops; one set underwent voicing intervocalically, and the other has been preserved as such. I have provided evidence for ***C versus ***Tʃ – perhaps ***Tʃ should be represented as ***c in Pre-Proto-Mundurukú – and it is plausible to assume ***P versus ***p; ***C and ***P underwent voicing, and ***Tʃ and ***p remained voiceless, and correspond to /p/ and /ʧ/ synchronically. The changes would be more or less as shown in (76) and (77).

(76) Pre-Proto-Mundurukú	***C		***Tʃ
Proto-Mundurukú	**ʧ / #_, C._	**D / v_v	**ʧ

(77) Pre-Proto-Mundurukú	***P		***p
Proto-Mundurukú	**P / #_, C._	**B / v_v	**p

If this hypothesis is correct, the alternations p/b and ʧ/ʤ came into the language simultaneously, as a result of the changes above. A lenition process voiced ***C and ***P intervocalically, but morphemes that occurred in different contexts acquired both voiced and voiceless variants. This was later reinterpreted as a regular alternation, and acquired the morphosyntactic properties we now find in the language.

7.5 Conclusion

This chapter examined consonant mutation, a phonological process that serves to mark certain syntactic structures. What seems to be a single phenomenon is in fact two: lenition and fortition. Lenition targets the voiceless stops /p, ʧ/ and fortition targets /d/; the difference between arises only when they appear outside the contexts that favour the alternations. These alternations conflict with general phonological requirements that preserve the contrasts /p/ versus /b/, /t/ versus /d/, and /ʧ/ versus /ʤ/.

To account for consonant mutation, I argued that the grammar needs a language-specific constraint, DHR[voice]. In addition, I showed that there is dialectal difference, which results from a historical change. The contrast betwen /d/ and /n/ originated from a change in nasal harmony in addition to phonologization of allophonic variants. These historical changes also affected consonant mutation by adding a nasal variant in the t/d alternation, and by causing dialectal variations. The analysis of both dialects, I believe, cannot be accounted for by constraint reranking, as OT asserts. Instead, I suggested that the primary difference is in the underlying representations of alternating morphemes. The historical approach supports the analysis.

I also hypothesized about the historical origin of the alternations p/b and ʧ/ʤ: the proposal is that these alternations came into the grammar after a sound change that voiced voiceless stops intervocalically. Because some morphemes occurred in more than one environment, they acquired voiceless and voiced variants, which is now consonant mutation.

Aside from this, the synchronic ranking is as follows.

(78) Ranking for consonant mutation and its interaction with nasal harmony

*dṽ

W-CONTIGUITY

DHR[voi]

MAXPATH[nas], NAS/SON

MAX[±voi]

DEP[+son]

*OR-NAS

DEPPATH[nas]

CHAPTER 8

The phonetics and phonology of tones and creaky voice

8.1 Introduction

This chapter concludes this study of the Mundurukú phonology by exploring its tone system and the tone-creaky voice interaction.

Braun and Crofts (1965; also Crofts 1973, 1985) analyzed the language as having four opposing tone levels, three of tone and one of laryngealization (i.e. creaky voice) – accent 1 is a super-high tone, accent 2 a high level tone, accent 3 a low level tone, and accent 4 is creakiness.[1]

In this chapter (see also Picanço 1997, 2002a-c), I defend the hypothesis that the tone system of Mundurukú can be analyzed as having only two opposing levels: Low and High (hereafter L and H respectively).

The sections are organized around the following problems. First we will look at the dual behavior of L and H tones. On the surface, we find two types of L tones; one triggers dissimilation of a following L, the other is inert (Section 8.4). Similarly, surface H tones may be stable – H tones that are always H – or unstable – H tones that surface as H in some contexts, and as L in others (Sections 8.3 and 8.5 respectively). There is also tonal polarity, which is a property of certain groups of morphemes; they surface on a tone opposite to that of the preceding vowel (Section 8.5). These five tonal behaviors are accounted for by assuming a four-way lexical distinction: a mora, the tone-bearing unit, may be lexically specified for H,

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[1] In this study I will not examine "accent 1", the super-high tone. I assume, following Picanço (2002b), that this tone is not contrastive in the language; it functions as an intonational tone, surfacing at the right edge of a sentence in Yes/No questions, as illustrated in (ii), in which case it behaves like a boundary tone (Pierrehumbert 1980); or in emphatic phrases as a higher pitch associated with morphemes that are semantically emphatic, (iii). In the examples a super-high tone is marked as (v̋).

(i) bío e-y-aóka
[HL L LH L]
tapir 2Su-3Ob-kill
'You killed a tapir.'

(ii) bío də́ e-y-aóka̋
[HL H L LH SH]
tapir Q 2Su-3Ob-kill
'Was it a tapir that you killed?'

(iii) i-díp ʧi̋ʧã̋
[L H SH-SH]
3Su-be.beautiful Intens
'It's very beautiful.'

L, or none; that is, it may be toneless (Section 8.2). Lexical H tones are stable, and lexical L tones trigger dissimilation of a following L; toneless moras get L tone by default, but this tone is inert. Unstable H tones and tonal polarity are explained by assuming a floating H tone in the underlying representation of these morphemes.

I then proceed to investigate the tone-creaky voice interaction. Creaky voice is phonologically treated as a feature that distinguishes vowels, not as a tonal feature. Several arguments are offered to show that creaky vowels behave like modal vowels bearing a L tone. I also provide evidence to show that the relationship of creaky voice and tonal features is unidirectional; a creaky vowel requires certain tonal configurations to be realized on the surface; tones, on the other hand, function independently. These and other issues are examined in detail in Section §8.7.

The last section, Section 8.8, challenges the analysis in the realms of the Richness of the Base (Prince and Smolensky 1993). The various patterns unattested in the language, but predicted to be possible, are confronted with the predictions that the analysis makes. It is hoped that the arguments presented here in favor of the analysis will be convincing, or at least, stimulating from a theoretical point of view.

8.2 Tone processes and theoretical assumptions

Mundurukú is a tonal language; that is, it makes use of pitch variations to lexically differentiate items. (1) gives some pairs that differ only in their pitch level, either H or L. (H tone is indicated by an acute accent above the vowel (v́), and L tone is unmarked.)

(1)	(a)	é	[H]	‘path’
		e	[L]	‘tobacco’
	(b)	wə̃́y	[H]	‘port’
		wə̃y	[L]	‘far’
	(c)	íhí	[HH]	‘winter’
		íhi	[HL]	‘monkey, sp.’
	(d)	oʔát	[LH]	‘S/he fell.’
		oʔat	[LL]	‘I fell.’

(e)	ípárá	[HHH]	‘pineapple (plant)’
	ipádá	[LHH]	‘macaw, sp.’
(f)	áʤóʤót	[HHH]	‘grandparent’
	aʤoʤot	[LLL]	‘We (incl.) came.’

Tones in Mundurukú do not always have the same surface realization; they interact with each other by dissimilating or triggering dissimilation. Overall, there are five tonal behaviors, all of which will be examined here; these are illustrated in (2)-(4). First we find the dual behavior of morpheme-final H tones. The nouns *wenə̃́y* ‘Brazil nut’, (2)a, and *ʤarã́y* ‘orange tree’, (2)b, have the same surface tonal realization in isolation, [L-H], but behave differently when followed by another tone. The H tone of *ʤarã́y* is maintained preceding the classifier -*ʔa* ‘round object’, whereas the H tone of *wenə̃́* changes to L in the same context (§8.6). The tone of the classifier also changes, but this is because it has polar tone (see (4) below).

(2)	(a)	wenə̃́-y nut-CL ‘Brazil nut’	L-H	→	wenə̃-ʔá nut-CL ‘Brazil nut pod’	L-L-H
	(b)	ʤarã́y orange ‘orange (tree)’	L-H	→	ʤarã́y-ʔa orange-CL ‘orange’	L-H-L

Second, there are also two types of surface L tones (§8.4); one triggers dissimilation of a following L, (3)a, and the other is inert, (3)b.

(3)	(a)	e + diŋ tobacco-smoke ‘tobacco smoke’	→	edíŋ	L-H
	(b)	ka + diŋ thing-smoke ‘dust’	→	kadiŋ	L-L

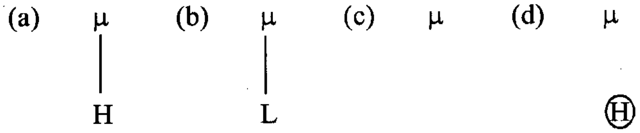
And third, there is also tonal polarity (§8.5). A number of morphemes realize a tone opposite to that of the preceding syllable, as illustrated by the inalienable noun *dəp* 'leaf' in (4); this noun surfaces on a H tone following L, (4)a, and on L following H, (4)b.

(4) (a) áko + dəp → ákodə́p HL-H
banana-leaf
'banana leaf'

(b) bórṍ + dəp → bórṍdəp HH-L
cotton-leaf
'cotton leaf'

The account offered here treats the five tonal behaviors as the reflex of a four-way contrast in underlying representations (UR's), given in (5)a-d. I follow Pulleyblank (1994) in assuming that the tone-bearing unit (TBU) is the mora. Moras may be either /H/, /L/ or toneless. A fourth possibility is a floating H tone, which is a property of certain morphemes, as we will see later.

(5)



Assuming the distinctions in (5)a-c, there are twelve possible lexical patterns for morphemes with one or two moras: H, L, ∅, HH, HL, H∅, LL, LH, L∅, ∅H, ∅L and ∅∅ ("∅" represents a toneless mora). I will return to these patterns in section 8.8, comparing these to the ones the analysis predicts. HH and LL are excluded, I suggest, by the Obligatory Contour Principle (hereafter OCP: Leben 1973; Goldsmith 1976; McCarthy 1986; Odden 1986). Following Odden (1986), I assume the validity of the OCP as a principle of lexical representations; hence, the representation assumed for morphemes with a sequence of like tones is as shown in (6).

(6) UR SR

(a)

'toucan'

(b)

‘cocoa (tree)’

Here I pursue an analysis in which the five tonal behaviors reflect the four-way contrast in the underlying representations of tones. Lexically associated H tones are stable; their behavior is reflected in the pattern illustrated in (2)b above, to be examined in Section 8.3. Floating H tones, on the other hand, are subject to certain conditions in order to be realized on the surface; they are manifested phonologically in the form of unstable H tones, (2)a, and polar tones, (4). These patterns are examined in sections 8.5 and 8.6. Likewise, the difference between a L tone that triggers dissimilation, (3)a, and a L tone that is inert, (3)b, is also due to a difference in their underlying representations. Lexically associated L tones are subject to the OCP; toneless moras get L by default but do not trigger dissimilation (Section 8.4).

As a first step, H and L tones will be referred to by tonal features. As Pulleyblank (1986: 125) remarks, “tones (like other segments) are composed of distinctive feature specifications.” He proposes, following Yip (1980), that tone features include register, [upper]-feature, and a sub-component of the it, [raised]-feature. Combining [upper] and [raised], four tone levels can be generated.

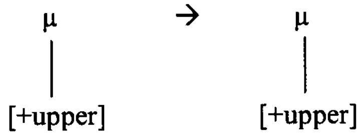
(7) Tonal hierarchy (Pulleyblank 1986: 125)

[+upper]	[+raised]	H
	[-raised]	HM
[-upper]	[+raised]	M
	[-raised]	L

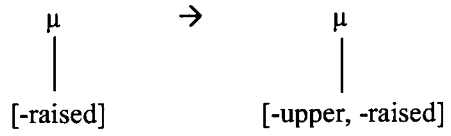
Systems with two levels have H lexically represented as [+upper], and L as [-raised]; toneless vowels have no specifications and are assigned [-upper] on the surface, the universal default value. In the analysis of Mundurukú tones, I will refer to /H, L, ∅/ by their respective tonal features, as shown in (8).

(8) UR SR

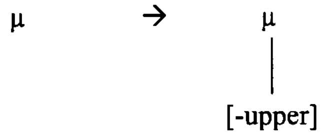
(a)



(b)



(c)



If a mora is lexically associated with a tonal feature, this feature must be preserved in the output; this is done by faithfulness constraints, formulated here in the form of the feature-based version of correspondence theory (Pulleyblank 1996).

(9) Faithfulness constraints

(a) MAXPATH-[+upper]

Any input path between [+upper] and an anchor must have a correspondent path in the output.

(b) MAXPATH-[-raised]

Any input path between [-raised] and an anchor must have a correspondent path in the output.

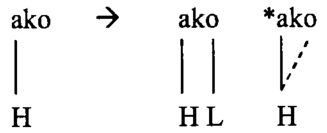
Assignment of a tonal register to toneless moras will be guarateed by the constraint HAVEREGISTER.

(10) HAVEREGISTER (=HAVEREG)

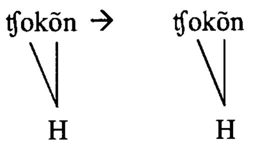
Every mora must have at least one register feature.

HAVEREGISTER determines that moras must have a register feature, but does not determine how this can be achieved. One possibility is through spreading, an alternative we want to avoid in Mundurukú; prelinked tones are preserved and toneless moras get a L tone by default, (11)a (see especially §8.4). Multiple associations are allowed only if a morpheme is lexically specified, (11)b.

(11) (a)



‘banana (tree)’

(b)  'toucan'

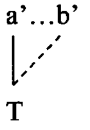
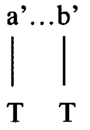
Following Myers (1997), I propose the faithfulness constraint UNIFORMITY-IO(Tone) to prevent tone spread.

(12) UNIFORMITY-IO(Tone) (=UNIF-T)

If *a* and *b* are distinct elements with respect to a tone T in the input, then their output correspondents *a'* and *b'* are also distinct with respect to T.

UNIFORMITY violations are schematized below. A language that disallows spreading, like Mundurukú, requires UNIFORMITY(T) to be ranked higher than DEP(T), which prohibits insertion of a tone in the output.

(13) No spreading

	Input	Output	UNIFORMITY-IO(T) >>	DEPT
(a)			*	✓
(b)			✓	*

Since Mundurukú prohibits tone spread in general, I assume that UNIFORMITY is undominated. The faithfulness constraints that are violated in order to prevent tone spreading are the following.

(14) (a) DEP[+upper] (=DEPH)

Every feature [+upper] in the ouput must have a correspondent in the input.

(b) DEP[-raised]

Every feature [-raised] in the output must have a correspondent in the input.

(c) DEP[-upper] (=DEPL)

Every feature [-upper] in the output must have a correspondent in the input.

The default value [-upper] is determined by the ranking UNIFORMITY(T) >> HAVEREGister >> DEPH >> DEPL, as demonstrated by the choice of candidate (c) in Tableau 8.1. Further examples will be provided in the following sections.

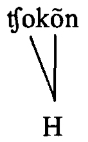
Tableau 8.1. Assignment of [-upper].

…μ μ… [+u]	UNIF-T	HAVEREG	MAXPATH [+upper]	DEPH	DEPL
a. μ μ [+u]	*!				
b. μ μ [+u]		*!			
c. μ μ [-u] [+u]			*!		*
d. ☞ μ μ [+u] [-u]					*

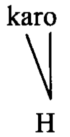
8.3 High tones

Languages tend to obey the OCP in the lexicon, but may not collapse identical tones originated from distinct morphemes (Odden 1986). In the analysis of Mundurukú a sequence of surface H tones in the same morpheme conforms to the OCP by having multiply linked tones (15).

(15) Underlying Surface

(a)


→ ʧókṍn 'toucan'

(b)


→ káró 'macaw, sp.'

(c)


→ ípárá 'pinapple tree'

Morpheme concatenation, on the other hand, often creates a sequence H + H, without being penalized by the Obligatory Contour Principle. These sequences, if originated from distinct morphemes, will be represented as separate H tones.

(16) (a) ʧókṍn-ʔít-ʔít 'little toucan'

H H H

toucan-Dim-RED

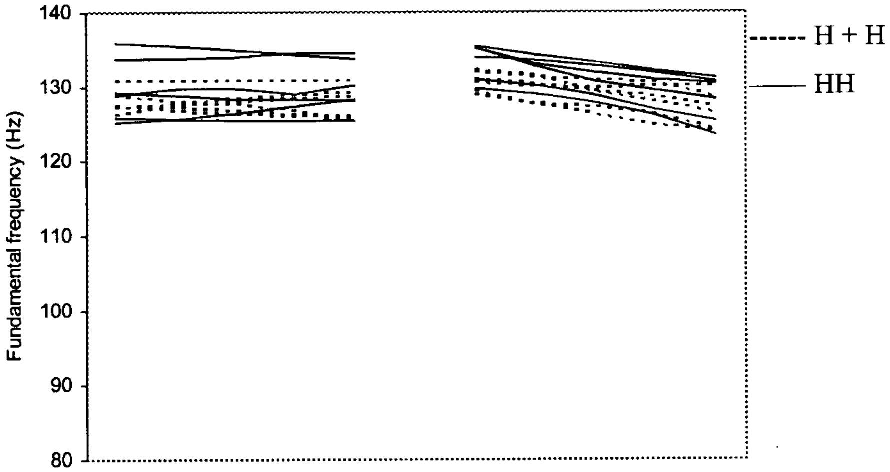
(b) ʤarã́y-ʧə́p-ʧə́p-ʔa 'kind of orange, bitter'

L H H H L

orange-bitter-RED-CL

Figure 8.1 illustrates sequences of H tone within the morpheme (HH) in contrast to a sequence of H tone originated from separate morphemes (H+H). As it can be noted, there is no difference in pitch between them.

Figure 8.1. Sequences of H tones within the morpheme (HH) and in morpheme concatenation (H+H).



These facts suggest that the faithfulness constraint preserving H tones in the output is ranked higher than the OCP constraint banning adjacent H tones.

(17) *HH

A sequence [+upper]-[+upper] is prohibited.

An illustration is given in Tableau 8.2. The optimal candidate does not receive any penalties as it remains as in the input; the second candidate deletes H and is penalized by MAXPATH[+upper].

Tableau 8.2. Sequence of H-tones. Word: *ʧókṍn-ʔítʔít* 'little toucan'

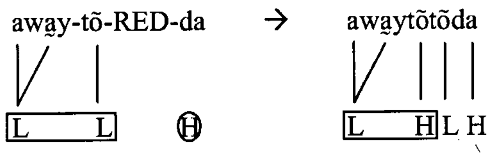
ʧokõn-ʔit-RED H H	MAXPATH [+upper]	*HH
a. ☞ ʧókṍn-ʔítʔít H HH		**
b. ʧókṍn-ʔitʔit H L L	*!	

8.4 Underlying L-tone versus surface L-tone

In this section I examine the dual behavior of L tones. On one side we find surface L tones that require the following to be H; on the other we find those that are inert. This asymmetry results, I suggest, from a distinction between lexical and default tones. Morphemes such as *tõ* 'purple', *diŋ* 'smoke', *rət* 'be white', and the classifier *ba̠* are underlyingly L toned. Not only do they surface on a H tone following another lexical L, as in the examples below, but they also trigger dissimilation. Compare, for example, the realization of *diŋ* in (18)b and *ba̠* in (18)e, where they undergo dissimilation, to their realization in (18)c and (18)d respectively, where they trigger dissimilation.

(18) /L + L/

(a)



'sweet potato, sp.'

potato-purple-RED-CL

(b)

'tobacco smoke'

tobacco-smoke

(c)	t-iŋ-rət	→	tiŋrət	'The smoke is white.'
	| |		| |	
	$\boxed{\text{L L}}$		$\boxed{\text{L H}}$	
	3-smoke-be.white			
(d)	i-ba̰-rət	→	iba̰rət	'It's (e.g. banana) white.'
	| |		| | |	
	∅$\boxed{\text{L L}}$		L$\boxed{\text{L H}}$	
	1-CL-be.white			
(e)	waʤe-ba̰	→	waʤeba	'cocoa'
	\\ |		\\ |	
	$\boxed{\text{L L}}$		$\boxed{\text{L H}}$	
	cocoa-CL			

L tones assigned by default do not trigger dissimilation.

(19) Sequences /∅ + L/

(a)	ka-tõ	→	katõ	'a village name'
	|		| |	
	∅ L		$\boxed{\text{L L}}$	
	thing-purple			
(b)	ka-diŋ	→	kadiŋ	'dust'
	|		| |	
	∅ L		$\boxed{\text{L L}}$	
	thing-smoke			
(c)	i-rət-RED=at	→	irərət=at	'the white moiety'
	| |		| | | |	
	∅ L H		$\boxed{\text{L L}}$L H	
	3-be.white-RED=NOM			

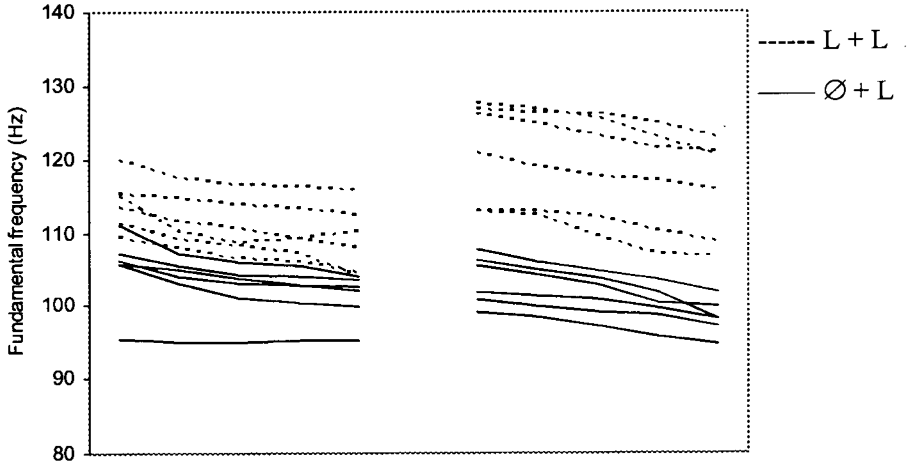
(d) ako-ba̯ → akoba̯ 'banana'

H ∅ L H L L

banana-CL

Dissimilation in a sequence /L+L/ and non-dissimilation in a sequence /∅+L/ are illustrated in Figure 8.2. The noun *diŋ* 'smoke' is realized on a H tone following a lexical L tone, as in the word *edíŋ* 'tobacco smoke', but it is L following a toneless vowel, as in *kadiŋ* 'dust'. The graph also shows that a toneless mora is realized at about the same pitch level as a following lexical L tone.

Figure 8.2. Surface realization of the noun diŋ 'smoke' following a lexical L tone (L+L: edíŋ 'tobacco smoke') and following and toneless mora(∅+L: kadiŋ 'dust').



Lexical L tones also trigger dissimilation of a default L tone. Observe the tonal realizations of the the plural marker *yə̃*, which is toneless. This clitic surfaces with a H tone if combined with a lexically specified L tone, (20)a, but it is realized with a L tone following another toneless mora, (20)b, or a lexically specified H tone, (20)c.

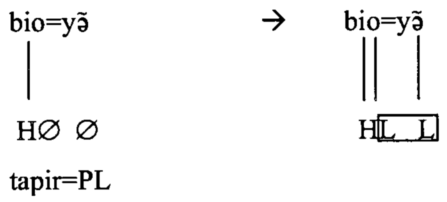
(20) Sequences /L + ∅/, /∅ + ∅/ and /H + ∅/

(a) poʃo=yə̃ → poʃo=yə̃ 'birds, sp.' /L+∅/

L ∅ L H

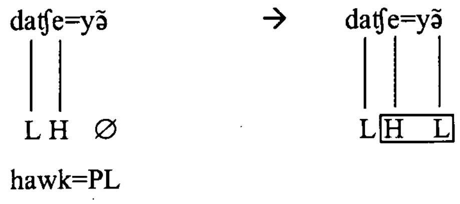
bird(sp.)=PL

(b)



'tapirs' /∅+∅/

(c)

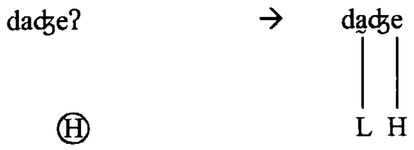


'hawks, sp.' /H+∅/

Another difference is observed in combinations with a floating H tone. A floating H tone is typically associated with the rightmost mora in the morpheme, as in the examples in (21) (see §8.5 and §8.6 for details on floating tones), but it may also be realized on a toneless mora, (22)a. However, it does not surface if the following mora is underlyingly specified for a tone, either L, (22)b-c, or H, (22)d.

(21) Morphemes with floating H tone

(a)



'peccary'

(b)

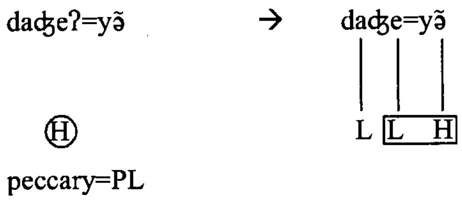
'ground, soil'

(c)

'sky'

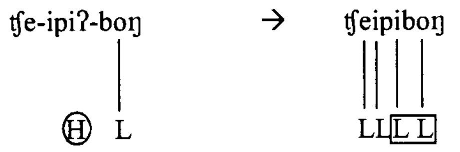
(22) Sequences /Ⓗ+ ∅/ versus /Ⓗ+ L or H/

(a)



'peccaries'

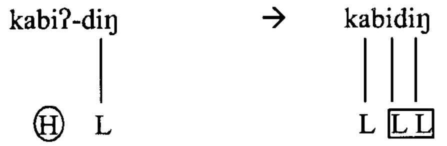
(b)



3.Poss-ground-be.big

'His/her plot of land is big.'

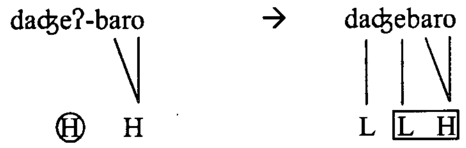
(c)



sky-smoke

'mist'

(d)



peccary-fake

'porcine'

From an OT perspective, L-dissimilation can be seen as the result of the OCP effect. The constraint *LL can be posited to prohibit a sequence of L-tones.

(23) *LL – A sequence of L-tones is prohibited.

A problem with this OCP constraint concerns the effect of a lexical L on a toneless mora. Let us consider two alternatives. First, assume that toneless moras remain toneless on the surface, as shown in (24). The OCP constraint selects the correct outputs for the sequences /L+L/, /∅+L/ and /∅+∅/, but does not predict dissimilation in a sequence /L+∅/.

(24) *Hypothesis 1*: Underlying toneless moras are toneless on the surface

Input	Output	*LL	Prediction	Expected
μ + μ L L	μ μ L L	Violated	LH ✓	LH
μ + μ L	μ μ L	Respected	LL ☹	LH
μ + μ L	μ μ L	Respected	LL ✓	LL
μ + μ	μ μ	Respected	LL ✓	L

Now suppose that all toneless moras are assigned a L tone on the surface. *LL predicts dissimilation in all sequences. Both underlying toneless and L tone moras are now assigned identical representations in the output; consequently, they are no longer susceptible to distinctions of any sort by the OCP constraint.

(25) *Hypothesis 2*: Underlying toneless moras are assigned a L tone on the surface

Input	Output	*LL	Prediction	Expected
$\begin{array}{ccc}\mu & + & \mu \\ \vert & & \vert \\ \mathrm{L} & & \mathrm{L}\end{array}$	$\begin{array}{cc}\mu & \mu \\ \vert & \vert \\ \mathrm{L} & \mathrm{L}\end{array}$	Violated	LH ✓	LH
$\begin{array}{ccc}\mu & + & \mu \\ \vert & & \\ \mathrm{L} & & \end{array}$	$\begin{array}{cc}\mu & \mu \\ \vert & \vert \\ \mathrm{L} & \mathrm{L}\end{array}$	Violated	LH ✓	LH
$\begin{array}{ccc}\mu & + & \mu \\ & & \vert \\ & & \mathrm{L}\end{array}$	$\begin{array}{cc}\mu & \mu \\ \vert & \vert \\ \mathrm{L} & \mathrm{L}\end{array}$	Violated	LH ☹	LL
$\begin{array}{ccc}\mu & + & \mu \\ \vert & & \vert \\ \mathrm{L} & & \mathrm{L}\end{array}$	$\begin{array}{cc}\mu & \mu \\ \vert & \vert \\ \mathrm{L} & \mathrm{L}\end{array}$	Violated	LH ☹	LL

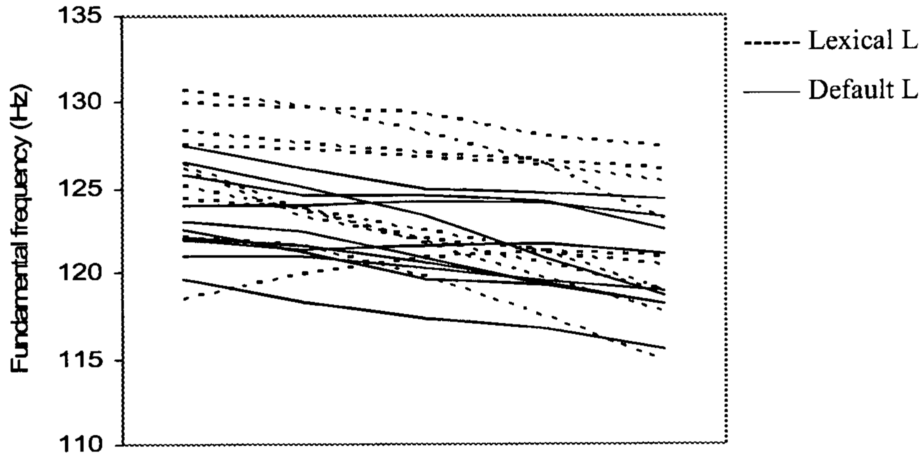
From this it follows that neither option captures the fact that L-dissimilation is triggered only by a lexical L-tone in Mundurukú; the target may be either a lexical or default L tone. This effect, as I suggest, is correlated to the fact that a default L may be not perceptually distinguishable in pitch from an underlying L. If we generalize this and rethink the similarity effects of the OCP, we shall be able to account for the effect of an underlying L-tone over a toneless vowel, without making reference to input values. In fact, measures of fundamental frequency for both lexical and default L tones show that the pitch of a default L is indistinguishable from the pitch of a L that is already present in the input.

Ten tokens were measured for each tone in the sequence /ʤe/ in the Mundurukú words *daʤebáró* 'porcine' (representing a default L tone), and *waʤebá* 'cocoa' (representing a lexical L tone). All tokens are plotted in Figure 8.3. The mean values are 124 Hz (s.d. 3.61) for lexical L versus 122 Hz (s.d. 2.44) for a default tone.[2] This similarity is confirmed by the t-test results, which indicate that default and lexical L tones cannot be differentiated (t=-1.45, s.d.=3.08, d.f.=18, p=0.16).

---

[2] Fundamental frequency measures were obtained at six points in the vowel, as explained in Chapter 2. These points were averaged, and a representative value was obtained for each token.

Figure 8.3. Graph showing F0 realization for default and lexical L-tones in two sequences /ʤe/ in the Mundurukú words daʤebáró 'porcine' and waʤebá 'cocoa'. (AK; ten tokens for each tone).



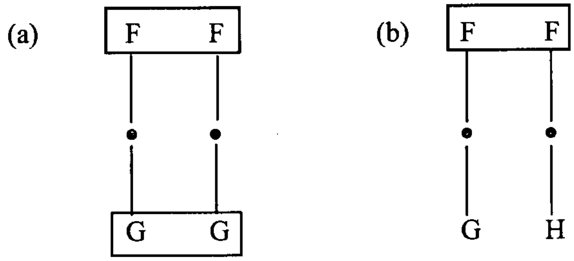
The issue is that dissimilation is not triggered by just any occurrences of L tone. The trigger is crucially an underlying L tone; the target can be either an input or output value. The question is how do we distinguish lexical versus default L tones, since this constitutes the requisite information to explain dissimilation?

The analysis proposed here is that the properties of L-dissimilation in Mundurukú are due to their being subject to the OCP-subsidiary feature effects – the more similar the elements are, the stronger the interaction (Suzuki 1998).

8.4.1 Similarity effects of the OCP

Suzuki (1998) observes that the identity avoidance effect is stronger the more similar the elements are. He defines similarity in terms of cooccurrence restrictions applying between segments that share multiple features. For instance, two adjacent elements sharing features on the [F]-tier and [G]-tier are more susceptible to the OCP-effects than segments sharing features on the [F]-tier only.

(26) Identity avoidance effects

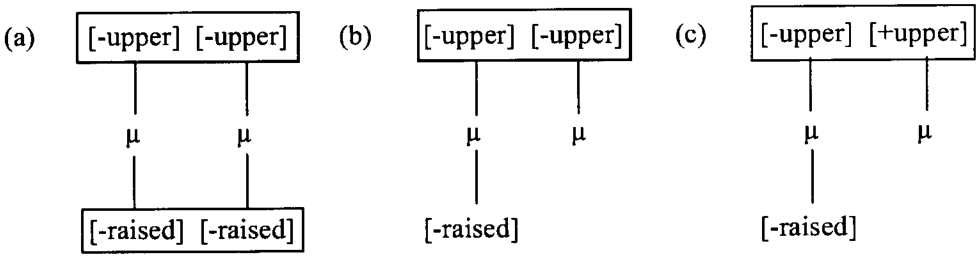


stronger weaker (Suzuki 1998: 19)

Suzuki's essential insight is that, although the identity avoidance effect will be stronger in (26)a, it does not necessarily preclude interaction in the pair in (26)b. A similar generalization can be proposed in our discussion of tones. Both lexical and default L tones share the feature [-upper] on the surface, but an underlying L is additionally specified for the feature [-raised]. Thus, although an underlying L-tone is not phonologically *identical* to a default L tone, it is not the case that they cannot interact.

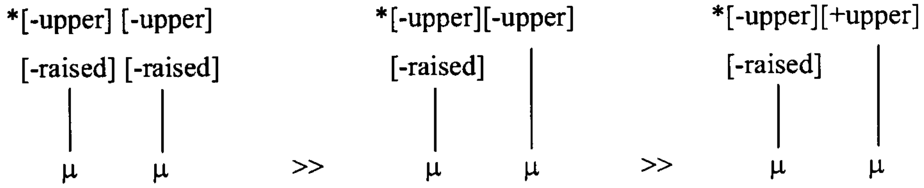
Two tone-bearing units are identical if they share the same tone specifications. This is schematically represented in (27). The pair in (27)a represents a sequence /L+L/; this sequence is identical as both units share [-upper] and the subsidiary feature [-raised]. The pair in (27)b, on the other hand, is not identical because they share only [-upper]; this case refers to a sequence /L+∅/. For comparison purposes, I provide the pair where tone-bearing units are maximally distinct, i.e. a sequence /L+H/ as in (27)c.

(27)



Under this approach, lexical L tones may affect not only moras that have identical tonal specifications, but also those that do not. Based on this, I propose the following hierarchy of the OCP-effects in Mundurukú.

(28) Identity avoidance



The OCP hierarchy will be represented in the form of the following constraints.

(29) OCP constraints

(a) *LL – A [-upper, -raised] mora may not be immediately preceded by a [-upper, -raised] mora.

(b) *L∅ – A [-upper, -raised] mora may not be immediately preceded by a [-upper] mora.

(c) *LH – A [-upper, -raised] mora may not be immediately preceded by a [+upper] mora.

The tableau below shows the dissimilation of two adjacent lexical L-tones. The ranking HAVEREG >> *LL >> MAXPATH[-raised] >> DEPH >> DEPL guarantees that every mora will have at least one register feature, excluding candidate (b), and this cannot be [+upper], unless this is overriden by the OCP constraint *LL which enforces dissimilation to H.[3]

Tableau 8.3. Sequence /L+L/. Word: *edíŋ* 'tobacco smoke'

e- diŋ | | [-r] [-r]	HAVEREG	*LL	MAXPATH [-raised]	DEPH	DEPL
a. ☞ e diŋ | | [-u,-r][+u]			*	*	*
b. e diŋ | | [-r] [-r]	*!*				
c. e diŋ | | [-u,-r][-u,-r]		*!			**

Next, consider a sequence /∅+L/. The optimal candidate realizes a toneless mora with the register feature [-upper], which is better than leaving a toneless mora without a tonal feature, candidate (c), or assigning it the feature [+upper], as in candidate (b). Spreading a feature to a toneless mora is banned by UNIFORMITY(T), not included in the tableau; but recall that this constraint is undominated in the language.

---

[3] An output such as *édiŋ* in which the first L is realized as H would be equally good in this tableau. However, as I suggest in §8.8 that the language has a prohibition on a sequence [+upper]-[-raised], so that this candidate is excluded.

Tableau 8.4. Sequence /∅+L/. Word: *kadiŋ* 'dust'

ka-diŋ | [-r]	HAVEREG	*LL	MAXPATH [-raised]	DEPH	DEPL
a. ☞ ka diŋ | | [-u][-u,-r]					*
b. ka diŋ | | [+u] [-u,-r]				*!	*
c. ka diŋ | [-u,-r]	*!				*

Most importantly, consider the role of *L∅ in a sequence /L+∅/. Insertion of [-upper] satisfies the higher ranked constraints but fatally violates *L∅, candidate (a). This constraint must be dominated by HAVEREG to enforce assignment of the register feature [upper] in the output, and by MAXPATH[-raised] to prevent dissimilation of the preceding L tone mora. Dissimilation occurs because a mora that is assigned [-upper] is non-distinct from another that is [-upper, -raised]. The optimal output is then candidate (c), which realizes the clitic on a H tone, i.e. [+upper].

Tableau 8.5. Sequence /L+∅/. Word: *poʃo=yə̃́* 'birds (sp.)'

poʃo=yə̃ |/ [-r]	HAVEREG	*LL	MAXPATH [-raised]	*L∅	DEPH	DEPL
a. poʃo=yə̃ |/ | [-u,-r][-u]				*!		**
b. po ʃo =yə̃ | | | [-u,-r][+u][-u]			*!		*	**
c. ☞ poʃo=yə̃ |/ | [-u,-r][+u]					*	**

Finally, consider a sequence /∅+∅/. Dissimilation to [+upper], candidate (b), is banned if not required by either **LL or *L∅, but these do not affect a sequence /∅+∅/. Two adjacent default L tones do not violate *L∅ because this constraint makes reference to the feature [-raised]. The option is then to assign the default value [-upper] to the sequence.

Tableau 8.6. Sequence /∅+∅/. Word: *bío=yə̃* 'tapirs'

bio=yə̃ | [+u]	HAVEREG	*LL	MAXPATH [-raised]	*L∅	DEPH	DEPL
a. ☞ b i o=yə̃ | | | [+u][-u][-u]						**
b. b i o= yə̃ | | | [+u][-u][+u]					*!	

The dual behavior of L tones in Mundurukú is precisely as expected from the point of view that identity avoidance effects are driven by similarities between trigger and target. Tones do not have to be identical in their representations to violate the OCP; interaction may result when one of the tonal features of a tone-bearing unit happens to be non-distinct from those of the trigger.

The next section follows up the discussion by examining the dual behavior of H tones. Two related cases will be investigated: tonal polarity (§8.5) and unstable H tones (§8.6).

8.5 Tonal polarity

Tonal polarity refers to a phenomenon where a morpheme is assigned a tone opposite to an adjacent tone. One issue is whether polarization equals dissimilation. Schuh (1978) and Newman (1995) propose that morphemes may be polar by nature; i.e. their surface tone is determined exclusively by the context at which they occur. If there exists evidence to presume that these morphemes have an underlying tone, then the process is one of dissimilation. For example, in the Guddiri dialect of Hausa, the diminutive *ɗan* (masc.) shows polarity: *ɗán ráagóo* 'a small ram' / *ɗàn yáaròo* 'a small boy'. However, the diminutive exists in the language as an independent (H-tone) noun *ɗán* 'son', suggesting that this is in fact a case of dissimilation rather than true tonal polarity (Newman 1995; Schuh 1978).

At another extreme, Kenstowicz, Nikiema and Ourso (1988) propose that polar tones are underlyingly H in all languages and the apparent polarity results from dissimilatory processes. Similarly, Pulleyblank (1986) treats polar tones in Margi as floating H tones underlyingly, but the morphemes are lexically marked as extratonal. Extratonality, in conjunction with a rule of H-deletion, generates the polarity effect.

A more recent, constraint-based account has been proposed in Suzuki (1998). Tonal polarity is a dissimilatory process that results from the requirements of two Generalized OCP constraints in a given domain – one prohibits a sequence of H-tone, (*H...H), and the other prohibits a sequence of Low tones, (*L...L).

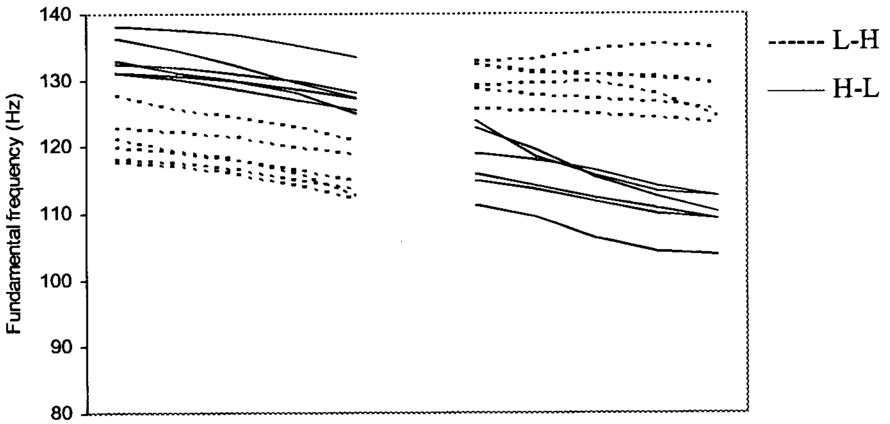
Mundurukú has a number of morphemes that exhibit tonal polarity in a very specific context, but surface L otherwise. The analysis proposed here also argues for tonal polarity as a dissimilatory process (§8.5.2). I follow Pulleyblank in assuming that these morphemes have a floating H tone underlyingly, whose association is subject to particular conditions.[4]

Particularly interesting is the fact that, although common in tone languages, tonal polarity is never a general phonological process. The morphemes involved, as I show here, interact with the whole system by not being derived from general patterns, and by showing properties that may not be extended to other members of the class to which they belong. After examining these properties, I propose that the phenomenon is best captured in terms of the OCP effects, which prevent a floating H tone to be associated with a mora if the preceding mora is already H.

8.5.1 Properties of tonal polarity

In Mundurukú, we find polar tones in the class of inalienable nouns, verbs, postpositions and a number of particles. In all cases, the tone of the morpheme has an opposite value to that of the preceding tone, H following L and L following H. Tonal polarity is illustrated in Figure 8.4.

Figure 8.4. Graph illustrating tonal polarity of the classifier -ta in the words *məsə́kta* 'manioc' (H-L) versus *kasoptá* 'star' (L-H).



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[4] In the past (Picanço 2002a), I analyzed polar tones as phonologically conditioned allomorphy. Here I offer an alternative analysis for the phenomenon, based on phonological principles only.

Polar tones have several properties that distinguish them from ordinary tones. First, tonal polarity is idiosyncratic. That is, it is peculiar to certain morphemes. To illustrate, monosyllabic inalienable nouns may be divided into two basic tonal groups: nouns that have L tone and those that exhibit tonal polarity.[5]

(30) Inalienable nouns with tonal polarity

(a) áko-də́p 'banana leaf' bórṍ-dəp 'cotton leaf '
banana-leaf cotton-leaf

(b) o̰-ʃí 'my mother' otʃé-ʃi 'our (excl.) mother'
1-mother 1pl.excl.-mother

(c) ka-sop-tá 'star' məsə́k-ta 'manioc'
thing-flame-CL manioc-CL

(d) káŋa-dí 'sugarcane juice' kápé-di 'coffee (liquid)'
sugarcane-CL coffee-CL

(e) tawé doy 'monkey's blood' dápsém toy 'deer's blood'
monkey blood deer blood

(f) o-nə̃́y 'my teeth' otʃé-nə̃y 'our (excl.) teeth'
1-tooth 1pl.excl.-tooth

(31) Inalienable nouns with L tone

(a) o-kat 'my cultivated field, garden'
1-garden

(b) ka-diŋ 'dust'
thing-smoke

---

[5] The corpus has two inalienable nouns that have H-tone: *-kə́* 'cultivated field' and *-tʃó* 'basket'.

(c) o-ba̰ ‘my arm’
1-arm

(d) o-ka̰ ‘my village, place’
1-place

We also find tonal polarity in verbs (32), postpositions (33), and a variety of particles (34).

(32) Verbs with polar tones

(a) o-ʤo-ʔó ‘I ate it.’ o̰-ʤó-ʔo ‘S/he ate it.’
1Su-3Ob-eat 3Su-3Ob-eat

(b) o-ʤo-á ‘I bit it.’ o̰-ʤó-a ‘S/he bit it.’
1Su-3Ob-bite 3Su-3Ob-bite

(c) o-t-a-dá ‘I cooked it.’ o̰-t-á-da ‘S/he cooked it.’
1Su-3-CL-cook 3Su-3-CL-cook

(33) Postpositions with polar tones

(a) o-tayʃi=bé ‘to my wife’ ayáʧát=pe ‘to the woman’
1-wife=Loc woman=Loc

(b) ək-ʔá=be=wí ‘from a house’ o-kat=pé=wi ‘from my garden’
house-CL=Loc=from 1-garden=Loc=from

(34) Particles with polar tones

(a) bío də́ … ‘Is it a tapir…?’ daʧé də… ‘Is it a hawk(sp.)…?’
tapir Q hawk Q

(b) ʤarã́y-ʔa dák ‘orange too’ ək-ʔá dak ‘a house too’
orange-CL too house-CL too

(c) epe-sot t̲ʃ̲ə̲́y̲ 'Come now!' e-y-a-ʔó d̲ʒ̲ə̲y̲ 'Eat it now!'
2plSu-come Imminent 2Su-3Ob-eat Imminent

The second property is that tonal polarity is peripheral. As already remarked by Pulleyblank (1986: 214), "polarity effects occur at the edges of a domain." (See also Archangeli and Pulleyblank 1994.) Mundurukú provides good examples for this property.

Most inalienable nouns can be incorporated into a verb, occurring in a position that is no longer peripheral. In this case, tonal polarity is blocked and the noun gets a L tone by default. The examples in (35) to (37) contrast the behavior of polarizing nouns in contexts that favor tonal polarity, the (a) cases, to their behavior in contexts that do not, the (b) cases. Note that in the latter, the nouns surface L toned but this tone does not affect a following L, a property associated with default L tones, as discussed in §8.4 above.

(35) (a) áko-də́p 'banana leaf' bórő-dəp 'cotton leaf'
banana-leaf cotton-leaf

(b) t-ə̲p̲-boŋ 'The leaf is big.'
leaf-be.big

(36) (a) ka-sop-tá 'star' məsék-ta 'manioc'
thing-flame-CL manioc-CL

(b) t-a̲-ḛro̰ 'It's (e.g. manioc) tender/soft.'
3-CL-be.tender

(37) (a) káŋa-dí 'sugarcane juice' kápé-di 'coffee (liquid)'
sugarcane-CL coffee-CL

(b) t-i̲-rət 'It's (e.g. liquid) white.'
3-CL-be.white

Similarly, in a sequence of two or more polar nouns, only the rightmost element exhibits tonal polarity; preceding nouns surface on a L tone. In (38)a, *-bə* 'finger' occurs at the right periphery, where it surfaces H following the L tone of the prefix *o-*. The addition of another polar morpheme, for example, *-nə̃* 'nail' in (38)b, blocks tonal polarity in *-bə*, but not in *-nə̃*. The polarity effect is again blocked by the diminutive suffix *-ʔ́itʔ́it* in (38)c, and *-nə̃* surfaces on a L tone. A similar example is provided in (39), with the classifer *-bi*.

(38) (a) o̰-bə́ 'my finger'
1-finger

(b) o-bə̰-nə̃́ 'my fingernail'
1-finger-nail

(c) o-bə-nə̃-ʔ́itʔ́it 'my little fingernail'
1-finger-nail-DIM

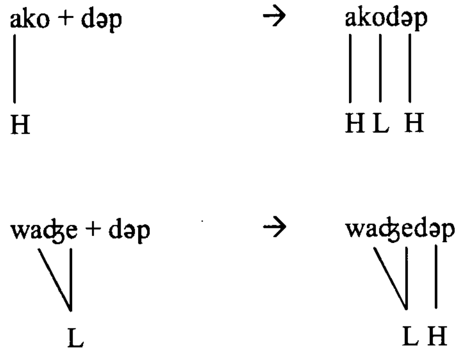
(39) (a) w-ək-ʃa̰-bí 'my back'
1-belly-chest-CL

(b) w-aʔɔ̃́-ʃa-bi-dá 'my heart'
1-voice-chest-CL-CL

The third property of tonal polarity is that it does not distinguish between lexical and default tones. For example, *dəp* 'leaf' is on a H tone regardless the preceding L is underlyingly specified or assigned by default.

(40) (a) 'banana leaf'

(b) 'cocoa leaf'



Finally, tonal polarity does not follow the general patterns observed in the language. Recall that a sequence of H tones originating from distinct morphemes requires no strategy to repair the OCP constraint *HH, as (41) illustrates. A polar tone, on the other hand, cannot surface on a H tone following another H, as seen in the examples above. Given this, we can assume that the OCP restriction on a sequence H+H is still relevant in Mundurukú, although its application is more restricted, as we will see shortly.

(41) (a) ʧokõn-ʔitʔit 'a little toucan'

To sum up, the basic properties of tonal polarity in Mundurukú are the following:

(i) It is morpheme-specific.
(ii) It is peripheral.
(iii) It does not distinguish between lexical and derived tones.
(iv) It does not follow the general requirements to which tones are or are not subject.

8.5.2 Proposal: Polar tone as floating H tone

We have seen that Mundurukú tonal polarity applies arbitrarily to a group of morphemes, which manifest polarity at the right periphery of a given domain, and L otherwise. This domain is the Prosodic Word (PWd), one of hierarchically ordered phonological constituents of the prosodic hierarchy (Selkirk 1981; Nespor and Vogel 1986).

(42) Prosodic hierarchy

$$\begin{array}{cc} \text{Prosodic word} & (\omega) \\ | & \\ \text{Foot} & (\Phi) \\ | & \\ \text{Syllable} & (\sigma) \\ | & \\ \text{Mora} & (\mu) \end{array}$$

The prosodic word is intended to define a domain that does not necessarily coincide with the morphological word; it may include derivations, compounding as well as cliticization. Postpositions and several particles behave as clitics in the language. That is, they lack word-level prosodic structure; hence, they adjoin to a preceding word in order to be realized.

My central claim is that polar tones are the manifestation of underlyingly floating H tones, a property of a number of morphemes. Their representations are illustrated in (43).

(43) Underlying representations of polar tones

(a) $\begin{pmatrix} \text{di} \\ \\ \text{[+upper]} \end{pmatrix}$ 'CL: liquid' (b) $\begin{pmatrix} \text{doy} \\ \\ \text{[+upper]} \end{pmatrix}$ 'blood'

To be realized, a floating H tone must be aligned with the right edge of a prosodic word. This is expressed here as the following Alignment constraint (McCarthy and Prince 1993b).

(44) Align(H) – Align (Floating H tone, Right, PWd, Right)

A floating [+upper] feature must be aligned with the right edge of a prosodic word.

There is an objection to the association of a floating H tone, namely that it obeys the OCP constraint prohibiting a sequence of H tones (*HH). This constraint is in conflict with faithfulness to [+upper], which tries to preserve the tonal feature.

(45) *HH

A sequence [+upper]-[+upper] is prohibited.

(46) Max(H)

A feature [+upper] in the input must have a correspondent in the output.

The ranking Align(H) >> *HH >> Max(H) predicts that the realization of a floating H tone is not going to happen unless (i) the TBU is at the right edge of a PWd, and (ii) the preceding tone is not H.

Consider the example in Tableau 8.7. The morpheme is at the right edge but the classifier fails to realize the floating tone because the preceding tone is already H.

Tableau 8.7. Sequence /H+Ⓗ/. Word: *kápédi* 'coffee (liquid)'

kape - di [+u] [+u]	HaveReg	MaxPath [+upper]	Align(H)	*HH	Max(H)	DepH	DepL
a. kape di [+u][+u]				*!			
b. ☞ kape di [+u][-u]					*		*
c. kape di [+u]	*!				*		

Another case in which one of the conditions is not respected is given in Tableau 8.8. Here there is no preceding tone, but the classifier is not at the right edge of a PWd, fatally violating Align(H). MaxPath prevents the association of a floating tone with a mora that bears a tonal feature underlyingly, but as we will see shortly, it does not prohibit its realization on a toneless mora.

Tableau 8.8. Sequence /Ⓗ+L/. Word: *tirət* 'The liquid is white.'

t-i - rət | [+u][-r]	HaveReg	MaxPath [-raised]	Align(H)	*HH	Max(H)	DepH	DepL
a. ti rət | | [+u][-u,-r]			*!				*
b. ti rət | | [-u][+u]		*!					*
c. ☞ ti rət | | [-u][-u,-r]					*		**

Now consider the next tableau. All the requirements that restrict the association of a floating H tone are met; hence Max(H) ensures its realization in the output.

Tableau 8.9. Sequence /∅+Ⓗ/. Word: *káŋadí* 'sugarcane juice'

kaŋa - di | [+u] [+u]	HaveReg	MaxPath [+upper]	Align(H)	*HH	Max(H)	DepH	DepL
a. ☞ ka ŋa di | | | [+u][-u][+u]							*
b. ka ŋa di | | | [+u][-u][-u]					*!		**

Finally, the ranking successfully accounts for a sequence of polar tones, as in the following tableau. (/ʔ/ in these morphemes is examined in §8.7.)

Tableau 8.10. Sequence of polar tones. Word: *obə̥nə̃́* 'my finger nail'

<table>
<tr><th>o-bəʔ -nə̃ʔ
[+u] [+u]</th><th>HAVEREG</th><th>MAXPATH
[+upper]</th><th>ALIGN(H)</th><th>*HH</th><th>MAX(H)</th><th>DEPH</th><th>DEPL</th></tr>
<tr><td>a. o bə nə̃
| | |
[-u][+u][-u]</td><td></td><td></td><td>*!</td><td></td><td>*</td><td></td><td>**</td></tr>
<tr><td>b. o bə nə̃
| | |
[-u][+u][+u]</td><td></td><td></td><td>*!</td><td>*</td><td></td><td></td><td>*</td></tr>
<tr><td>c. ☞ o bə̥ nə̃
| | |
[-u][-u][+u]</td><td></td><td></td><td></td><td></td><td>*</td><td></td><td>**</td></tr>
<tr><td>d. o bə nə̃
| | |
[+u][-u][+u]</td><td></td><td></td><td>*!</td><td></td><td></td><td></td><td>*</td></tr>
</table>

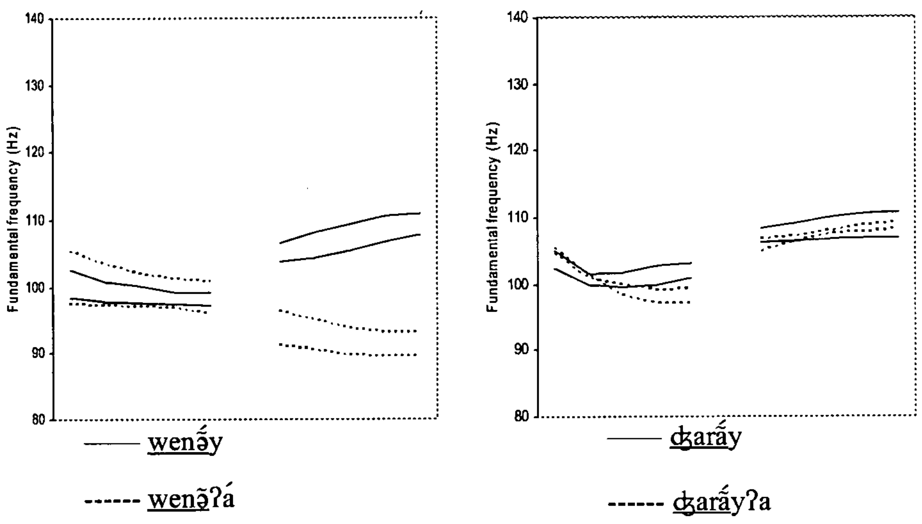
Taking this direction, the analysis is consistent with other tonal aspects observed in the language. For example, tonal polarity is treated as distinct from dissimilation of L tones, and is not a phenomenon that affects H tones altogether. Another advantage is that it can be extended to unstable H tones, examined next. Like polar tones, I propose that unstable H tones are also floating tones in the input.

8.6 Unstable H tones

The analysis developed so far also succeeds in explaining the dual behavior of H tones. Recall that nouns such as *wenə̃́y* 'Brazil nut' and *ʤarã́y* 'orange (tree)' have tonal melody [LH] in isolation, but distinct tonal behavior when followed by another tone: *wenə̃́-* loses its H tone, and surfaces [LL], whereas *ʤarã́y* does not change. The dual behavior of H tones is illustrated in Figure 8.5. It shows clearly that the H tone of *wenə̃́-* changes to L. (Only two tokens were available for these pairs.)

(47)	(a)	wenə̃́-y	'Brazil nut'	→	wenə̃-ʔá	'nut pod'
		nut-CL			nut-CL	
	(b)	ʤarã́y	'orange (tree)'	→	ʤarã́y-ʔa	'orange'
					orange-CL	

Figure 8.5. Graphs illustrating unstable H tones versus stable H tones.



Morphemes with an unstable H tone do not realize this tone in derived contexts. Compare them in isolation, (48), to their realizations in derived contexts, (49). In isolation, the tonal melody is [LH], but H changes to L in the derived words.

(48) Unstable H tones in isolation

(a)	da̰ydó	'armadillo'
(b)	ko̰bé	'canoe'
(c)	ḭpĩ́	'ground, soil'
(d)	ka̰bĩ́	'sky'
(e)	da̰ʤé	'peccary'
(f)	wenə̃́-y nut-CL	'Brazil nut'
(g)	o-daó 1-leg/bone	'my leg/bone'

(h) t-akə̃́ ‘branch of s.t.’
3-branch

(i) koa̰tó ‘summer’

(49) Unstable H tones in derived contexts

(a) daydo-dáp-dáp ‘armadillo, sp.’
armadillo-hair-RED

(b) kobe=bé ‘in the canoe’
canoe=Loc

(c) ʧe-ipi-boŋ ‘his/her plot of land is big’
3.Poss-ground-be.big

(d) kabi=daŋ ‘in the sky’
sky=Loc

(e) daʤe-báró ‘porcine’
peccary-fake

(f) wenə̃-ʔá ‘nut pod’
nut-CL

(g) o-dao-boŋ ‘My leg/bone is big.’
1-leg/bone-be.big

(h) t-akə̃-boŋ ‘The branch is big.’
3-branch-be.big

(i) koato bímá… ‘in summer time…’
summer when

Illustrations of the contrast with H tones that do not change are given below.

(50) Stable H tones

(a) datʃé 'hawk, sp.' → datʃé-ʔítʔít 'a little hawk'
hawk-DIM

(b) t-o̰bə́y 'his/her sling' → t-o̰bə́y-e 'his/her woven sling'
3-sling 3-sling-envira.fiber

(c) ka̰wí 'clay' → ka̰wí-pek-pek 'red clay'
clay-be.red-RED

(d) yaó 'fish, sp.' → yaó-ʔa 'head of the fish'
fish-CL

(e) t-a̰dí 'pomace' → t-a̰dí-rət 'The pomace is white.'
3-pomace 3-pomace-be.white

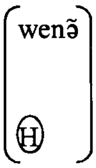
(f) kisé 'knife' → kisé-ʔip 'handle of a knife'
knife-CL

(g) ʤarã́y 'orange tree' → ʤarã́y-ʔa 'orange'
orange-CL

The properties of unstable H tones are nearly identical to those of polar tones. First, the process affects a small set of morphemes; thus far I have observed this pattern only in nouns. Second, it obeys the peripherality condition; that is, it only surfaces at the right edge of a prosodic word. And third, if H is not realized, these morphemes get L tone by default.

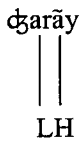
Given this similarity to polar tones, I suggest that unstable H tones are also the manifestation of floating tones, in opposition to H tones that are lexically associated.

(51) (a)



'Brazil nut'

(b)



'orange (tree)'

As shown in Tableau 8.11, the behavior of an unstable H tone can be accounted for by the same ranking that derives the properties of polar tones. This ranking picks a candidate that does not realize a floating H if the TBU is not at the right edge of a prosodic word.

Tableau 8.11. Unstable H tones. Word: *wenə̃ʔá* 'nut pod'

wenə̃-ʔa [+u] [+u]	HaveReg	MaxPath [+upper]	Align(H)	*HH	Max(H)	DepH	DepL
a. we nə̃ ʔa | | | [-u][+u][-u]			*!		*		**
b. we nə̃ ʔa | | | [-u][+u][+u]			*!	*			*
c. ☞ we nə̃ ʔa | | | [-u][-u][+u]					*		**
d. we nə̃ ʔa | | | [+u][-u][+u]			*!				*

Prelinked tones, on the other hand, behave differently. They must be realized, regardless the position at which they occur. MaxPath[+upper] guarantees that no changes will take place in the output.

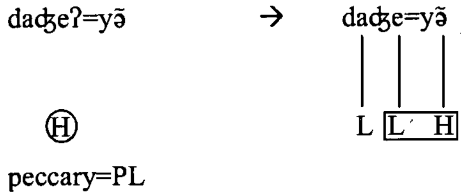
Tableau 8.12. Prelinked H tones. Word: *ʤarã́yʔa* 'orange'

ʤa rãy -ʔa | | [-r][+u] [+u]	HaveReg	MaxPath [+upper]	Align(H)	*HH	Max(H)	DepH	DepL
a. ☞ ʤa rãy ʔa | | | [-u,-r][+u][-u]					*		**
b. ʤa rãy ʔa | | | [-u,-r][+u][+u]				*!			*
c. ʤa rãy ʔa | | | [-u,-r][-u][+u]		*!			**		**

The difference between floating and prelinked H tones is also observed in combinations with a toneless mora. Recall that a toneless mora is generally assigned L by default. However, following a morpheme with a floating H tone, a mora may realize the floating tone if at the periphery, as in (52)a. If the H tone is prelinked, a toneless mora surfaces L, (52)b.

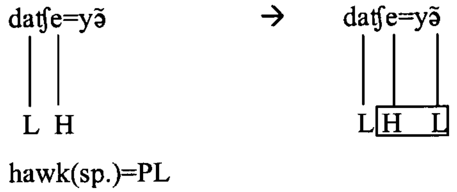
(52) Floating and prelinked H tones preceding a toneless mora

(a)



'peccaries'

(b)



'hawks (sp.)'

This analysis predicts that a floating tone may surface on a toneless mora at the right edge of a prosodic word, as illustrated in the following tableau. Association with this mora satisfies ALIGN(H), and is better because it preserves the feature in the output, enforced by MAX(H).

Tableau 8.13. Sequence /Ⓗ+∅/. Word: *da̠ʤ́e=yə̃́* 'peccaries'

daʤeʔ=yə̃ [+u]	HAVEREG	MAXPATH [+upper]	ALIGN(H)	*HH	MAX(H)	DEPH	DEPL
a. da ʤe yə̃ [-u][+u][-u]			*!				**
b. da ʤe yə̃ [-u][-u][-u]					*!		***
c. ☞ da ʤe yə̃ [-u][-u][+u]							**

The next issue concerns the interaction between phonation types and tones. The majority of nouns with an unstable H tone, and some nouns with tonal polarity, have an interesting pattern that is related to creaky voice. The pattern is a H tone on the last vowel and creaky voice on the preceding; if H changes to L, creaky voice disappears, as in the examples below.

(53)	(a)	da̠ʤé	→	daʤe-báró	'porcine'
		peccary		peccary-fake	

(b)	ḭpí	→	ʧe-ipi-boŋ	‘his/her plot of land is big’
	ground/soil		3.Poss-ground-be.big	
(c)	da̰ydó	→	daydo-dáp-dáp	‘armadillo, sp.’
	armadillo		armadillo-hair-RED	
(d)	ka̰bí	→	kabi-diŋ	‘mist’
	sky		sky-smoke	
(e)	koa̰tó	→	koato bímá	‘in the summer time...’
	summer		summer when	

This pattern is examined next as I examine the behavior of creaky voice with respect to tones.

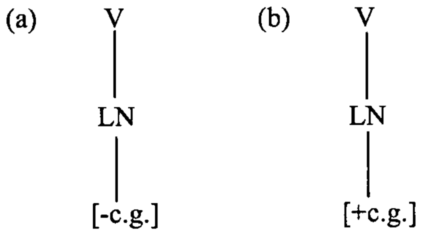
8.7 The interaction between creaky voice and tone

We saw in Chapter 2 that Mundurukú makes a contrast between creaky and modal voice on vowels. Some minimal pairs are provided below.

(54)	Creaky voice	Modal voice
(a)	wḭda̰	wida
	‘jaguar’	‘kind of clay’
(b)	i-pa̰ra̰ra̰	i-parara
	3Su-be.sunburned	3Su-be.afraid
	‘S/he’s sunburned.’	‘S/he’s afraid/scared.’
(c)	a̰y	áy
	‘sloth (monkey, sp.)’	‘rodent, sp.’
(d)	ʤe-ʃḭ-ʃḭ-ʃḭ-m	ʤe-ʃi-ʃi-m
	CoRef.Poss-tremble-RED-RED-IMPRF	CoRef.Poss-spit-RED-IMPRF
	‘to tremble’	‘to spit’

An acoustic analysis of the properties that distinguish creaky from modal voice was provided in Chapter 2. Here, I will deal with the restrictions which creaky voice is subject to in order to be realized on the surface. Before proceeding, let me introduce the underlying representations I propose for modal and creaky vowels. I assume a two-way distinction between [-constricted glottis] or [+constricted glottis], linked to the Laryngeal Node (LN). This feature is independent of tonal specifications, so we expect to find creaky vowels on both H and L tones. However, this is not the case; not all tonal combinations are possible, as examined next (see also §8.8).

(55)



8.7.1 If [+c.g.] then L tone

First of all, creaky vowels do not contrast in tone in Mundurukú: if creaky voice, then L tone. The general observation is that nonmodal phonation is associated with lowered fundamental frequency (F0), relative to modal phonation (e.g. Gordon and Ladefoged 2001). Tonal languages, in particular, tend to not realize tonal and phonation contrasts simultaneously on the same vowel (Silverman 1997). The reason is that the articulatory antagonism that may be involved in the realization of pitch versus the realization of nonmodal phonation. Here I will limit the discussion to creaky voice quality versus F0; for a broader overview, see Silverman (1997, and references cited in there), and especially Kingston (1985a, b), on which this discussion is based.

Briefly, Kingston highlights that stiffness of the vocal folds can be independently controlled by two mechanisms: contraction of the cricothyroid or thyroarytenoid muscles – permitting the speaker to control the rate of vibration of the vocal folds, while maintaing the same glottal constriction. If the thyroarytenoid muscle is strongly contracted without contracting the cricothyroid muscle, as Kingston explains, lower and upper margins of the folds come into contact, their medial compression increases, the closed phase of the vibratory cycle lengthens. If vibration is not extended to the body of the folds, F0 lowers considerably. This results in creaky voice quality.

The comparison of F0 measures of creaky and L tone modal vowels provided in Chapter 2 showed that the lowering effect is characteristic in the production of creaky phonation in Mundurukú. F0 may thus be an important acoustic cue that distinguishes them, and this may be a consequence of the way it is produced by the speakers, as seen above. Phonologically, this is expressed as a restriction on tonal distinctions, which limits creaky vowels to a L tone on the surface. Aside from this, they behave like modal vowels (see below).

The constraint on H tone in creaky vowels can be formulated in the form of a grounded constraint, following Archangeli and Pulleyblank (1994).

(56) *[c.g.]/[+upper] (=*CG/H)
If [+constricted glottis] then not [+upper]; or
If [+constricted glottis] then [-upper]

This constraint predicts that even if a creaky vowel is not assigned a tonal feature underlyingly, it will be realized as [-upper] in the output. (Faithfulness to [+c.g.] will be examined below, so a candidate such as [v̰] is not included in the tableau.)

Tableau 8.14. If [+c.g.] then not [+upper].

V̰	*CG/H	HAVEREG	DEP(L)
a. ☞ v̰ | [-u]			*
b. v̰́ | [+u]	*!		

*CG/H is never violated in Munduruků. For example, if a lexical L tone triggers dissimilation of a creaky vowel, as it does with other L tone modal vowels, this vowel surfaces modal, and on a H tone.

(57) (a) waʤe-ba̰ → waʤebá 'cocoa'
\| / \|
L L
cocoa-CL

(b) ʃin-tõ̰m → ʃintṍm 'flour for pancake'
\| \|
L L
pancake-CL

The waveforms below compare the realizations of the classifer *-ba̰* in two words: *áko-ba̰* 'banana', Figure 8.6, where the vowel /a̰/ is on a L tone and therefore creaky; and *waʤe-bá* 'cocoa', Figure 8.7, where the vowel is realized with modal voice because of its dissimilation to a H tone.

Figure 8.6. Waveform showing a creaky vowel in the Mundurukú word *ákoba̰* 'banana'. (JT)

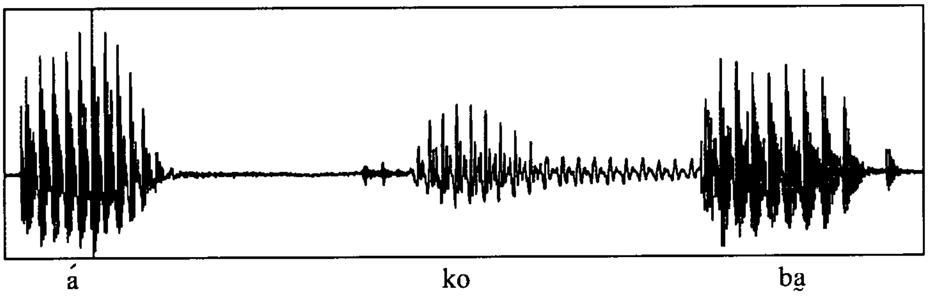
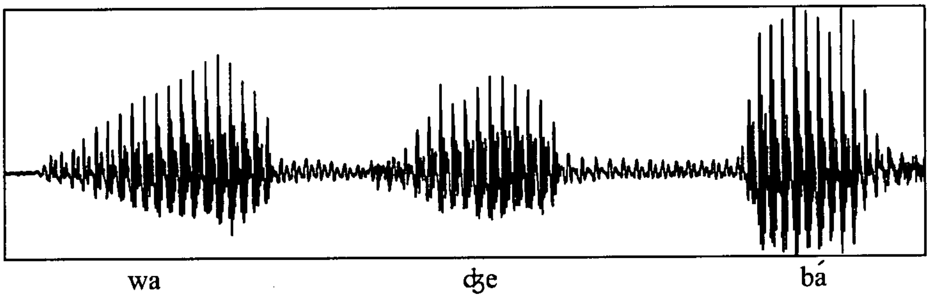


Figure 8.7. Waveform showing loss of creaky voice in a sequence /L+L/. Word: *waʤebá* 'cocoa'. (JT)



Loss of creaky voice in L-dissimilation indicates that *CG/H outranks faithfulness to specifications of the feature [+constricted glottis], MAX[c.g.]. I also assume faithfulness to input specifications of this feature, DEPPATH[c.g.], against the constraint *CG (Howe and Pulleyblank 2001).

(58) (a) MAX[c.g.]
A feature [+constricted glottis] in the input must have a correspondent in the output.

(b) DEPPATH[c.g.]
Any output path between [+constricted glottis] and an anchor must have a correspondent path in the input.

(b) *CG
Specifications of the feature [+constricted glottis] are prohibited.

The modal voice quality that results if a creaky vowel is affected by a preceding L tone is obtained by the ranking *CG/H >> *LL >> MAXPATH[-raised] >> DEPPATH[c.g.] >> MAX[c.g.] >> *CG. In the following tableau, two candidates, (a) and (b), are tied with each other until evaluated by DEPPATH[c.g.]. Note that realizing the feature [c.g.] on the preceding vowel is plausible, and true in Mundurukú as we will see below, but not in this case. Figure 8.7 above showed that the vowel /e/ in *waʤebá* is also modal, meaning that creaky voice is in fact completely lost.

Tableau 8.15. Creaky voice and *LL.

waʤe-ba̰ [-r] [-r]	*CG/H	*LL	MAXPATH [-raised]	DEPPATH [c.g.]	MAX [c.g.]	*CG	DEP(H)
a. ☞ waʤeba [-u,-r][+u]			*		*		*
b. waʤḛba [-u,-r][+u]			*	*!		*	*
c. waʤeba̰ [-u,-r][+u]	*!		*			*	*
d. waʤeba̰ [-u,-r][-u,-r]		*!				*	

The examples below are to illustrate the creaky vowel of the classifier *-ba̰* participating in the process of L-dissimilation as the trigger.

(59) (a) ako-ba̰ i-ba̰-boŋ → ákoba̰ iba̰bóŋ
H L [L L]
banana-CL 3-CL-be.big
'The banana is big.'

(b) ako-ba̰ i-ba̰-rət → ákoba̰ iba̰rə́t
H L [L L]
banana-CL 3-CL-be.white
'The banana is white.'

8.7.2 Creaky voice and H tone

The second restriction on the realization of creaky voice is found in the nature of the following tone. The general pattern is creaky voice on one vowel and a H tone on the following,[6] as in the examples in (60). This pattern prevails in both derived and underived contexts, except if all vowels in the morpheme are creaky; if not, the second dissimilates to H, (60)e.[7]

(60) Sequences with a creaky vowel (V̰)

(a)	$\begin{array}{cc} \underset{\sim}{V} & V \\ \mid & \mid \\ L & L \end{array}$		i-ba̰-boŋ → iba̰bóŋ 3-CL-be.big 'It's (e.g. banana) big.'
(b)	$\begin{array}{cc} \underset{\sim}{V} & V \\ \mid & \mid \\ L & H \end{array}$	ka̰wí 'clay'	i-ba̰-pík 3-CL-be.burned 'It's (e.g. banana) burned.'
(c)	$\begin{array}{cc} V & \underset{\sim}{V} \\ \mid & \mid \\ H & L \end{array}$		ʃírírí-ba̰ ingá-CL 'ingá fruit, sp.'
(d)	$\begin{array}{cc} V & \underset{\sim}{V} \\ \mid & \mid \\ L & L \end{array}$	-daka̰t 'to cut s.t.'	áko-ba̰ banana-CL 'banana'
(e)	$\begin{array}{cc} \underset{\sim}{V} & \underset{\sim}{V} \\ \mid & \mid \\ L & L \end{array}$	wḭda̰ 'jaguar'	i-ba̰-ḛro̰ → iba̰éro̰ 3-CL-be.tender 'It's (e.g. banana) tender.'

---

[6] For proposals on the relationship of tonal and laryngeal features, see Halle and Stevens 1971, Yip 1990, 1993, 1995, etc.

[7] It is also possible to get a sequence of creaky vowels in derived contexts if the second morpheme is the reduplicant, as in *ʤeʃḭʃḭʃim* 'to tremble'. If these vowels come from independent morphemes, then the second changes to H.

In this respect, creaky voice differs from modal phonation, which allows different sequences of tones, as shown in (61). However, creaky vowels are not so different from modal vowels that are lexically specified for [-raised]; these too require the following tone to be H on the surface (see §8.4 above).

(61) Sequences with modal vowels

(a)	$\begin{array}{cc} V & V \\ \vert & \vert \\ L & L \end{array}$	poʃo 'bird, sp.'	t-iŋ-rət → tiŋrə́t 3-smoke-be.white 'The smoke is white.'
(b)	$\begin{array}{cc} V & V \\ \vert & \vert \\ L & H \end{array}$	dekó 'monkey, sp.'	ʤe-kő̃n CoRef.Poss-eat 'to eat' (Intr.)
(c)	$\begin{array}{cc} V & V \\ \vert & \vert \\ H & L \end{array}$	bío 'tapir'	ʃẽ́-pak-pak bird(sp.)-be.red-RED 'red cigana (bird, sp.)'
(d)	$\begin{array}{cc} V & V \\ \vert & \vert \\ H & H \end{array}$	dóá 'spider'	ʤarã́y-tʃə́p-tʃə́-ʔa orange-be.bitter-RED-CL 'kind of orange'

(62) is another contribution to the argument that the surface realization of creaky voice depends on tones, but not conversely. In these examples, creaky voice is not sufficient to maintain a H tone on the following syllable. On the contrary, the H tone changes to L independently, as we have already seen in §8.6, and so removing the context that favors the realization of creaky voice, namely a H tone in the following vowel. As a result, creakiness disappears.

(62)	(a)	da̰ʤé peccary	→	daʤe-báró peccary-fake	'porcine'
	(b)	ḭpí ground/soil	→	tʃe-ipi-boŋ 3.Poss-ground-be.big	'his/her plot of land is big'

(c) da̰ydó → daydo-dáp-dáp 'armadillo, sp.'
armadillo armadillo-hair-RED

(d) ka̰bí → kabi-diŋ 'mist'
sky sky-smoke

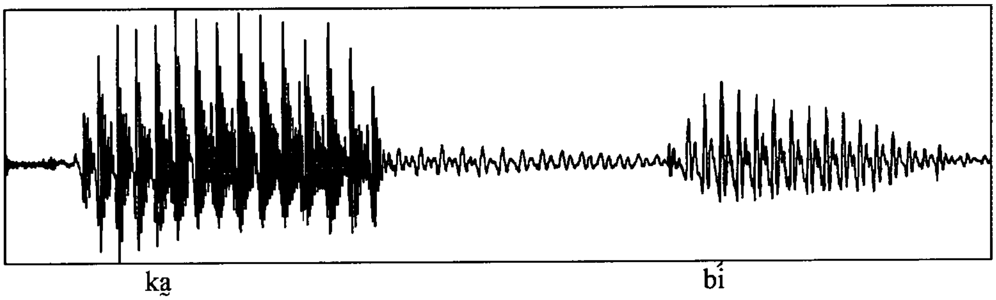
(e) koa̰tó → koato bímá 'in the summer time...'
summer summer when

(f) o̰-bə́ → o-bə-boŋ 'My finger is big.'
1-finger 1-finger-be.big

(g) o̰-ʃí → o-ʃi ʃat 'my mother's food'
1-mother 1-mother food

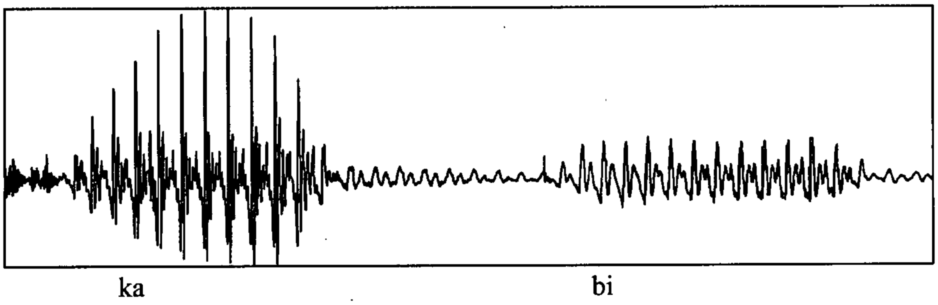
Loss of creaky voice in this pattern is illustrated by the noun *ka̰bí* 'sky' in the three figures below. Consider first the noun as pronounced in isolation, Figure 8.8, in which creakiness surfaces in the first vowel, preceding a H tone.

Figure 8.8. Waveform of the Mundurukú word *ka̰bí* 'sky'. (JT)



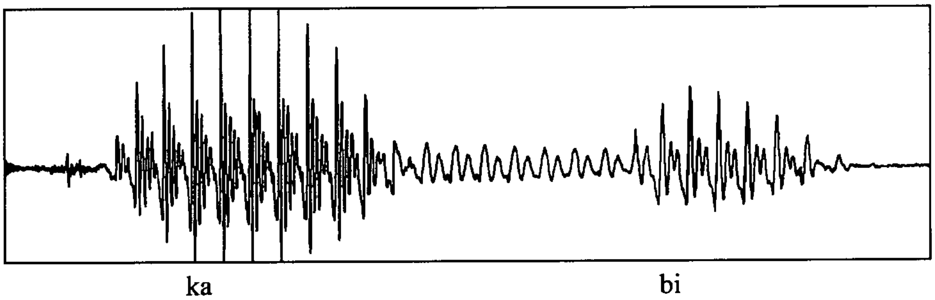
Now compare the same noun in a derived context, shown in Figure 8.9. The waveform has been extracted from the word *kabi-diŋ* 'mist' [LLL], in which case *ka̰bí* is pronounced [LL]. As can be noted, neither vowel surfaces creaky.

Figure 8.9. Waveform of the noun *ka̰bí* 'sky' in the Mundurukú word *kabi-diŋ* 'mist'. (JT)



Similarly, Figure 8.10 shows that creaky voice is lost even if the following morpheme has a H tone. The word is *kabi-kéréré* 'cloud' [LLHHH].

Figure 8.10. Waveform of the noun *ka̰bí* 'sky' in the Mundurukú word *kabi-kéréré* 'cloud'. (JT)



The cases in (62) above contrast with the ones below in two ways. First, not all H tones preceded by a creaky vowel are unstable, (63)a-b. And second, although the majority of morphemes with an unstable H tone also has a creaky vowel, there are also cases of unstable H tones without creakiness, as in (63)c-f. This means that the H tone, whether stable or unstable, is phonologically independent of creaky voice.

(63) (a) t-o̰bə́y → t-o̰bə́y-e 'his/her woven sling'
3-sling 3-sling-envira.fiber

(b) ka̰wí → ka̰wí-pek-pek 'kind of clay'
clay clay-be.red-RED

(c) t-akə̃́ → t-akə̃-boŋ 'The branch is big.'
3-branch 3-branch-be.big

(d) wenə̃́-y → wenə̃-ʔá 'nut pod'
nut-CL nut-CL

(e)	o-daó	→	o-dao-rət	'My leg/bone is white.'
	1-leg.bone		1-leg.bone-be.white	
(f)	w-etá	→	w-eta-ʃeé	'my eye lid'
	1-eye		1-eye-skin	

Braun and Crofts (1965: 27) tried to capture the high tone-creaky voice relation by proposing a rule of phonetic laryngealization (creaky voice): "Etic laryngealization occurs on a CV^3 syllable preceding a syllable with accent 2 and an onset of ʔ, s, š, č, ǰ or b." (The superscript number in CV^3 corresponds to a low tone syllable, accent 2 to a high tone, and the consonants /š, č, ǰ/ correspond to /ʃ, ʧ, ʤ/ respectively.) This rule predicts that all words with [LH] tonal melody, whose H-tone syllable begins with one of these consonants, will manifest creaky voice on the L-toned vowel. But the interaction between creaky voice and a H tone is not as simple. For example, the words in (64) meet the conditions described by Braun and Crofts but the vowels are modal.

(64)	(a)	daʃá	'firewood'	*da̰ʃá
	(b)	daʧé	'hawk, sp.'	*da̰ʧé
	(c)	ʃiʤáp	'shelter'	*ʃḭʤáp
	(d)	kisé	'knife'	*kḭsé

These facts show that a H tone, whether stable (pre-linked) or unstable (floating) is independent of the feature [+constricted glottis], but not vice-versa. That is, the feature [+constricted glottis] cannot surface unless the following tone is H. The patterns are summarized in (65). We find creaky and modal vowels preceding unstable as well as stable H tones; what we do not find is a combination creaky voice + H tone in which the vowel surfaces creaky if H itself is not realized.

(65) Surface patterns

(a)	V̰CV́	→	VCV	VCV́	→	VCV
(b)	V̰CV́	→	V̰CV́	VCV́	→	VCV́
(c)	*V̰CV́	→	V̰CV			

The situation gets more complex when we look at monosyllabic nouns, in particular nouns with tonal polarity on the surface. They too have developed a similar relation to creakiness. Consider the cases in (66). All these nouns trigger creakiness on a preceding vowel, but do not themselves realize the feature, even if the following tone is H. In (66)d, *-kṍ* 'tongue' triggers creaky voice and surfaces creaky, but this is because it is combined with *-bi* 'mouth', which also has this effect.

(66) (a) o̰-bə́ → o-bə-boŋ 'My finger is big.'
1-finger 1-finger-be.big

(b) o̰-bí → o-bi-dí 'saliva of my mouth'
1-mouth 1-mouth-CL

(c) o̰-ʃí → o-ʃi ʃat 'my mother's food'
1-mother 1-mother food

(d) o̰-kṍ → o-kõ̰-bí 'roof of my mouth'
1-tongue 1-tongue-mouth

The examples below show that this is in fact a property of these morphemes. The same prefix *o-* '1st person possessive' precedes other nouns with a polar tone and does not manifest creakiness, (67)a-b. (67)c-d provide further evidence: (c) shows the effect of *-bə* 'finger', here functioning as a classifier, in the root *pəy-*, and (d) shows that *-bə* itself has a modal vowel despite the fact that this vowel is on a L tone. Likewise, (67)e-f show *-bi* 'mouth' in a context where it triggers creaky voice versus a context where it combines with a morpheme that does not. Like the cases seen above, creakiness is completely lost if the following H tone changes to L.

(67) (a) o-dóy 'my blood'
1-blood

(b) o-nə̃́y 'my teeth'
1-tooth

(c) pə̰y-bə́ 'snake'
snake-CL(finger)

(d) bórő-bə 'cotton string'
cotton-CL

(e) w-ə̰k-ʃa̰-bí 'my back'
1-belly-chest-CL(mouth)

(f) w-aʔő-ʃa-bi-dá 'my heart'
1-voice-chest-CL(mouth)-CL

Comparing these to the surface patterns in (65) above, it is evident that creakiness is not underlyingly associated with the vowel that realizes it on the surface. That is, it comes from the following syllable. For example, *o̰bí* 'my finger' and *ka̰bí* 'sky' exhibit the same behavior with respect to tone and creakiness.

(68) (a) o̰-bí → o-bi-boŋ 'My mouth is big.'
1-finger 1-mouth-be.big

o-bi-dí 'saliva of my mouth'
1-mouth-CL

(b) ka̰bí → kabi-diŋ 'mist'
sky sky-smoke

kabi-kérére 'cloud'
sky-?

The question is: Why does not the feature [+c.g.] surface on the final vowel when the H tone changes to L? In other words, why is not a word such as *ka̰bí* 'sky' realized as **kabḭkérére* 'cloud', since the H tone of the second morpheme also provides the appropriate context for the realization of creakiness?

I suggest that creaky voice on these cases is the manifestation of an underlying laryngeal /ʔ/ morpheme-finally, but this consonant cannot occur in coda position. The underlying representations suggested for these morphemes are illustrated below.

(69) (a) $\begin{pmatrix}\text{kabiʔ}\\ \textcircled{H}\end{pmatrix}$ → ka̰bí 'sky'

(b) $\begin{pmatrix}\text{o-piʔ}\\ \textcircled{H}\end{pmatrix}$ → o̰bí 'my mouth'

A reason to believe that this may be a laryngeal consonant underlyingly is the fact that all morphemes that manifest this pattern have a CV syllable morpheme-finally.[8] A list of words in this group is given below.

(70)	(a)	ḭpí	'ground, soil'
	(b)	koa̰tó	'summer'
	(c)	ta̰ypə́	'his penis'
	(d)	o̰kṍ	'my tongue'
	(e)	ko̰bé	'canoe'
	(f)	ko̰bə́	'tree, sp.'
	(g)	pə̰ybə́	'snake'
	(h)	sə̃ŋta̰bí	'door'
	(i)	ka̰bí	'sky'
	(j)	idḭbí	'water, river'
	(k)	ta̰bí	'her vagina'
	(l)	o̰bí	'my mouth'
	(m)	oŋḛbí	'my armpit'
	(n)	okaŋo̰bí	'my ankle'
	(o)	da̰ydó	'armadillo'
	(p)	da̰ʤé	'peccary'
	(q)	ə̰rə̃́	'hammock'

---

[8] The preceding syllable is also CV or CVG (G=glide), a fact that I cannot explain.

(r)	o̰ʃí	'my mother'
(s)	obə̰nə́	'my fingernail'

To offer an account of the presence versus absence of /ʔ/, I first propose a markedness constraint prohibiting /ʔ/ in coda position;

(71) *ʔ]σ

The laryngeal /ʔ/ is prohibited in coda position.

Combining this with the constraints relevant to the realization of a floating H tone, we obtain *ka̰bí*, candidate (a), as the optimal output. While *ʔ]$_σ$ forces /ʔ/ to be realized as creaky voice on the vowel, ruling out (c), *CG/H and ALIGN(H) prevent creakiness from surfacing on the final vowel, excluding candidates (b) and (d) respectively. In the conflict between faithfulness to H, MAX(H), or to the laryngeal feature, DEPPATH[c.g.], tone wins.[9]

Tableau 8.16. From *kabiʔ*to *ka̰bí*'sky'.

kabiʔ [+u]	*CG/H	*ʔ]$_σ$	ALIGN(H)	MAX(H)	DEPPATH [c.g.]	MAX [c.g.]	*CG
a.☞ ka̰ bi [-u][+u]					*		*
b. ka bḭ [-u][+u]	*!				*		*
c. ka bíʔ [-u][-u]		*!					*
d. ka bḭ [+u][-u]			*!		*		*
e. ka bḭ [-u][-u]				*!	*		*

---

[9] A candidate without [c.g.], e.g. *kabí*, would win over *ka̰bí* with this ranking, as Douglas Pulleyblank (p.c.) has pointed out. Yet, since /ʔ/ is a consonant, this problem must be examined in the context of the interaction between the tone system and the segmental analysis proposed in the preceding chapters; and this will not be dealt with here. I will leave this question open for the moment.

If a floating H tone cannot be realized, the ranking predicts that /ʔ/ must not surface. This is shown in the following tableau. Candidates (a) and (e) violate MAX(H), but (a) is better because it does not realize creaky voice on the vowel.

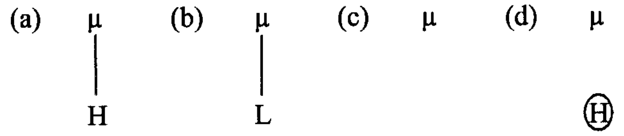
Tableau 8.17. No H tone, no creaky voice. Word: *kabikérére* 'cloud'.

kabiʔ-kérére [+u]	*CG/H	*ʔ]$_\sigma$	ALIGN(H)	MAX(H)	DEPPATH [c.g.]	MAX [c.g.]	*CG
a. ☞ ka bi -ké… [-u][-u]				*		*	
b. ka bi -ké… [-u][+u]	*!		*		*		*
c. ka biʔ -ké… [-u][-u]		*!		*			*
d. ka bi -ké… [+u][-u]			*!		*		*
e. ka bi -ké [-u][-u]				*	*!		*

8.8 Evaluating the proposal

In §8.2 I propose that moras may be H, L or toneless underlyingly; certain morphemes that have a toneless mora may also have a floating H tone.

(72)



Considering the H-L-∅ distinction, a paradigm of 12 combinations are predicted for morphemes with one or two syllables.

(73)	(a)	H	HH	HL	H∅
	(b)	L	LH	LL	L∅
	(c)	∅	∅H	∅L	∅∅

The sequences HH and LL were excluded, as I assumed, by the OCP. These are represented by a multiply linked tone. There are four gaps in this paradigm: HL, ∅L, L∅, and ∅H. The sequence ∅H is found on the surface as a variant of disyllabic morphemes that have a floating H tone, as in (74). But overall, toneless moras are restricted to bound roots (e.g. *pəy-* 'snake') and affixes.

(74) (a) o-dao → odao 'my leg/bone'
Ⓗ L LH
1-leg.bone

The paradigm of possible combinations and illustrations for each of these sequences are given in (75). The gaps are discussed below.

(75) Paradigm of possible combinations and gaps

μ │ H	μ │ L	μ
é 'path' [ɛ́]	e 'tobacco' [ɛ̀]	pəy- 'snake' pəy-tõ-bə́ snake-purple-CL [pə̀ytõ̀bə́]
μ μ ╲╱ H	μ μ │ │ H L	μ μ │ H
tʃókṍn 'toucan' [tʃókṍn]	None	áko 'banana (tree)' [ákò]
μ μ │ │ L H	μ μ ╲╱ L	μ μ │ L
ʤarã́y 'orange (tree)' [ʤã̀r̃ã́ỹ]	waʤe 'cocoa (tree)' [wàʤɛ̀]	None
μ μ │ H	μ μ │ L	μ μ
None	None	epe- '2nd person plural' epe-t-obə́ʃik 'You found him/her.' 2pl.Su-3Ob-find [èpètòbə́ʃìk]

Three of these gaps, /L∅, ∅H, ∅L/, can be accounted for by the analysis proposed here. First, consider the combinations /L∅/ and /∅H/. The ranking UNIF(T), HAVEREG >> MAXPATH[+upper], *LL >> MAXPATH[-raised], DEPPATH[-raised] >> *L∅ >> DEP(H) >> DEP(L) predicts that these sequences, if available in the input, must surface as a sequence [LH]. For instance, *ʤarã́y* 'orange (tree)' would surface [LH] if we assumed any of the three underlying representations below.

(76)	(a)	ʤarãy | | L H	(b)	ʤarãy | H	(c)	ʤarãy | L

The representation in (76)a is the one assumed here, based on the principle of Lexicon Optimization. (76)b and (76)c appear in Tableau 8.18 and Tableau 8.19 respectively.

Tableau 8.18. Sequence /∅H/ → [LH]

ʤarãy | H	UNIF(T)	HAVEREG	MAXPATH [+upper]	DEP(H)	DEP(L)
a. ☞ ʤarãy | | L H					*
b. ʤarãy ∨ H	*!				
c. ʤarãy | H		*!			*
d. ʤarãy | | H L			*!		

Tableau 8.19. Sequence /∅H/ → [LH]

ʤarãy L	UNIF(T)	HAVE REG	*LL	DEPPATH [-raised]	*L∅	DEP(H)	DEP(L)
a. ☞ ʤarãy L H						*	
b. ʤarãy L	*!		*	*			
c. ʤarãy L[-r]		*!		*			*
d. ʤarãy L		*!					*
e. ʤarãy L[-u]					*!		*

Similarly, the combination /∅L/ is predicted to surface as [LL]. This is illustrated in the following tableau. Suppose that the underlying representation of *waʤe* 'cocoa (tree)' is /∅L/.

Tableau 8.20. Sequence /∅L/ → [LL]

waʤe L	UNIF(T)	HAVE REG	*LL	DEPPATH [-raised]	*L∅	DEP(H)	DEP(L)
a. ☞ waʤe [-u]L							*
b. waʤe L	*!			*			
c. waʤe H L						*!	

As for /HL/, there is no obvious reason for this gap. There are 25 disyllabic words with the melody [HL] in the corpus: 11 are mono-morphemic (e.g. *áko* 'banana (tree)'); 4 are borrowings (e.g. *péta* 'feast'/ Portuguese: *festa*); 4 seem to be reduplicated forms that have been lexicalized (e.g. *ĩ́ĩ* 'hawk, sp.'); and the others have at least two separate morphemes. Likewise, polysyllabic words ending with melodies [...HL] are rare, all of which involve more than one morpheme. For instance, amongst four-syllable words, there is only one occurrence of /H+L/: /kóró-ʃín-pa̰/ → *kóróʃínpa̰* 'kind of beans'.

I suggest that the language has a constraint prohibiting the sequence /HL/.

(77) *HL

A sequence [+upper]-[-upper, -raised] is prohibited.

This constraint can account for the absence of /HL/ sequences in input forms, as well as the fact that in dissimilation of L tones, it is the second L that changes to H.

(78) (a) e-diŋ → edíŋ *édiŋ

tobacco-smoke

'tobacco smoke'

(b) waʤe-ba̰ → waʤebá *waʤéba̰

cocoa-CL

'cocoa'

Dissimilation is illustrated in the following tableau. *HL must be ranked higher than MAXPATH[-raised], which demands faithfulness to the feature [-raised].

Tableau 8.21. Sequence /L+L/. Word: *edíŋ* 'tobacco smoke'

e- diŋ | | [-r] [-r]	HAVEREG	*LL	*HL	MAXPATH [-raised]	DEPH	DEPL
a. ☞ e diŋ | | [-u,-r][+u]				*	*	*
b. e diŋ | | [-r] [-r]	*!*					
c. e diŋ | | [-u,-r][-u,-r]		*!				**
d. e diŋ | | [+u][-u,-r]			*!	*	*	

Interestingly, these predictions are consistent with the surface distribution of tones in the language. For example, word initial L tones are three times as frequent as H tones in the same position – 259 words beginning with L vs. 83 beginning with H (monosyllabic nouns not included). Word-finally, high tones are far more frequent (223 words) than L tones (119); consequently, [LH] sequences outnumber any other sequence in about 50% of the patterns attested thus far. This may be related to the fact that many input sequences are predicted to surface as [LH]. These are listed in (79), including hypothetical combinations with a floating H tone.

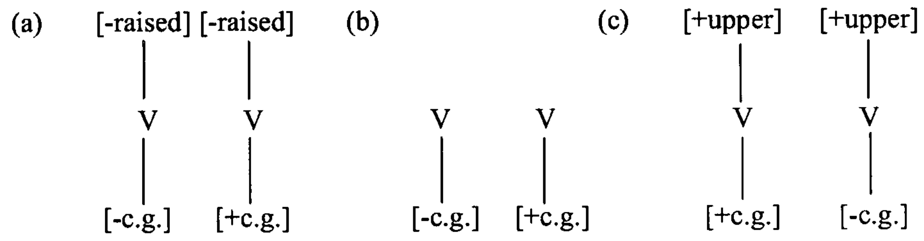
(79)	(a)	LH	∅H	L∅	LL
	(b)	∅Ⓗ in isolation	ⒽH	Ⓗ∅	ⒽⒽ

In words with similar tones, [LL] sequences are preferred: 71 cases versus 39 for [HH]. Three input sequences (in addition to a multiply linked representation) are predicted to surface as [LL] and only one as [HH].

(80)		Input	Output
	(a)	∅L, ∅∅,Ⓗ L	[LL]
	(b)	HH	[HH]

Let us now turn to the interaction of tones and creaky voice. I suggested in the beginning of section 8.7 that Munduruku makes a contrast between [-constricted glottis] and [+constricted glottis] vowels, and that specifications of this feature were independent of tonal specifications, following the Richness of the Base. Given this, modal or creaky vowels should in principle be allowed to occur on both H and L tones. This is true for modal vowels, but not for their creaky counterparts. Underlyingly, all the following combinations of tonal and laryngeal features are predicted.

(81)



On the surface, however, creaky vowels are more restricted in terms of their tonal realizations. The first restriction is on the combination of a H tone with a creaky vowel. An output such as [v̰́], even if present in the input, is eliminated by *CG/H. The analysis proposed here predicts that the H tone wins in this case, so the optimal output is [v́]. The preference for preserving tones was demonstrated in the analysis of dissimilation of L tones. The position of MAXPATH[-raised] relative to MAX[c.g.] in the ranking determines that it is better to preserve a tone than creakiness.

The second restriction on creaky voice is the following tone, which must be H. In (82) and (83), I give a list of all possible sequences of modal and creaky vowels (which can potentially surface on a L tone), and compare these to their surface realizations and what the analysis can account for. The combinations in (82)a-d are not problematic. Any combinations of an underlying L tone vowel + L or toneless vowel is predicted to be realized as [LH], due especially to the OCP constraints *LL and *L∅. If the first vowel is [+constricted glottis], this feature is retained on the surface; if a creaky vowel follows a lexical L tone, creakiness is lost, as already seen above in §8.7.

(82) Combinations of modal and creaky vowels

<table>
<tr><th></th><th>Input</th><th>Output (expected)</th><th>Consistent with the analysis</th></tr>
<tr><td>(a)</td><td>V + V̰
| |
[-r][-r]</td><td>V̀ V́</td><td>✓</td></tr>
<tr><td>(b)</td><td>V + V̰
|
[-r]</td><td>V̀ V́</td><td>✓</td></tr>
<tr><td>(c)</td><td>V̰ + V
| |
[-r][-r]</td><td>V̰̀ V́</td><td>✓</td></tr>
<tr><td>(d)</td><td>V̰ + V̰
| |
[-r][-r]</td><td>V̰̀ V́</td><td>✓</td></tr>
</table>

The problem is sequences with a hypothetical toneless creaky vowel, given in (83). I have not found any cases of a creaky vowel that behaves as if it was toneless. A pattern that is closer to this behavior is the creaky-floating H interaction discussed in §8.7.2, in which creakiness was analyzed as the surface realization of an underlying /ʔ/ in coda position. Thus, underlyingly, these vowels are modal, i.e. [-constricted glottis].

(83)	Input	Output (expected)	Consistent with the analysis
(a)	V̰ V̰ | [-r]	V̰̀V́	✓
(b)	V̰ V | [-r]	V̀V̀	No (predicted: [v̰̀v̀])
(c)	V̰ V̰ | [-r]	V̰̀V́, V̰̀V̰̀, V̀V̰̀ (?)	✓ (predicted: [v̰̀v̰̀])
(d)	V̰ V̰	V̰̀V́, V̰̀V̰̀, V̀V̰̀ (?)	✓ (predicted: [v̰̀v̰̀])

Before commenting on these predictions, let us consider the sequences of L tone modal and creaky vowels that are attested within the morpheme; one in particular occurs neither in derived nor in non-derived contexts, namely a sequence creaky vowel + L tone modal vowel.

(84)	(a)	V̰̀V̰̀	wḭda̰	‘jaguar’
	(b)	V̀V̰̀	-daka̰t	‘to cut s.t.’
	(c)	V̰̀V́	-do̰bə́y	‘sling’
	(d)	*V̰̀V̀		

Given the patterns observed in the language, the sequence in (83)a above is consistent with the analysis because the first creaky vowel is [-raised], so dissimilation is expected, resulting in a sequence [v̰̀v́]. However, we expect that a combination creaky vowel + [-raised] modal vowel, (83)b, be realized as [v̀v̀], but not *[v̰̀v̀], since (i) creaky vowels never surface preceding a modal vowel on a L tone, and (ii) lexical tones tend to be preserved, especially if in combination with a toneless vowel; but the analysis wrongly predicts that the output should be [v̰̀v̀], as shown in the following tableau.

Tableau 8.22. Wrong prediction: hypothetical sequence /V̰+V̀/.

v̰ v │ [-r]	MAXPATH [-raised]	DEPPATH [c.g.]	MAX [c.g.]	*CG
a. v̰v́	*!			*
b. ☹ v̰v				*
c. vv			*!	
d. v̰v̰		*!		**
e. vv̰		*!		*

The sequences in (83)c and (83)d are partly consistent with the analysis, which predicts [v̰̀v̰̀] for both combinations; this surface form is attested in the language.

Tableau 8.23. Hypothetical sequence /V̰+V̰̀/.

v̰ v̰ │ [-r]	MAXPATH [-raised]	DEPPATH [c.g.]	MAX [c.g.]	*CG
a. v̰v́	*!		*	*
b. v̰v			*!	*
c. vv			*!*	
d.☞ v̰v̰				**
e. vv̰			*!	*

Tableau 8.24. Hypothetical sequence /V̰+V̰/.

v̰ v̰	MAXPATH [-raised]	DEPPATH [c.g.]	MAX [c.g.]	*CG
a. v̰v́			*!	*
b. v̰v			*!	*
c. vv			*!*	
d.☞ v̰v̰				**
e. vv̰			*!	*

To account for the gap *V̰̀V̀, and the wrong prediction the analysis makes, I suggest the constraint *CG-L.

(85) *CG-L

A sequence [+constricted glottis, -upper]-[-constricted glottis, -upper] is prohibited.

This constraint must be crucially ranked above MAX[c.g.] to prevent faithfulness to this feature in a sequence V̰V. The optimal output would then be a sequence of modal vowels [v̀v̀]; this is consistent with the fact that tone wins over creaky phonation.

Tableau 8.25. Hypothetical sequence /V̰+V̀/.

V̰ V [-r]	HAVEREG	MAXPATH [-raised]	DEPPATH [c.g.]	*CG-L	MAX [c.g.]	*CG
a. v̰v́		*!				*
b. v̰v				*!		*
c.☞ vv					*	
d. v̰v̰			*!			**
e. vv̰			*!		*	*

I finalize this chapter with the general ranking of all constraints discussed here.

(86) General ranking

UNIFORMITY(T), HAVEREGISTER *CG/H, *ʔ]$_\sigma$

MAXPATH[+upper] *LL, *HL

MAXPATH[-raised], DEPPATH[-raised]

ALIGN(H), *L∅

*HH

MAX(H)

DEPPATH[c.g.], *GC-L

*CG

MAX[c.g.]

DEPH

DEPL

*LH

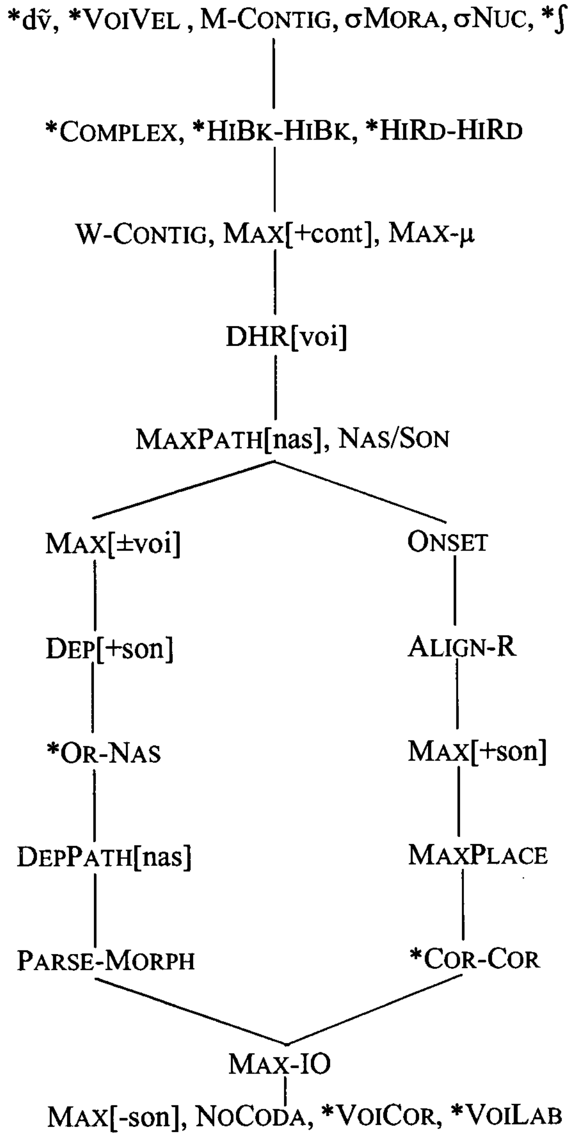
CHAPTER 9

Conclusion

9.1 Building the global ranking

To conclude the study of the phonology of Mundurukú, this chapter presents the final product, all the preceding parts considered. The hypothesis I defend for the OT-based grammar of the phonology of Mundurukú, given in (1), is that the language makes use of two pathways of rankings, each of which is responsible for the various processes examined in this study.

(1) Preliminary ranking (to be altered)



Some processes that provide further support for the analysis have not been previously discussed, but will be in this chapter. These include reduplication, the emphatic morpheme {=nma̱} and the 3rd person marker {t-}.

First, consider ranking I. The processes which it accounts for are: (i) basic syllabification, (ii) gemination of a morpheme-final consonant, (iii) deletion in a sequence coronal+coronal, (iv) phonotactic restrictions (*wo, *yi), (v) no glide formation in VV sequences, (vi) selection of the allomorphs {i-/y-} and {o-/w-}, (vii) an obligatory onset in reduplication, and (viii) the realizations of the imperfective {-m}. All these processes were examined in Chapter 4.

(2) Ranking I

*VoiVel, *dṽ, M-Contig, σMora, σNuc, *ʃə

|

*Complex, *HiBk-HiBk, *HiRd-HiRd

|

W-Contig, Max[+cont], Max-μ

|

DHR[voi]

|

MaxPath[+nas], Nas/Son

|

Onset

|

Align-R

|

Max[+son]

|

MaxPlace

|

*Cor-Cor

|

Max-IO

|

Max[-son], NoCoda, *VoiCor, *VoiLab

Ranking II, given in (3), generates: (i) the contrasts between voiceless, voiced and nasal stops, (ii) no contrast between /d, n/ before /ṽ/, (iii) nasal harmony (Chapter 6), (iv) consonant mutation, (v) interaction between consonant mutation and nasality (Chapter 7), and (vi) other processes such as the realization of the emphatic morpheme {=nma̰} and {t-} (see §9.2.1 and §9.2.2 below).

(3) Ranking II

*VoiVel, *dṽ, M-Contig, σMora, σNuc, *ʃə
*Complex, *HiBk-HiBk, *HiRd-HiRd
W-Contig, Max[+cont], Max-μ
DHR[voi]
MaxPath[+nas], Nas/Son
Max[±voi]
Dep[+son]
*Or-Nas
DepPath[+nas]
Parse-Morph
Max-IO
Max[-son], NoCoda, *VoiCor, *VoiLab

9.2 Further support

9.2.1 The emphatic clitic {=nma̯}

As further support for the analysis, consider the behavior of the emphatic clitic *-nma̯*, shown in the examples below. This case is interesting because this clitic contains a cluster /nm/; /n/ surfaces only if the preceding morpheme ends in a vowel, as in (4)c-d. Unlike the imperfective {-m} examined in Chapter 4, the nasal does not fuse with a preceding stop, as shown in (4)a. If the preceding syllable already has a coda, /n/ does not surface.

(4) (a) ayátʃát-nma̯ → a.yá.tʃát.ma̯ 'It's really a woman.'
woman-Emph *a.yá.tʃán.ma̯

(b) pə̋ŋ-nma̯ → pə̋ŋ.ma̯ 'only one.'
one-Emph

(c) íʃé-nma̯ → í.ʃén.ma̯ 'It's really him.'
3.DEM- Emph

(d) kisé-nma̯ → ki.sén.ma̯ 'It's really a knife.'
knife- Emph

The two tableaux below show {=nma̯} following a vowel, Tableau 9.1, and following a voiceless stop, Tableau 9.2. M-CONTIGUITY and W-CONTIGUITY prevent insertion, either inside the morpheme, as candidate (b) in Tableau 9.1, or between morphemes, as (c) in Tableau 9.2. Following a vowel, the cluster /nm/ must surface, because it is better to not delete anything than to respect NOCODA. However, if a coda position is already occupied, then /n/ of {=nma̯} must be deleted. Because /n/ is placed at the edge of the morpheme, deletion respects the contiguity of segments within the morpheme, showing again the relevance of CONTIGUITY in predicting that deletion of segments is allowed only at the edge of a morpheme.

Tableau 9.1. Surface realization of {=nma̰} following a vowel.

kisé=nma̰		M-CONTIG	W-CONTIG	MAX PATH [nas]	MAX [±voi]	DEP [+son]	DEP PATH [nas]	MAX IO	NO CODA
a. ☞	ki.sén.ma̰								*
b.	ki.sé.nə.ma̰	*!							
c.	ki.sẽ́.ma̰			*!			*	*	
d.	ki.sé.ma̰							*!	

Tableau 9.2. Surface realization of {=nma̰} following a voiceless stop.

vp=nma̰		M-CONTIG	*COMP	W-CONTIG	MAX PATH [nas]	MAX [±voi]	DEP [+son]	DEP PATH [nas]	MAX IO
a. ☞	…vp.ma̰								*
b.	…vp.nə.ma̰	*!							
c.	…vpn.ma̰		*!						
d.	…v.pən.ma̰			*!					
e.	…ṽp.ma̰				*!			*	
f.	…vn.ma̰					*!			*

Following a nasal, e.g. *pə̃́ŋ* + *nma̰* → *pə̃́ŋma̰* 'only one', the sequence of three nasal consonants [ŋnm] is excluded by *COMPLEX; hence only two nasals may surface. But the ranking cannot decide that /ŋ/, which belongs to the root, must be favored over /n/ or /m/. For that I follow Beckman (1998) in assuming that segments of roots are more faithful to their inputs than affixes. In our discussion, it is more important to preserve [+sonorant] segments of a root than those of affixes or affix-like morphemes.

(5) MAX[+sonorant]$_{\text{ROOT}}$ (=MAX[+son]$_{\text{RT}}$)

Input [+sonorant] segments of a root must have output correspondents.

With this requirement, /ŋ/ of *pə̃́ŋ+nma̰* is preserved, and the output selected is *pə̃́ŋma̰*, as illustrated by candidate (a) in the following tableau. Again, we could also imagine a candidate in which /n/ is preserved and /m/ is deleted (e.g. *pə̃́ŋ-na̰* instead of *pə̃́ŋ-ma̰*), but this candidate would be ruled out by M-CONTIGUITY since the string {n-a} is not a contiguous string in the input.

Tableau 9.3. Surface realization of {=nma̰} following a nasal consonant.

pə̃́ŋ=nma̰		M-CONTIG	*COMP	W-CONTIG	MAX PATH [nas]	MAX [±voi]	DEP [+son]	DEP PATH [nas]	MAX [+son]$_{RT}$
a. ☞	…ŋ.ma̰								
b.	…ŋ.nə.ma̰	*!							
c.	…ŋən.ma̰			*!					
d.	…ŋn.ma̰		*!						
e.	…n.ma̰								*!

9.2.2 *Third person {t-}*

Another morpheme whose realization follows ranking II is the third person prefix {t-}. In the beginning of Chapter 7, I showed the difference between a [t] that results from consonant mutation, and [t] that is the surface realization of the third person. The relevant examples are given below. When combined with a morpheme-initial /d/, as in (6)a-b, /d/ is deleted so that only the third person prefix consonant /t/ surfaces, and this prefix consonant is always voiceless. These cases are different from the voiceless form [t] in consonant mutation, illustrated in (6)c-d, since the voiced-voiceless variants are determined by the preceding segment, as discussed in Chapter 7. The third person prefix does not undergo mutation.

(6) (a) o-t-dakḁt → otakḁt 'I cut it.'
1Su-3Ob-cut

(b) t-doy → toy 'his/her blood'
3-blood

(c) dápsém doy → dápsém toy 'deer's blood'
deer blood

(d) o-doy → odóy 'my blood'
1-blood

To ensure the realization of {t-}, I invoke the constraint PARSE-MORPH (e.g. Akinlabi 1996).

(7) PARSE-MORPH
A morph must be realized in the output.

Deletion of a morpheme-initial /d/ is shown in Tableau 9.4. PARSE-MORPH forces the realization of the prefix when other strategies have been exhausted, for example, the formation of a complex cluster in candidate (c), and insertion of a vowel in candidate (d). The option is then to delete of the root-initial consonant in favor of the prefix.

Tableau 9.4. Deletion in {t-} + /d/ morpheme-initially. Input: *t-daka̰t → taka̰t* 'to cut s.t.'

t-daka̰t		W-CONTIG	*COMP	MAX PATH [nas]	MAX [±voi]	DEP [+son]	DEP PATH [nas]	MAX [+son]$_{RT}$	PARSE-MORPH	MAX IO
a. ☞	taka̰t				*					*
b.	daka̰t				*				*!	*
c.	tdaka̰t		*!							
d.	tə.daka̰t	*!				*				

9.3 Placing Reduplication in the OT-grammar

Reduplication came up several times in the preceding chapters, but a formal account of the patterns has not yet been proposed. This section is devoted to the reduplicative morpheme and to how reduplication interacts with the various processes examined in this study.

From a morphological point of view, reduplication in Mundurukú is affixal, strictly speaking, the suffixation of morphological material. The reduplicative morpheme (RED) has the status of a morphological category which may be inflectional, such as aspect (§9.2), or derivational, such as the formation of a verbal predicate (§9.3.2).

From a phonological point of view, RED may or may not contain segmental content. In Mundurukú, reduplication copies the final syllable of the stem; its segmental and featural content is generally identical to that of the stem that undergoes reduplication, unless other processes apply which may alter this identity. Fixed elements appear in two of all patterns of reduplication investigated here, both of them are fixed vowels (see §9.4).

There is a strong requirement in reduplication in Mundurukú: the reduplicative morpheme must be a well-formed syllable, with at least an onset and nucleus.[1]

(8) RED =

In general, the phonological material that fills up these positions is copied from the final syllable of the stem, (9)a-b. But if this syllable does not have onset (i.e. V or VC types), the following repair strategies are employed: (i) in V-reduplication, (9)c, RED gains an epenthetic /h/ in onset position (see Chapter 4, and below); and (ii) in VC-reduplication, (9)d, the coda consonant is lengthened to provide the required onset.

(9) (a) ...CV + RED → ...CV-CV
(b) ...CVC + RED → ...CVC-CVC
(c) ...V + RED → ...V-hV
(d) ...VC + RED → ...VC-^{C}V

This section examines the interaction between reduplication and various of the processes examined in the previous chapters, including syllabification (§9.3.1), t-deletion (§9.3.2), and consonant mutation (§9.3.3). In addition, it also deals with reduplication with fixed segmentism (§9.4).

---

[1] The language also has total reduplication in that the reduplicative morpheme copies the whole base; this pattern is mostly used to denote repetition of an event, for example, *pə́ʃik-pə́ʃik* 'to pull several times'. The most used pattern is partial reduplication, in that only the final syllable of the base is copied.

9.3.1 Progressive reduplication

Reduplication can be used to mark the progressive aspect in Mundurukú. The reduplicative morpheme copies the final syllable of the verb stem, including features such as tone, creaky voice, and nasality.

(10)	Stem	Progressive	
(a)	ka̰pík	ka̰pík-pík	‘working’
(b)	a̰ʤók	a̰ʤók-ʤók	‘bathing’
(c)	a̰ʤẽ́m	a̰ʤẽ́m-ʤẽ́m	‘arriving’
(d)	daka̰t	daka̰t-ka̰t	‘cutting’
(e)	kawẽ́n	kawẽ́n-wẽ́n	‘talking’
(f)	ʃéy	ʃéy-ʃéy	‘dreaming’
(g)	dḛ	dḛ-dḛ	‘grating’
(h)	ʃḭ-ʃḭ	ʃḭ-ʃḭ-ʃḭ	‘trembling’
(i)	ʃi	ʃi-ʃi	‘spitting’

If the syllable to be copied is VC, the final consonant lengthens to provide an onset for the reduplicant.

(11)	(a)	ṍm	ṍm-[^{m}]ṍm	‘entering’
	(b)	mə-taít	mə-taít-[^{t}]ít	‘reviving s.t.’
	(c)	mə-ók	mə-ók-[^{k}]ók	‘blackening s.t.’

But if the syllable is V, an epenthetic /h/ surfaces in onset position.

(12)	(a)	taẽ́	taẽ́-hẽ́	‘choosing s.t.’
	(b)	á	á-há	‘biting’
	(c)	ʤe-ə́	ʤe-ə́-hə́	‘going up, climbing’
	(d)	ʤe-kabía̰	ʤe-ka̰bía̰-ha̰	‘dawning’

The first observation concerns the shape of RED in progressive reduplication, which can be described in terms of a prosodic unit, i.e. a syllable. Marantz (1982) remarks that reduplicants tend to have a pre-determined template, in his terms, empty CV-slots that are filled up with phonological material copied from the base. Similarly, McCarthy and Prince (1986, 1990) introduced the notion of *prosodic templates*, stating that RED must refer to authentic prosodic units (e.g. mora, syllable, foot, etc.). This idea was incorporated into OT (McCarthy and Prince 1993) in the form of constraints defining templates. In Mundurukú, this constraint is as in (13)a. (13)b-c introduce the faithfulness constraints relevant for the base-reduplicant relationship; their definitions refer to both segmental, (13), and featural content (e.g. tone, creaky voice and nasality), (14), present in the base.

(13) (a) RED = σ (=RED_σ)
The reduplicant is a syllable.

(b) MAX-BR
A segment of the base must have a correspondent segment in the reduplicant.

(c) DEP-BR
A segment in the reduplicant must have a correspondent segment in the base.

(14) (a) MAX-BR[+nas]
If the feature [+nasal] is in the base, then it is in the reduplicant.

(b) MAX-BR[T]
If a tonal feature is in the base, then it is in the reduplicant.

(c) MAX-BR[+c.g.]
If the feature [+constricted glottis] is in the base, then it is the reduplicant.

Faithfulness to the base's featural material is fully required in reduplication, unless overridden by other highly-ranked requirements, as we will see later. From these MAX-BR[+nas] is never violated; MAX-BR[T] and MAX-BR[+c.g.] can be violated in reduplication with fixed vowels (§9.3), indicating that the ranking of MAX-BR constraints is as follows.

(15) MAX-BR[+nas] >> MAX-BR >> MAX-BR[T], MAX-BR[+c.g.]

An illustration is given in the following tableau. Candidates (c) and (d) are excluded because the base contains a L-tone creaky vowel [a̰] whereas the reduplicant has a H-tone modal vowel in (c), and a L-tone modal vowel in (d).

Tableau 9.5. Input: *daka̰t* 'to cut'.

daka̰t-RED		REDσ	MAX-BR [+nas]	MAX-BR	MAX-BR [T]	MAX-BR [+c.g.]
a. ☞	da.ka̰t.ka̰t					
b.	da.ka̰t.da.ka̰t	*!				
c.	da.ka̰t.kát				*!	*
d.	da.ka̰t.kat					*!

Reduplication begins to show a strong interaction with syllabification when the base ends in a V or VC syllable. First, let us consider VC-reduplication, shown in the following tableau. The reduplicant is a syllable that requires an onset. This indicates that this pattern must respect the ranking ONSET >> ALIGN-R, dominating the constraints that protect the Base-RED relation. Gemination of the base-final consonant is forced by ALIGN-R, because a geminate satisfies both requirements: it provides an onset for the following syllable as well as maintains alignment of a morpheme boundary with a syllable boundary.

Tableau 9.6. Input: *ṍm* 'enter'.

ṍm-RED		REDσ	MAX-BR [+nas]	MAX-BR	ONSET	ALIGN-R	DEP-BR
a. ☞	ṍm.]^{m}ṍm]						
b.	ṍm.]ṍm]				*!		
c.	ṍ.m]ṍm]					*!	

9.3.2 Reduplication and t-deletion

An interesting opacity case is found in the interaction between t-deletion and reduplication. The relevant examples are given in (16). Reduplication creates a sequence /t/ + coronal, which is prohibited in Mundurukú, as we have already seen in Chapter 4. This triggers the deletion of /t/ in the base, but this consonant still surfaces in the reduplicant.

(16) (a) a-ʤot-ʤot → aʤoʤot 'We (incl.) are coming.'
1pl.incl-come-RED

(b) sə̃́t-sə̃t → sə̃́sə̃t 'monkey, sp.'
monkey-RED

(c) ʤe-da̰t-da̰t-n → ʤeda̰da̰n 'to vomit'
CoRef.Poss-vomit-RED-Vzr?

(d) o-ʃat-ʃet → oʃaʃet 'I have food.'
1-food-RED.Exist

Reduplication and t-deletion apply in a counterbleeding order: /t/ is deleted after reduplication has applied; this way /t/ shows up in the reduplicant even though it is no longer present in the base. A tentative analysis is proposed in the following tableau. Deletion of /t/ in the base is a DEP-BR violation, meaning that this constraint must be dominated by both *CORCOR and MAX-BR, which helps to prevent a change in place of articulation, as in candidate (e), and to avoid either a sequence of coronals or deletion of /t/.[2]

---

[2] However, the analysis faces an important problem: it does not force the reduplicant to have [t] morpheme-finally. Thus, a candidate such as *ʤoʤo*, in which neither base nor the reduplicant have [t], wins. (Thanks to Pat Shaw and Douglas Pulleyblank for pointing that out to me.) Here I offer no solution to this problem.

Tableau 9.7. Reduplication and t-deletion

-ʤot-RED		RED$_{\sigma}$	W-CONTIG	MAX-BR	ONSET	ALIGN-R	*COR-COR	DEP-BR
a. ☞	ʤo-ʤot							*
b.	ʤot-ʤot						*!	
c.	ʤotə-ʤot		*!			*		
d.	ʤok-ʤot			*!				*

9.3.4 *Reduplication and consonant mutation*

The next pattern concerns the interaction between reduplication and consonant mutation. We saw in Chapter 7 that consonant mutation changes the feature [voice] of certain morpheme-initial stops: /p, d, ʧ/ have voiced variants, [b, d, ʤ], following [-consonantal] segments (vowels and glides), and voiceless variants, [p, t, ʧ], following [+consonantal] segments. The basic ranking is as follows.

(17) *VOIVEL, *dṽ
|
W-CONTIG
|
DHR[voi]
|
MAX[±voice]

If a morpheme-initial stop undergoes consonant mutation, the reduplicant copies this consonant accordingly.

(18)	Voiced variant	Voiceless variant
(a)	o-t-i-bə́-bə́	o-t-ot-pə́-pə́
	1Su-3-CL-pick-RED	1Su-3-CL-pick-RED
	‘I pick it up (e.g. water).’	‘I picked it up (e.g. broom).’

(b) o-t-a-dá-dá o-t-o̰m-tá-tá
1Su-3-CL-cook-RED 1Su-3-CL-cook-RED
'I cooked it (e.g. corn)' 'I cooked it (e.g. flour)'

(c) o-ʤo-ʤó-ʤó o-t-əp-ʧó-ʧó
1Su-3Ob-see-RED 1Su-3-leaf-see-RED
'I saw it.' 'I saw a leaf.'

Reduplication of the voiced variant is illustrated in Tableau 9.8. MAX-BR forces the consonant in the reduplicant to also be voiced, as it is in the base.

Tableau 9.8. Reduplication and consonant mutation: voiced variant.

o-ʧó-RED		W-CONTIG	MAX-BR	DHR[voi]	MAX[±voi]	DEP-BR
a. ☞	o.ʤó.ʤó				*	
b.	o.ʧó.ʤó		*!	*		*
c.	o.ʤó.ʧó		*!		*	*
d.	o.ʧó.ʧó			*!		

The voiceless variant appears in Tableau 9.9. Candidate (b) respects DHR[voi] but fatally violates W-CONTIG because epenthesis is not allowed between morphemes. Here again, candidate (d) fails to satisfy MAX-BR which requires the reduplicant to have the variant that surfaces in the base, even though the base ends in a vowel.

Tableau 9.9. Reduplication and consonant mutation: voiceless variant.

C-ʧó-RED		W-CONTIG	MAX-BR	DHR[voi]	MAX[±voi]	DEP-BR
a. ☞	C.ʧó.ʧó					
b.	Cə.ʤó.ʤó	*!			*	
c.	C.ʤó.ʤó			*!	*	
d.	C.ʧó.ʤó		*!			*

9.4 Reduplication with fixed segmentism

There are two patterns of reduplication with fixed segments, both of which have fixed vowels: one is a H-tone vowel /ə́/ ‘not so’, (19), and the other is a L-tone vowel /e/ ‘have, exist’, (20) (see also Chapter 4). The reduplicant copies the onset, coda and other features of the vowel (e.g. nasality), except for tone and the vowel itself.

(19) Reduplication with fixed vowel /ə́/

(a) i-pak-pə́k ‘It’s not so red.’
3Su-be.red-RED

(b) yo-boŋ-bə́ŋ ‘It’s no so big.’
3Su-be.big-RED

(c) y-apĩ́n-pə̃́n ‘It’s not so short.’
3Su-be.short-RED

(d) i-rẽm-rə̃́m ‘It’s not so blue.’
3Su-be.blue-RED

(20) Reduplication with fixed vowel /e/

(a) yo-boŋ-beŋ ‘It expands.’ (It has the property of expanding)
3Su-be.big-RED

(b) o-dək-ʔá-ʔe ‘I have a house.’
1-house-CL-RED

(c) y-apĩ́n-pẽn ‘It shrinks.’ (It has the property of shrinking)
3Su-be.small-RED

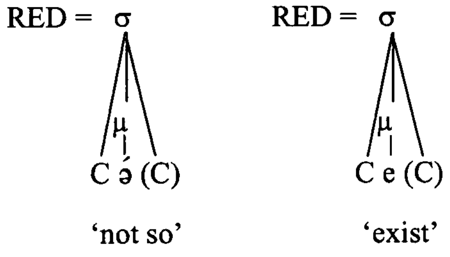
(d) áko-ba̰-bḛ ‘There are bananas.’
banana-CL-RED

(e) w-e-wiap-ep 'I have a fan.'
1-Poss-fan-RED

(f) t-eí-he 'It has price.'
3-price-RED

Following a proposal by Kim and Picanço (2003), I assume that fixed vowels are underlyingly specified in the representation of these reduplicative morphemes.

(21)



Consider first reduplication with a fixed vowel /ə́/ in the following tableau. MAX-μ guarantees its realization in the output, thus ruling out candidate (c). Candidate (d) realizes the vowel but not nasality, as opposed to (a) which miminally violates MAX-BR by copying this feature as well.

Tableau 9.10. Reduplication with a fixed vowel /ə́/.

apĩ́n-RED$_\sigma$ | ə́		RED$_\sigma$	MAX-μ	MAX-BR[+nas]	MAX-BR	DEP-BR
a. ☞	apĩ́n-pə̃́n				*	*
b.	apĩ́n-apə̃́n	*!			*	*
c.	apĩ́n-pĩ́n		*!			
d.	apĩ́n-pə́n			*!	*	*

9.4.1 *Reduplication and *ʃə*

Reduplication with the vowel /ə́/ is in conflict with a phonotactic restriction: *ʃə. In examining the phonotactic patterns in Mundurukú (Chapter 5), we saw that the language prohibits the sequence /ʃ/+/ə/. This prohibition is manifested in reduplication in the form of a faithfulness violation in the reduplicant. Consider the following examples, which contain reduplication with the vowel /ə́/ 'not so'. If the base contains /ʃ/ in onset position, this consonant is replaced by [s] to avoid the forbidden sequence *ʃə* from emerging in the reduplicant, as illustrated in (22).

(22) (a) i-poʃí-sə́ 'It's not so heavy.' *ipoʃíʃə́
3Su-be.heavy-RED

(b) t-aʃíp-sə́p 'It's not so hot.' *taʃípʃə́p
3Su-be.hot-RED

In Chapter 5, I assumed a language-specific constraint that bans the combination /ʃ/+/ə/.

(23) *ʃə – A sequence *ʃə* is prohibited.

An illustration is provided in the tableau below. Both *ʃə and MAX-μ dominate MAX-BR in order to ban either *ʃə́* or *ʃí* in the reduplicant, and MAX[-ant][3] bans the change ʃí → sí in the base. [s] in the reduplicant is better than [t], because the former shares with [ʃ] the feature [+continuant], here enforced by MAX-BR[+cont].

---

[3] MAX[-ant] – Any input specifications of the feature [-anterior] must have an output correspondents.

This is not an adhoc constraint for the analysis. There is a morphophonological alternation, not examined here, that involves assimilation to the feature [-anterior], illustrated in (i). The labial nasal /m/ of the causative prefix {mə-} assimilates the feature [-anterior] of a preceding /i/ if another prefix is present, as {o-} in (i). If this prefix is not present, there is no assimilation, as in (ii).

(i) o-i-mə-pík → oŋəpík [òɲə̀pík]
1Su-3Ob-CAUS-be.burned
'I burned it.'

(ii) i-mə-pík-pí-ŋ őn
3Ob-CAUS-be.burned-RED-IMPRF 1sg
'I'm burning it.'

Tableau 9.11. Reduplication with a fixed vowel /ə́/ and *ʃə.

poʃí-RED$_σ$ | ə́		*ʃə	RED$_σ$	MAX-μ	MAX-[-ant]	MAX-BR	MAX-BR [+cont]	DEP-BR
a.	*!					*		*
b.	poʃí-ʃí			*!	*			
c.	posí-sə́				*!	*		*
d.	poʃí-tə́					**	*!	**
e. ☞	poʃí-sə́					**		**

9.4.2 *V-Reduplication and epenthetic /h/*

As already seen in Chapter 4, V-reduplication, a pattern of reduplication in which the syllable copied is simply V, requires an onset in the reduplicant. This onset is [h]. In reduplication with the fixed vowel /e/, the requirement is no different. If the base has a single vowel, [h] is inserted in the reduplicant, as illustrated in (20)f above, and formalized in Tableau 9.12 below. The result is a complete discrepancy between base and reduplicant, which ultimately share none of their segments; but this is only with the purpose of satisfying the privileged requirements.

Tableau 9.12. Reduplication with a fixed vowel /e/ and epenthetic /h/.

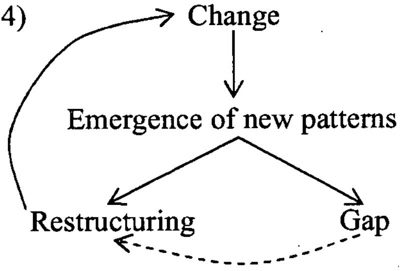
t-deí-RED$_σ$ | e	RED$_σ$	MAX-μ	MAX-BR	ONSET	PARSE-MORPH	DEP-BR
a. te.í-te.í	*!	*		**		
b. te.í-hí		*!		*		*
c. te.í-e			*	**!		*
d. de.í-he			*	*	*!(t-)	**
e. ☞ te.í-he			*	*	*	**

This concludes the study of reduplication, and of the Mundurukú phonology. The next two sections conclude this work by comparing the historical and synchronic facts, and offering the global ranking out of which all processes examined in this dissertation can be generated.

9.5 Language change and its consequences

Turning now to the historical findings, all the changes investigated here may be characterized as shown in the following diagram. Every change in one area entails a corrosion somewhere else in the system by causing the emergence of new patterns. These are either restructured or continue in the language in the form of gaps, which may eventually be repaired. Restructuring may itself imply a new change so that the system seems to function like a cycle.

(24)



To illustrate this point, consider the changes that gave rise to the phonotactic restrictions *ʧi, *ʤi and *[ɲ]i, and to new contrasts in the language.

(25) Stage I

Change:	***C > **ʧ/**D
New patterns:	**ʧ restricted to: before _ i, word-initially and post-consonantally. The sequence **Di not found; no **D word-initially. Allophony: **[D] / **[N] because of nasal harmony. alternation **ʧ/**D in some morphemes.
Restructuring:	**ʧ merges with ***Tʃ → **ʧ comes to have unrestricted distribution. **ʧ/**D alternation as a regular morphophonological process.
Gaps:	The sequence **Di not found; no **D word-initially.
Restructuring:	Borrowings with **D word-initially (e.g. *ʤarã́y* ‘orange (tree)’, from Portuguese *laranja*).
Results:	**ʧ may precede all vowels, and may occur word-initially and post-consonantally. A new morphophonological alternation.

Gap not repaired: the sequence **Di not found.

Gap repaired: **D may occur word-initially.

(26) Stage II

Change: **D > *ʤ

New patterns: Contrast between *ʧ and *ʤ

Loss of the allophonic alternation *ʤ/*ɲ

*ʧ/*ʤ alternation

Restructuring: Primary split: *ʤ becomes independent; *ɲ merges with */ŋ/

*ʤ found in both oral and nasal contexts.

Gap: *ʤ not found before /i/.

(27) Stage III

Change: *ʧi > ʃi

New pattern: *ʧ may precede all vowels but /i/.

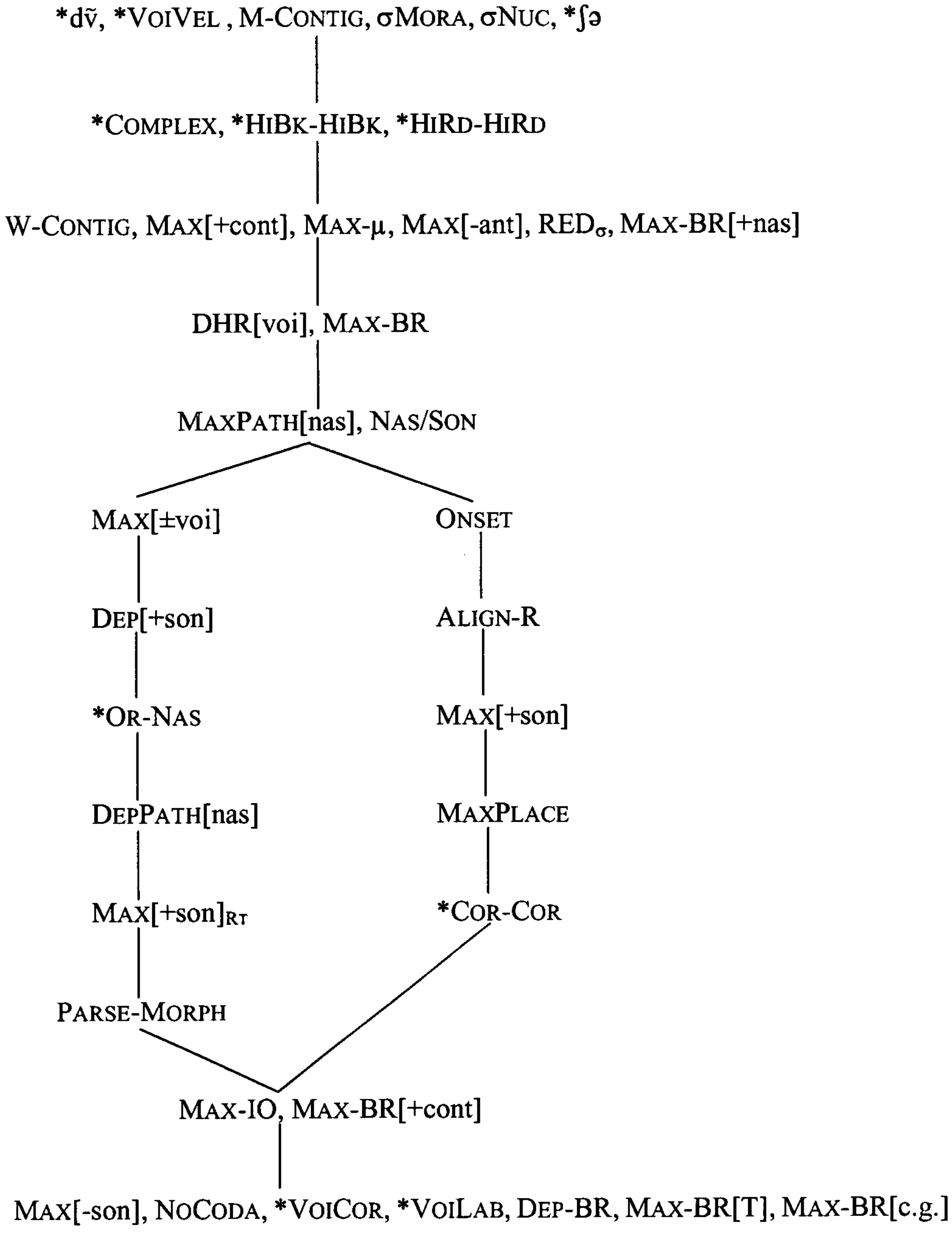
Restructuring: None

Gap: The sequence ʧi not found.

9.6 The OT-based grammar of the phonology of Mundurukú

(28) provides the ultimate product: the OT-based grammar of Mundurukú. Excluding the ranking that determines the tonal system and creaky voice (see Chapter 8), all other phonological processes can be generated by one or other pathway in ranking. Crucially, where the structure splits, the constraints on one side cannot be ranked or co-ranked relative to the ones on the other side. Why this must be this way is a question I cannot answer; but given the analysis of various processes and morpheme-specific requirements, the final observation is that these two sub-rankings must be regarded as mutually exclusive. (The constraints on the bottom are those which play no major role in the phonology of the language; their relative ranking does not seem to be essentially required.)

(28) The OT-grammar of Mundurukú



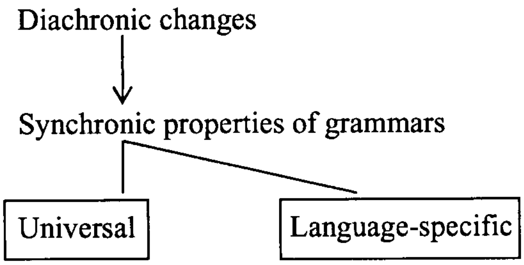
To summarize the discussion, the primary generalizations obtained with this study are the following.

1. Languages make use mostly of universal constraints, but language-specific statements may also be part of the design of languages.

2. Different rankings may not suffice to explain differences between grammars. Two related grammars may have the same ranking, but different underlying representations (e.g. the difference between dialects A and B examined in Chapter 7), or different applications of the same constraint, from more/less restricted to less/more restricted (e.g. the difference in nasal harmony between Mundurukú and Kuruaya, Chapter 6).
3. Synchronically, there may not be a sudden emergence of 'unmarked' properties. It may simply be a consequence of the evaluation of candidates. Every candidate equally strives to win, but evaluation depends on the ranking, and the position of particular constraints in the ranking (e.g. emergence of ONSET in reduplication, chapters 4 & 9).
4. 'Restrictions' on the distribution of segments may not necessarily be synonymous of 'prohibitions'; they may be accidental gaps caused by sound changes (see especially Chapter 5 and §9.5 above).
5. Language-specific constraints may emerge as the language evolves, as a consequence of diachronic changes (e.g. *dṽ, chapters 5 and 6).
6. Constraints may be lost as the language evolves. Once a constraint loses its status for another which it crucially dominates, this constraint may be completely lost, allowing new patterns to be generated (e.g. *#r, Chapter 4).

Most importantly, a synchronic grammar is a composite of universal and language-specific properties, both which manifested in the form of grammar-specific uses; these in turn are determined by diachronic changes. This is relatively consistent with the view that the changes a language undergoes explain its structure (e.g. Bybee 1988; Blevins 2004; for a good discussion see Kiparsky 2004).

(29)



Appendix

List of Constraints

Faithfulness constraints

(1) MAX-IO (p.100)

Input segments (C and V) have output correspondents.

(2) MAX-μ (p.107)

Input moras have output correspondents.

(3) MAX[+cont] (p.155)

Input [+continuant] segments have output correspondents.

(4) MAX[+son] (p.155)

Input [+sonorant] segments have output correspondents.

(5) MAX[-son] (p.155)

Input [-sonorant] segments have output correspondents.

(6) MAX[±voice] (p.276)

Input [±voice] segments have output correspondents.

(7) MAX[-ant] (p.384, fn)

Any input specifications of the feature [-anterior] must have an output correspondent.

(8) MAX[+sonorant]$_{\text{ROOT}}$ (=MAX[+son]$_{\text{RT}}$) (p.372)

Input [+sonorant] segments of a root must have output correspondents.

(9) MAX[c.g.] (p.347)

A feature [+constricted glottis] in the input must have a correspondent in the output.

(10) MAX(H) (p.336)

A feature [+upper] in the input must have a correspondent in the output.

(11) MAX-BR (p.377)

A segment of the base must have a correspondent segment in the reduplicant.

(12) MAX-BR[+nas] (p.377)

If the feature [+nasal] is in the base, then it is the reduplicant.

(13) MAX-BR[T] (p.377)

If a tonal feature is in the base, then it is the reduplicant.

(14) MAX-BR[+nas] (p.377)

If the feature [+nasal] is in the base, then it is in the reduplicant.

(15) MAX-BR[+c.g.] (p.377)

If the feature [+constricted glottis] is in the base, then it is in the reduplicant.

(16) MAX-BR[+cont] (p.384, txt)

If a [+continuant] segment is in the base, then it is in the reduplicant.

(17) MAXPATH[nasal] (p.161, 229)

Any input path between [+nasal] and an anchor must have a correspondent path in the input.

(18) MAXPATH-[+upper] (p.315)

Any input path between [+upper] and an anchor must have a correspondent path in the output.

(19) MAXPATH[-raised] (p.315)

Any input path between [-raised] and an anchor must have a correspondent path in the output.

(20) MAXPATHPLACE (p.155)

Any input path between Place specifications and an anchor must have a correspondent path in the output.

(21) DEP[+upper] (=DEPH) (p.316)

Every feature [+upper] in the ouput must have a correspondent in the input.

(22) DEP[-raised] (p.316)

Every feature [-raised] in the output must have a correspondent in the input.

(23) DEP[-upper] (=DEPL) (p.316)

Every feature [-upper] in the output must have a correspondent in the input.

(24) DEP[+son] (p.291)

A [+sonorant] segment in the output must have a correspondent in the input.

(25) DEP-BR (p.377)

A segment in the reduplicant must have a correspondent segment in the base.

(26) DEPPATH[nasal] (p.229)

Any output path between [+nasal] and an anchor must have a correspondent path in the input.

(27) DEPPATH[c.g.] (p.347)

Any output path between [+constricted glottis] and an anchor must have a correspondent path in the input.

(28) UNIFORMITY-IO(Tone) (=UNIF-T) (p.316)

If *a* and *b* are distinct elements with respect to a tone T in the input, then their output correspondents *a'* and *b'* are also distinct with respect to T.

(29) W-CONTIGUITY (p.99)

The portions (i.e. morphemes) of W(ord) standing in correspondence form a contiguous string, as do the correspondent portions of W.

(30) M-CONTIGUITY (p.99)

The portions (i.e. segments) of M(orpheme) standing in correspondence form a contiguous string, as do the correspondent portions of M.

(31) PARSE-MORPH - A morph must be realized in the output. (p.374)

Sequential prohibitions

(32) *COR-COR – A sequence coronal-coronal is prohibited. (p.155)

(33) *HIBK-HIBK (p.111)

A sequence [+high, -back]-[+high, -back] is prohibited within a syllable.

(34) *HIRD-HIRD (p.111)

A sequence [+high, +round]-[+high, +round] is prohibited within a syllable.

(35) *HH (p.318, 336)

A sequence [+upper]-[+upper] is prohibited.

(36) *LL (p.326)

A [-upper, -raised] mora may not be immediately preceded by a [-upper, -raised] mora.

(37) *L∅ (p.326)

A [-upper, -raised] mora may not be immediately preceded by a [-upper] mora.

(38) *HL (p.362)

A sequence [+upper]-[-upper, -raised] is prohibited.

(39) *CG-L (p.367)

A sequence [+constricted glottis, -upper]-[-constricted glottis, -upper] is prohibited.

(40) *ORAL-NASAL (revised) (p.243)

In a string of segments $s_n \ldots s_2$, s_1, if

- (i) s_2 immediately precedes s_1, s_n immediately precedes s_2, and
- (ii) s_2, s_n are [+sonorant, ±syllabic], but
- (iii) s_1 is [+sonorant, +syllabic, +nasal],

then s_2, s_n must also be [+nasal].

Grounded constraints

(41) NAS/SON (p.225)

If [+nasal], then [+sonorant].

(42) *[c.g.]/[+upper] (=*CG/H) (p.346)

If [+constricted glottis] then not [+upper]; or

If [+constricted glottis] then [-upper]

(43) *VOIVEL – A velar [-sonorant] must not be voiced. (p.276)

(44) *VOICOR – A coronal [-sonorant] must not be voiced. (p.276)

(45) *VOILAB – A labial [-sonorant] must not be voiced. (p.276)

Alignment constraints

(46) ALIGN(H) – Align (Floating H tone, Right, PWd, Right) (p.336)

A floating [+upper] feature must be aligned with the right edge of a prosodic word.

(47) ALIGN-R – Align (Morpheme, Right, Syllable, Right) (p.130)

The right edge of a morpheme must be aligned with the right edge of a syllable.

Well-formedness and markedness constraints

(48) *COMPLEX$_{(Def)}$ (p.96)

Given a string of segments (Cs and Vs), and three positions within a syllable (onset, nucleus and coda), parsing of more than one segment to the same position is prohibited.

(49) σNUC – Syllables must have nuclei. (p.97)

(50) σMORA – Syllables must have weight (as encoded by the mora). (p.97)

(51) ONSET – A syllable must have onset. (p.97)

(52) NOCODA – A syllable must not have coda. (p.97)

(53) RED = σ (=RED$_\sigma$) (p.377)

The reduplicant is a syllable.

(54) HAVEREGISTER (p.315)

Every mora must have at least one register feature.

(55) *CG (p.347)

Specifications of the feature [+constricted glottis] are prohibited.

(56) *ʔ]σ (p.357)

The laryngeal /ʔ/ is prohibited in coda position.

Language-specific constraints

(57) *dṽ – The sequence dṽ is prohibited. (p.289)

(58) *ʃə – A sequence *ʃə* is prohibited. (p.216, 384)

(59) Dependent-Head-Relation[voice] (DHR[voi]) (p.286)

In a Dependent-Head relation, α is a segment of Dependent, and β a segment of Head. Let α and β be adjacent,

(i) if β is [-son, +cons, -cont], but α is [-cons], then β is [+voiced]; but

(ii) if α is [+cons], then β is [-voice].

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