

A Crosslinguistic Study of Consonant-Tone Interaction

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**A CROSSLINGUISTIC STUDY
OF
CONSONANT-TONE INTERACTION**

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of the Ohio State University

By

Mary M. Bradshaw, M.A.

The Ohio State University
1999

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ABSTRACT

This thesis undertakes a crosslinguistic study of interaction between consonants and tone in order to arrive at relevant phonological generalizations. Surveying over 25 tone languages from Africa and Asia, it is found that only voiced consonants are involved in such interactions. In consonant-tone interaction, L tones are inserted and H tones blocked after voiced consonants. Moreover, voiceless obstruents become voiced in the presence of L tone in several languages.

The involvement of voiced consonants and the lack of involvement of voiceless consonants in consonant-tone effects provide a new argument for the position that the feature which represents voicing is privative. Added to the arguments based on voicing dissimilation in Japanese (Mester & Ito 1989) and laryngeal neutralization (Lombardi 1994), the case for privativity of this particular feature is thereby strengthened.

Specifically, this thesis proposes a Multiplanar Hypothesis of Consonant-Tone Interaction which claims that (1) tone is dual in nature and must be so represented in feature geometry, (2) a single privative feature, referred to as [L/voice], encompasses both L tone and the traditional feature [voice], and (3) the feature [L/voice] can be associated subsegmentally to the Laryngeal node and/or prosodically to the mora. The resulting theory allows a principled and unified analysis of consonant-tone phenomena.

The proposal of a privative feature [L/voice] leads to a reexamination of the phonetic correlates of the traditional feature [voice] and their modification to accommodate the interaction of voicing and tone. Specifically, it is proposed that the phonetic correlate of [L/voice] is a laryngeal configuration, probably involving larynx height, in which the

fundamental frequency of a vowel is lowered. After voiced obstruents, the onset pitch of a vowel is lowered. Vowels realized with a L tone are also characterized by lowered pitch.

This thesis also investigates the phonetic side of consonant-tone interaction and uncovers a mismatch between phonetically natural versus phonologically relevant interactions. An investigation of this mismatch leads to the conclusion that the role of phonetics in the phonology must be limited by purely phonological factors when a conflict arises. In this case, the privativity of [L/voice] limits the interaction to voiced consonants, although voiceless obstruents have significant effects on pitch phonetically.

Dedicated to my parents,
Arthur and Norma Archung

ACKNOWLEDGMENTS

First and foremost, I have an enormous intellectual debt to Dave Odden, my advisor and intellectual mentor. In addition to his explicit attempts to guide me (which were more effective than they appeared to be), he has served as a model for the kind of phonologist I would like to become, dedicated to the field and to students of phonology, adept at data collection and interpretation, knowledgeable and rigorous theoretically. I have benefited enormously from his genius for phonology which transcends theoretical frameworks and his encyclopedic knowledge of different languages and how they work. This dissertation, and all of my work, owe much not only to his general guidance of my intellectual development but also specifically to his insightful comments and discussion. Moreover, his sometimes goofy, sometimes subtle, sense of humor and warm friendship have contributed much to my enjoyment of my student years at OSU.

I am also grateful for the benefit of the insights of my other committee members, Beth Hume and Keith Johnson. They too serve as models of dedicated linguists, highly involved in the field and the exchange of ideas. Beth always made me focus on the latest theoretical developments in the field (and especially made me take them seriously). Keith made sure I never ignored the contributions of phonetics to an understanding of phonology. Their comments on this dissertation in particular have been very helpful and enhance whatever positive contribution it has to make.

I have to confess that I found studying phonology at Ohio State very enjoyable and I'm going to miss it. I am grateful to a very supportive department that contributed to that sense of fun and to all the students there who have delighted me with their company. There are too many to thank so I will mention only Ruth Roberts-Kohn, Jen Muller,

Bettina Migge and Robert Poletto, with whom I have shared many good times, both intellectual and social.

My family has also contributed to this dissertation in providing the emotional and sometimes financial support that allowed me the freedom to pursue this goal and the balance to keep me on track. My children, Heather and Eric, have acted as treasured companions as well as constant reminders that much of life is neither linguistics nor intellectual. My parents, Norma and Arthur, through their deep generosity and emotional support, have taught me that the world is a loving place. I am more grateful than I ever say to my brothers and sisters whose countless acts of kindness, including that of taking an interest in the obscure branch of knowledge I study, have provided great comfort. The love I share with my family gives meaning to my life, and I am the most grateful for that.

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Research Publication

1. Voice-Tone Interaction: A Phonology-Phonetics Mismatch. Proceedings of the XVI West Coast Conference in Formal Linguistics, (1999)
2. One-Step Tone-Raising in Ali. *Varia*, ed. by M. Bradshaw, D. Odden and D. Wyckoff. OSU Working Papers No. 51, 1-19, (1998).
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FIELDS OF STUDY

Major Field: Linguistics

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CHAPTER 1

INTRODUCTION

1.1 THE PURPOSE

The main purpose of this thesis is to provide an indepth study of the phenomenon of consonant-tone interaction incorporating original fieldwork in Suma, Gbaya bokota and Siswati and amassing the scattered descriptions of many other languages in which consonant-tone interaction is active. Consonant-tone interaction is a crosslinguistically significant effect found in a number of unrelated languages. Most commonly, it involves voiced oral obstruents which show an affinity for L tone and an incompatibility with H tone. In a few languages, it includes voiced sonorants in addition to obstruents. and incorporating the data on the triggering of consonant voicing by L tone--data which has not been dealt with systematically elsewhere. There have been claims for interaction between voiceless obstruents and tone (Peng 1992, among others), and these will be reanalyzed either as interactions between voiced obstruents and tone or as cases in which there is no phonological consonant-tone interaction. Other possible interactions, such as between breathy voiced consonants and tone, would be analyzed as a subset of the interaction between voiced consonants and tone. That is, the interaction would be between the feature specifying voicing (rather than that specifying aspiration) and tone just as it is in plain voiced consonants. Excluded from the discussion are languages which appear to have an interaction between tones and glides. Such languages are better analyzed in terms of the moraic difference between vowels and glides, and the ensuing tonal effects are related to

the moraic changes, hence, the interaction is strictly suprasegmental. Also excluded are languages that at first glance appear to have an interaction between the laryngeal consonants ? *h* and tone. The Otomanguean languages of Central America, for which relevant data is sparse, have some regularities between tones and ‘interrupted vowels’ that are pronounced with a medial glottal stop (*aʔa*). The relevant segments have been analyzed as vowels with laryngeal features and as such place this phenomenon outside the scope of consonant-tone interaction. Mohawk is another language that has been analyzed as an interaction involving the laryngeal consonants ? *h*, but it is amenable to reanalysis in moraic terms.

1.2 THE MULTIPLANAR ACCOUNT

A further goal of this study is to provide a formal representation of voiced consonants and L tone and their interaction within a nonlinear model of feature organization. Assuming a model of feature geometry like that in Clements & Hume 1995, I draw inspiration from Hume 1994’s crossplanar account of consonant and vowel place features to propose a Multiplanar account of consonant-tone interaction. The blocking and triggering effects of voiced obstruents and L tone are integrated within the framework of feature geometry by means of a single privative feature, [L/voice], which replaces both L tone and [voice].

1.3 A PHONETICS/ PHONOLOGY MISMATCH

This study also aims to draw attention to the phonetics-phonology mismatch inherent in consonant-tone interaction and the conclusions it leads to concerning the role of phonetics in the phonology. Phonological consonant-tone interaction involves voiced obstruents and sometimes sonorants. Voiceless obstruents never participate in this interaction, and I attribute this to the privativity of [L/voice], and this privativity is an abstract phonological factor that takes precedence over phonetic factors. Phonetically it

has been found that voiceless obstruents have a significant effect on the pitch of the following consonant. While the nature of the relationship between voiced obstruents and L tone is consistent with phonetic findings that voiced obstruents lower the pitch of a following vowel, the failure of voiceless obstruents to interact with H tone in a way analogous to the interaction of voiced obstruents and L tone is surprising and unexpected from a phonetic standpoint. This suggests that phonetic tendencies and phonological factors can be teased apart and when they are, phonological factors can operate independently of the phonetics. Thus, phonetics contributes to our understanding of phonological phenomena, but it does not drive them.

1.4 PRIVATIVITY OF [VOICE]

This dissertation provides a new argument for the claim that the feature which represents voicing contrasts is privative. The failure of voiceless obstruents to interact with tone is accounted for by this privativity. Other arguments for privativity of [voice] come from Mester & Ito 1989. Drawing on their work on Japanese rendaku and Lyman’s Law, Mester & Ito argue that the dissimilatory effects which they describe provide evidence of such privativity. In Rendaku, a morpheme-initial, word-internal voiceless obstruent becomes voiced when words are compounded, as shown in (2a). However, Lyman’s Law prohibits more than one voiced segment in a word. Thus, if there is already a voiced segment, as in (2b), Rendaku is blocked. Only voiced obstruents count as voiced, since sonorants do not block Rendaku, as shown in (2c).

(2) Japanese Rendaku and Lyman’s Law (Ito & Mester 1986)

- | | | | |
|----|----------------------|--------------------|-----------|
| a. | maki+suši → makizuši | ‘rolled sushi’ | |
| | ko+tanuki → kodanuki | ‘baby raccoon-dog’ | |
| b. | kami+kaze → kamikaze | ‘divine wind’ | *kamigaze |
| c. | ori+kami → origami | ‘paper folding’ | |

Rendaku is analyzed as the insertion of a floating [voice] feature. Lyman’s Law operates when two specifications for [voice] occur adjacently on the same tier. If

voiceless obstruents were specified as [-voice], then no dissimilatory effect should occur if a voiceless obstruent intervenes between the initial obstruent and the voiced obstruent that triggers Lyman's Law. Yet the intervention of a voiceless obstruent makes no difference, as shown in (3) where Lyman's Law is not blocked.

- (2) onna+kotoba → onnakotoba 'women's speech' *onnagotoba
doku+tokage → dokutokage 'poisonous lizard' *dokudokage

Mester & Ito 1989 argues briefly and Lombardi 1994 argues extensively that the facts of neutralization of laryngeal contrasts crosslinguistically require that [voice] be privative if a coherent theory of neutralization is to be constructed. They further argue that a privative feature can account for all the known facts about phonological voicing phenomena and constitutes a more restrictive theory than positing a binary voicing feature. The facts about consonant-tone interaction are consistent with these arguments, and add to them.

1.5 THE LAYOUT

First, the phonological phenomena characteristic of consonant-tone interaction with data from 22 languages are presented in Chapter 2. In Chapter 3, the proposed account of the phenomena associated with consonant-tone interaction, the Multiplanar account, which involves a modification to feature geometry, is introduced and compared to other models of consonant-tone interaction. This is followed by a case study of Siswati showing the Multiplanar approach in action in Chapter 4. In Chapter 5, some potential problem cases are shown not to pose a problem for the Multiplanar approach. Chapter 6 examines the phonetic side of consonant-tone interaction and proposes a definition of the feature [L/voice], which amounts to a redefinition of the traditional feature [voice]. Chapter 7 explores the mismatch between the phonetic effects of voiceless obstruents on pitch and their exclusion from the synchronic phonological interaction between consonants and tone.

CHAPTER 2

CONSONANT-TONE INTERACTION

2.1 INTRODUCTION

Consonants that interact with tone, depending on the language, are either the set of voiced obstruents or the set of voiced consonants. Other interactions have been identified, but the strongly and consistently attested interaction is the one between voiced consonants and tone. Thus, the strong claim proposed here is that consonant-tone interaction is exclusively limited to interaction between tone and a set of consonants specified with the feature [voice]. The consonants which are so specified always include voiced obstruents and sometimes include sonorants. The evidence from consonant-tone interaction suggests that implosives should be thought of as unspecified for the feature [voice] as they are systematically excluded from the class of consonants which interact with tone. Nasal-stop sequences, which have a somewhat vague status phonologically, being sometimes identified as prenasalized stops, sometimes as nasal-stop clusters and sometimes as allophones of obstruents or of fully nasal consonants, vary from language to language in terms of their participation in consonant-tone interaction, and this variation can provide clues as to their featural status.

In (1), the depressors consonants are listed for each language with consonant-tone effects. Where there is a lack of explicit statements in the data available on a language about the presence or status of certain consonants, especially nasal-obstruent sequences

and implosives, I have indicated this with a question mark. The broadest generalizations, as I have stated already, are that voiced obstruents always and voiceless obstruents never participate in consonant-tone interaction. In addition, there are no cases of implosives acting as depressor consonants. In three languages, sonorants can act as depressors and in two languages, nasal-obstruent sequences do. It is interesting to note that in two of the potential problem cases discussed in Chapter 5, Kanakuru and Podoko, nasal-obstruent sequences pattern with voiced obstruents.

(1) Consonants that interact with tone crosslinguistically

Languages	voiced obstruents	sonorants	nasal + obstruent	implosives	voiceless obstruents
Nguni: Siswati, Isixhosa, etc.	yes	no	yes	no	no
Gbaya: Suma, Gbaya bokota	yes	no	no	no	no
Yaka	yes	no	no	no	no
Makaa	yes	?	?	?	no
Mijikenda: Digo, Chirihe, Chikauma, etc.	yes	no	no	no	no
Ikalanga	yes	no	?	no	no
Ewe	yes	yes	NA	NA	no
Siya	yes	no	NA?	NA?	no
Dagara-wule	yes	no	NA	no	no
Ebrié					
Miya	yes	no	no	no	no
Ouldeme	yes	no	yes	no	no
Bolanci	yes	no	no	NA?	no
Bade	yes	no	NA?	no	no
Nupe	yes	yes	NA	NA	no
Ngizim	yes	yes	NA?	no	no
Mulwi	yes	no	no	no	no

Besides being restricted to a certain class of consonants, consonant-tone interaction is also limited in terms of how tones are affected. To wit, this interaction takes the

form of either the attraction of a L tone or the repelling of a H tone. In at least one instance, L is also repelled in a dissimilatory effect. The attraction of L takes the form of apparent L insertion or the conditioning of L spread. The repelling of H takes the form of the blocking of H docking, of H shift and of H spread as well as the triggering of H shift. The blocking of H can usually be alternatively described in terms of L maintenance, where a L tone after a voiced consonant cannot be dislodged. Significantly, consonant-tone interaction does not involve H insertion or the triggering of H spread or docking. The other effect that is found is one in which L tone triggers voicing on obstruents.

(2) Consonant-Tone Effects involving Voiced Consonants

Effects on L tone	Effects on H tone	Effects on voicing
1. L insertion	1. blocking H docking	1. Voicing insertion
2. L Spread	2. blocking H shift	
3. blocking L docking	3. blocking H spread	
4. downstep insertion	4. H Shift	

Because consonant-tone interaction involves, in the general case, the presence of a L tone after the participating consonants which is not amenable to being dislodged, the effects of this kind of interaction are referred to as depressor effects and the participating consonants are referred to as depressor consonants.

In this chapter, I present examples of the different kinds of depressor effects from a variety of languages which are genetically unrelated and geographically separated. It will be noted that a majority (though not all) of these languages are spoken on the continent of Africa. Asian tone languages generally have less tonal alternation, especially word internally, than African tone languages, and the processes described here crucially involve tone alternation. The nonAfrican languages exemplified below show voicing being triggered by L tone. Otherwise, Asian languages are well known for the historical interaction of consonant voicing and tone. African languages too show evidence of this historical interaction. But the historical side of this phenomena will not be the subject of this work.

2.2 L TONE INSERTION

L tone insertion refers to the appearance of a phonological L tone on a vocalic mora following a depressor consonant when there is evidence that the L tone was not underlyingly present on that vocalic mora.

2.2.1 Suma

The Gbaya language, Suma, spoken in the Central African Republic, provides an example of L insertion after depressor consonants. In Suma, voiced obstruents (*b, d, g, gb, v, z*) only occur word-initially. There is a general tendency for all depressor-initial words to begin with a L or rising (LH) tone, but this is only a tendency among nouns. Among verbs, the tone pattern is determined by the morphology and verbs are underlyingly toneless. The imperfective form of the verb is characterized by a grammatical H tone which is the sole tone in verbs with nondepressor consonants, as in (3a). Prenasalized stops (which are allophonic variants of nasal consonants) and implosives do not act as depressors. In verbs with initial depressor consonants as in (3b), a L tone precedes the grammatical H in the imperfective and in any form of the verb that is characterized by a H tone (such as the nominal). The initial L tone results in either a rising tone (*bòm*) or a level L (*bùsì*) on the initial syllable of the verb depending on whether the verb is monosyllabic or longer (3c). This in itself is enough to demonstrate that the L tone is not an automatic phonetic effect. If it were the lowered pitch would result in a rising tone on the initial syllable of all such depressor-initial verbs.

(3) Imperfective Form: Suma (Bradshaw 1995)

a. Non-depressors¹

ǒúk	'applaud'	ǎǎǎ	'mount'
éé	'leave behind'	fǒdí	'stir briskly'
kírí	'look for'	nǒy	'boil'
rém	'be able to'	yárí	'unravel'
ndǎngí	'boom'	nǐkírí	'exaggerate'

¹ Underlined vowels are nasalized.

b. Depressors

bòm	'be blind'	dík	'be sonorous'
ǎǎy	'reprimand'	gbǎk	'borrow'
vǎy	'bet'	ǎǎ	'lean'
ǎǎǎ	'swell'	zǎfí	'sneeze'
bùsì	'be bland'	díkílí	'tickle'
ǎǎbǐ	'twist'	zíkídí	'delay'

- c. bom + imperfective H → bòm (*bóm)
 busi + imperfective H → bùsì (*bùsí)

It should be noted that the tone patterns of verbs in Suma are not lexically fixed underlying tones. They alternate depending on which grammatical morpheme is present. Underlyingly all verbs are toneless, and changes in aspect are marked by tone alternations. Thus, *busi* is realized as *bùsì* in the imperfective, as *bùsá* in the perfective, and as *bùsì* in an adverbial form.

Further evidence for the phonological nature of this L tone comes from the presence of depressor-initial nouns with initial H tones. It is expected that these words would have phonetic lowering effects on the fundamental frequency of vowels after depressor consonants, and thus they provide a contrast between phonetic and phonological lowering effects.

(4) Suma nouns with initial H tones (Bradshaw 1995)

bóná	'plant: <i>Sporobolus pyramidales</i> '
dórò	'the trail of a small animal'
vûy	'cord made from bark'
vúlà	'acne, pustule'
zǎm	'taboo'

Evidence for the phonological nature of the consonant-tone interaction also comes from monomoraic verbs in Suma. Monomoraic verbs in the imperfective surface with a simple H tone even when they are depressor-initial, as in (5). When another mora is added, as in the nominalized forms of these verbs, the expected depressor L surfaces. The depressor L cannot surface on monomoraic verbs because there is a restriction on tone in Suma such that no more than one tone per mora is allowed.

(5)	<i>Imperfective</i>	<i>Nominalized</i>
	bé 'refuse'	běá 'refusing'
	dé 'do'	děá 'doing'
	dú 'collect'	dúá 'collecting'
	fó 'agitate'	fóá 'agitation'

This directly relates to number of moras rather than number of syllables. As we have seen, monosyllabic verb stems such as *bóm* 'be blind' can have a rising tone on a single syllable. The same is true for monosyllabic verb stems with long vowels, such as *gĩ* 'lean' and *děé* 'swell'. Furthermore, only monosyllabic verb stems can be bimoraic. Thus, all polysyllabic verb stems have monomoraic syllables and none of these syllables has contour tones.

The L tone we find after a voiced obstruent in Suma cannot be accounted for as simply a phonetic phenomenon. The interaction between the restriction on L tone realization and the number of moras present in (5) is a phonological effect. Moreover, the L tones found after the verbs in (3) and (5) are not automatically or underlyingly present. They can be followed by other tones as their morphology varies. All verbs alternate tonally in the perfective, where they are followed by M tones. In that case (i.e. before a M tone), the depressor L does not surface (i.e. *gōbā* 'twisted'). If L were underlyingly present, there is no reason it could not surface on the first syllable of a verb since LM tone patterns are attested in the language (i.e. *bòdū* 'mud'; *mòkpārē* 'bile'). Most importantly, there is a contrast between L tones and H tones after voiced obstruents among nouns which have lexical tones. Therefore, L insertion is a phonological phenomenon in Suma because there is a contrast between a voiced obstruent followed simply by phonetically lowered pitch at the onset of the vowel and one followed by a L tone. The alternations make it clear that the depressor effect is active in the phonology and not merely a fact about lexical distribution.

2.2.2 Siswati

In Siswati, an Nguni language spoken primarily in South Africa and Swaziland, L tones also surface after depressor consonants². The depressor consonants in Siswati include the set of voiced obstruents (*b, d, g, gc, v, z, ʒ, dz, dv, h, dʒ*). It should be noted that *gc* represents the voiced alveolar click, and that *dv* is in complementary distribution with *dz*, occurring only before labial vowels (*u, o*), and therefore can be considered an allophonic variant of *dz*. In addition, the nasal-obstruent sequences in which the obstruent is voiced are clusters (*mb, nd, ŋg, nd, ndz, ŋgc*) and also act as depressors. These depressor clusters contrast with nasal-obstruent sequences in which the obstruent is voiceless, such as *impúḡane* 'fly'. In the case of the velar cluster *ŋg*, the *g* is consistently deleted except when it is the initial segment or the initial consonant of a root. Thus, *ŋ* acts as a depressor on the surface because it is a reduced form of the cluster *ŋg*.

L insertion in Siswati results in L or LH tones after depressor consonants, as in (6). Underlyingly toneless moras become L and H-toned moras end up with a rising tone. Neither falling tones nor level H's occur after depressors, with the exception of *ŋ* in a particular case which will be discussed in the next chapter.

(6) Siswati (Bradshaw 1996)

	<i>L Tone</i>		<i>LH Tone</i>	
[b]	lúbààmbò	'rib'	lubànjàana	'little rib'
[d]	lídààdà	'duck'	edàdèèni	'on the duck'
[g]	sígòòdzi	'region'	kugǽjǽima	'to run'
[gc]	íngcùùǽbu	'carriage'	kúgcééba	'to tidy up'
[v]	kúvǽàla	'to close'	kúvùúka	'to wake up'
[z]	kucábuza	'to kiss'	gèczá	'bathe!'
[h]	kúhǽlíika	'to rake'	kúhǽǽàata	'to pour a little'
[ʒ]	ínǽòòvù	'elephant'	kúǽǽ	'to eat'
[dz]	kúcindzètéela	'to oppress'	sígòòdzi	'region'
[dv]	sáándvò	'hammer'	indvòjàana	'little man'
[j]	lúújú	'honey'	ínjǽána	'little dog'
[ŋg]	ínyaaḡà	'moon, month'	ínyaaḡà	'healer'

² Previous analyses of Siswati have analyzed the tone system differently, dealing with the L tone as a subsegmental feature, [depression]. That approach is critiqued and the present approach justified in Chapter 4.

Verbs in Mulwi, which are always consonant-initial, can have either a L, LH or H tone pattern. Focusing on obstruents, there is an interesting difference between tone patterns. Voiced obstruent initial verbs are either L or LH, as expected; while voiceless obstruent initial verbs are either H or L in tone, and never LH.

- (11) a. *bizì* 'spend the year' *bizí* 'apply pressure'
 b. *kì* 'flow' *kí* 'accompany'

This distribution of tone patterns suggests that there is L insertion before the class of H toned verbs that begin with voiced obstruents. As illustrated in (12), the verbs can be classed into H and L tones with the LH pattern being derived from L insertion.

- (12) voiced obstruent L H → LH
 voiceless obstruent L H

The L tone in Mulwi is clearly phonological in nature. It can occur after any consonant, and it contrasts with H tones after depressor consonants in non-initial position. Tourneux does note a phonetic difference in the realization of the L tone after voiced obstruents in contrast to other consonants. After voiced obstruents, it is lower in pitch.

2.2.4 Yaka

Yaka, also referred to as Aka, is a Bantu language spoken by pygmies in the Central African Republic. Kutsch Lojenga 1998 reports that the depressor consonants, when they are root-initial, cause an underlying H tone to be realized as a rising (LH) tone. The depressor consonants are the set of voiced stops *b d ʒ g gb*. Implosives and prenasalized stops do not act as depressors. Fricatives do not act as depressors because Yaka has no underlyingly voiced fricatives, and in the one case where voiced fricatives are derived, all consonants are followed by a L tone. This case will be examined more closely in section 2.9.3. Verbs (13a) and nouns (13b) with root-initial depressors and underlying H tones are shown with their surface rising tones in (13).

- (13) Yaka (Kutsch Lojenga 1998)
- | | | | | |
|----|-----------------|------------------|-------------------------------------|--------------|
| a. | <i>bisɛ</i> | 'to take out of' | <i>dũmba</i> | 'to knock' |
| | <i>dʒõnga</i> | 'to seek' | <i>gĩmba</i> | 'to descend' |
| | <i>gběla</i> | 'to hand over' | | |
| b. | <i>bika</i> | <i>ʒa-bika</i> | 'parrot' | Class 1a/2 |
| | <i>e-dǒlé</i> | <i>ʒe-dǒlé</i> | 'jumping over something' | Class 7/8 |
| | <i>dʒěkpé</i> | <i>ʒa-dʒěkpé</i> | 'necklace of beads' | Class 1a/2 |
| | <i>gĩli</i> | <i>ʒa-gĩli</i> | 'group' | Class 1a/2 |
| | <i>mo-gbǒlo</i> | <i>me-gbǒlo</i> | 'group of houses built in a circle' | Class 3/4 |

The noun classes are given in (13b) to make it clear that the initial L tones are not due to a grammatical morpheme in any of these classes. Nouns lacking root-initial depressors also lack the initial L tone, as shown in (14). Note that these nouns are in the same classes as the nouns in (13b).

- (14) *béka* *ʒa-béka* 'friend' Class 1a/2
 kálá *ʒa-kálá* 'crab' Class 1a/2
 mo-lé *me-lé* 'tree' Class 3/4
 e-bóbo *ʒe-bóbo* 'gorilla' Class 7/8
 ʒúma *ma-ʒúma* 'house' Class 9/6

Thus, L is inserted after a root-initial depressor consonant in Yaka. Evidence that the tone is phonological comes from the contrast between root-initial depressors with LH tones and root medial depressors with simple H tones following them. If the L tone in question were nothing more than the lowered pitch automatically produced by a depressor consonant, no such contrast should be possible.

- (15) *bǒbó* *ʒa-bǒbó* 'marrow' Class 1a/2
 dǔdú *ma-dǔdú* 'leftover' Class 5/6
 e-kódʒó *ʒe-kódʒó* 'tree, sp.' Class 7/8
 dagéli *ʒa-dagéli* 'plant, sp.' Class 1a/2
 gběgbélé *ʒa-gběgbélé* 'hunt of wild animals' Class 1a/2

Further evidence comes from the existence of a floating L tone prefix that marks nouns of class 5 and produces rising tones after both depressor and nondepressor consonants (*ʒáú* 'monkey, sp.' and *dǔdú* 'leftover'). The alternations in noun roots between noun class 5

and 6 will be examined in more detail in section 2.9.3. These alternations provide evidence that the L tone in rising tones is phonologically active, rather than underlyingly present on the vowel. The only rising tones that occur in Yaka are on nouns in class 5 or after depressor consonants.

2.3 DOWNSTEP INSERTION

In some languages, depressor consonants trigger the insertion of downstep between H tones. Downstep, the contrastive pitch lowering between adjacent H's, has been analyzed as either an effect marking the adjacent boundaries of two separate H tones (Clark 1990) or an effect marking the presence of a floating (and otherwise unrealized) L tone between H tones. In this case, the downstep reflects the presence of a L tone, and so is akin to L insertion, with the difference being the lack of actual docking.

2.3.1 Makaa

Heath 1991 describes the nonpossessive associate construction involving disyllabic nouns in Makaa, a Bantu language spoken in Cameroun. In this construction, downstepping, transcribed as *!*, occurs after a final voiced obstruent in the head noun when the proper conditions are met. The associative morpheme, which varies by noun class, must be vowel-initial so that the depressor consonant forms an onset to it, and the head noun must be H in tone.

- (16) Makaa (Heath 1991)
 ò-káámbug + AM + mà-bágó → ò-káámbug + ó-mó-bágó → ò-káámbug !ó-mó-bágó
ants of the ashes
 ò-káámbug + AM+ jùgà → ò-káámbug !ó jùgà → ò-káámbug !ó jùgà
ants of the plug

When the head noun is high and the modifying noun is also high, and there is an empty associative morpheme and no prefix on the modifying noun, a default vowel is in-

serted after the final depressor and a L tone is inserted. These conditions occur only when the head noun is in class 1, 9 or 10.

- (17) Makaa (Heath 1991)

káámbug + AM + cúú → káámbug ù cúú *ant of the animal*
 káámbug + AM + cáanzó → káámbug ù cáanzó *ant of the broth*

Since the depressor effects involve a choice between a downstep or an inserted L tone, it seems reasonable to assume that the downstep itself involves an inserted L tone that remains unassociated to any vowel.

No depressor effects occur when the depressor consonant does not form an onset to the associative morpheme. This happens when the depressor is not final, as in (18a), or when the associative morpheme is consonant-initial, as in (18b). Default vowel-insertion does not occur when the modifying noun has a prefix, as in (18c), or when the modifying noun is L in tone (18d). The data in (18d) suggests that the default vowel is added to serve as a bearer of the L tone.

- (18) a. mpándú cúú *mouse of the animal*
 òcúú ó mà-bágó *animals of the ashes*
 b. mì-ŋkúnkúd mí mà-bágó *brave men of the ashes*
 c. ŋkúnkúd mó-bágó *brave man of the ashes*
 káámbug mà-bágó *ant of the ashes*
 d. káámbug jùgà *ant of the plug*

Thus, the generalization is that in the nonpossessive associative construction in Makaa, depressor effects only occur when the depressor consonant forms an onset to the associative morpheme.

2.3.2 Chikauma & Chirihe

In two of the Mijikenda languages, Chikauma and Chirihe, Cassimjee & Kisserth 1992 found that downstep is inserted after a depressor consonant following a process of H spread. As shown in (19), there is a process by which H moves to the penult. In (19a), toneless verbs are given a H-toned prefix and the prefixal H is realized on the pe-

nult. When a depressor consonant intervenes between the prefix and the penult, H spreads anyway, but a downstep is realized on the first realization of H after the depressor consonant.

(19) Chikauma & Chirihe (Cassimjee & Kisseberth 1992)

a.	n-a-rima	w-a-ríma	(cultivate)
	n-a-sukuma	w-a-sukúma	(push)
b.	n-a-gula	w-á-g!úla	(buy)
	n-a-jítha	w-á-j!ítha	(cook)
	n-a-lagula	w-a-lág!úla	(treat medically)
	n-a-rejeza	w-a-réj!éza	(loosen)

Although only one H is introduced by the prefix in these cases, this H apparently undergoes fission (or cloning) when depressor consonants are present since there are gaps in its realization. H is not realized after a depressor except on the penult. Thus, when H spreads beyond a depressor, as shown in (20), there is a gap between the H before the depressor and the H on the penult. (20a) shows the same alternation pattern as in (19) but with the conditions necessary to induce a gap in H realization, i.e., a depressor consonant before the penult. (20b) shows data in which an object prefix with a depressor consonant is introduced.

(20) Chikauma (Cassimjee & Kisseberth 1992)

a.	n-a-galuka	w-á-gallúka	(change)
b.	na-zi-fugula	wa-ni-fúg!úla	wá-zi-fúg!úla (untie)
	na-zi-sonjerera	wa-ni-sonjeréra	wá-zi-sonjer!éra (approach)
	na-zi-tsukula	wa-ni-tsukúla	wá-zi-tsuk!úla

It will also be noticed that when the H moves to the penult with no intervening depressors, the only H is actually on the penult (*wanisonjeréra*). When intervening depressors are present, they are always preceded by a H tone (*walág!úla*). Cassimjee & Kisseberth account for this by positing spreading from the original site to the penult followed by delinking of all but the rightmost H in a H tone span. Since the depressor consonants create additional H spans through fission, more H's are realized.

2.4 CONDITIONING OF L SPREAD AND L DOCKING

In several languages, a L tone spreads or docks only when the intervening consonant is voiced. In these languages, sonorants are specified as phonologically voiced either underlyingly or at some point in the phonology.

2.4.1 Ngizim

Ngizim is a Chadic language spoken in Nigeria and described in Schuh 1971. There is a process of L spread in Ngizim that takes place when a LH word is followed by a H word. As shown in (21), this results in the lowering of the word final H with an ensuing LL tone pattern on the word. The other conditioning factor in this process is the quality of the intervening consonant. If it is a voiced obstruent or sonorant, spreading occurs. If it is a voiceless obstruent or implosive, no spreading occurs. This is a case in which sonorants appear to be specified for the feature [voice].

(21) Ngizim:	[b]	/gùbás báí/	→	[gùbàs báí]	'it's not a warthog'
	[gb]	/mùgbá báí/	→	[mùgbà báí]	'it's not a monitor'
	[r]	/màrì báí/	→	[màrì báí]	'it's not a beard'
		/màaróm tón/	→	[màaròm tón]	'big nose'
	[d]	/àa dáu báí/	→	[àadúu báí]	'it's not south'
		/kiidá báí/	→	[kiidá báí]	'he didn't eat (it)'
	[k]	/tàmàakú báí/	→	[tàmàakú báí]	'it's not a sheep'
	[t]	/šitá báí/	→	[šitá báí]	'it's not pepper'

The alternative hypothesis, that L spread is blocked by consonants specified as voiceless is ruled out by the blocking effect of implosives which would not be specified as [-voice]. Thus, the analysis in which voiced consonants condition L spread is preferred, following Hyman 1973. It is also worth noting that there is a blocking effect of voiced obstruents on H spread which also excludes implosives and voiceless obstruents. This effect will be described in Section 2.8.2.

2.4.2 Nupe

Nupe is a Kwa language spoken in Nigeria. George 1970 describes a situation in which the L of a preceding grammatical morpheme (a nominal prefix or tense/aspect marker in the examples below) spreads to the root vowel unless the intervening consonant is a voiceless obstruent, as in (22).

(22) Nupe (George 1970)			
/è+tú/	→	[ètú]	'parasite'
/è+dú/	→	[èdú]	'taxes'
/è+lé/	→	[èlě]	'past'
/tú/	'hoot' →	[étí]	'is hooting'
/gí/	'eat' →	[à gí]	'will eat'
/lá/	'carry' →	[èlǎ]	'is carrying'

George analyzes the rising tone found after voiced obstruents as an allophone of H, but it would be more accurate to say that it is a derived tone pattern. It surfaces where the conditioning environment is deleted through a vowel deletion process (i.e. *wu à bǎ* → *wu bǎ* 'it will be sour'). Like in Ngizim, this phenomena can be seen as the spreading of L which is conditioned by the presence of a voiced consonant.

2.4.3 Ewe

Verbs in the imperative in Ewe provide evidence for the existence of an underlying L tone and constitute a case in which stem-initial sonorants and voiced obstruents pattern together to the exclusion of voiceless obstruents⁵. This patterning is characteristic of high verbs in the singular imperative. Toneless verbs show no consonantal influence. The basic pattern for verbs in the imperative is that all initial consonants can be followed by a L tone, none can be followed by a M tone and neither voiced obstruents nor sonorants can be followed by a H tone.

⁵ Most analyses of Ewe (Stahlke 1971, Ansre 1961, Clements 1978) posit only an underlying high and nonhigh tone. I argue for underlying H, M and L in chapter 5. In any case, the existence of a phonological contrast between L and M has been commonly recognized.

The singular imperative is characterized by a floating L morpheme. Toneless verbs, in which the tone is determined by context, surface with L in the imperative, as illustrated in (23). These verbs have an initial L regardless of the nature of the initial consonant. This corresponds to their uniform behavior outside the imperative, where they are M in tone unless there is an immediately following L tone, as illustrated in the second column.

(23) Toneless Verbs (Stahlke 1971)			
nǎ ànyí	'sit down'	énǎ ànyí	'he sat down'
ɸlè nyí lá	'buy the cow'	éɸlè nyí lá	'he bought the cow'
qǎ núdquú	'cook food'	éqǎ núdquú	'he cooked food'

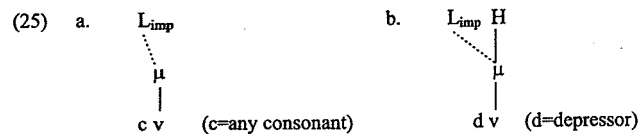
When the verb in the imperative singular has an underlying H tone, the surface tone is conditioned by the stem-initial consonant. When it begins with a voiced obstruent or a sonorant, the floating L morpheme docks and the tone pattern is LH. When it begins with a voiceless obstruent, the tone pattern remains H. Outside of the imperative, all of these verbs are realized with a H tone.

(24) High Verbs (Stahlke 1971)			
vǎá	'come!'	évá	'he came'
nǎá gǎ kǒfí	'give Kofi money!'	éná gǎ kǒfí	'he gave Kofi money'
kpǎ ádò	'see a squirrel!'	ékpǎ ábò	'he saw an arm'

This pattern could be interpreted either as the blocking of imperative L by a stem-initial voiceless obstruent or as the conditioning of L docking by a voiced consonant. If the latter, it directly corresponds to the conditioning of L spread by voiced obstruents and sonorants in Ngizim. There are several reasons why the latter hypothesis is to be preferred. First, L blocking is attested crosslinguistically, while there is no compelling evidence for the blocking of L by voiceless obstruents in other languages. Second, the blocking hypothesis would require that the voicing feature be binary in nature, and any argument that supports the privacy of that feature (as in Lombardi 1994, Mester & Ito 1989) supports an analysis in terms of spreading rather than blocking.

A blocking analysis of the tone patterns in the Ewe imperative is also more complicated than a spreading hypothesis. The imperative L morpheme is realized in both toneless and high verbs. The default pattern in toneless verbs, when no grammatical tone is present, is to be M in tone unless there is an immediately following L tone which spreads leftwards (see *éḡā núḡiḡiḡú* 'he eats food'). But the consonantly-induced difference is only realized in high verbs. Whatever (presumably [-voice]) might block the docking of the imperative L tone must be absent in toneless verbs and present in high verbs. Nor does this blocking occur in any other verb form. These facts are hard to account for in a blocking analysis. It is reckless to postulate that voiceless obstruents in toneless verbs are unspecified for [-voice] while voiceless obstruents in high verbs are so specified. It is at least surprising to postulate that voiceless obstruents are only specified for [-voice] in the imperative singular and not elsewhere.

In contrast, if the voiced consonant is the conditioning factor, there is nothing to block the imperative L from docking in the imperative singular, and the differential behavior between toneless and high verbs can be attributed to the need for a tone in the imperative. That is, toneless verbs need a tone and the imperative L may be the only tone available. The high verbs already have a H tone, and rising tone is a marked tone pattern, so the L tone is only inserted if triggered by a voiced consonant. The proposed processes by which imperative L docks are given in (25).



2.5 BLOCKING OF L DOCKING

The presence of voiced obstruents can lead to the prevention of a L tone's docking. This effect blocks the realization of a grammatical L tone.

2.5.1 Siswati

Siswati verbs in the imperative are assigned a grammatical L tone, which is realized only on toneless verbs. Verbs with an underlying H tone are not affected. In toneless verbs, the imperative L is assigned to the penult. Toneless disyllabic verbs have a level L on the penult and a final H, as shown in (26).

(26) Siswati (Bradshaw notes)

<i>Imperative</i>	<i>Gloss</i>	<i>Infinitive</i>
bùcá	'mix!'	kú-bùca
fiiká	'arrive!'	kú-fiika
vààlá	'close!'	kú-vààla
phèeká	'cook!'	kú-pheeka
ḡààlá	'count!'	kú-ḡaala
bùùdzá	'dream!'	kú-bùùdzà

Toneless verbs which are longer than 2 syllables have a rising tone on the penult in the imperative, as shown in (27).

(27)

landzèéla	'follow!'	ku-lándzèèla
khotsáama	'bend down!'	ku-khótsaama
phapháama	'wake up!'	ku-pháphaama
chapháata	'mock!'	ku-cháphaata

When toneless disyllabic verbs are in the plural form of the imperative, the suffix *-ni* is added, making them longer. In this form, they pattern with longer verbs and surface with a rising tone on the penult, as in (28).

(28)

fikáani	'arrive!'	kú-fiika
fiiláani	'grieve!'	kú-liila
yeláani	'winnow!'	kw-éela

The imperative L is not realized in toneless verbs with depressor consonants elsewhere in the word. In toneless verbs with nonpenultimate depressor onsets, there is a level H on the penult, as in (29).



- | | | | | |
|------|-------------|------------------|-------------|-------------------|
| (29) | bicááni | 'mix!' | válááni | 'close!' |
| | ǃisááni | 'make eat!' | landzèlééla | 'follow for!' |
| | landzèlíisa | 'make follow!' | gèzisééla | 'make bathe for!' |
| | vàlíisa | 'make close!' | vàlééla | 'close for!' |
| | bicééla | 'mix for!' | bicíisa | 'make mix!' |
| | maǃalééla | 'take to court!' | maǃalíisa | 'surprise!' |

The explanation for the loss of the depressor effect when there is a depressor consonant elsewhere cannot be based on a constraint against multiple L's in a word, since words with multiple L's do occur, such as *kúbàsóóbà* 'to watch over'.

Another explanation is suggested by the fact that the tone pattern in toneless verbs with depressor consonants is the same as that of a verb with underlying H tones in the plural imperative. That is, high verbs are characterized by a level H on the penult in the imperative, as in (30).





- | | | | |
|------|--------------------------|-------------|-------------------|
| (30) | <i>Plural Imperative</i> | | <i>Infinitive</i> |
| | ǃafunááni | 'chew!' | kúǃáfúúna |
| | sikááni | 'slice!' | kúšíika |
| | laǃááni | 'discard!' | kúlááǃa |
| | ǃonááni | 'see!' | kúǃóóna |
| | letsááni | 'bring!' | kúléétsa |
| | ǃulalááni | 'kill!' | kúǃúláála |
| | ǃukanisááni | 'separate!' | kúǃukánisa |
| | tfalááni | 'carry!' | kúǃfáála |

This suggests that the lack of a grammatical L in both the toneless verbs with depressors and verbs with underlying H tones could be due to a similar blocking process. The grammatical L which targets the penult is blocked by the presence of either an underlying H tone or a L tone present due to a depressor consonant.

- | | | | | | |
|---------|---|--------------------|----|---|------------------|
| (31) a. | landzèlééla | <i>follow for!</i> | b. | khotsááma | <i>separate!</i> |
| |  | | |  | |

The case of high verbs in the imperative is slightly more complicated because at first glance it might seem that the imperative L could dock and create a rising tone. Al-

though rising tones are disfavored, they do occur on the penult regularly in low verbs in the imperative. In this case, however, the tonal distinction between high and low verbs would be lost. There are at least two possible accounts of the blocking effect of H in high verbs. It is possible that imperative L attempts to dock at an early stage, before the H has shifted to the penult, as in (32a). It is equally plausible that the imperative L cannot cause delinking of a lexical tone even when that lexical tone has moved from its underlying position. Thus, one would be left with a tone pattern as in (32b); a tone pattern never found in Siswati⁶.

- | | | | | | | | |
|------|----|---|---|---|---|---|-------------------|
| (32) | a. | ǃukanisaani | → | ǃukanisááni | → | ǃukanisááni | <i>bend down!</i> |
| | |  | |  | |  | |
| | b. | ǃukanisááni | → | *ǃukanisááni | | | |
| | |  | | | | | |

The remote past negative also bears a grammatical L that is blocked from docking in verbs with depressor consonants.

2.6 DEPRESSOR INDUCED H TONE SHIFT

Depressor-induced H tone shift (DIHTS) refers to a depressor effect that has been noted in the Nguni languages. The name is taken from Cassimjee 1998. This process effects H tones after depressor consonants by causing them to shift rightward. In their place, a L tone surfaces.

2.6.1 Transkei varieties of Isixhosa

In the Transkei varieties of Isixhosa, a Nguni language described in Cassimjee 1998 and spoken in the Republic of South Africa, DIHTS occurs after a process of Ante-

⁶ Such a tone pattern might be phonetically indistinguishable from the rising tone that is found on the penult in Siswati when a depressor onset is present. However, the tone pattern is phonologically excluded.

penult Attraction causes a H to be placed on the antepenult. Antepenult Attraction is illustrated in (33).

- (33) Isixhosa (Cassimjee 1998)⁷
- | | | | | |
|--------------------|---|------------------|----------------|--------------------|
| bá+ya+moneela | → | bayamóneela | (be jealous) | <bayamóneela> |
| bá+ya+nǃaala | → | bayánǃàala | (make the bed) | <bayánǃàala> |
| zí+ya+namatheliisa | → | ziyanamathéliisa | (cement) | <ziyanamathéliisa> |

When a depressor consonant is present, DIHTS operates to shift the H once to the right, resulting in a falling tone on the long penult, as shown in (34).

- (34) bá+ya+sombuluula → bayasombùlúula (solve a problem) <bayasombùlúula>
 bá+ya+daniisa → bayadániisa (dance) <bayadániisa>
 bá+ya+phazamiisa → bayaphazàmiisa (disturb) <bayaphazàmiisa>

2.6.2 Siswati

In Siswati, spoken in southern Africa, DIHTS once again affects a H that is found on the antepenultimate syllable due to a process of Antepenult Attraction. The data in (35) give evidence for Antepenult Attraction in Siswati. The H tone of the infinitive prefix is realized on the antepenultimate syllable when suffixal extensions are added to the verb. Although these verbs have only one H tone, in verbs with multiple H's, only the rightmost H is affected.

- (35) Siswati (Bradshaw notes)

kú-liim-a	'to plow'
ku- <u>lím</u> -iis-a	'to cause to plow'
ku-liim-ís-aan-a	'to cause e.o. to plow'
ku- <u>lím</u> -is-él-aan-a	'to cause to plow for e.o.'

⁷ Cassimjee makes the traditional assumptions about depressor consonants in the Nguni languages that tend to obscure the true nature of the depressor effects. This will be clarified in relation to Siswati in Chapter 5. Here I translate into my notation and give Cassimjee's notation on the side. The dots under the segments in Cassimjee's notation indicate the abstract quality 'depression'.

When the onset consonant in the antepenultimate syllable is a voiced obstruent, the antepenult H shifts once to the right and surfaces on the penultimate syllable, as illustrated in (36).

- (36)
- | | |
|----------------|--------------------------------|
| ku-bòcáana | 'to smear each other' |
| ku-cafuzèláana | 'to kiss each other for' |
| k-ongèséela | 'to cause to economize for' |
| kuɓoŋisáana | 'to cause each other to thank' |

2.7 BLOCKING OF H SHIFT

In addition to blocking L tones from docking, depressor consonants have blocking effects on H tone. One such effect prevents H tone from shifting. When H cannot be shifted, a L tone is inserted and the result is a rising tone. In languages where DIHTS occurs, it is also blocked by a depressor consonant. Thus, in these languages, depressor consonants both trigger and block H shift.

2.7.1 Isixhosa

In Isixhosa, some H's are not shifted from the antepenult even when a depressor consonant is present in the onset. In these cases, illustrated in (37), the following penult also has a depressor consonant onset. The H tone is essentially trapped between 2 depressors and H Shift is blocked. What surfaces is a rising tone on the antepenult, because of L insertion.

- (37) Blocking of DIHTS in Isixhosa (Cassimjee 1998)

bá+ya+guzuula	→	bayagùzùula	(scrape)	<bayagùzùula>
bá+ya+vingceela	→	bayavingcèela	(stop)	<bayavingcèela>
bá+ya+dudeelwa	→	bayadùdèelwa	(pass the age for marrying)	<bayadùdèelwa>

2.7.2 Siswati

In Siswati, like Isixhosa, the antepenult H is not shifted to the penult just in case a depressor consonant blocks the way. As shown in (38), when the penult has a depressor consonant onset, the H tone remains on the antepenult as part of a rising tone.

(38) Blocking of DIHTS in Siswati (Bradshaw 1996)

ingóväänà	'little elephant'	lidádàànà	'little duck'
edádèèni	'on the duck'	eǰǰǰèèni	'in the cooking'

Another H Shift in Siswati, one that is not depressor related, is also blocked by depressor consonants. The H shift in question is caused by the grammatical L tone that is assigned in copular nominals. This grammatical L targets the initial mora of the noun. If the initial mora is toneless, there are no other tone changes, as in (39).

(39) sicàtfuulo	→ sicàtfuulo	'it's a shoe'
umíbìila	→ ñùmíbìila	'it's maize'
umgàànù	→ ùmgàànù	'it's a Marula tree'
imítuutí	→ yimítuutí	'it's sauces'
emáncóobo	→ ñemáncóobo	'it's boiled dried corn'

Note that when vowel-initial nouns become copular nouns, they have a consonant onset. The onset is [y] before [i] and [ɲ] before other vowels

If the initial mora of the noun bears a H, the H is shifted onto the next syllable in its copular form. When the next syllable is the penult, a falling tone results, as in (40).

The resemblance to DIHTS is not accidental, since rising tones are disfavored in Siswati. If the H did not shift, a rising tone would result.

(40) síḡaambò	→ síḡaambò	'it's a handle'
línceéḡa	→ línceéḡa	'it's a wound'
sícooco	→ sícoóco	'it's a frog'
ínyooni	→ yínyóoni	'it's a bird'
imfèene	→ yimfèene	'it's a baboon'

The shifting of H to the next syllable is blocked by an intervening depressor consonant. In these cases (41), a rise surfaces on the initial syllable. This is the same blocking phenomenon we saw in relation to DIHTS.

(41) síbààmù	→ síbààmù	'it's a gun'
lùbààmbò	→ lùbààmbò	'it's a rib'
lídààdà	→ lídààdà	'it's a duck'
inǰòòvù	→ yinǰòòvù	'it's an elephant'
indvùükù	→ yindvùükù	'it's a stick'
ingwèènyà	→ yingwèènyà	'it's a crocodile'
indvòòdzà	→ yindvòòdzà	'it's a man'
libùbèesi	→ libùbèesi	'it's a lion'

2.7.3 Digo

Digo is a Mijikenda language of Kenya and Tanzania described in Kisseberth 1984 and Cassimjee & Kisseberth 1992. In Digo, a prefixal H normally shifts to the root. An initial voiced obstruent prevents this H shift. In Digo, prenasalized stops are excluded from the class of depressor consonants.

In the first two examples in (42), the root-initial voiced obstruent prevents shift. In the second two examples, H shift (and H spread) takes place in the absence of an intervening voiced obstruent. In the final example, H shift takes place but H Spread is blocked by the voiced obstruent.

(42) Digo (Kisseberth 1984)

ni-ká-bomór-a	'I have demolished'
ni-ká-vwinir-a	'I have sung for'
ni-ka-káráng-â	'I have fried'
ni-ka-kúmbúkírâ	'I have remembered'
a-ka-ézekër-â	's/he has thatched for'

The shift of a prefixal H to the root is also blocked by depressor consonants in the past tense. The verbs in (43) are underlyingly toneless. The assignment of a prefixal H to the final vowel is indifferent to intervening depressor consonants. But the subsequent shift of the other prefixal H is blocked by the stem-initial depressors in the first two examples in (43).

- (43) n-a-vugūr-â 'I untied' (*n-a-vúgūr-â)
 n-a-vumikíz-a 'I agreed'
- n-a-tsóŕ-â 'I picked up' (*n-a-tsǒŕ-â)
 n-a-róngóz-â 'I led'

2.8 BLOCKING OF H DOCKING

Another blocking effect involving H tones prevents them from docking. The inserted H's that are blocked by depressor consonants are of two kinds. One involves the docking of a grammatical floating H tone and the other involves a phonological H tone that can be interpreted as breaking up (or marking boundaries between) two L tones.

2.8.1 Gbaya bokota

In the Ubangui language, Gbaya bokota, spoken in the Central African Republic and closely related to Suma (discussed in section 2.2.1), there is a floating H tone which marks the associative construction. This construction most typically involves two nouns in which the leftmost noun is the head and the rightmost noun modifies it. When the modifier noun begins with a L tone in isolation, it has a H tone in the associative construction, as in (44a). When the modifier noun begins with a voiced obstruent, as in (44b), the expected H tone is blocked, and the original L tone is maintained.

(44) Associative Construction: Gbaya bokota⁸ (Bradshaw field notes)

- | | | |
|----|-----------------------------|----------------------|
| a. | wò + mbòrō → wō mbóŕō | 'hunger for monkey' |
| | wò + tòrō → wō tórō | 'hunger for dog' |
| | wò + rì → wō rí | 'thirst for water' |
| | wò + kām → wō kām | 'hunger for boule' |
| | wò + sādē → wō sādē | 'hunger for meat' |
| | gbàà + mbòŋgò → gbàà mbóŋgò | 'corn seed' |
| | ēē + mbòrō → ēē mbóŕō | 'monkey paws' |
| b. | wò + gòrē → wō gòrē | 'hunger for chicken' |
| | wò + dùwà → wō dùwà | 'hunger for goat' |
| | wò + zàwà → wō zàwà | 'hunger for peanuts' |
| | gbàà + zàwà → gbàà zàwà | 'peanut seed' |
| | ēē + dàwà → ēē dàwà | 'lion paws' |

⁸ Nasalized vowels are underlined.

Prenasalized stops, as in Suma, do not count as depressor consonants in Gbaya bokota. Based on more extensive information on related languages like Suma (Bradshaw notes) and Gbeya (Samarin 1966), it is reasonable to assume that prenasalized stops are allophonic variants of fully nasal *m*, *n*, *ŋ*. When the nasal appears before an oral vowel it is pronounced with anticipatory closing of the velum resulting in *mb*, *nd*, *ŋg*.

2.8.2 Miya

In the Chadic language, Miya (Schuh 1998), spoken in Nigeria, there is what Schuh describes as a process of Low Raising in which the first syllable of a span of L tones becomes H after a L tone. We can analyze this as a process of H insertion that serves to break up adjacent L tones. As it is always at the beginning of a word, it marks a boundary that might have been otherwise blurred tonally. It's worth noting that Miya is analyzed as having moras with H, L or no tone underlyingly. Prenasalized stops do not count as depressor consonants.

(45) Miya (Schuh 1998)

- | | |
|---|-------------------------|
| pòràm ⁹ + kǎvǎn → pòràm kǎvǎn | 'blood of a buffalo' |
| mbàdà + kǎvǎn → mbàdà kǎvǎn | 'thigh of a buffalo' |
| sàbò + máatsǎŕ → sàbò máatsǎŕ | 'seven people' |
| wùná + ghǎrùw ¹⁰ → wùná ghǎrùw | 'calf (child of cow)' |
| zǎkiy + ndándàn-yà → zǎkiy ndándàn-yà | 'heavy stone' |
| vènà + mbǎrgù → vènà mbǎrgù | 'mouth of ram' |
| vènà + kǎvǎkǎ → vènà kǎvǎkǎ | 'mouth of gray monitor' |

When the initial consonant of the second noun is a voiced obstruent, the phonological H is not present and the L tone is maintained.

⁹The L tones on this lexical item are derived by Initial H Lowering which precedes Low Raising in a serial derivation. Thus, underlyingly *pàràm* is H-toned.

¹⁰*gh* is not a depressor consonant in Miya. Schuh classifies it as a voiced laryngeal fricative in contrast with *h*, but he says it is only mildly fricativized. Thus, it may actually be a sonorant, such as a laryngeal glide.

- (46) pèràm + dlàngèr → pèràm dlàngèr 'blood of an animal'
 sèbè + v àatlè → sèbè v àatlè 'five people'
 wùnà + bàday → wùnà bàday 'small basket (child of basket)'
 vènà + gùzèm → vènà gùzèm 'mouth of Nile monitor'
 vènà + dùwàkò → vènà dùwàkò 'mouth of horse'

2.8.3 Digo

As described by Kisseberth 1984, the lexical H of Digo docks on the final vowel of the verb and subsequently spreads to the penult (47a). When the final vowel is immediately preceded by a depressor consonant, the H is blocked from docking there and docks instead on the penult (47b).

- (47) Digo (Kisseberth 1984)
- | | | | |
|------------------|-----------------------|---------------|--------------------------|
| a. ku-arük-â | 'to begin, start' | ku-bomör-â | 'to demolish' |
| ku-gongomë-â | 'to hammer' | ku-furuküt-â | 'to move restlessly' |
| ku-sindik-â | 'to shut the door' | ku-yakinish-â | 'to confirm' |
| b. ku-dunduríz-a | 'to place in reserve' | ku-gukíz-a | 'to apply heat' |
| ku-koróg-a | 'to stir' | ku-siríg-a | 'to rub' |
| ku-kurúg-a | 'to smoothen' | ku-tanyiríz-a | 'to drive off predators' |

2.9 BLOCKING OF H SPREAD

2.9.1 Bade

Bade, a Chadic language spoken in Nigeria, has a process in which a H spreads to a L-toned mora when the mora is followed by a H-toned mora, according to Schuh 1978. Thus, the tone pattern HLH is realized as HH!H. As shown in (48), H spread takes place when the intervening consonant is a voiceless obstruent (*k*) or a sonorant (*l*), but not when it is a voiced obstruent (*g*).

- (48) Bade (Schuh 1978): HLH → HH!H
- | | |
|------------------------|--------------|
| nón kàtáw → nón ká!táw | 'I returned' |
| nón làwáw → nón lá!wáw | 'I ran' |
| nón gáfáw → nón gáfáw | 'I caught' |

2.9.2 Ngizim

Ngizim is another Chadic language spoken in Nigeria in which voiced obstruents have a blocking effect on the spread of H tone, according to Schuh 1971. In Ngizim, a H tone normally spreads to an adjacent L-toned mora when the L is between two H's. However, if a voiced obstruent intervenes, the H spread is blocked. The other consonants, including implosives, have no effect.

- (49) Ngizim (Schuh 1971)
- | | | |
|-----|---------------------------|-----------------|
| [b] | /ná bàkò-w/ → [ná bàkú] | 'I burned (it)' |
| [d] | /ná dānkò-w/ → [ná dānkú] | 'I sewed' |
| [k] | /ná kàasúw/ → [ná kàasúw] | 'I swept' |
| [r] | /â rāpcí/ → [â rāpcí] | 'open!' |

2.9.3 Bolanci

In the Bolanci language of Northern Nigeria, Lukas 1969 describes several processes of H Spread. One process affects nouns in genitive constructions. As in (50a), a final H tone in the first noun spreads once to an initial L tone mora in the second noun. When the initial consonant of the second noun is a voiced obstruent, H is blocked from spreading, as in (50b).

- (50) Bolanci (Lukas 1969)
- | | | | |
|------------|----------|-------------|---------------------|
| a. láawò | 'child' | kúm láawò | 'ear of the child' |
| mòndù | 'woman' | kúm mòndù | 'ear of the woman' |
| sàawùrà | 'falcon' | kúm sàawùrà | 'ear of the falcon' |
| b. gāndùkì | 'hare' | kúm gāndùkì | 'ear of the hare' |

Another process of H spread occurs word internally in verbs when a H-toned subject prefix adjoins a verb stem with an initial L tone. In the second singular masculine perfect or future forms in (51) the H tone of the subject marker spreads into the stem when the intervening consonant is not a voiced obstruent, and it is blocked from spreading when the consonant is a voiced obstruent.

(57) Blocking of H Spread (Bradshaw 1996)

kú + khulúúma → kúkhulúúma	'to speak'
kú + lanyéela → kúlányéela	'to plant'
kú + bekéteela → kúbékéteela	'to be patient'
kú + tshanyéela → kútshanyéela	'to sweep'
kú + tukániisa → kútúkániisa	'to make separate'

The blocking effect is shown in (58) where there is a voiced obstruent between the two underlying H's. Note that H spread is completely blocked. H does not even spread to syllables with nondepressor consonants. Thus, the effect is clearly phonological because if it were phonetic we would expect all of the syllables to have a H except for the ones with depressor consonant onsets.

(58) kú + gayíiŋa → kúgàyíiŋà	'to dry roast'
kú + candvúula → kúcandvúúla	'to hammer'
kú + cindzéteela → kúcindzètéela	'to oppress'
kú + khaŋéeta → kúkhaŋèeta	'to hold out one's hands'
kú + taŋányeela → kútaŋányeela	'to participate'

Phrasal H Spread in Siswati follows essentially the same pattern as Word Internal H Spread. When there are two H tones across words, H spreads to fill in the toneless moras, as in (59). The initial H of the subject prefix in the first two tokens shifts to the verb stem by a process of Local Shift before spreading occurs.

(59) ú-lima + ínsímu → ulímá ínsímu	'he plows the field'
ú-bala + ticátfuulo → ubálá ticátfuulo	'he counts shoes'
kú-phúma + énŋiini → kúphúmá énŋiini	'to go out of a house'

An intervening voiced obstruent blocks H spread, as in (60). The Local Shift that causes the prefix H to shift to the stem is not blocked by depressor consonants as can be seen in *ugèzà*.

(60) ú-banza + ticátfuulo → ubánzà ticátfuulo	'he chops up shoes'
ú-geza + bántfaana → ugèzà bántfaana	'he bathes the children'
ú-bilisa bàtáata → ubilísa bàtáata	'he boils sweet potatoes'

2.9.7 Dagara-wule

Dagara-wule is a Gur language spoken in Burkina Faso. The depressor effects are described in Somé 1998, where the lack of equivalent depressor effects in closely related Dagara-lobr and Dagara-birfuor is also demonstrated. The depressors consonants in Dagara-wule include the voiced obstruents (b, d, g, gb, v, z, j, ñ) and exclude the voiceless obstruents, implosives and sonorants.

Normally in Dagara-wule, a H spreads from a noun such as *ní* 'person' to its following modifier when the modifier has an initial L tone otherwise. The case in (61) involves modifiers with a LH tone; usually the H is a floating tone.

(61) Dagara-wule (Somé 1998)		
ní + plá → ní plá	[ní plá]	'a white'
ní + fúud → ní fúud	[ní fúur]	'act of defying someone'
ní + tédđ → ní tédđ	[ní tēr]	'related'
ní + kpílú → ní kpílê	[ní kpílê]	'strong people'
ní + yáaf → ní yáal	[ní yáal]	'person made ridiculous'

However, when the modifier begins with a voiced obstruent, as in (62), the spread of H is blocked.

(62) ní + bàalú → ní bàalù	[ní bàalù]	'pitied'
ní + vlá → ní vlà	[ní vlà]	'good person'
ní + zìé → ní zìè	[ní zìè]	'light-skinned person'
ní + gbòlò → ní gbòlò	[ní gbòlò]	'fat people'

The same pattern is found when the modifier consists of a verb with a LHL tone. A twist in this case, is that the initial L tone of the modifier is realized as a downstep in the surface form.

(63) a. ní + wèddâ → ní wéd!dá	[ní wé!rá]	'person who operates'
ní + ñàddâ → ní ñád!dá	[ní ñá!rá]	'person before standing'
ní + ñòddâ → ní ñòd!dá	[ní ñò!rá]	'person to put in hot water'
ní + hàbdâ → ní hàb!dá	[ní hàw!rá]	'person to squeeze'

2.10 CONDITIONING OF [VOICE] INSERTION

2.10.1 Yabem

Yabem is an Oceanic Austronesian language of the North Huon Gulf in Papua New Guinea. Data relevant to the conditioning of obstruent voicing comes from Ross 1993 and Bradshaw 1979. In addition, Poser 1981 argues for such an analysis of Yabem based on Bradshaw 1979, Dempwolff 1939 and Zahn 1940.

In Yabem, the 1st singular prefix on monosyllabic verb stems in the realis form is realized as either *ká* or *gà* depending on whether the verb root is L or H in tone, as in (70).

(70)	<i>ká-pún</i>	'I plant'	<i>gà-bù</i>	'I insult'
	<i>ká-táj</i>	'I weep'	<i>gà-gùŋ</i>	'I spear'
	<i>ká-kó</i>	'I stand'	<i>gà-dèng</i>	'I move towards'

Furthermore, there is a correspondence between tone and voicing which is spelled out in the chart in (71) which is based on information derived from Bradshaw 1979 and Ross 1993. In these short verbs, all obstruents are either voiced or voiceless and all tones are either H or L. Moreover, voiceless stops occur only with H tones, and voiced obstruents (all of which are stops) occur only with L tones.

(71) Cooccurrence Restrictions in Yabem

	L	H	voiced stop	voiceless stop	fricatives & sonorants
L	✓	∅	✓	∅	✓
H	∅	✓	∅	✓	✓
voiced stops	✓	∅	✓	∅	✓
voiceless stops	∅	✓	∅	✓	✓
fricatives & sonorants	✓	✓	✓	✓	✓

Note: the fricatives are not contrastive for voicing.

It initially appears plausible both that voicing can be predicted from tone and that tone from voicing, but only one of these predictions actually works. Specifically, it is

voicing that is predictable from tone. In some verb stems, as in (72), there are no contrastively voiced consonants and such verbs may be H or L in tone, depending on their underlying tone pattern. Neither fricatives nor sonorants contrast in voicing in Yabem. The tone on verb stems with no stops is unpredictable. This indicates that voicing is predictable from tone, and tone is unpredictable. It follows then that tone is underlying and obstruent voicing is derived from tone.

(72)	<i>ká-sóm</i>	'I speak'
	<i>gà-sùŋ</i>	'I shove'

Longer verbs, as in (73), provide evidence that it is L tone rather than H tone that determines stop voicing. When the realis prefix is attached to a disyllabic verb stem, it is uniformly realized as *ká*. In these forms, the verb stem does not affect the realization of the realis prefix because the realis prefix is not within the same foot as the verb stem. Thus, the domain for the voicing process is a foot, and the underlying form of the prefix is *ká*. Since the underlying form of the prefix has a voiceless obstruent and a H tone, it is the L tone that triggers voicing, as pointed out by Ross 1993.

(73)	a.	<i>ká-léti</i>	'I run'
		<i>ká-kátóŋ</i>	'I make a heap'
	b.	<i>ká-dàbìŋ</i>	'I approach'
		<i>ká-gàbwàʔ</i>	'I untie'
		<i>ká-dámwè</i>	'I lick'
		<i>ká-màdòm</i>	'I break in two'

Thus, as in (74), the depressor effect in question is one in which voicing on obstruents is triggered by the presence of a L tone.

(74)	<i>ká + bù</i> → <i>gà-bù</i>	'I insult'
	<i>ká + gùŋ</i> → <i>gà-gùŋ</i>	'I spear'
	<i>ká + dèng</i> → <i>gà-dèng</i>	'I move towards'

2.10.2 Jingpho

Gemination in Jingpho morphemes with L tone produces voiced obstruents; with H tone, obstruents remain voiceless. Thus, obstruents become voiced after L tone. There is no evidence that obstruents become voiceless after H tone since the voiceless obstruent geminates alternate with voiceless obstruent singletons.

(75) Jingpho (Maddieson 1974)

yák	'difficult'	yàggai	'it is difficult'
cát	'tight'	cáttai	'it is tight'

2.10.3 Yaka

Yaka, a Bantu language spoken in the Central African Republic, provides another case in which L tone triggers obstruent voicing. As Kutsch Lojenga 1998 describes it, nouns which are class 5 in the singular and class 6 in the plural alternate tonally between an initial H tone in the plural and an initial rising tone in the singular. Since there is no other prefix for class 5 nouns, it is postulated that the prefix is a floating L tone.

(76) Yaka (Kutsch Lojenga 1998)

<i>Class 5</i>		<i>Class 6</i>	
bíla	'oil palm'	ma-bíla	'oil palms'
dǒká	'neck of axe or hoe'	ma-dǒka	'necks of axes or hoes'
lǒi	'ear'	ma-lói	'ears'
nǒi	'dripping of water'	ma-nói	'drippings of water'
ndíki	'wild yam, sp.'	ma-ndíki	'wild yams, sp.'
yáká	'Yaka language, speech'	ma-yáká	'Yaka languages'

When the root-initial consonant is a voiceless obstruent, the floating L tone not only surfaces on the initial vowel, but also voicing is triggered on the initial obstruent¹¹. Both stops and fricatives become voiced, although only stops have a voiced series underlyingly.

¹¹ Kutsch Lojenga postulates a floating [voice] feature in addition to the floating L tone, but there is no evidence that supports such an analysis in preference to the one suggested here and when this analysis was suggested to her, she had no objection to it.

ingly. There are two fricatives in Yaka, φ s. The s voices to the noncontinuant d_3 , while φ voices to β which is not underlyingly present.

(77)

<i>Class 5</i>		<i>Class 6</i>	
bǒdi	'kind of honey'	ma-pódi	'honeys'
dǎdi	'sun'	ma-tádi	'suns'
dǒlóló	'mushroom'	ma-sóló	'mushrooms'
gǎngala	'wooden frame'	ma-kángala	'wooden frames'
gbǒngbǒlóló	'bat, sp.'	ma-kpǒngólóló	'bats, sp.'
βǒǰa	'word'	ma-ǰóǰa	'words'

2.11 SUMMARY

Depressor effects are diverse, but they always indicate a special relationship between voicing and L tone, usually in requiring that a L be inserted or maintained after a voiced obstruent, but sometimes in requiring that a voiceless obstruent become voiced before a L tone. These effects occur in an impressive number of languages and it is clear that not every case of depressor effects has been described in the literature, as new cases are being mentioned continually. The languages which display depressor effects are also diverse both genetically and geographically. The languages are spoken in all parts of Africa and in Asia. They fall into language families as diverse as Niger Congo, Austronesian and Thai. These effects are not the result of historical accident. Even when depressor effects occur in closely related languages, such as Suma and Gbaya bokota, the effects which surface are significantly different between the two languages. Thus, in Suma, the depressor effect shows up in the phonology of the verbal aspectual system, while in Gbaya bokota, it shows up in the associative construction. The associative construction in Suma is quite similar to that in Gbaya bokota, but without the depressor effect. Thus, it is not unreasonable to suppose that the depressor effects were derived independently within a group of languages which are predisposed in some way to this kind of development.

A comprehensive list of languages with depressor effects included in this study is given in (78).

(78) List of languages with depressor effects

AfroAsiatic

Chadic

- Ngizim (Schuh 1971): Nigeria
 - H spread blocked & L spread conditioned by voiced obstruents
- Bade (Schuh 1978): Nigeria
 - H spread blocked by voiced obstruents
- Ouldeme (de Colombel 1986): Cameroon
 - 'syllables with a depressor consonant take L' (Swackhamer 1991)
- Mulwi (Tourmeux 1982): Cameroon, Chad
 - L inserted after voiced obstruents
- Bolanci (Lukas 1969): Nigeria
 - H Spread blocked by voiced obstruents
- Miya (Schuh 1998): Nigeria
 - H Docking blocked by voiced obstruents

Niger Kordofanian

Niger Congo

Adamawa-Ubangi

- Suma (Bradshaw 1995a): Central African Republic
 - L inserted after voiced obstruents before a H tone
- Gbaya 6okota (Bradshaw, field notes): Central African Republic
 - Docking of associative H blocked by voiced obstruent

Kwa

- Ewe (Stahlke 1971, Ansre 1961, Smith 1968): Ghana, Togo
 - L docking conditioned by voiced obstruents in singular imperative
- Ebrié (Kutsch Lojenga 1985): Ivory Coast
 - H spread blocked after voiced obstruents
- Siya (Ford 1986): Ghana
 - H spread blocked after voiced obstruents

Gur

- Dagara-wule (Somé 1998): Burkina Faso, Ghana
 - H spread blocked by voiced obstruents

Benue Congo

Narrow Bantu

- Makaa (Heath 1991): Cameroon
 - In associative construction with a final depressor, a L-toned vowel is epenthesized or a downstep triggered if other conditions are met

Bantu

Nguni

- Zulu (Cope 1970, Khumalo 1987): S. Africa
 - H spread blocked by voiced obstruents; L insertion

Siswati (Bradshaw 1996): S. Africa & Swaziland

H spread & H shift blocked by voiced obstruents; H shift triggered by voiced obstruents; L insertion, etc.

Isixhosa (Cassimjee 1998): S. Africa

H shift triggered & blocked by voiced obstruents

Phuthi (Donnelly p.c.): Lesotho

H shift triggered & blocked by voiced obstruents

Mijikenda

Digo (Kisseberth 1984): E. Africa

H spread, H shift & H docking blocked by voiced obstruents

Chonyi (Cassimjee & Kisseberth 1992): E. Africa

prefix H fails to shift/spread when verb has initial voiced obstruent

Duruma (Cassimjee & Kisseberth 1992): E. Africa

prefix H fails to shift/spread when verb has initial voiced obstruent

Dzihana (Cassimjee & Kisseberth 1992): E. Africa

prefix H fails to shift/spread when verb has initial voiced obstruent

Kambe (Cassimjee & Kisseberth 1992): E. Africa

prefix H fails to shift/spread when verb has initial voiced obstruent

Chikauma (Cassimjee & Kisseberth 1992): E. Africa

L inserted & downstep triggered after voiced obstruents, prefix H fails to shift/spread when verb has initial voiced obstruent

Rabai (Cassimjee & Kisseberth 1992): E. Africa

prefix H fails to shift/spread when verb has initial voiced obstruent

Chirihe (Cassimjee & Kisseberth 1992): E. Africa

L inserted & downstep triggered after voiced obstruents, prefix H fails to shift/spread when verb has initial voiced obstruent

Giryama (Cassimjee & Kisseberth 1992): E. Africa

prefix H fails to shift/spread when verb has initial voiced obstruent

Shona

Ikalanga (Hyman & Mathangwane 1994): Botswana

H spread blocked by voiced obstruents

Yaka (Kutsch Lojenga 1998): Central African Republic, Rep. of Congo-Brazzaville

L inserted after root-initial voiced obstruents, L triggers voicing

Austronesian

Yabem (Bradshaw 1979, Ross 1993): North Huon Gulf

L triggers voicing

Thai

Jingpho (Maddieson 1974):

L triggers voicing in geminates

CHAPTER 3

A MULTIPLANAR APPROACH TO CONSONANT-TONE INTERACTION

3.1 INTRODUCTION

It is important to recognize that consonant-tone interaction involves not just any consonant, but specifically those consonants that are voiced, and especially those that are contrastively voiced, i.e. voiced obstruents. This provides evidence that tones interact with a segmental feature of voiced consonants, and that feature would be [voice]. But it is not entirely clear, especially given the most common approaches to tone within feature geometry, why it is that [voice] would interact with tone. Generally, phonology has aimed at capturing interactions such as this one in terms of features that interact on a single tier. It has been proposed that tone may share features with voicing (Halle & Stevens 1971, Duanmu 1990), but the preponderance of evidence suggests that tone is suprasegmental, while voicing is subsegmental. Given the evidence from consonant-tone interaction, we are led to the conclusion that tone has a dual nature, one that is both segmental and suprasegmental. In this chapter, I present a modification of feature geometry designed to account for consonant-tone interaction. The motivation for the change I propose comes from the dual nature of tone.

3.2 THE SUPRASEGMENTAL NATURE OF TONE

In Chapter 2, evidence for the segmental nature of tone as demonstrated by its interaction with voiced consonants is laid out in some detail. Here I present some of the evidence for the suprasegmental nature of tone. In its suprasegmental manifestation, tone is usually represented as associating to the mora, though there have also been arguments for associating it to the syllable (Clements 1984, Hyman 1988, Odden 1990). I will take the position that it is the mora that is the suprasegmental tone-bearing unit.

Since the autosegmental approach was proposed, it has been the standard assumption that tones are suprasegmental. The irrelevance of segments to tone processes in many languages argues against the segmental nature of tone and for its suprasegmental nature. Even in languages with consonant-tone interaction, there are always some tone operations that ignore all segmental factors. In Siswati and the other Nguni languages, where there is extensive consonant-tone interaction, there are tone processes that are unaffected by depressor consonants. One such process is Antepenult Attraction in which the rightmost H of a word is attracted to the antepenultimate syllable. The data in (1a) illustrate Antepenult Attraction in Siswati. The H that originates on the infinitive prefix is realized on the antepenultimate syllable of the verb. In (1b), intervening depressor consonants (*b, ʔ*) do not block the H from migrating to the antepenult.

- (1) a. kú-liima 'to plow'
ku-límiisa 'to cause to plow'
ku-limísaana 'to cause e.o. to plow'
ku-limisélaana 'to cause to plow for e.o.'
- b. e-sí-bamu-an-eni → esibànyáneeni 'on the small gun'
kú-khántiḡ-is-el-an-a → kúkhántiḡisélaana 'to cause to dry roast for

While Antepenult Attraction ignores segmental properties, processes like depressor-induced H shift (DIHTS) are sensitive to depressor consonants. (2a) illustrates the interaction of DIHTS and Antepenult Attraction. The shifting of H from the prefix to the

antepenult in Antepenult Attraction ignores the depressor consonants (*b, z, g*), while the shifting of H from the antepenult to the penult in DIHTS is sensitive to the presence of voicing on an obstruent. Similarly, Antepenult Attraction interacts with H shift blocking in (2b) where the shifting of H to the antepenult is not blocked, while the shifting of H to the penult is blocked.

- (2) a. kú-bocana → ku-bòcáana 'to smear each other'
 kú-cafuzelana → ku-cafuzèláana 'to kiss each other for'
 kú-ongesela → k-ongèséela 'to cause to economize for'
- b. ín-ɣovo-ana → inǰòvǎànà 'little elephant'
 lí-dada-ana → lidádàànà 'little duck'
 lú-bambo-ana → lubǎnjǎànà 'little rib'
 ín-dvodza-ana → indvǒjáànà 'little man'
 é-dada-eni → edǎdèèni 'on the duck'
 é-ɣaɣa-eni → eǰǎɣèèni 'in the cooking hut'

More evidence that tone associates to the mora is found in the existence of contour tones in which, for example, a L and a H tone may both be realized on a single vowel (*ǎ* or *â*). It has been traditionally assumed that phonological features internal to a single segment cannot be linearly ordered. Even with the advent of feature geometry, where such a possibility appears more easily implemented, the internal ordering of features under the root node has been prohibited (see Clements & Hume 1995 and the No Branching Constraint). Under these assumptions, the presence of contour tones on single segments demands that tone be linked above the level of the segment. If not, HL and LH contours in the same language would be formally indistinct within a feature theory which does not recognize linear ordering of phonological elements under the segmental root node.

A further argument for the suprasegmental (and moraic) nature of tone is found in languages where there is a correspondence between the number of tones and the number of moras present in a word. In the Suma language, the number of tones on a word is limited to the number of moras present (Bradshaw 1995). As shown in (3), a trimoraic word (CVCVC) can have up to three tones. A bimoraic word, whether disyllabic (CVCV) or

monosyllabic (CVV, CVC) can have up to two tones. A monomoraic word (CV) can have only one tone.

(3)	1 tone	2 tones	3 tones
CμCμCμ	níkírí 'exaggerate'	zíkídí 'delay'	sùmárí 'secret society'
CμCμ	kírí 'look for' yárí 'unravel'	gòbí 'twist' záfí 'sneeze'	NA
Cμμ (CVC)	búk 'applaud' rém 'be able to'	bòm 'be blind' dík 'be sonorous'	NA
Cμμ (CVV)	lǎá 'suck' kúú 'stand up'	dúú 'be long' gǐí 'lean'	NA
Cμ	fó 'agitate' bé 'refuse'	NA	NA

When a monomoraic verb such as *bé* 'refuse' becomes bimoraic through suffixation, two tones are possible, as in *bǎá* 'refusing' where the expected depressor L tone surfaces. This active correspondence between the number of moras and the number of permissible tones is accounted for in a straightforward way if tones are suprasegmental (and moraic) in nature.

Another source of evidence for the suprasegmental (and moraic) nature of tone comes from languages in which grammatical tones are assigned to a specific mora, ignoring the number of segments and syllables in the process. In Kikuria (Odden 1995) and in Kimatuumbi (Odden 1996), a grammatical H is assigned to a particular mora of the verb stem; which mora depending on the particular tense/aspect to be expressed. For example, in the perfective form of Kikuria verbs, given in (4), H is assigned to the fourth mora of the verb stem. No generalization for the location of tone assignment can be made with reference to syllables or segments.

(4) Kikuria (Odden 1995)	Segment	Syllable	Gloss
n-[terék-eré]	8	4	'I have cooked'
n-[karaang-ére]	7	3	'I have fried'
n-[ga-karaang-ére]	6	3	'I have fried them'
m-[beebeét-ére]	4	2	'I have sieved'
m-[ba-bebeét-éeye]	6	3	'I have sieved for them'

This assignment of H by mora counting is found in other forms of the verb as well. Odden 1995 goes on to show that H is assigned to the third mora in the subjunctive, to the second mora in the recent past, and to the first mora in the remote past.

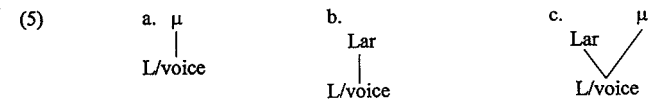
There is compelling evidence of various kinds that tone is suprasegmental rather than segmental. This evidence makes a strong case for associating tone to the mora. If tone is represented at a level totally removed from segmental information, it is expected that there would be no interaction between tone and segmental features. But contrary to expectation, such interaction does occur and provides compelling arguments for associating the tone under the segmental root node, which contradict the arguments for associating tone suprasegmentally. In order to resolve the conflicting demands of the evidence for segmental and suprasegmental representations of tone, I propose a Multiplanar approach that succeeds in capturing tone's dual nature. It differs significantly from previous approaches, most of which have chosen between a strictly suprasegmental or strictly segmental characterization of tone.

3.3 THE MULTIPLANAR APPROACH

The Multiplanar approach seeks to incorporate the generalization, arising from a consideration of consonant-tone interaction, that tone is segmental as well as suprasegmental. Another generalization that it seeks to incorporate is that the segmental interaction involves consonants that are voiced. The reason voiced obstruents alone interact with tone can be traced to the presence of a privative feature for voicing¹ which is generally found only on voiced obstruents. The privative nature of [voice] accounts straightforwardly for the exclusion of voiceless obstruents, which necessarily lack a voicing specification, from depressor effects. Implosives likewise are assumed to lack a voicing specification, as are sonorants in most (but not all) languages. The only consonants that are inevitably specified for [voice] are voiced obstruents, and these are the consonants that inevitably participate in consonant-tone interaction if any occurs.

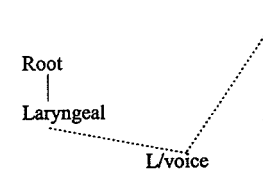
¹ The privative nature of [voice] is argued for in Mester & Ito 1989 and Lombardi 1994.

Merely identifying the importance of [voice] does not provide an account of why depressor effects are associated with it. When elements such as L tone and voicing interact and produce assimilatory and dissimilatory effects, this reflects the existence of a common feature on a common tier. Therefore, it is proposed that L tone and [voice] are one and the same feature. The difference in their phonetic realizations is due to a difference in their featural configurations. That is, when this feature attaches to a mora, as in (5a), it is realized as lowered pitch and is suprasegmental in nature. When it attaches to the Laryngeal node of a segment, as in (5b), it is realized as voicing and is segmental in nature. In (5c), the dual nature of this feature is expressed, when it is attached to both the Laryngeal node and the mora. Thus, with the representation in (5c), both voicing and lowered pitch are realized. Thus, a L tone is realized on a vowel after a depressor consonant, and H tone is blocked from spreading there.



The full Multiplanar model is illustrated in (6). It consists of a single privative feature which represents both L tone and voicing and which can attach to both the Laryngeal node of a segment and to a mora.

(6) Multiplanar Model of Consonant-Tone Interaction²

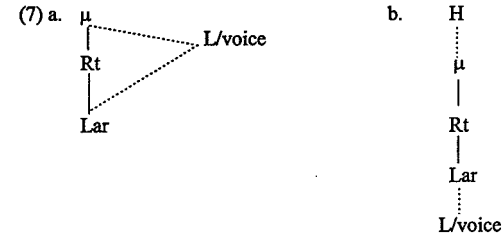


² I presented my first version of this model in Bradshaw 1995.

The L/voice feature is discussed in more detail in Chapter 6, where its phonetic correlates are defined. Because of its tonal manifestation, i.e. when it is associated to a mora, and its interaction with other tones, we might expect it to correspond to a particular tone feature. This is an area that will remain unexplored in this dissertation. The languages that participate in consonant-tone interaction do not lend themselves readily to a clear analysis in terms of tone features. Only two have four tones, and those with three or two tones show little evidence for any one particular featural analysis. Moreover, the tone features needed for tone languages in general is still an open area for research. The analysis of tone in Kikamba (Roberts-Kohn 199x), in Ju'hoasi (Miller-Ockhuizen 1996) and in Ali (Bradshaw 1998) indicate that tone features such as [+/- raised pitch] and [+/- upper register] are not sufficient to describe the range of tonal behaviors in tone languages. However, it is interesting to note that consonant-tone interaction involves the lowest phonological tone present in any tone language, although this fact must remain unexplained for the moment.

Another interesting aspect of consonant-tone interaction, one that is mirrored in the Multiplanar account, is that the asymmetry in which only L tone participates in these interactions, to the exclusion of other tones such as M and H. In the Multiplanar account, L alone among the tones is crossplanar in nature. A L tone can be associated to either the Laryngeal node or to the mora. The question arises as to whether it can be associated to both the Laryngeal node and the mora of the same segment. There is no evidence that obstruents are ever tone-bearing, so we must consider sonorants, which can be tone-bearing and are occasionally phonologically voiced, in order to answer this question. In fact, no data has yet been uncovered in which a sonorant is both tone-bearing and phonologically voiced. In principle, however, this is possible. Such a segment, if it were to occur in a tone language, might be realized as L in tone because it is attached to a mora which is so specified, as in (7a). Alternatively, such a segment might be realized as H in tone when its mora is associated to a H, as in (7b). There is no contradiction in the feature geometric figure of (7b), although it might at first glance appear that a segment is

specified for both H and L tone simultaneously. It is actually the mora that is specified as H and the segment which is specified as L/voice, and the manifestation of L/voice on the Laryngeal plane differs from its manifestation on the tonal plane. Thus, (7b) simply represents a phonologically voiced sonorant which is realized with contrastively high pitch. No difference in realization would be expected for a H-toned sonorant which is underspecified for voicing (and such underspecification is assumed here to be the unmarked case). This being said, it is unlikely that sonorants with the configurations in (7) will be found, given the rarity of sonorants that are phonologically voiced.



There are a number of advantages to the Multiplanar model. It provides a 'nonaccidental' account of voice-tone interaction. It is consistent with current feature theory which allows for features to be transplanar in nature (see Hume 1994). It captures the dual nature of tone, whereby it is both segmental and suprasegmental. It allows for opacity and transparency effects. Finally, it correctly predicts a number of phenomena that are not predicted by other approaches. It predicts the bidirectionality of voice-tone interaction found in languages like Yabem. It predicts that there can be a distinction between a L tone that is linked to both a consonant and a mora, and one that is linked only to a mora. This has practical consequences for an account of *ŋ* in Siswati. It predicts that a depressor effect can occur without the insertion of a L tone on a mora as is found in Chirihe and Chikauma. These advantages and predictions are dealt with in more detail in

the sections after Section 3.4 in which other models that have been used to deal with consonant-tone interaction are examined.

The Multiplanar approach also makes several predictions that are falsifiable and can serve as a test of the theory's validity. It predicts that there can be no clearcut cases of consonant-tone interaction involving voiceless obstruents. The few questionable cases that I've been able to find do not pose a problem. Yet it is not difficult to imagine what a clearcut case might look like. For example, a language might have verbs that alternate tonally according to tense such that in the past, a grammatical L tone is realized, in the present, a M tone, and in the future, a H tone. Voiceless obstruent initial verbs would be HL in the past, M in the present and H in the future in contrast to all other verbs which would simply alternate between L, M and H.

(8) Hypothetical data

<i>Verb</i>	<i>Past</i>	<i>Present</i>	<i>Future</i>	
pa	pà	pā	pá	'see'
ba	bà	bā	bá	'dry roast'
ma	mà	mā	má	'be blind'
a	à	ā	á	'hunt'

The crucial point is that there would be actual alternations in which voiceless obstruents would have a H tone before any following L, but voiced obstruents would not have a L tone before a following H. Other kinds of language data could also make the case that voiceless obstruents must participate in consonant-tone interaction, and such data would falsify the Multiplanar approach. One more scenario should suffice to illustrate a strong case against this approach. If it is false, we might expect to find a language similar to the Nguni languages in which all voiceless obstruents are followed by H tones. A process that causes a L to be displaced to the antepenult might be followed by a process like DIHTS, and the L tone would shift to the penult if the antepenult begins with a voiceless obstruent. However, if the penult also has a voiceless obstruent onset, the L tone might be blocked and a falling tone might appear on the antepenult.

The Multiplanar approach could also be falsified, at least theoretically, by a language in which there is a clear contrast between breathy voiced and plain voiced obstruents, and in which the breathy voiced obstruents participated in phonologically active consonant-tone effects to the exclusion of the voiced obstruents. However, it is difficult to find a language which has both a clear contrast and tone, though the Khoisan language, Ju/'hoasi, is one such example. A clear contrast would most straightforwardly involve 4 series of obstruents: breathy voiced, plain voiced, voiceless and voiceless unaspirated. It is even more difficult to find a tone language with a clear phonological contrast between breathy and plain voiced obstruents and with consonant-tone interaction that is phonologically active. If such a language were found, it is predicted that the consonant-tone interaction would include both plain voiced and breathy voiced consonants. If it only included breathy voiced consonants, then the Multiplanar approach would be proved false.

3.4 OTHER MODELS

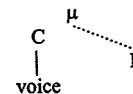
3.4.1 Suprasegmental Approaches

Because of the compelling arguments for the suprasegmental nature of tone, some phonologists have taken a suprasegmental approach to consonant-tone interaction in which tones are associated to the mora.

3.4.1.1 Simple Suprasegmental Approaches

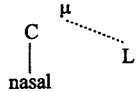
The most straightforward suprasegmental approaches to consonant-tone interaction, like those in Bradshaw 1995 and Hyman & Mathangwane 1998, simply allowed [voice] to trigger the insertion of L on a mora, as in (9).

(9) Suprasegmental approaches of Bradshaw 1995 and Hyman & Mathangwane 1998



The main problem with this sort of approach is that the relationship between L tone and [voice] is accidental. As in (10), we could equally well imagine L being inserted after a consonant specified as [nasal] or [lateral] or anything else.

(10) Unattested but equivalent L insertion process



3.4.1.2 Peng 1992 Approach: Grounded Phonology

Peng 1992 attempts an explicit and detailed account of the interaction between voiced obstruents and tone. Although his focus is on the importance of the segmental interaction, his approach is essentially suprasegmental. It relies on adopting the Hyman (1985) representation of moraic theory in which onset consonants are linked to the same mora as the nuclear vowel, as in (11a). In this representation, the mora can serve as the tone-bearing unit and tone can be independent of segmental factors, but there is still a direct link between the consonant that conditions tone and the tone, in contrast to the more widely accepted version of moraic theory, shown in (11b).



Peng adopts the framework of grounded phonology (Archangeli and Pulleyblank, 1992) which makes this connection between the voicing of the consonant and the tone more direct because of its notion of 'path'. Path is defined as in (12).

- (12) There is a *path* between α and β iff
- (i) α and β belonged to a linked set Σ of nodes/features, and
 - (ii) in the set Σ , there is no more than one instance of each node/feature.

According to this definition, the onset consonants in (11a,b) are on the same path as the leftmost mora, while the coda consonant (only in 11a) is not because there is another mora intervening. Likewise, no two segments are on the same path because there is always more than one root node intervening between the subsegmental feature content of different segments.

The connection between the laryngeal node of voiced obstruents and the tone itself (through the mora) is expressed by the notion that they are on the same path and conditions can be placed on paths. This is where stipulation enters into this model. The path conditions, which amount to constraints, are conditions on particular processes rather than being true for all processes or being surface true. What we stipulate as conditions on processes involving consonant-tone interaction varies. We can stipulate that [voice] and H cannot cooccur on a path. We can stipulate that [voice] and L must cooccur on a path. What stops us from stipulating that [voice] and H must cooccur or that [voice] and L must not cooccur? It is only the added stipulation that path conditions must be phonetically motivated. If we accept the stipulation, we must have a method of judging what is phonetically motivated, and that method must not be based on an assessment of what happens in the phonology of languages crosslinguistically since doing so would render the claim of phonetic motivation vacuous. However, the questions that phonetics asks about consonant-tone interaction seem to be determined by the phonological observation that voiced obstruents interact with tone in a particular way.

Peng considers the voicing feature to be binary. From one perspective, this seems required by the need to account for the blocking effect of voiceless obstruents as well as voiced obstruents in languages like Ngizim. His path conditions for the blocking of L must account for the effects of implosives as well as voiceless obstruents. Thus, he ends up with 2 disjoint path conditions: (i) if [-Hi] (ie. L) then not [c.g.] and (ii) if [-Hi] then not [+voice]. It is indeed hard to imagine how one can account for voiceless obstruents and implosives patterning together to the exclusion of voiced obstruents using the features available to us. However, if we are forced to write disjoint specifications to capture

the patterning, this does not entail that the disjoint features must be those chosen by Peng. It is equally legitimate to have the positive path conditions: (i) if [-Hi] then [voice] and (ii) if [-Hi] then [+sonorant]. As will be discussed in chapter 6, there appears to be some phonetic motivation for an interaction between L tone and sonorants, as well as a phonetic motivation for sonorants and voiced obstruents patterning together although this fails to occur in most languages. However, if these conditions are stated positively rather than negatively, then both voiced obstruents and sonorants violate them because both conditions cannot be satisfied. Thus, the notion of a privative voicing feature is incompatible with Peng's model of voice-tone interaction unless disjoint path conditions of the either/or variety are allowed. Such a path condition would state: if [-Hi], then [voice] or [+sonorant].

Peng's approach is relatively unconstrained. In order to capture the blocking effects of voiced obstruents at least four different pairs of path conditions could be invoked, as given in (13). The fact that some path conditions, i.e. (13b,c), would never be invoked since they imply the tones would not occur with sonorants, makes the system even more unconstrained. Note that Peng considers sonorants to be phonologically unspecified for voicing. Peng fails to demonstrate that we need this many possible path conditions to deal with consonant-tone interaction crosslinguistically. Certainly, the Multiplanar approach is a more restrictive theory.

- (13) a. if H, then not [+voice]
 b. if L, then [+voice]
 c. if H, then [-voice]
 d. if L, then not [-voice]
 e. if [+voice], then L
 f. if [+voice], then not H
 g. if [-voice], then not L
 h. if [-voice], then H

Although Peng 1992 offers a model with some appeal because of the connection between the onset consonant and the following vowel which excludes coda consonants, in

the final analysis it fails to capture consonant-tone interaction in the representation. Instead it relies on processes and constraints on processes (called path conditions) to capture the interaction. This approach is barely less arbitrary than an approach with rules or constraints that do not refer to paths, and it introduces its own set of problems.

3.4.2 Segmental Approaches

3.4.2.1 Halle & Stevens 1971 Approach

There have also been segmental approaches where the TBU is clearly identified as the Laryngeal node of the segment. The first such approach seems to be Halle & Stevens 1971, where the same two binary features express both voicing and tone. Their representation treats pitch in vowels and voicing in consonants as the same phenomenon in an articulatory sense through reference to laryngeal musculature, as Bao 1990 points out. The binary features they introduce for this purpose are [stiff vocal folds], [slack vocal folds], [spread glottis] and [constricted glottis]. With these four features, only nine distinctions are deemed possible, since the combinations [+stiff, +slack] and [+constricted, +spread] are declared 'logically and physiologically impossible'. The tonal distinctions are made with the values [-constricted glottis, -spread glottis]. Thus, there are only 3 possible tonal distinctions, corresponding to the 3 possible combinations of [stiff] and [slack], as illustrated in (14).

(14) Halle & Stevens 1971's Segmental Approach

	H	M	L
stiff	+	-	-
slack	-	-	+

This model both overgenerates and undergenerates. It overgenerates the number of consonant types and undergenerates the number of possible tone contrasts in a language. For reference, the full table illustrating the nine combinations of their laryngeal features is given in (15).

(15) Laryngeal feature specifications (Halle & Stevens 1971)

	1	2	3	4	5	6	7	8	9
obstruents	b _l	b	p	p _k	b ^h	p ^h	ʔ	ʔ ^h	p ^ʔ
glides	w, y				f	h, W, Y			ʔ, ʔw, ʔy
vowels	v	v̤	v̥	voiceless vowels	breathy vowels			creaky voice vowels	glottalized vowels
spread glottis	-	-	-	+	+	+	-	-	-
constricted glottis	-	-	-	-	-	-	+	+	+
stiff vocal cords	-	-	+	-	-	+	-	-	+
slack vocal cords	-	+	-	-	+	-	-	+	-

Although only three tone contrasts can be generated with these features, it is widely accepted that languages with at least four tone contrasts are attested³, and it has even been claimed that as many as five and six tone contrasts exist in other languages⁴. The problem of undergenerating possible tone contrasts in the Halle and Steven 1971 model has been pointed out repeatedly (Fromkin 1972, Anderson 1978, Yip 1980, Bao 1990, Duanmu 1990) and is not controversial.

The overgeneration problem comes down to the fact that the need for the nine possible laryngeal contrasts predicted by the Halle & Stevens' model has not been attested in any language. Especially questionable is the need to make a contrast between *b_l*

³ These languages include Siya (Ford 1986), Kikamba (Roberts-Kohno 19xx) and Ewe (Clements 1978) among a number of others.

⁴ Languages that have been claimed to contrast 5 tones include *Copala Trique* (Longacre 1952, 1959; Hollenbach 1984); *Ticuna* (mentioned in Hollenbach 1984); *Kporo* (mentioned in Hollenbach 1984); *Chinantepec* (Skinner 1962, cited in Edmondson & Gregerson 1992), *Kam* (Edmondson & Gregerson 1992), *Hei Miao* (aka *Black Miao*) and *Tahua Yao* (Chang 1953), Ivory Coast dialect of *Dan* (Beard & Zemp 1967); *Ngamambo Bamileke* (Asongwed & Hyman 1977, cited in Anderson 1978) a Tai language of Guizhou, China, *Shuicheng Fa'er Bouyei* (Report of the Survey of Buyi Languages, Peking, 1959, in Chinese, cited in Wang 1967, further details given in Edmondson & Gregerson 1992). Six phonological tones are analyzed as necessary in *Chori*, a Plateau language of Nigeria (Dihoff 1967, cited in Odden 1995).

and *b*, between *p_k* and *p^h* and between *ʔb* and *ʔ*. *b_l* is said to represent a 'lax voiceless stop' and is identified with the *b* that occurs word initially in English; while *p_k* is identified as the 'moderately aspirated stop of Korean'. There is no evidence that *b_l* and *b*, *p_k* and *p^h*, or *ʔb* and *ʔ* are contrastive in any language.

The laryngeal feature specifications of this model also predict that vowels cannot be both breathy and bear tone. Here a breathy vowel must be specified as [+s.g., -c.g.] whereas a vowel with any tone must be specified as [-s.g., -c.g.]. Yet there are languages such as the Tibeto-Burman language Gurung (Glover 1970) in which breathy vowels bear tone. Phonologically, the tone contrast on either a breathy or clear vowel can be either H or L, as shown in (16). Phonetically, the breathy vowel's L tone is lower than that of the clear vowel. A H tone on a clear vowel is phonetically high, but on a breathy vowel it is realized as a glide from low to mid pitch. In the Tibeto-Burman language, Gurung, vowels contrast phonologically in both breathiness and tone (Glover 1970).

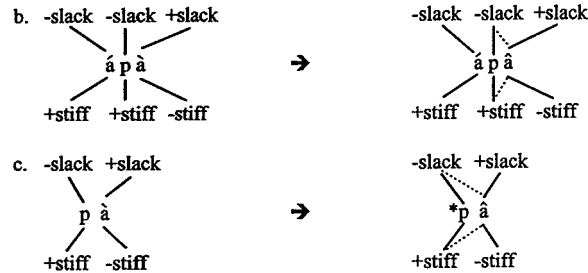
(16) Gurung (Glover 1970)

Orthogr.	Phonemic	Phonetic	Gloss
mih	/mi ^h /	[m ^h i ^h]	'person'
mi	/mi/	[m ^l i]	'fire, tail'
mehq	/mɛ ^h /	[m ^h ɛ ^h]	'cow'
myaaqba	/myáába/	[m ^h yáába]	'to scour'
kuturuge	/kukuruge/	[kukurug ^h e]	'bracken'
kuhrImba.c	/ku ^h rimbae/	[ku ^h rimbae]	'next year's'

Another problem arises in accounting for transparency effects related to tone spreading if we interpret Halle & Stevens from a more contemporary vantage in which autosegmentalism is assumed. Since almost all segments in the Halle & Stevens model are specified for laryngeal features, this model would predict opacity where it doesn't exist. For example, a plain *p* and a H-toned vowel have the same laryngeal specifications, as in (17a). Thus, the spreading of a H tone across a *p*, as in *ápà* → *ápà* (17b), is expected, and this kind of process is found, but it is also expected that H would spread from

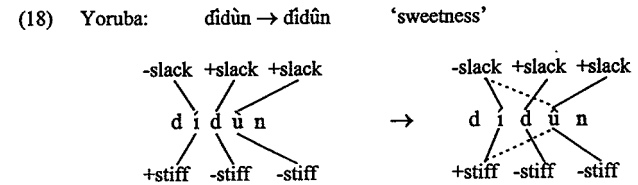
a *p* when it is not preceded by a vowel, as in *pà* → **pâ* (17c), and this is not actually attested in any language.

- (17) a. *p* = [-spread, -constricted, +stiff, -slack]
v̂ = [-spread, -constricted, +stiff, -slack]
v̄ = [-spread, -constricted, -stiff, +slack]



Due to the laryngeal specification of all segments, and contrary to what is attested in all tone languages with any form of tone spreading, this model predicts that tone does not spread from vowel to vowel when there is an intervening consonant. One can assume some form of underspecification, as Duanmu 1990 apparently does when he points out a problem the Halle & Stevens model has with tone spreading across sonorants but not across obstruents. As Duanmu interprets the model, when tone spreads across sonorants, it spreads from the vowels, and when it spreads across obstruents it spreads from the onset. This would be problematic because tone rules would uniformly have to treat *awa*, *apa* and *aba* differently. Duanmu claims that tone spreads from the vowel in forms like *áwà* → *áwâ*, whereas in the model, the glide *w* is specified as [-stiff, -slack] and would not be transparent to spreading of these features. If contrastive underspecification is not assumed, no consonants would be transparent to tone spread. Thus, the most prevalent type of tone process, one in which consonants are ignored, is a situation this model cannot account for.

Another aspect of the transparency problem is that there are many tone languages with contrastive voicing where voiced obstruents are transparent to tone spreading. In (18) an example from Yoruba, cited in Duanmu 1990, illustrates a H tone spreading over a voiced obstruent. In the Halle & Stevens model, this should never be possible because of the ban against crossing association lines.



This use of the same feature for both voicing and tone is similar to the Multiplanar model, but there are important differences in how this is implemented. Perhaps the most significant difference is that the Halle & Stevens 1971 approach is not framed within feature geometry, which didn't exist at the time. Another obvious difference is that the Multiplanar model confines the interaction to L tone and [voice], while Halle & Stevens include all laryngeal features in the interaction, contrary to what is actually found phonologically. Moreover, the Halle & Stevens approach ignores the suprasegmental aspects of tone.

3.2.2 Subsegmental Laryngeal Node Approach of Bao 1990

Retaining the idea of Halle and Stevens that voicing and tone are the same phonological entity, Halle's students, Duanmu and Bao propose that tone features are under the laryngeal node which is under the root node. In their models then, tone is a subsegmental feature combination.

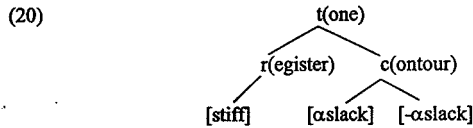
Bao 1990 uses the same binary features introduced by Halle and Steven 1971, but he differs from them in allowing [+stiff, +slack] as a possible combination, thereby allowing for a 4 tone language. In Bao's system, shown in (19), [stiff] refers to register

(equivalent to [upper] in Yip 1980); while [slack] refers to pitch (equivalent to [raised] in Yip 1980). Four phonological tone contrasts are possible.

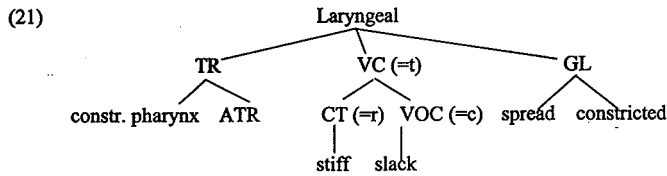
(19)

+stiff	-slack	H
	+slack	higher M
-stiff	-slack	lower M
	+slack	L

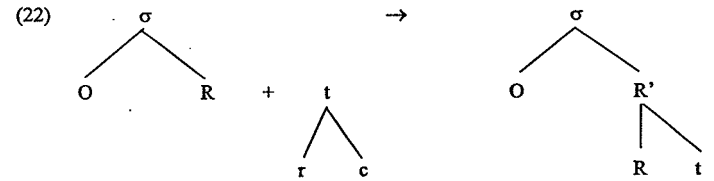
The actual geometry that Bao 1990 proposes is unclear, mainly because he distinguishes between a phonological and a phonetic feature geometry. First he presents the geometry in (20), which seems to be a phonological representation of tone before it docks.



Subsequently, he provides the phonetic geometry in (21) which purports to capture the interaction between obstruent voicing and tone. VC is the same as *t* in (20) and means vocal cords. CT is the same as *r*, and means cricothyroid muscle. VOC is the same as *c*, and means vocalis muscle.



It is not clear how tone ends up associated to the laryngeal node. In the phonology, Bao sees tone as an independent autosegment that adjoins to the rhyme of the syllable, resulting in a rhyme prime, as in (22).

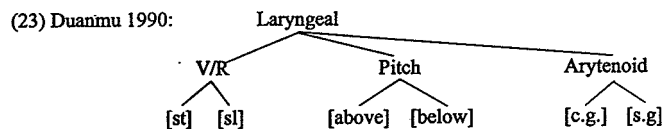


Bao's distinction between a phonological and a phonetic feature geometry is highly unusual for the time it was written (though now it seems like an idea that has caught on). In any case, the relationship and purpose of the two unreconciled feature geometries is never explained. The consonant-tone interaction that concerns us here is phonological in nature, so it is a serious flaw that Bao's account only deals with it in his phonetic representation and fails to deal with it in his phonological representation.

Since Bao's view of tone in the phonological feature geometry has nothing to do with obstruent voicing, it is questionable whether it should even be considered here. However, he is seen as taking a stand on this issue by both Duanmu 1990 and Yip 1995, who believe that he has said that obstruent voicing and tone are the same thing. He may indeed say this at the phonetic level, but he does not say it for the phonological level. Since it is highly unusual to propose separate and unreconciled feature geometries for the phonetic and phonological levels, we might choose to interpret his phonetic model as a phonological one, as Duanmu 1990 does. However, Bao himself recognizes that this would be problematic since he asserts that tone must be considered independent of segments phonologically. To support this point, he cites the phenomenon of tone preservation, whereby tone is preserved after deletion of a segment and he cites language games in which tone is preserved after reduplication and substitution. (Note that Bao's phonetic model implies that sonorants and implosives are not voiced phonetically; only obstruents are.)

3.2.3 Subsegmental Laryngeal Node Approach of Duanmu 1990

Duanmu 1990, presents a refinement of the Halle and Stevens 1971 segmental approach in which a number of the earlier models problems are recognized and an attempt is made to rectify them. Duanmu's model, shown in (23) specifies tone not only by [stiff] and [slack], but also by the features [above] and [below].



V/R = Voicing/Register; st = stiff vocal folds; sl = slack vocal folds

Because of the addition of these features, Duanmu's model overgenerates the number of possible phonological tone contrasts, allowing up to nine, as shown in (24). As mentioned in section 3.4.2.1, the upper limit on tone contrasts in a single language is six. So in contrast to the overgeneration of segment types found in Halle & Stevens 1971, Duanmu's solution overgenerates tone types.

(24)	[-st, -sl, +above, -below]	H	
	[-st, -sl, -above, -below]	L	
	[-st, -sl, -above, +below]	M	
	[-st, +sl, +above, -below]	!H	
	[-st, +sl, -above, -below]	!L	
	[-st, +sl, -above, +below]	!M	
	[+st, -sl, +above, -below]	H'	!=lowered
	[+st, -sl, -above, -below]	L'	'=raised
	[+st, -sl, -above, +below]	M'	

Duanmu's model avoids some of the problems of Bao's and Halle & Stevens' models by having tone features partially independent of voicing features. The features used in voicing, [slack] and [stiff], are now used to specify register instead of tone. Since these features would not spread unless the whole laryngeal node spreads, he claims that they rarely do. Yip (1995) supports him in the contention that Register rarely if ever

spreads. Note that if the entire Laryngeal node spreads, voicing, glottalization, and tone all spread. Furthermore, consonants with any laryngeal specifications can be expected to block register spreading. However, it is not clear that register fails to spread, especially if one looks outside of the Asian tone languages that Yip and Duanmu work with. In languages with three or more tones, normally one expects both register and pitch to spread if any tone spreading occurs. In Siya, a four tone language discussed in chapter 2, there is a tone process whereby L raises to H before H or Superhigh. Here register must be spreading because L raises to H rather than to Superhigh before a Superhigh tone and yet this spreading takes place across consonants that can be specified for laryngeal features.

(25) Siya (Ford 1986)

é-bí-là + à-íí + ní + yà → ébilà áíí ní yà 'the seeds are here'
 á-yrò + yé → áyró yé (→ áyró yé) 'he let go of him'

There are several other problems with Duanmu's approach. He has abandoned the connection between tone and voicing inherent in Halle & Stevens model. In Duanmu's model, the state of the vocal folds and voicing are irrelevant to whether a tone is H, M or L. Thus, this model does not directly account for the segmental nature of tone. Moreover, it incorrectly characterizes the nature of the relationship between consonants and tone. Duanmu's model does not capture the interaction between L tone and voiced obstruents (though it does capture the somewhat rarer interaction between voiced obstruents and downstep.) Furthermore, interaction between voiceless obstruents and raised tones (H', M', L') is incorrectly predicted because [+stiff, -slack] characterizes both voiceless obstruents and raised tones. No cases of this kind of interaction have ever been described. A final problem with Duanmu's approach is his failure to account for the suprasegmental nature of tone. Although he recognizes that the number of tones is often limited by the number of moras, and he claims that the mora is the TBU, this is not captured in his model. Since Duanmu's model captures neither the segmental nor the suprasegmental nature of tone, it cannot provide an adequate account of consonant-tone interaction.

3.4.3 Combination approaches

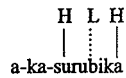
3.4.3.1 Kisseberth 1984 Approach

Another approach, the simplest and least explicit one, associates a L tone directly to a consonant. Although this approach, taken by both Kisseberth 1984 and Goldsmith 1990 in accounting for Digo, is not a featural representation, it is an attempt to make a connection between tone and consonants in the representation without committing to a segmental or a suprasegmental tone-bearing unit. Kisseberth 1984 shows the tone associated to the consonant, as in (26).

(26) L Association to Consonants

Kisseberth 1984: a-ká-súrúbika → akasúrúbikâ ‘he is strong’

L Insertion:



We cannot really say whether this reflects the segmental or suprasegmental nature of tone. At the time it was written, the distinction was not relevant (although Cassimjee & Kisseberth 1992 maintains the same representation). This approach can be illustrated more abstractly as in (27). This representation is slightly misleading in that it suggests that any tone may be assigned to any consonant. However, in the works cited, only L tone is ever assigned to a consonant and only voiced oral obstruents are ever assigned tone. This seems arbitrary and unexplainable.

(27)

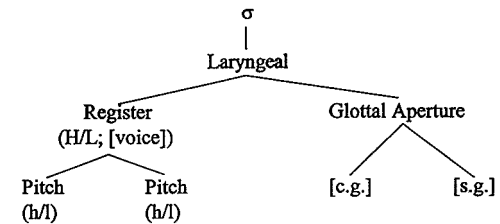


In any case, the relationship between voicing and tone is once again accidental. In both Kisseberth and Goldsmith, it remains unaccounted for that only L tone is ever assigned to a consonant, and only voiced obstruents are ever assigned tone.

3.4.3.2 Prosodic Laryngeal node approach of Yip 1995

If the laryngeal node as the de facto tone-bearing unit faces insurmountable problems, one might attempt to capture the interaction between obstruent voicing and tone in terms of a laryngeal node that is not under the root node but rather is prosodic in nature. Although Yip 1995 does not commit herself to such a position, she suggests the possibility in reference to the figure in (28) which is her translation of her model into a laryngeal node configuration. She states: ‘I will not discuss the issue of whether the Laryngeal node associates directly to the syllable, as shown here, or via the segmental Root node’ (p. 484).

(28)



The problems of treating tone as a subsegmental feature or feature combination have already been discussed. But if the laryngeal node is prosodic, those problems are not relevant. Unfortunately, a new set of problems arises.

The most serious problem entailed by such a model is that it predicts that obstruent voicing is a property of the syllable rather than of the segment. This is clearly wrong for most languages. In English, for example, voicing can occur on the onset to the exclusion of the coda (*dot*), the coda to the exclusion of the onset (*tag*), the coda and onset (*dog*) or neither (*tack*).

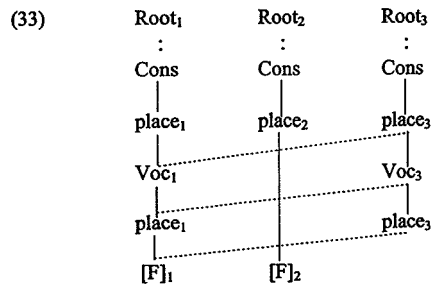
Yip herself recognizes that there is another serious problem in that her model cannot deal with African tone languages in which tones spread over sequences of syllables regardless of consonant type. Her solution that African tone languages have a different tone geometry than Asian tone languages is hard to swallow. If our only choice is

In my terms, the operations in which features adjacent on the same tier interact are *tier sensitive* and those in which features must crucially be adjacent on the same plane as well as on the same tier are *plane sensitive*. Thus, in this approach, HTS1 and HTS2 in Ikalanga are plane sensitive. A L feature on the Laryngeal node does not block tone spreading from mora to mora.

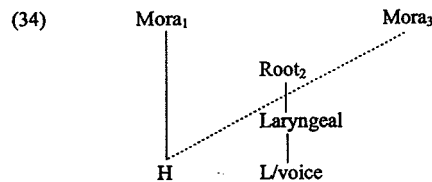
The No Line Crossing restriction is preserved as revised in Clements 1990, i.e. association lines may not cross on a plane.

(32) No Line Crossing (Clements 1990): Association lines may not cross on a plane.

Hume 1994 illustrates the well-formed spreading operations as in (33). $[F]_1$ can spread across $[F]_2$ to $place_3$ because $[F]_1$ and $[F]_2$ are not on the same plane.



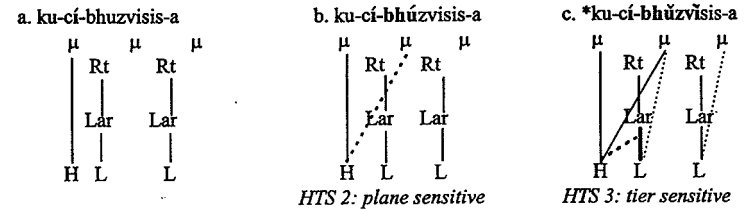
When this approach is applied to consonant-tone interaction, as in (34), a L/voice feature in the Multiplanar model need not block a H tone from spreading as long as it is not on the same plane as the H tone.



One advantage of this way of handling transparency and opacity is that it is nonaccidental. The L tone is not inserted; it is there underlyingly.

In the Multiplanar model, the transparency of depressor consonants to HTS2 is handled as in (35b) where HTS2 is plane sensitive and is not blocked by a L tone on another plane. HTS3 is blocked by the L tone on the same tier, as in (35c) because the process is plane sensitive.

(35) Multiplanar analysis of Ikalanga: ku-c[i-bhuzvi]sis-a → ku-c[i-bhūzvī]sis-a



3.5.2 Problem of η in Siswati

The Multiplanar approach to opacity and transparency also seems to have an advantage in dealing with the problem of η in Siswati. The segment η in Siswati poses a dilemma in terms of transparency and opacity. It generally acts as a depressor consonant on the surface, but in one process it is transparent while the other depressor consonants are opaque. It may seem strange that η should pattern with the voiced obstruents which constitute the depressor consonants in Siswati but it turns out to be the reduced form of the cluster ηg . More precisely, there is a process of g-Deletion that reduces ηg to a simple η when it is not the first consonant in a root. Thus, η is not truly a depressor consonant although it behaves as one on the surface. It is actually g that causes the depressor effects before it is deleted.

η acts like a depressor consonant in that L or rising tone predictably occurs after it even in words where nothing else is going on tonally. After other nasals and nondepres-

sors in general, rising tone does not occur and the usual nonhigh tone is M. The tonal contrast between *ŋ* and other nasals is shown in (36).

(36)	[ŋ]	ínyaaŋà	'moon, month'	ínyaaŋǎ	'healer'
	[m]	ínsimu	'farm'	ínkoomó	'cow'
	[n]	ímikhóono	'arms'	ínóono	'neat, tidy person'

In all tone processes, barring one, that reflect depressor effects, *ŋ* acts like the other depressor consonants. For example, depressor consonants block the operation of word-internal H Spread, a process in which all toneless moras between two H's in the same word receive a H tone. The usual operation of the process is shown in (37a). All depressor consonants including *ŋ* block this process, as shown in (37b). This and other tone processes of Siswati are described in more detail in Chapter 5.

(37) a. kú + tókániisa → kúúkániisa 'to make separate'

- b. kú + fundziisa → kúfundziisa 'to teach'
 kú + khaŋeéta → kúkhaŋeéta 'to hold out one's hands'
 kú + ŋanyéela → kúŋanyéela 'to participate'

Although *ŋ* generally acts as a depressor consonant, there is one process, phrasal H spread, in which its behavior deviates from that of the true depressors. Illustrated in (38), Phrasal H spread is a plateauing effect whereby all toneless moras are realized with H tones between two H tones in the same phrase. In (38), the third person singular prefix contributes a H which shifts to the stem and spreads to all the vowels up to the H-toned vowel in the following noun.

(38) Phrasal H Spread across words without intervening depressors

ú-bála + ticátfuulo → uǎláá ticátfuulo 'he counts shoes'

When depressor consonants intervene between the two H's, as in (39), phrasal H spread is blocked.

(39) Phrasal H Spread blocked by intervening depressor consonants

ú-banza + ticátfuulo → uǎnzà ticátfuulo 'he chops up shoes'
 ú-géza + bántfaana → uǎzà bántfaana 'he bathes the children'
 ú-bílisa + batáata → ubílisa batáata 'he boils sweet potatoes'

When *ŋ* is the intervening consonant, as in (40), phrasal H spread operates as if no depressor consonant is present. It patterns with the nondepressor context in (38) and not with the depressor context in (39).

(40) Phrasal H Spread across words with intervening *ŋ*

ú-ŋoŋa + ticátfuulo → uǎŋǎá ticátfuulo 'he praises the shoes'

If we adopt the suprasegmental model of Bradshaw 1995 or Hyman & Mathangwane 1998 in which L is inserted after the depressor consonant, then we fail to distinguish between *ŋ* and other depressor consonants. Yet such a distinction is crucial since the behavior of *ŋ* differs from that of the true depressor consonants. In the suprasegmental approach, L Insertion must precede the deletion of *g* from the *ŋg* cluster in order for *ŋ* to ever act as a depressor. This is illustrated in (41) for word internal H spread, a process in which *ŋ* does act as a depressor. Here H spread fails to operate because a L is inserted between the two H's.

(41) Word Internal H Spread: kúkhantiŋisélaana 'to cause to dry roast for e.o.'

$$\begin{array}{ccccccc} & & & L-INSERTION & & g-DELETION & \\ kú-khantiŋ-is-él-aan-a & \rightarrow & kúkhantiŋisélaana & \rightarrow & kúkhantiŋisélaana & & \\ | & & | & & | & & | \\ H & & H & & LH & & LH \end{array}$$

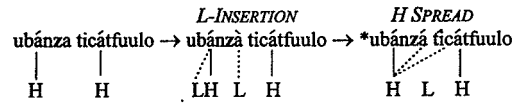
Phrasal H Spread, illustrated in (42), must be somehow different since in this case the spreading of H causes delinking of the L tone.

(42) Phrasal H Spread: uǎŋǎá ticátfuulo 'he praises shoes'

$$\begin{array}{ccccccc} & & & L-INSERTION & & g-DELETION & H SPREAD \\ uǎŋǎa ticátfuulo & \rightarrow & uǎŋǎá ticátfuulo & \rightarrow & uǎŋǎá ticátfuulo & \rightarrow & uǎŋǎá ticátfuulo \\ | & & | & & | & & | \\ H & & H & & H & & H \\ & & & & & & | \\ & & & & & & L \\ & & & & & & | \\ & & & & & & H \end{array}$$

The phrase in (42) illustrates the problem of *ŋ* in contrast to other depressor consonants. If the same process seen in (42) is applied in (43), the wrong results follow. In (43), the depressor consonant *z* actually blocks phrasal H spread. But if the L is delinked in the case of *ŋg*, it should also be delinked in the case of other depressor consonants.

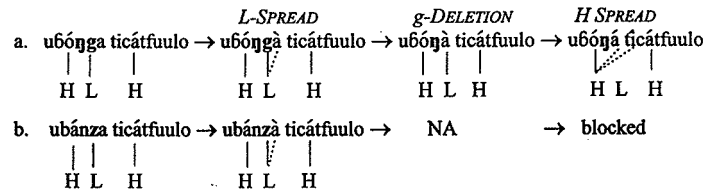
(43) Phrasal H Spread: ubānzà ticátfuulo 'he chops shoes'



Thus, in a suprasegmental model, the account that gives the right results for *ŋ* gives the wrong results for all other depressor consonants. If this were the correct approach, Phrasal H spread would not be a consonant-tone interaction, and *ŋ* would never act independently of the other depressor consonants.

The Multiplanar model allows for a distinction between *ŋ* and other depressor consonants in this situation, based on the fact that after *ŋ* L is singly linked, while after other depressor consonants it is multiply linked. The analysis proceeds as in (44a) where the L/voice feature of the voiced obstruent spreads to the following mora before *g*-Deletion leaving a L linked only to a vowel mora when the *ŋg* cluster is simplified. This contrasts with (44b) where the L/voice feature after other depressors remains multiply linked to both the vowel mora and the consonant. The singly linked L in (44a) is delinked by phrasal H Spread. The multiply linked L in (44b) cannot be delinked by Phrasal H Spread and so the process is blocked.

(44) Phrasal H Spread in the Multiplanar model



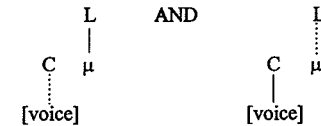
Thus, the Multiplanar model allows for a principled account of phrasal H spread in Siswati while the suprasegmental model, in which L tone is associated only to moras, does not.

3.6 BIDIRECTIONALITY: TONE TRIGGERS VOICING

Another advantage of the Multiplanar model is that it predicts the bidirectionality of consonant-tone interaction. Not only can voiced obstruents trigger tonal effects, but also L tone can trigger voicing effects.

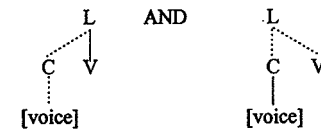
In a suprasegmental approach like that of Bradshaw 1995 or Hyman & Mathangwane 1998, as in (45), there would be two formally arbitrary rules that happen to look similar in form. The feature [voice] is inserted before a L tone and L is inserted after a voiced obstruent.

(45) Suprasegmental Approach



The approach of Kisseberth 1984 and Goldsmith 1990, illustrated in (46), where L is associated to a consonant would handle bidirectionality in essentially the same fashion. This is simply a variant of (45) in the sense that it consists of two formally arbitrary rules which are similar in form.

(46) Consonantal Association (Kisseberth 1984, Goldsmith 1990)



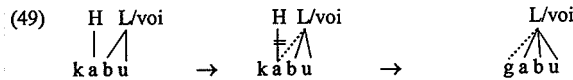
The Multiplanar approach, in (47), where a single feature characterizes both L tone and voicing, handles bidirectionality as a simple spreading operation in which the feature may spread either from a mora to a consonant or from a consonant to a mora.

(47) Multiplanar Approach



The most robust case in which tone triggers voicing is that of Yabem, an Oceanic Austronesian language of the North Huon Gulf in Papua New Guinea. As seen previously in chapter 2, the first singular realis prefix alternates such that *ká* becomes *gà* when it is parsed into the same foot as a verb stem with a L tone. In (48), the direction of the change in the tone and voicing of the realis prefix is indicated. In (48), this change is depicted graphically. First, the L/voice feature spreads to the mora of the realis prefix. It then spreads again to the initial voiceless *k* resulting in a voiced *g*.

- (48)
- | | | | |
|---------------------------|---------------------------|-------------------------|------------------|
| <i>ká</i> + <i>bù</i> → | <i>kà</i> - <i>bù</i> → | <i>gà</i> - <i>bù</i> | 'I insult' |
| <i>ká</i> + <i>gùŋ</i> → | <i>kà</i> - <i>gùŋ</i> → | <i>gà</i> - <i>gùŋ</i> | 'I spear' |
| <i>ká</i> + <i>dèng</i> → | <i>kà</i> - <i>dèng</i> → | <i>gà</i> - <i>dèng</i> | 'I move towards' |



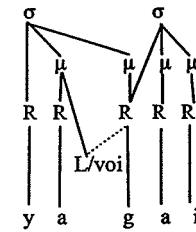
As predicted from the Multiplanar model, there is no evidence that H tone conditions voicelessness in Yabem.

L also triggers voicing in Jingpho. As shown in (50), Jingpho gemination produces voiced obstruents in morphemes with L tone, while, with H tone, obstruents remain voiceless. The voicing process in the Multiplanar framework is shown in (51).

(50) Jingpho (Maddieson 1974)

- | | | | |
|------------|-------------|---------------|-------------------|
| <i>yàk</i> | 'difficult' | <i>yàggai</i> | 'it is difficult' |
| <i>cát</i> | 'tight' | <i>cáttai</i> | 'it is tight' |

(51) Voicing of *yàggai* 'it is difficult'



3.7 MORE ON TRANSPARENCY AND OPACITY

Another prediction of the Multiplanar model is that processes which can be extrinsically ordered will sometimes vary in the transparency of depressor consonants to H tone in such a way that the situation could arise in which depressor consonants are opaque, then transparent, then opaque. Thus, the Multiplanar model allows depressor consonants to be both transparent and opaque to tone processes and to switch back and forth between the two states.

A relevant case involves phrasal H spread in Siswati, a process in which a H tone spreads from one word to the next when the following word also contains a H tone.

- (52)
- | | | |
|---------------------------------------|------------------------------------|---------------------|
| <i>ngúma</i> + <i>eticatfúlweni</i> → | <i>ŋímá</i> <i>éficátfúlwéeni</i> | 'I stand on shoes' |
| <i>uŋála</i> + <i>eticatfúlweni</i> → | <i>uŋála</i> <i>éficátfúlwéeni</i> | 'he sits on shoes' |
| <i>bábóna</i> + <i>bántfana</i> → | <i>baBóná</i> <i>bántfaana</i> | 'they see children' |

H does not spread if the second word does not contain a H tone.

- (53)
- | | | |
|------------------------------------|-------------------------------------|----------------------|
| <i>baBóna</i> + <i>chochocho</i> → | <i>baBóna</i> <i>chochocho</i> | 'they see a trachea' |
| | (* <i>baBóná</i> <i>chochocho</i>) | |

H spread is blocked by voiced obstruents.

- (54)
- | | | |
|------------------------------------|--------------------------------|--------------------------|
| <i>uBánza</i> + <i>ticátfulo</i> → | <i>uBánza</i> <i>ticátfulu</i> | 'he praises shoes' |
| <i>ugéza</i> + <i>bántfana</i> → | <i>ugéza</i> <i>bántfaana</i> | 'he bathes the children' |

However, not all intervening voiced obstruents block this H spread. Only depressor consonants in the first of the adjacent words are opaque. Depressor consonants in the second word are not blockers.

- (55) ɓábóna + síbanyana → ɓábóná síbànyáana ‘they see a small gun’
 úbóna + bódokotela → úbóná bódòkòteela ‘he sees a doctor’

It is necessary to handle this switch between opacity and transparency by positing two processes of H spread, one to which depressor consonants are transparent, and another (Antepenult Attraction) to which depressor consonants are opaque. In (56), the relevant processes are ordered and those which demonstrate the opacity or transparency of depressor consonants are marked with a + and - respectively. Note that tier sensitive Phrasal H Spread in which depressor consonants are opaque is followed by plane sensitive Antepenult Attraction in which depressor consonant are transparent, and Antepenult Attraction is followed by tier sensitive DIHTS in which depressor consonants are opaque.

(56)	UR	úbóna + bódokotela	úbánza + tícátfulo	ɓábóna + síbanyana
	Various	úbóna bódokotela	ufánza tícátfulo	ɓábóna síbanyana
	+Phras H Spr	úbóná bódokotela	blocked	ɓábóná síbanyana
	-Antepenult			
	Attraction	úbóná bódókótela	ufánza tícátfulo	ɓábóná síbányana
	L/voi Spr	úbóná bódòkòtela	ufánzà tícátfulo	ɓábóná síbányana
	Lengthening	úbóná bódòkòteela	ufánzà tícátfulo	ɓábóná síbànyáana
	+DIHTS	úbóná bódòkòteela	NA	ɓábóná síbànyáana
	H delink	NA	ufánzà tícátfulo	ɓábóná síbànyáana
	SR	úbóná bódòkòteela	ufánzà tícátfulo	ɓábóná síbànyáana

Only a Multiplanar account can handle this interaction between opacity and transparency in a straightforward manner.

3.8 CONCLUSION

The existence of consonant-tone interaction in a number of languages which are historically and geographically diverse emphasizes the need to recognize the segmental nature of tone, while not overlooking its suprasegmental nature. The Multiplanar model is an approach which incorporates the dual nature of tone. In doing so, it provides advantages for dealing with opacity and transparency effects and the bidirectionality of consonant-tone interaction. Other models fail to adequately account for the details of consonant-tone interaction.

process of H shifting and the blocking of H spreading. Other phenomenon which have been called depressor effects elsewhere (Rycroft 1980, 1981) do not involve depressor consonants. Lowered pitch, which I analyze as L tone but Rycroft refers to as 'depression', can also be encountered in syllables without depressor onsets. This 'depression' must be lexically specified or grammatically imposed.

The present analysis of Siswati's depressor effects as a tonal phenomenon differs from a number of other previous works on the subject. In virtually all publications on Siswati, if tones are marked, the only tones marked are H and falling tones, with unmarked vowels being interpreted as nonhigh in tone (see Downing 1994, Rycroft 1981, Rycroft 1980, Ziervogel and Mabuza 1976). Rather than referring to a third tone, the depressor effect has been attributed to a feature, [depression], realized anywhere lowered pitch is observed, which Rycroft 1980 correlates with breathy voicing of vowels and depressor consonants. It is worth noting that the actual existence of breathy voicing, especially on the consonants, is questionable³. In Rycroft's analysis, rising tone contours do not exist phonologically, but are assumed to be the phonetic realization of H on a depressed syllable (a syllable with 'depression').

One problem with the use of the feature [depression] is that it is not tied to any feature theory or to any language other than those in the Nguni group. This feature is ad hoc because it is invoked to apply to a limited phenomenon in a limited number of languages. Furthermore, there is a possible account that is not ad hoc, i.e. an analysis in terms of three tones. It is also possible to translate the feature [depression] into subsegmental features that are not ad hoc. The most likely such features, if one wishes to acknowledge Rycroft's description of the phonetic correlate of [depression] as breathy voice, are [spread glottis, voice]. However, an analysis in purely segmental terms turns out to be inadequate in accounting for tone blocking effects. Thus, the Multiplanar approach taken here utilizes the feature L/voice which has both segmental and suprasegmental properties, as mentioned previously. An analysis which uses tone rather than

³See especially Traill, Khumalo and Fridjhon 1987 on Zulu depression.

strictly subsegmental features has the advantage of allowing us to unify the depressor effects in Siswati, which are not particularly unique in nature, with those found in other languages.

The notation used to transcribe the Siswati data utilizes IPA symbols instead of the conventional orthography adopted for Siswati, with several exceptions. The voiceless and voiced dental clicks are marked using the orthographic conventions [c] and [gc] respectively. Furthermore, the orthographic convention of marking both allophones of the alveolar affricates ([ts, dz] and [tʃ, dʒ]) is retained, although it will be seen that [tʃ, dʒ] occur only before labial vowels and glides.

4.2 DEPRESSOR CONSONANTS

After the set of depressor consonants, given in (4), vowels are realized with a L tone or with a rise. These consonants, with the exception of [ŋ], can be characterized as voiced obstruents. Since it is assumed within the Multiplanar model that voicing is privative and is realized only where it is contrastive, namely on obstruents, the depressor consonants are specified to the exclusion of all other segments in Siswati by the feature [L/voice].

(4)	stop	b	d	g	
	fricative	v	z		f
	affricate		dz(dv)	dʒ	
	lateral		ɬ		
	click		gc		
	nasal				ŋ

The inclusion of [ŋ] among the depressor consonants is justified on the basis of its behavior. This inclusion is straightforward if [ŋ] is analyzed as a reduction of [ŋg]. As noted in Rycroft 1981a and Taljaard, Khumalo and Bosch 1991, [ŋg] occurs only when it is the initial consonant grouping in a stem. In other words, the [g] of the cluster surfaces only when this cluster is either strictly stem-initial or when it follows an initial vowel, as in (5).

(5)	kóogà	'to economize'	(ku + onga)
	kóngiwa	'to be conserved'	(ku + ongiwa)
	kúngéna	'to enter'	(ku + ŋgena)
	kúngèniisa	'to let in'	(ku + ŋgenisa)
	kwénggaama	'to lean over'	(ku + enggama)
	kwengáméela	'to preside over'	(ku + engamela)

The reduced variant [ŋ] occurs elsewhere, i.e. either outside the stem or within a stem but not stem-initially, as in (6) where the stem begins after the hyphen.

(6)	ŋisá-háambà	'I'm still walking'
	uŋá-lúúmi	'don't bite!'
	ku-pharjáláala	'to die'
	i-nyaaŋá	'healer'
	àbá-limàáŋà	'they didn't plow'

This complementary distribution, combined with the depressor behavior of [ŋ], argue in favor of an analysis of [ŋ] as a reduced variant of [ŋg].

Other nasals do not show the same sort of distribution. As shown in (7a), the nasals *m n ny* can occur either stem-initially or stem-internally. Unlike [ŋg], other nasal-stop clusters can occur stem-medially, as shown in (7b).

(7) a.	m	kúú-ma	'to stand'
	n	lí-nóóno	'neat & tidy person'
	n	kú-naatsa	'to drink'
	ny/m	i-nyaaama	'meat'
	ny	sí-bànyáana	'little gun'
b.	mb	kú-haambà	'to travel'
	ndv	kú-candvùula	'to hammer'
	ndz	kú-fundziisa	'to teach'
	nj	lí-cénjàana	'small leaf'
	ngc	kú-gcàngcáatsa	'to cheat'
	nd	indándáatho	'ring'
	nɕ	impháanɕà	'baldness'
	mv	úmveémvè	'sp. bird'

Another peculiarity of [ŋ] as a depressor is that it behaves inconsistently. As seen in chapter 3, it acts as a depressor in every way except when it comes to blocking phrasal

H Spread (a plateauing effect between H's adjacent on the tonal tier which crosses word boundaries). An analysis of [ŋ] as a variant of [ŋg] which has lost its obstruent member makes this inconsistent behavior more comprehensible.

4.3 DEPRESSOR CONSONANTS AS TRIGGERS

Depressor consonants are associated with lowered pitch on the following vowel. This pitch lowering can be either in the form of a level L or a rising tone. A rising tone occurs when the vowel after the depressor bears a H tone. In other cases, when the vowel bears a H tone, that tone is shifted rightwards to the next syllable. In a Multiplanar analysis, these two effects can be accounted for by tonal processes in which the depressor consonants are the triggers.

A L tone is consistently found after the depressor consonants, either in the form of a level L or as part of a rising tone, as shown in (8).

(8)	[b]	lúbààmbò	'rib'	lubándzàana	'little rib'
	[d]	lídààdà	'duck'	edàdèèni	'on the duck'
	[g]	sígòòdzì	'region'	kugídziimà	'to run'
	[gc]	ìŋgcùùbù	'carrion'	kúgcèéβa	'to tidy up'
	[v]	kúvääla	'to close'	kúvùúka	'to wake up'
	[z]	kucábuzà	'to kiss'	gèèzà	'bathe!'
	[f]	kúfálíika	'to rake'	kufálíjäätà	'to pour a little'
	[β]	ínjòòvò	'elephant'	kúulǎ	'to eat'
	[dz]	kúicindzétécla	'to oppress'	sígòòdzì	'region'
	[dv]	sáándvò	'hammer'	indvòdzàana	'little man'
	[dz]	lúúdzù	'honey'	indzàana	'little dog'
	[ŋ]	ínyaaŋǎ	'moon, month'	ínyaaŋǎ	'healer'

Although rising and falling tones are found in Siswati, their distribution is quite restricted and, in general, they are disfavored tone patterns. Both occur on bimoraic penults⁴, but falling tones never occur on monomoraic syllables and rising tones only do so after depressor consonants (with one exceptional set, discussed later). It might be tempting to analyze rising tones on monomoraic syllables as phonetic realizations of H on de-

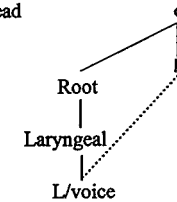
⁴ Penult rising tones are found in words without depressor consonants, such as *lichááwe* 'warrior'.

pressed syllables because such an analysis would allow for a consistent pattern in which only long syllables bear contour tones and in which only one tone per mora is permitted. However, there is evidence that rises are not an automatic phonetic effect. They occur after [ŋ] which is not a voiced obstruent on the surface. Moreover, both rising and falling tones participate in tonal contrasts that are clearly phonological. The tonal contrasts that falling tones take part in are independent of conditioning factors. For example, *sicooco* 'tree' has a toneless (M) penult; *licéembè* 'leaf' has a level H penult; and *licáandzà* has a falling penult. The contrast involving a rising tone occurs after [ŋ] as shown in (9). The presence of such a contrast provides a strong argument for the phonological nature of rising tones after depressors in Siswati.

(9)	Rising	ínyaaŋǎ	'moon'
	Level H	ubóŋǎ ticátfuulo	'he praises the shoes'

In order to account for the presence of L or rising tones after depressor consonants, a process of Multiplanar L Spread is proposed whereby a L/voice feature spreads rightwards from a depressor consonant to a mora, as in (10).

(10) Multiplanar L Spread



This can be expressed simply as in (11), where D represents a depressor consonant.



This process generates rising tones when the mora of the vowel following the depressor consonant bears a H, as illustrated in (12).

(12)



As stated previously, however, rising tones are disfavored in Siswati and are avoided when possible. In order to avoid a rising tone, a H tone on a vowel following a depressor consonant shifts rightwards to the next syllable. To illustrate this process, it is necessary to refer to another process, Antepenult Attraction, that has been previously described in chapter 3. By this process, which is indifferent to depressor consonants, the rightmost H in a word is attracted to the antepenultimate syllable. Evidence for Antepenult Attraction is given in (13) where the prefixal H is realized on the antepenult of toneless nouns (13a) and verbs (13b).

- (13) a. *cocooco* 'trachea'
bó + cocooco → *bocócooco* 'tracheas'
sí + cooco → *sícooco* 'frog'
sí + coco + aana → *sicócaana* 'little frog'
sí + catfuulo → *sicatfuulo* 'shoe'
sí + catfulo + aana → *sicatfulwaana* 'little shoe'
- b. *kúliima* 'to plow'
kulímiisa 'to cause to plow'
kulimísaana 'to cause e.o. to plow'
kulimisélaana 'to cause to plow for e.o.'

In contrast, when the antepenult has a depressor onset, the H surfaces on the penult as part of a falling tone, as shown in (14).

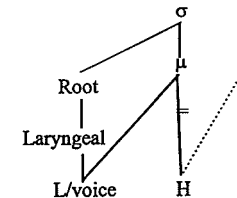
- (14) a. *sigcòkwáana* 'little hat' *indvùkwáana* 'little cane'
sibànyáana 'little gun' *ingwènyáana* 'little crocodile'
esibàmíini 'in the gun' *esigcòkwéeni* 'on the hat'
- b. *kubòcáana* 'to smear e.o.'
kucabuzéláana 'to kiss e.o. for'
kongèséela 'to cause to economize for'
kulunjiséela 'to make good for'
kubonjisáana 'to cause e.o. to thank'
kuphanáláala 'to die'

This pattern, where H moves to the penult because of a depressor consonant in the antepenult, is attributed to a process of depressor-induced H tone shift (DIHTS). H first migrates from the prefix to the antepenult and then, following Multiplanar L Spread, it is shifted rightwards to the penult, as in (15).

- (15) a. *sí + gcokwaana* → *sigcòkwaana* → *sigcòkwaana* → *sigcòkwáana* *little hat*
b. *kú + bocaana* → *kubòcaana* → *kubòcaana* → *kubocáana* *to smear e.o.*

DIHTS, in (16), moves H to the next mora to avoid a rising tone. Although DIHTS has been considered to be triggered by depressor consonants, it is also valid to regard it as triggered by Multiplanar L Spread and rise avoidance, with no reference to depressors. An explicit representation of DIHTS is given in (16).

(16) DIHTS



More simply, DIHTS can be represented as in (17).



DIHTS predicts that surface rising tones won't be found unless something explicitly blocks H from shifting. H is never shifted to a mora which already bears a L tone, as will be seen in the next section. It also fails to shift to a phrase-final syllable. Evidence for this comes from the existence of penult rises, which would be avoided by a shifting of H to the final syllable, as in (18).

- (18) *kúvùúka* 'to wake up'
kúfùúka 'to hook'

Further evidence for a prohibition against shifting H to the final syllable comes from a failure of Local Shift, which shifts the rightmost H once rightwards⁵. Short words which would be expected to undergo Local Shift, as in (19) fail to do so if the H would be shifted to the final syllable.

- (19) kú + lwa → kúlwa → kúúlwá 'to fight'
 kú + na → kúna → kúúna 'to rain'

Since H is never shifted to a L-toned mora nor to a phrase-final syllable, it is expected that rising tones will only occur on the penult and before depressor consonants.

4.4 OPACITY EFFECTS OF DEPRESSOR CONSONANTS.

Depressor consonants, or the L which occurs after them, not only cause H to shift in DIHTS, but also act to block DIHTS from occurring. In addition, they block the operation of two different processes of H Spread.

4.4.1 Blocking of DIHTS

In words where DIHTS would be expected to occur, it will fail to operate if the penult has a depressor onset. The presence of a depressor consonant between the H and its target mora blocks DIHTS. The H is, in effect, trapped between two depressor consonants, resulting in a rising tone, as shown in (20).

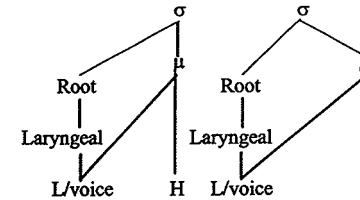
- (20) inǃǃvǃǃàà 'little elephant' lidǃǃààà 'little duck'
 lubǃǃndǃǃàà 'little rib' indvǃǃdǃǃàà 'little man'
 edǃǃààèè 'on the duck' eǃǃǃǃèè 'in the cooking hut'

The conditions under which DIHTS fails to operate are explicitly represented in (21). There are two equally compelling explanations for the failure. It may be that DIHTS is tier sensitive and thus is blocked by the presence of the consonantly associated

⁵ Local Shift is proposed in Downing 1990 to account for tone patterns in other Nguni languages.

L/voice feature. Since there is no possibility of H associating to a consonant under the Multiplanar approach, this would automatically result in a blocking of DIHTS.

(21)



The other possibility suggested by the blocking of DIHTS is that there is a prohibition against H shifting to a mora already bearing a L tone. This prohibition can be expressed as a constraint, as in (22).

- (22) *H L
 μ μ

There are no falls on monomoraic syllables in Siswati, so the constraint in (21) is surface true. However, it is worth noting that there is asymmetry in the behavior of H and L in this respect. A L is not blocked from spreading to a mora which has a H although the resulting rise may cause the H to shift further. The reason for the asymmetry may lie in the fact that it is the consonantal association of L which blocks the shifting of H.

4.4.2 Blocking of H Spread

DIHTS is only one of several tone processes that are blocked as a consequence of the presence of depressor consonants. Two other processes that are blocked are word-internal H Spread and phrasal H-Spread.

In verbs with underlying H's, when the H-toned infinitive prefix is added, a string of H's are realized extending from the H of the prefix to the rightmost H of the stem, as shown in (23)⁶.

- (23) kú + khulúúma → kúkhulúúma 'to speak'
 kú + tshanyééla → kúts hanyééla 'to sweep'
 kú + ʔukániisa → kúʔukániisa 'to make separate'
 kú + ʔekéteela → kúʔekéteela 'to be patient'

This can be accounted for by a process of H Spread (24) in which H spreads rightwards to the next adjacent H on the tonal tier⁷.



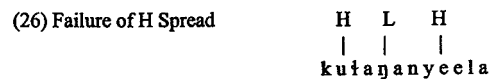
When a depressor consonant intervenes between the two H's, H spread is blocked and only the endmost H's surface, as shown in (25).

- (25) kú + vuúka → kúvùúka 'to wake up'
 kú + gayíiŋa → kúgàyíiŋà 'to dry roast'
 kú + candvuúla → kúcandvuúla 'to hammer'
 kú + cindzetéela → kúcindzetéela 'to oppress'
 kú + fundziisa → kúfundziisa 'to teach'
 kú + khaŋeéta → kúkhaŋeéta 'to hold out one's hands'
 kú + ʔaŋanyéela → kúʔaŋanyéela 'to participate'

The failure of H Spread can be understood in terms of a failure to meet the conditions necessary for H Spread to occur. H Spread demands the adjacency of two H's on the tonal tier. When a L/voice feature is present on a depressor consonant, the conditions for H Spread are absent, as shown in (26).

⁶ The location of the rightmost H on either the penult or the antepenult results from the interaction of Antepenult Attraction and Local Shift.

⁷ In the absence of clear evidence, rightward spreading is assumed. Note also that C in (24) is meant to represent the root node rather than a skeletal slot.



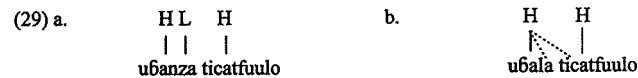
The case of phrasal H Spread is exactly parallel to that of word-internal H Spread. It can be illustrated between a verb and its object as in (27).

- (27) ú-lima + ínsíimu → ulímá ínsíimu 'he plows the field'
 ú-ʔala + ticátfuulo → uʔalá ticátfuulo 'he counts shoes'
 ku-phúma + énʒiini → kúphúmá énʒiini 'to go out of a house'
 ú-vala + imínyaaŋò → uválá imínyaaŋò 'he closes the door'

When a depressor consonant intervenes between the two H's, there is no phrasal H spread, as in (28).

- (28) uʔánzà ticátfuulo 'he chops up shoes'
 ugèzà ʔántvaana 'he bathes the children'
 uʔílísa bàtáata 'he boils sweet potatoes'
 ugjímísa dòkòtèèlà 'he chases a doctor'

As with word-internal H Spread, blocking appears to be caused by a L on the tonal tier which ensures that the necessary conditions for H Spread are not met, as in (29a). In (29b), phrasal H Spread is not blocked.



However, there is further data that suggests that consonantal L is transparent to phrasal H Spread. Although a depressor consonant within the verb or an initial depressor consonant on the object blocks H Spread, a depressor consonant within the object does not block H spread entirely, as can be seen in (30), where the pre-Spread H tones are underlined.

- (30) uʔoléká síbànyàana 'he lends a little gun'
 ʔaklavùlá fíbùʔéesi 'they pierce the lion'
 ʔatséŋá fítsanjànyàana 'they sell very small ropes'

The H's that are adjacent on the tonal tier are blocked by a depressor consonant, and yet spreading extends into the object. Thus, it appears that consonantal L is transparent to the H tones for the purpose of conditioning H Spread, while it is opaque for the purpose of spreading itself. Especially noteworthy is that L is opaque for the purpose of conditioning word-internal H spread, which suggests not only that the two H spreads are separate processes, but also that the opacity of depressor consonants for H Spread is not the result of Multiplanar L Spread, but rather directly attributed to the opacity of consonantal L. This phenomenon cannot be handled by an account of depressor effects that involves L insertion without segmental involvement. It also appears that phrasal H Spread extends only as far as the prefixal domain of the object and not into the noun stem.

Further motivation for dividing phrasal H Spread and word-internal H Spread comes from the behavior of [ŋ]. Phrasal H Spread is the one tonal process in which [ŋ] acts as a nondepressor. In other words, it does not block phrasal H Spread, as in (31).

- (31) ú-ḥoŋa + tícátfuulo → uḥóŋá tícátfuulo 'he praises the shoes'
 asíḥonáŋa + tícátfuulo → asíḥonánáŋá tícátfuulo 'we didn't see shoes'
 kú-luŋela + bántvaana → kulúŋélá bántvaana 'to be good for children'

[ŋ] acts as depressor for word-internal H Spread, as shown in (25), but not for phrasal H Spread, as shown in (31). Moreover, in some phrases (32) where phrasal H Spread operates, [ŋ] acts as a blocker of word-internal H Spread, making clear that word-internal and phrasal H Spread are separate processes.

- (32) kútsenǰísá ínǰáama 'to sell meat'

4.5 LEXICAL AND GRAMMATICAL L TONES

In addition to the L tones associated with depressor consonants, Siswati exhibits lexical and grammatical L tones neither of which occur with any particular consonants or consonant types. Rycroft claims that Siswati is unique among the Nguni languages in this respect. Since lowered pitch is unpredictable and since it must be included in underlying representations of both lexical and grammatical morphemes, there is strong evi-

dence for the existence of a L tone within a three tone system rather than the previously claimed 'depression' of a syllable.

4.5.1 Lexical L Tones

Underlying L's occur in both roots and affixes. In some nouns, syllables without depressor onsets consistently demonstrate the presence of a L tone. In such cases, the L tone is not associated with a depressor consonant, but is underlyingly present on the vocalic mora. A sample of relevant nouns from this limited set are shown in (33).

- (33) líchááwe 'warrior' líláádi 'ladder'
 líyēēmḥe 'shirt' ínkányēéti 'star, planet'
 báfáana 'boys' líkhátáane 'tick; sponger'

Underlying L's are also present in some subject prefixes, which contrast with nonlow subject prefixes in the same tense. This contrast indicates that the L tones are not grammatically imposed. In the present habitual, the second singular subject prefix is L, as shown in (34), where they contrast with third singular subject prefixes.

- (34) útshátshá lúḥiisi 'you take milk' utshátshá lúḥiisi 'he takes milk'
 ùḥóná ínḥǰ 'you see a house' uḥóná ínḥǰ 'he sees a house'

Some subject prefixes have rising tones and have been treated elsewhere (Rycroft 1980) as being depressed H-toned syllables. These subject prefixes contrast with other subject prefixes with level H tones (i.e. nondepressed H-toned syllables) as in (35) where subject prefixes in the remote past tense have a rising tone with first and second person prefixes and a level H with third person prefixes.

- (35) wéfiiká 'you arrived' wéfiiká 'he arrived'
 séfiiká 'we arrived' séfiiká 'it (cl 7) arrived'
 sǎliimá 'we plowed' báliimá 'they plowed'

There are no depressor consonants to motivate these rising tones, but this is not an underlying rising tone either. Rising tones are created in this context by the coalescence of a M

toned and a H toned vowel. This coalescence takes place in subject prefixes in the remote past and in object prefixes in other forms of the verb. In the remote past, the subject prefix is M in the first and second person, but H in the third person. The tense marker is H-toned *á*. The vowel features of the rightmost coalescing vowel spread leftwards, as in (36). Subsequently the long syllable is shortened (since long vowels are only permitted in the penult) and the tone pattern of the syllable is preserved.

- (36) *si + á + limá* → *saálimá* → *sáliimá* 'we plowed'
6á + á + limá → *6áálimá* → *6áliimá* 'they plowed'

Object prefixes are underlyingly H in tone and this H regularly shifts rightwards to the initial stem mora. When the verb is vowel-initial or monosyllabic, this results in a rising tone which is not attributable to the presence of a depressor consonant. Penult rises of this nature are illustrated in (37), where the object prefix + stem groupings are set off from the other prefixes by hyphens.

- (37) *a6ánaku-yaákha* 'they will not build it'
akánaku-tíkha 'he will not pluck them'
asínaku-yoósa 'we will not roast it'
asínaku-weéla 'we will not winnow it'
ñiya-taába 'I divide it'

This rise only occurs when the object prefix precedes a vowel-initial verb and only when the H cannot shift further rightwards. In the cases above, H cannot shift to a final syllable. It does however shift rightwards to an adjacent mora in the same syllable. In other cases, the H can and does shift rightwards, presenting a case of nondepressor-induced H Shift, as in (38).

- (38) *ñiyaba6éela* 'I divide it for them'
ñiya-6á-a6ela → *ñiyabaá6eela* → *ñiyaba6éela*
kubakhéela 'to fetch (water) for them'
kú-6á-akhela → *kú6aákheela* → *kúbakhéela*

This shift of H is blocked by the presence of a depressor consonant in the penult, as in (39). It will be noted that the nondepressor-induced rising tone acts exactly the same as the depressor-induced one, underlining both the existence of a prohibition against rising tones in Siswati and the stronger prohibition against spreading a H over a depressor consonant. Rycroft would be forced to treat such cases as 'depressed' syllables, but the explanation for the rising tone is more straightforward than that. Since Rycroft's 'depression' is either underlying, induced by depressor consonants, or grammatically imposed, these cases would have to be analyzed as grammatically imposed. However, it is clear that the rising tones have no morphemic content and are a result of phonological processes.

- (39) *kú6õñgèèla* 'to feed for them'
kú-6á-ongela → *kú6oõñgèèla* → *kú6õñgèèla*

Although the antepenult rise created in (39) is on a short syllable and is not perceptibly distinguished from a depressor-related rise, it is phonologically distinct as it consists of the juxtaposition of a M and H, rather than a L and H. If M is unspecified for tonal features, then there is a problem in accounting for how it can be part of a rise on a short syllable. This problem can be handled by filling in the default values of M before deletion of the nonpenult H takes place.

4.5.2 Grammatical L Tones: Verbs in the Imperative

Grammatical L tones are found on verbs in the imperative and in the remote past negative, and on nouns in the copulative. Verbs in the imperative surface with L's which cannot be accounted for underlyingly nor in terms of depressor consonants. This floating L morpheme only affects verbs with no underlying L or H tones.

In toneless verbs in the imperative, the penultimate syllable has a L tone. Toneless disyllabic verbs have a level L on the penult and a final H, as in (40).

(40)	<i>Imperative</i>	<i>Gloss</i>	<i>Infinitive</i>
	bùicá	'mix!'	kúbùicà
	fùiká	'arrive!'	kúfiika
	vàalá	'close!'	kúvàalà
	phèèkà	'cook!'	kúpheeka
	ḡàalà	'count!'	kúḡaala
	bùùdzà	'dream!'	kúbùùdzà

Toneless verbs which are longer than two syllables have a rising tone on the penult in the imperative, as shown in (41).

(41)	landzèèla	'follow!'	kulándzèèlà
	khotsáama	'bend down!'	kukhóttsaama
	phapháama	'wake up!'	kupháphaama
	chapháata	'mock!'	kucháphaata

In the plural form of the imperative, toneless disyllabic verbs lengthen due to the suffixation of the plural marker *-ni*. In this form, they pattern with longer verbs and surface with a rising tone on the penult, as in (42).

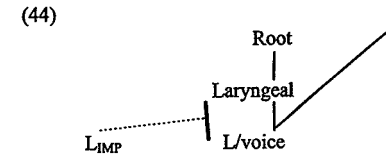
(42)	fikáani	'arrive!'	kúfiika
	liláani	'grieve!'	kúliila
	yeláani	'winnow!'	kwéela

There is no evidence for a grammatical L tone in verbs with depressor consonants. In toneless verbs with nonpenultimate depressor onsets, there is a level H on the penult, as in (43).

(43)	bicáani	'mix! (pl.)'
	váláani	'close! (pl.)'
	ḡisáani	'make eat! (pl.)'
	landzèlécéla	'follow for!'
	landzèlíisa	'make follow!'
	ḡèzisécéla	'make bathe for!'
	válíisa	'make close!'
	válécéla	'close for!'
	bicécéla	'mix for!'
	bicííisa	'make mix!'
	manḡalécéla	'take to court!'
	manḡalííisa	'surprise!'

Note in the last two examples that [ŋ] patterns with the other depressor consonants in blocking grammatical depression in imperatives.

The reason that grammatical L does not show up when depressor consonants are present is because the docking of grammatical L is blocked by the presence of another L/voice feature, as in (44). The imperative L tone is apparently a prefix as it is blocked by any depressor consonant which precedes the penult. More precisely, it is a prefix which targets the penultimate syllable.



This effect is not strictly depressor in nature since verbs with underlying H tones in the plural imperative also lack a grammatical L tone and are characterized by a level H on the penult in the imperative, as in (45).

(45)	<i>Plural Imperative</i>		<i>Infinitive</i>
	lafunáani	'chew!'	kúfáfúuna
	sikáani	'slice!'	kúfíika
	laťáani	'discard!'	kúlááta
	bonáani	'see!'	kúbóona
	letsáani	'bring!'	kúlécétsa
	ḡulaláani	'kill!'	kúḡuláála
	ṡukanisáani	'separate!'	kúṡukánisa
	ṡfaláani	'carry!'	kúṡfáala

Thus, the lack of an imperative L on verbs with either underlying H's or underlying L's must be due to a similar blocking process⁸.

⁸ I have not dealt with the H that is also associated with the imperative mode: a H that is realized on the final syllable in short toneless stems and on the penult for all other verbs. Without attempting a detailed analysis here, it should be clear that the H must not be blocked by tones that occur before the penult since the H occurs without regard to other tones. I would like to suggest that the H, unlike the L, is a prefix, and it is also plane sensitive in that it is not blocked by preceding depressor consonants, as will be seen in reference to the Remote Past Negative forms.

[ŋ]'s, which act as blockers in the stem, do not act as blockers when they are outside of the stem. In (46), penultimate depression is not blocked by the preceding [ŋ] of the object prefix. This indicates that the floating L morpheme is ordered between the other prefixes and the stem: Obj. + L + stem. The initial H tones do not prevent grammatical L insertion because they are not stem H's but are shifted from the object prefixes.

- (46) ɲi-pháphamĩise 'wake me up!'
 ɲi-bálèènc 'count me (pl.)!'

4.5.3 Grammatical L Tones: Remote Past Negative

Grammatically-imposed L tones are also found in the remote past negative — a tense which consists of the following morphemes: *a* + subject prefix + stem + *ɲa*. This tone patterning resembles that of the imperative in a number of ways. Like the floating L morpheme in the imperative, that in the remote past negative affects only toneless verbs. The L tone is, as in the imperative, realized on the penult as a rising tone, as in (47).

- (47) asílimáàŋà 'we didn't plow'
 abálimeláàŋà 'they didn't plow for'
 abálimelanáàŋà 'they didn't plow for e.o.'
 anínatsáàŋà 'you (pl) didn't drink'
 abáphekhààŋà 'they didn't cook'
 abáphekeláàŋà 'they didn't cook for'
 abáphekelanáàŋà 'they didn't cook for e.o.'
 abáɬakuláàŋà 'they didn't weed'
 abáwáàŋà 'they didn't fall'
 abáyáàŋà 'they didn't go'
 abóɬáàŋà 'they didn't come'
 abóseláàŋà 'they didn't roast for'
 abóselanáàŋà 'they didn't roast for e.o.'
 abéláàŋà 'they didn't winnow'
 abábáàŋà 'they didn't divide'
 abáfikáàŋà 'they didn't arrive'

As in the imperative, the grammatical L is not realized when there is a depressor consonant preceding the penult in the stem, as in (48).

- (48) asívàlèláàŋà 'we didn't close for'
 abávàlèlanáàŋà 'they didn't close for e.o.'
 abóŋgisáàŋà 'they didn't cause to economize'
 abáluŋisáàŋà 'they didn't cause to be good'
 asímponòlotáàŋà 'we didn't cry loudly'
 asígèzisáàŋà 'we didn't cause to bathe'
 asílandzèlisáàŋà 'we didn't cause to follow'

Although [ŋ] acts as a depressor consonant in blocking the grammatical L from docking to the penult, it only does so if it precedes the penult. The [ŋ] which serves as onset to the final syllable has no effect on L's docking. This supports an analysis in which the grammatical L is a prefix.

4.5.4 Grammatical L Tones: Copular Nominals

A copular nominal is derived from a noun by the insertion of a floating L morpheme on the first syllable of the noun. Because the grammatical L targets the first syllable rather than the penultimate syllable, as in the cases of grammatical depression in verbs, blocking of the depressor effect does not occur. If the first TBU is toneless, it becomes L in tone with no other changes, as in (49).

- (49) sicátfuulo → sicátfuulo 'it's a shoe'
 uníbiiila → ɲúmíiila 'it's maize'
 umgàànù → ùmgàànù 'it's a Marula tree'
 imífuutí → yimífuutí 'it's sauces'
 emáncóobo → ɲèmánzóobo 'it's boiled dried corn'

Note that when vowel-initial nouns become copular nouns, they have a consonant onset. The onset is [y] before [i] and [ŋ] before other vowels

If the first TBU of the noun bears a H, the H is shifted onto the next syllable.

When the next syllable is the penult, a falling tone results, as in (50).

- (50) síbáambò → sìbáambò 'it's a handle'
 línceeɓa → líncéeɓa 'it's a wound'
 sícócoco → sícócoco 'it's a frog'
 ínyooni → yínyooni 'it's a bird'
 ímfeene → yimfeene 'it's a baboon'

The shifting of H to the next syllable is blocked by an intervening depressor consonant. In these cases (51), a rise surfaces on the initial syllable. This is the same blocking phenomenon we saw in relation to DIHTS.

- (51)
- | | |
|------------------------|--------------------|
| síbaàmù → sibaàmù | 'it's a gun' |
| lúbààmbò → lübaàmbo | 'it's a rib' |
| lídaàdà → lidaadà | 'it's a duck' |
| ínḵòòvù → yínḵòòvù | 'it's an elephant' |
| índvùükù → yíndvùükù | 'it's a stick' |
| íngwèènyà → yíngwèènyà | 'it's a crocodile' |
| índvòòdzà → yíndvòòdzà | 'it's a man' |
| libùéési → libùéési | 'it's a lion' |

For disyllabic nouns with an initial fall followed by a final H, the insertion of L results in an initial rising-falling tone, as in (52).

- (52)
- | | |
|-------------------|--------------|
| íindzǎ → iindzǎ | 'it's a dog' |
| tʃáani → tʃáani | 'it's grass' |
| tʃwáalá → tʃwáalá | 'it's beer' |

Presumably, the OCP blocks the shift of H onto the penultimate mora immediately preceding a final H. The apparent counterexample of *iindzǎ* is due to the transparency of consonantal L to the OCP effect on H shift which precedes Multiplanar L Spread.

When the first H is multiply linked, the inserted L affects the first mora of the H, but not the others, as in (53).

- (53)
- | | |
|---------------------|---------------------|
| úmfáati → ñumfáati | 'it's a woman' |
| ímbiila → yimbiila | 'it's a rockrabbit' |
| úmá!ákhi → ùmá!ákhi | 'it's a builder' |

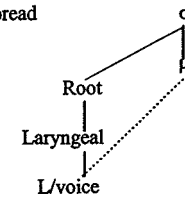
The copular nominal forms show that the grammatical L tone is not sensitive to depressor consonants that follow its target TBU. This supports the idea that copular morphology involves a prefixed floating L which is blocked only by depressor related L tones preceding the docking site. The docking of grammatical L in copular nominals is illustrated in (54).

- (54)
- | | | | |
|------------|----------|---------|-------------|
| sicátfuulo | sífaambò | sibaàmù | [ŋ]umá!ákhi |
| L H | LH L | L H L | L HH |

4.6 SUMMARY

The lowered pitch that occurs after depressor consonants and which occurs on vowels of some lexical items and which is grammatically imposed in some forms has been accounted for here in terms of a L tone. This L tone is lexically present in certain forms, such as *lichàáwe* 'warrior'. It is also lexically present as a grammatical morpheme for the imperative, the negative remote past and the copular nominative. L is inserted after depressor consonants by a process of L insertion, which has been expressed as in (55).

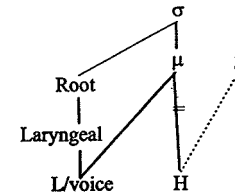
- (55) Multiplanar L Spread



Grammatical L has a designated TBU and is inserted by a process of association.

The results of L-insertion are the same in both cases. If L associates to a mora bearing a H tone, the H is shifted in order to avoid rising tones. This has been formulated with regard to depressor consonants as DIHTS, given again in (56).

- (56) DIHTS

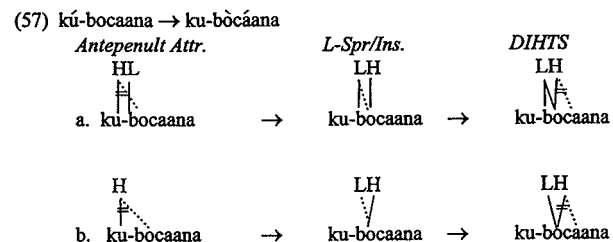


Since this is the same as what happens with grammatical L, it need not be thought of as ‘depressor-induced’ at all. It is the L-insertion that is depressor induced. The effects that follow are a consequence of the presence of L rather than a consequence of the presence of depressor consonants.

There are times when a rising tone cannot be avoided. Most notably, a H cannot be shifted to a phrase-final mora and it cannot be shifted to a mora bearing a L (such as is found after a depressor consonant). In these cases, a surface rise is generated.

Besides triggering a shift of H, a L blocks other tonal effects. As mentioned, it blocks the shift of H to a mora to which it is docked. In addition, it blocks word-internal and phrasal H Spread and it blocks the association of grammatical L to a penult TBU. Thus, a tonal approach provides a straightforward and natural account of depressor effects in Siswati. However, this has not been the traditional approach.

Siswati provides striking support for the Multiplanar approach. The account of transparency and opacity in terms of plane sensitivity and tier sensitivity predicts that there can be an interweaving of transparency and opacity, which is in direct contradiction to the approach to depressor effects in which L is simply suprasegmental and inserted after a depressor consonant (the L insertion approach). In the latter approach, the switch between transparency and opacity is accounted for in terms of the crucial ordering of L insertion. Thus, the relation between processes like Antepenult Attraction and L Shift in which depressor consonants are transparent and the processes DIHTS and word-internal H Spread in which depressor consonants are opaque are easily accounted for in the Multiplanar approach and in the L-insertion approach. In (57), the interaction of Antepenult Attraction and DIHTS are shown in a Multiplanar (57a) and a L-insertion (57b) approach. In the Multiplanar approach, the H shifts over the L/voice feature that is associated to the consonant because Antepenult Attraction is plane sensitive. In the L-insertion approach, there is no L/voice feature intervening between the original site of H and the antepenultimate syllable at the time that Antepenult Attraction occurs.



The difference between the two approaches becomes clear in relation to phrasal H spread where it has been shown that the L tone that blocks the operation of this H Spread is also transparent to the conditioning of it. In fact, it cannot be said that the process is either plane sensitive or tier sensitive, but that the conditioning is plane sensitive and the actual spreading is tier sensitive. Since the L-insertion approach has no means to capture this complex situation, it cannot account for the phenomenon.

CHAPTER 5

PROBLEM CASES

5.1 INTRODUCTION

Looking at consonant-tone interaction crosslinguistically, four kinds of tone languages can be discerned: those that have no consonant-tone interaction, those in which consonant-tone interaction involves only voiced obstruents, those in which consonant-tone interaction involves both voiced obstruents and sonorants, and those with some sort of anomalous consonant-tone interaction in which the interaction is phonetically and crosslinguistically unnatural. In this chapter, several examples of the rare latter type of tone language are considered.

There are cases in the literature that seem to contradict the idea that consonant-tone interaction always involves L tones and voicing, as found on voiced obstruents and sometimes sonorants. In Kanakuru and Podoko, there appears to be a correspondence between L tone and voiceless obstruents and another between H tone and voiced obstruents. In Ewe, there appears to be a correspondence not only between H tone and voiceless obstruents, but also one between all obstruents and L tone. It might be possible to take the position that there are types of consonant-tone interaction that we do not need to account for in terms of feature geometry because they are rare crosslinguistically. But it would be preferable to find some principled distinction between cases of anomalous consonant-tone interaction and cases of well behaved consonant-tone interaction. The anomalous consonant-tone interaction turns out not to be phonologically active, in the sense of involving

alternations. Instead it involves static conditions on morpheme structure and may well stem from historical processes. Such processes may become obscured with the passing of time and the implementation of conflicting or overlapping sound changes. However, the historical account is beyond the scope of this dissertation. Because these effects seem to have come into the phonology as distributional regularities rather than as phonological alternations, that is, they've been lexicalized rather than phonologized, I refer to them as lexical effects. Lexical effects can be essentially random or they can match the pattern of phonological effects, as in (1), where the lexical effect involves voiced obstruents and L tone. In Suma, the majority of depressor-initial words with lexical H tone have an initial L tone. Historically, it can be discerned that LH sequences changed to M, and afterwards the LH sequence was reintroduced when L's were inserted after depressor consonants (see Bradshaw n.d.). This resulted in the lexical distribution pattern exemplified in (1). Exceptions that exist may be due to subsequent borrowings. In any case, there are no tonal alternations crucially involving consonants in nouns in Suma. It is only underlying tone patterns that show this effect.

(1) Lexicalized Depressor Effects in Suma Nouns (Bradshaw notes)

biá	'cane rat'	zêré	'disease'
gók	'serpent'	gàsá	'big'
gèé	'neck'	zán	'different'
vù'mó	'fur'		

In cases like those of Kanakuru, Podoko and Ewe, lexical effects exhibit unexpected interactions between consonants and tone. These interactions are not only unexpected because they are rare crosslinguistically and lack a phonological explanation, but they are also unexpected phonetically, as is elucidated in Chapter 6.

If it turns out that other features besides [voice] and L tone are essential to consonant-tone interaction, then the Multiplanar model can only deal with a subset of the phonological data. But if it turns out that features like [sonorant] are not relevant to consonant-tone interaction in the active phonology of any language, then the Multiplanar model

can account for all cases of consonant-tone interaction. Furthermore, if it turns out that the interaction of tone with voiceless obstruents has to be explicitly formulated, then the use of a privative voicing feature is not possible, and the Multiplanar approach is again compromised. In this chapter, it is argued that the cases that appear to pose a problem for the Multiplanar model need not be accounted for in the active phonology of their languages. In so doing, I make a distinction between lexical effects which may be codified in morpheme structure effects and phonological effects which involve some kind of activity in the phonology as evidenced by alternations.

5.2 KANAKURU

Kanakuru is a Chadic language with a two-tone system. According to the analysis in Newman 1974, the content words of Kanakuru have either H, HL or LH lexical tones. Nouns, adjectives and adverbs have either H or HL underlying tones, while verbs are postulated to have either HL or LH underlying tones. The underlying tone pattern in verbs is predictable when they are obstruent-initial and unpredictable when they are sonorant-initial. Contrary to the phonetically expected pattern of L after voiced and H after voiceless obstruents, the postulated underlying tone patterns of verbs in Kanakuru have lexical effects involving H after voiced obstruents and L after voiceless obstruents. If the initial obstruent is voiceless, implosive or a prenasalized stop, as in (2a), the underlying tone pattern is LH. It is interesting that this set of consonants would not be characterized in terms of [-voice], but could possibly be characterized by the absence of a [voice] specification. If the initial obstruent is voiced, as in (2b), the underlying tone pattern is HL. If the initial segment is a sonorant, as in (2c), the underlying tone may be either HL or LH. Surface exceptions to these generalizations occur quite often, and verbs of the form CVV do not conform to them at all.

(2) Kanakuru (Newman 1974)

a.	tùpé 'to send'	pàpé 'to flay'
	shèní 'to remember'	dámí 'to be able'
	ḡìḡìré 'to crack'	
b.	dápè 'to collect'	
	jópólè 'to tumble'	
c.	ádé 'to eat (meat)'	átè 'to dip out'
	lùkùré 'to disperse'	lápàré 'to hold down'
	màané 'to return'	múulè 'to smooth'
	nàaré 'to dry'	núimè 'to repair'
	wùpè 'to sell'	wúfè 'to knot'

It is important to note the abstract nature of Newman's analysis of Kanakuru verbs. Tone patterns vary depending on context and stem type. Extrapolating from Newman's data and generalizations, there are two basic tone patterns. We could call them H and L patterns, with the L pattern found consistently with voiced obstruents. Within any pattern, as Newman makes clear, there is a low verb tone pattern (LoVTP) and a high verb tone pattern (HiVTP). There are also four stem types. The mono-stem, which is monosyllabic and completely lacking from the examples in (2), does not display a surface pattern with a L after voiceless obstruents and a H after voiced obstruents. The i-stem, which include all polysyllabic verbs ending in *-i*, do not display a surface pattern with a L after voiceless obstruents and a H after voiced obstruents. The e-stem, which includes all polysyllabic verbs ending in *-e* or *-o*, do display the relevant surface pattern, but only in final position in the LoVTP. Likewise, the p-stems, consisting of a verb root and a bound pronominal stem, display the relevant surface pattern only in final position in the LoVTP. Thus, only e-stems and p-stems display the relevant tone pattern on the surface, and then the only consonant-based difference in tones arises in one specific context: final position with LoVTP. Based on information drawn from Newman, the overall patterning is explicitly laid out in (3).

(3)	Monoverbs	i-stems	e-stems & p-stems
Voiced Obstruent Initial:			
LoVTP final	L	LH	HL
LoVTP nonfinal	L	L-L ¹	LL-L
HiVTP final	? ²	HH	HL
HiVTP nonfinal	H!	HH!	HH!

Voiceless Obstruent Initial: (includes implosives and prenasalized stops)			
LoVTP final	H	LH	LH
LoVTP nonfinal	L	LL	LL
HiVTP final	H	HH	HH
HiVTP nonfinal	H	HH	HH

The tonal contrast in the verb stems is real, but it is not as robust as might be expected. There are 75 voiced obstruent-initial verbs in Newman's data. Although all 75 form p-stems, which exhibit the contrastive HL pattern, 28 of the 75 are otherwise i-stems or monoverbs, which do not have any contrastive H following the voiced obstruent. In fact, it turns out that the monoverbs have contrastive L tone following voiced obstruents and contrastive H tone following voiceless obstruents in the only position where the contrast exists on the surface, i.e. in final position in LoVTP.

(4) Kanakuru Monoverbs finally in LoVTP (Newman 1974)

(ná) túi	'I ate it'	(ná) gài	'I forbade it'
(mán) !túa	'we ate it'	(mán) gaa	'we forbade it'
dée	'to grind'	bui	'to shoot'
kói	'to catch'	dée	'to finish'

The i-stems do not contrast in their initial tones regardless of their initial consonants. They are shown in LoVTP final position where they are always LH in (5).

(5)	à shiri	'he stole it'	à bání	'he knows it'
	à dǎhí	'he built it'	à gòmí	'he filled it'

The e-stems and p-stems show the relevant contrast, but only in LoVTP final position, as in (6).

¹ L-L indicates a L tone on the stem with a floating L tone following.

² No information on the surface tones of monostems in final position in HiVTP is given in Newman 1974.

(6)	à tüké	'he hid (it)'	à bómólè	'he scraped (it)'
	à tàkǎlé	'he tricked (it)'	à góm-nò	'he filled (it) for me'
	à shin-nó	'he stole from me'		

There are lexical exceptions to the generalization about underlying tone patterns in verbs. The full list from Newman's word list is given in (7). All involve voiceless obstruent initial or implosive initial verbs.

(7)	/b/	bálè	'to say'	ǎi	'to fail'
	/d/	dǎebè	'to dip out st.'	dǎkálè	'to become tangled'
	/t/	téerè	'to line up'	tǎngǎlè	'to stir'
	/k/	káarè	'to encircle'	kúlè	'to look after'

Once the static lexical tone pattern has been identified, the alternations that actually occur make no reference to the nature of the initial consonant. A sonorant-initial verb with underlying HL tone pattern acts no differently than an obstruent-initial verb with the same tone pattern. Likewise, a sonorant-initial verb with underlying LH tone pattern acts no differently than an obstruent-initial verb with a LH tone pattern.

(8)	shiri	'steal'	i-stem	
	à shiri	'he stole it'		LoVTP final
	nà shir gám	'I stole a ram'		LoVTP nonfinal
	à shin-nò áyim	'he stole money from me'		LoVTP nonfinal p-stem
	gámí	'fill'	i-stem	
	à gòmí	'he filled it'		LoVTP final
	nà góm bélé	'I filled a bag'		LoVTP nonfinal
	à góm-nò	'he filled it for me'		LoVTP final p-stem
	lákè	'untie'	e-stem	
	à lákè	'he untied (it)'		LoVTP final
	à lákè né	'he untied me'		LoVTP nonfinal
	jóbè	'wash'	e-stem	
	à jóbè jókó	'he washed a cap'		LoVTP nonfinal
	à jóbè-nò jókó	'he washed a cap for me'		LoVTP nonfinal p-stem

It is to be presumed that the same is true of the lexical exceptions in (7) although there is little real data to demonstrate this. *bálè* does pattern with other HL verbs and in

contrast to LH verbs in forming a verbal noun *ɓálà* 'talking' with a HL tone pattern rather than a HH tone pattern. Thus, alternations never depend on the nature of the consonants present but rather they depend on which underlying tone pattern is present.

Several characteristics of the anomalous pattern exemplified by Kanakuru can be identified. The consonant-tone interaction of this sort of pattern is phonetically and crosslinguistically unnatural. In addition, the interaction is confined to one morphological class. In the case of Kanakuru, that class is verbs. Furthermore, in this sort of case, there is no evidence for phonologically active consonant-tone interaction. What we want to say about this kind of pattern is that there are lexical regularities that have little bearing on the actual phonological component of the grammar. The Multiplanar representation has nothing to say about these cases and it should have nothing to say.

5.3 PODOKO

Another Chadic language, Podoko, spoken in Cameroun, has an unexpected consonant-tone interaction in verbs similar to that of Kanakuru in that some verb classes are characterized by a HL tone pattern which is correlated with the presence of an initial voiced obstruents. Swackhamer 1991 divides Podoko verbs into six tone classes, four of which involve a linked (as opposed to floating) H tone.

(9)	Class 1	LL	
	Class 2	LL + floating H	
	Class 3a	HL	(voiced obstruent initial)
	Class 3b	LH	(initial is not a voiced obstruent)
	Class 4a	HL + floating H	(voiced obstruent initial)
	Class 4b	LH + floating H	(initial is not a voiced obstruent)

In these four classes with linked H tones (classes 3 & 4), voiced obstruent-initial verbs are HL in tone, as in (10), while verbs with any other initial consonants are LH in tone, as in (11). In Podoko, prenasalized stops are treated as voiced obstruents.

(10)	básla	'castrate'	dágara	'repair'
	dúfa	'blunt'	dzába	'become ill'
	gára	'try'	búta	'fan'
	gwóvəta	'cook beans'	vála	'run, hurry'
	zála	'drag'	zlá	'help'
	mbúte	'catch disease'	ʔndzúma	'soak'
	ngwá	'want, like, love'	ngóla	'prevent'
	dógəza	'flow abundantly'	ndóha	'become fat'
	válana	'scold severely'	mbóla	'depart, send'
	ngwólma	'get better, cure'		
(11)	basá	'tolerate, endure'	usá	'confuse'
	díká	'squeeze together'	maslá	'leave'
	piyá	'hold, take hold of'	fikwá	'whistle'
	pavá	'arrive'	takáda	'calm'
	tsakála	'beg'	tsifá	'dampen'
	tsufá	'pay homage to'	kafá	'pay'
	kwamá	'slander'	sudá	'poison'
	ratsá	'cut several times'	hwalába	'stir up'
	mətadá	'lick, lap'	madáha	'decorate'
	ʔparáka	'jump, bound'	usalá	'look for'
	tədə	'pour, draw (liquid)'	naká	'see, look'
	ʔtəzá	'prick, pierce'	tsərvá	'run away'
	hwəlvá	'make a loud noise'	mətsədəka	'shine'
	məzá	'be in superfluity'		

Note that in LH verbs with more than two syllables the placement of the H tone is not predictable. Sometimes the non-initial H surfaces on the second syllable, as in *hwalába* 'stir up' or *madáha* 'decorate', and sometimes it surfaces on the third syllable, as in *mətadá* 'lick, lap' or *mətsədəka* 'shine'. It is therefore clear that the tone pattern cannot be mapped onto the verb by some consistent algorithm, and this supports an analysis in which the H tone is underlyingly associated to the mora on which it surfaces.

This consonant-tone interaction is defined as lexical rather than phonological because it is static, reflecting underlying tone patterns rather than tonal activity. Not only are there no alternations, but even the static relation between obstruents and tone is not

consistent for all verbs. With verbs of classes 1 and 2, shown in (12), where no linked H is present, tones act no different after voiced obstruents than after other consonants.

(12)	ɓaka	'do, happen'	para	'wash'
	tapa	'taste, do a little'	tsawa	'reach, arrive at'
	futa	'blow'	wala	'speak'
	dzama	'think'	vusa	'put in ashes'
	ngwafa	'tie, bind'	gasa	'take, catch'

Furthermore, non-initial voiced obstruents have no effect on tone, as shown in (13). In (13a), voiced obstruent initial verbs with the HL tone pattern show no variation when medial consonants are voiced obstruents. In (13b), this lack of variation is seen for verbs without initial voiced obstruents characterized by the LH tone pattern.

(13)	a. Class 3a (HL)			
	dáka	'to wall together'	dóga	'enrich'
	dzádaha	'to decorate'	gógazla	'to lose heart'
	b. Class 3b (LH)			
	ɓazá	'spoil, destroy'	ɓasá	'tolerate, endure'
	kwazláhwa	'stretch'	kwəsláha	'cough'
	sləngədə	'choke'		

At the same time, there is an expected consonant-tone interaction, that is interpreted by Swackhamer as allophonic. In her analysis there are two L tones, the higher variant which she calls L1, and the 'downstepped' variant which she calls L2. After the sequence of a H tone plus a depressor consonant, L2 occurs (though there is also grammatical downstep). In (14), L2 is marked with a grave accent, and L1 is left unmarked.

(14) ndávà 'ask' vs. ndóla 'cut' vs. (presumably) ʸnduva 'lessen'

Thus, the presence of a voiced obstruent is a necessary but not a sufficient condition for tone lowering. It would be possible to account for this contrast as being due to a L tone after a H being higher in pitch than elsewhere, while a voiced obstruent would have the

characteristic of cancelling out the effect. But evidence for such an account is not available.

There are several arguments for the tone patterns in Podoko, as in Kanakuru, being accounted for in terms of lexical distribution patterns and not in terms of the active phonology of the language. Again we find static underlying tone patterns that happen to refer to the voicing status of a preceding consonant, but no evidence of tone alternations that are sensitive to the nature of consonants.

5.4 EWE

Ewe is a Kwa language spoken in Nigeria. The Peki and Kpando varieties of Ewe have been described in Ansre 1961, Stahlke 1971 and Smith 1968 and the data from these descriptions is used here.

Ewe has been frequently cited in the literature on consonant-tone interaction (Hyman 1973, Hyman & Schuh 1974, Peng 1993, Odden 1995, and others). Although Ewe is cited most often for the interaction between voiced obstruents and L tone in monosyllabic noun tone patterns, and it is cited in Odden 1995 also for the unexpected correlation between obstruents in general and L tone nominal prefixes, the situation is even more complex than that. It not only seems as if there is interaction between voiced obstruents and tone in some contexts and between obstruents in general and tone in other contexts, but also there is some indication of voiceless obstruents and sonorants patterning together as well as voiced obstruents and sonorants patterning together in tone interactions.

(15) Pattern Together	To the Exclusion of	In the following case
voiceless obstruents & sonorants	voiced obstruents	initial tone of C-initial monosyllabic nouns
voiceless obstruents & voiced obstruents	sonorants	initial tone of V-initial monosyllabic nouns
voiced obstruents & sonorants	voiceless obstruents	a. imperative sg. tone pattern b. transparent to L spread c. falling tone of preceding high verbs d. nominal tone pattern after high verbs

Ewe is a problem case because it seems to require participation of the feature [sonorant] in consonant-tone interaction in order to deal with noun prefix effects. However, the feature [sonorant] is not an essential participant in consonant-tone interaction in any other language. Moreover, if the consonantal features with which tone interacts can be chosen randomly, then the importance of the feature [voice] and the approach that this importance leads to, i.e. the Multiplanar approach, are not justified.

Ewe poses still another problem for the Multiplanar approach. Stahlke 1971 has observed that in monosyllabic nouns, voiceless obstruents appear to block the spread of L. The Multiplanar approach entails the assumption that voicing is represented by a privative feature which is realized on voiced obstruents and, in some languages, on sonorants. Given this assumption, there is no way that voiceless obstruents can act as blockers to the exclusion of voiced obstruents. A similar phenomenon in Ngizim (see chapter 2) has been accounted for in terms of the conditioning of L Spread by the presence of a L/voice feature on sonorants and voiced obstruents. This analysis is not workable for Ewe because L Spread occurs across many voiceless obstruents, demonstrating that [L/voice] is not necessary to trigger the spread. If voiceless obstruents are capable of blocking L Spread and this can best be accounted for in terms of consonantal features, then voicing must be represented with a binary feature. But it is highly plausible in Ewe to account for the apparent blocking effect in terms of an underlying M tone that is prelinked to the

relevant nouns. Thus, Ewe is actually like Kanakuru and Podoko in that the apparent correlations between consonant and tone are actually best accounted for by underlying tonal specifications, though a more complicated version. The lexical regularities are in the lexicon and the tones that are lexically specified account for the patterns that emerge.

5.4.1 Ewe Consonants and Tones

Before looking at consonant-tone interaction in more detail, it is important to know what the consonants and tones of the language are. Consonants in Ewe have been classified into three sets which correspond to the voiced obstruents, the voiceless obstruents and the sonorants. They have been so classified because of the tonal behavior of surrounding vowels, which we examine further below. The consonant inventory is given in (16).

(16) Consonant Inventory

	Bi-labial	Labio-dental	Dental	Alveolar	Retro-flex	Palatal	Velar	Labio-velar
Obstruents	p, b		t, d		ɖ		k, g	kp, gb
	ɸ, β	f, v	ts, dz	s, z			x, h	
Sonorants	m		n			ny	ŋ	
	w		l, r			y	ɣ	

Note that *h* represents a voiced velar fricative and *ɣ* represents a velar sonorant.

- (17) *h* = voiced velar fricative
ɣ = velar sonorant

It is generally agreed that the dialects of Ewe which I deal with here have three phonologically distinct surface tones: H, M and L. The notation in (18) is used. I take the position that all three tones are found in underlying representations and, furthermore, that tone can be underlyingly unspecified.

- (18) \acute{v} H
 \tilde{v} M
 \grave{v} L
 v unspecified

Ewe has been analyzed (Ansre 1961) as a two tone language that has two allo- tones for the nonhigh tone. That translates into two underlying tones (high and nonhigh) and three surface tones (H, M, L). There are reasons to reject such an analysis, which Stahlke 1971 does. His most convincing argument is that the presence of L and M tones, though often predictable, must sometimes be lexically marked. He cites the numerals, whose initial tones are not predictable. The initial tones in the words $\grave{e}v\grave{e}$ 'two' and $\acute{a}d\grave{e}$ 'six' provide an example in which M and L do contrast. Since the initial tones in these two words both precede a voiced obstruent and a final L tone, the distinction between them must be represented underlyingly because the initial tone cannot be predicted from its phonological environment.

There is also evidence for floating M and L tones, which suggests the need for both of these tones in the tonal inventory. However, it has been assumed by those who espouse the two-tone approach, that the 'basic' tone is M and that the application of tone lowering rules result in surface L's. Both floating M and L tones occur before nouns in Ewe. Furthermore, there is a grammatical L tone in the imperative (see Chapter 2) which is not affiliated to any tautomorphic segmental material. As Stahlke points out, there is no good reason to postulate a floating M tone that invariably lowers to L by a morphological rule that must read something like 'lower the nonhigh tone to L when it is the imperative morpheme'. The alternative solution, that L tone is basic and tone raising rules result in M tones is also unduly complicated. It requires morphological rules referring not only to nouns, but specifically to monosyllabic nouns with initial sonorants. In any case, although M and L tones can be predicted in many contexts, the basis for the prediction is not consistent. Thus, one can predict the tone preceding a monosyllabic noun stem based on whether the initial consonant is an obstruent or a sonorant. But elsewhere, after the initial consonant of a monosyllabic noun for example, the L occurs after a voiced obstru-

ent and the M occurs after any other segment. Postulating contrastive tones underlyingly allows for an account without complicated morphologically based tone rules.

Thus, I take the position that Ewe is a three tone language underlyingly, with M being the default tone. As it happens, surface M tones are often unspecified underlyingly, but this is not always the case.

5.4.2 Ewe Nouns

There are at least four kinds of nouns in Ewe. There are consonant-initial monosyllabic nouns (19a), vowel-initial 'monosyllabic' nouns (19b), polysyllabic monomorphemic nouns (19c) and compound nouns (19d). The consonant-tone interaction which will be described here concerns only the monosyllabic nouns. Note that the assumption that VCV nouns are monosyllabic is in keeping with work by Downing (1998) and Odden (1995b) on the anomalous behavior of onsetless initial vowels. More specifically, it is assumed here that the initial vowels of these nouns are moraic but unsyllabified. Justification for calling them monosyllabic comes from the fact that they pattern with CV nouns.

- (19) a. $b\grave{e}$ 'thatch'
 b. $\grave{a}zi$ 'egg'
 c. $k\acute{u}v\acute{í}á$ 'laziness'
 d. $d\bar{e}-h\acute{á}\acute{a}$ 'palm wine'

5.4.2.1 Consonant-Initial Monosyllabic Nouns

In consonant-initial monosyllabic nouns, voiced obstruents act alone to the exclusion of voiceless obstruents and sonorants in always having an initial L tone after the consonant. There is a contrast between voiced obstruent initial nouns and other nouns in contexts where the M surfaces on the other nouns. This M fails to surface phrase finally in the Peki dialect. In the Kpando dialect it always surfaces.

(20) C-initial monosyllabic nouns:

	initial L	initial M	initial H
voiced obstruents	yes	no	no
voiceless obstruents	yes	yes	yes
sonorants	yes	yes	yes

As shown in (21), monosyllabic nouns beginning with a voiced obstruent have two surface tone patterns. Either they have a level L tone (21a) or they have a tone that rises from L (21b). The only exceptions arise when these nouns are compounded or when they form a phrase with a possessive pronoun.

(21) Voiced Obstruents Initial Monosyllabic Nouns

a.	bè	'thatch'	dà	'snake'
	gà	'money'	gbè	'voice'
	dzò	'fire'	βù	'blood'
	vù	'fight'	hà	'pig'
	glà ^a	'jaw'	dzrè	'quarrel'
b.	dzòó	'horn'	bàá	'mud'
	βùú	'drum'	zòó	'pot'

Monosyllabic nouns beginning with a voiceless obstruent have three contrastive patterns.

The M pattern emerges in both Peki and Kpando when there is a following H tone. The other patterns are level H and a rise from M to H.

(22) Voiceless Obstruent Initial Monosyllabic Nouns

a.	tē lá	'the yam'	kā lá	'the rope'
	kpō lá	'the club'	tsi lá	'the water'
	fū lá	'the sea'	xā lá	'the fish trap'
b.	tú	'gun'	ké	'sand'
	kpé	'stone'	fú	'bone'
	só	'horse'	xá	'broom'
c.	pěé	'chisel'	φōó	'guinea com'
	fīi	'digging stick'	tōó	'mortar'

Monosyllabic nouns beginning with a sonorant exhibit the same contrastive tone patterns as those beginning with a voiceless obstruent.

(23) Sonorant Initial Monosyllabic Nouns

a.	lā ^a lá	'the animal'	mō lá	'the face'
	nyi lá	'the cow'	γē lá	'the sun'
b.	ló	'crocodile'	mó	'road'
	nú	'thing'	ŋó	worm'
	wó	'flour'	yí	'cutlass'
	γé	'white clay'		
c.	nūú	'mouth'	lēé	'bridge'
	yāá	'air'		

A summary of the contrastive tone patterns of these nouns is given in (24) where D represents a voiced obstruent, T represents a voiceless obstruent and R represents a sonorant. In one context, there is a contrast between two kinds of Dv̄v̄ nouns which leads Stahlke 1971 to postulate an underlying contrast between Dv̄ and Dv̄v̄ nouns, but that is beyond the scope of this paper. In any case, the pattern presented here for consonant-initial nouns is what we generally expect in consonant-tone interaction. Voiced obstruents alone have an effect on tone and that effect involves either the presence of a following L or the avoidance of a following H.

(24) Summary of Patterns:	Dv̄	Tv̄	Rv̄
		Tv̄	Rv̄
	Dv̄v̄	Tv̄v̄	Rv̄v̄

5.4.2.2 Vowel-initial 'monosyllabic nouns' (noun prefix effects)

With vowel-initial monosyllabic nouns, an anomalous patterning of tone in relation to consonants presents itself. Voiced and voiceless obstruents, the natural class defined by [-sonorant], appear to pattern together in triggering a tonal effect. This would suggest that the feature [-sonorant] interacts with tone. Yet this pattern seems unique to Ewe. Another oddity is that the tone affected precedes the consonant. Phonological surveys and phonetic studies concur that the tones affected by consonants should, and in fact otherwise always do, follow the consonants.

(25) V-initial monosyllabic nouns:

	initial L	initial M	initial H
voiced obstruents	yes	no	no
voiceless obstruents	yes	no	no
sonorants	no	yes	no

The relevant tone is found on the initial vowel of vowel-initial monosyllabic nouns. It is L before obstruents, be they voiced (26a) or voiceless (26b), and it is M before sonorants (26c). The reader will note that the tones following the first consonants are the same as for consonant-initial monosyllabic nouns.

(26) V-initial Monosyllabic Nouns

a.	à-hà lá	'the wine'	à-gò lá	'the pine tree'
	à-gbáá	'plate'	à-zì	'egg'
	à-dò	'squirrel'	à-dùú	'tooth'
b.	à-fí	'tree'	à-fí	'ashes'
	à-sì lá	'the market'	à-fí lá	'the mouse'
	à-kpáá	'fish'		
c.	ā-lé	'sheep'	ā-nyí	'bee'
	ā-lò lá	'the sleep'	ā-mě lá	'the person'
	ā-māá	'greens'	ā-wū	'shirt'
	ā-ṅē	'rubber'	ā-lòó	'wrist'

Another similarity between consonant-initial and vowel-initial nouns is that voiced obstruents and voiceless obstruents are preceded by a L tone and sonorants are preceded by a M tone when a toneless verb precedes the noun. In (27a), the underlined nouns with initial voiced obstruents are preceded by underlyingly toneless verbs that are realized with a L tone. In (27b), the underlined nouns with initial voiceless obstruents are preceded by toneless verbs that are also realized with a L tone. In (27c), the underlined nouns with initial sonorants are preceded by toneless verbs that are realized with a M tone. Note that in all cases, the initial consonant of the verb has no effect on its tone.

(27) Toneless verbs before nouns

a.	wó wù <u>dzàtá</u> lá	they killed the <u>lion</u>
	wó dà <u>zè</u> lá	they threw the <u>pot</u>
	wó <u>φlè</u> <u>dzàtá</u> lá	they bought the <u>lion</u>
b.	wó wù <u>só</u> lá	they killed the <u>horse</u>
	wó dà <u>só</u> lá	they threw the <u>horse</u>
	wó <u>φlè</u> <u>só</u> lá	they bought the <u>horse</u>
c.	wó wù <u>nyí</u> lá	they killed the <u>cow</u>
	wó dà <u>nyí</u> lá	they threw the <u>cow</u>
	wó <u>φlè</u> <u>nyí</u> lá	they bought the <u>cow</u>

The possible surface tones of monosyllabic nouns in contexts where contrasts are not neutralized are given in (28). The tones given are realized on vowels before and after the initial consonant, represented by the period [.] in the following.

(28) voiced obstruent	L.L		L.LH
voiceless obstruent	L.M	L.H	L.MH
sonorant	M.M	M.H	M.MH

We can discern a number of lexical regularities in monosyllabic nouns. The initial tone is predictable; the initial vowel, where it is present, is always [a]; and all contour tones are rising. These regularities have led Ansre 1961 to call the final H of the contour tone a suffix, and they have led Stahlke 1971 to call the initial vowel and the initial tone a prefix. However there is no functional or semantic content to either the so-called suffix or the so-called prefix.

Other aspects of the nouns are unpredictable. The presence of an initial vowel is unpredictable; the presence of a final H is unpredictable; and the tone after a sonorant or a voiceless obstruent is unpredictable, at least in terms of whether it is H or not. In the case of H tone, it has always been a choice to treat this as underlying. It is not unreasonable to consider the initial vowel of a noun, where it exists, to be underlyingly present as a part of the noun root itself. It is equally reasonable to consider the final H to be part of the underlying tone pattern. Calling it a suffix does not add anything to our understanding of the phonology of Ewe or improve the analysis in any way.

We have a number of choices about what we prefer to call underlying and what we prefer to derive by some phonological operation. We also have choices about whether we prefer to call some element part of the noun root or morphologically separate from it. It has been the choice in earlier accounts to analyze the tones and initial vowel of VCV nouns and the floating tone before CV nouns as prefixes. The consequence of that choice is that the fact of there being a prefix containing segmental material must be noted in the lexical entry of any noun. Yet including that segmental material as part of the noun itself would be no more complicated. The fact that only *a* is found as an initial vowel in nouns may be accounted for in terms of prefixation historically, but this does not make any difference in a synchronic account. Another consequence of analyzing the initial vowel as a prefix is the need for complicated morphologically based rules. If we take the example of the noun *àgbàá* 'plate' in this kind of approach, the noun root must be lexically marked as [+Pfx] and [+Sfx] since it has initial *à* and a final H. In the grammar, a series of rules must apply to derive the predictable elements that are not present lexically. There must be a rule which inserts *a* before [+Pfx] nouns. There must be a rule that inserts a H on [+Sfx] nouns. There must be a rule that lowers the nonhigh tone on the prefix to L before a [-sonorant] consonant. There must be a rule that spreads that L tone to the mora after a voiced obstruent. If the word were *àkpāá* 'fish', then the final rule would be blocked because L could not spread to the mora after an initial voiceless obstruent just in case the word involved is a noun. It bears emphasizing that the operation of L spreading in Ewe is not sensitive to morphology. It is only the blocking of L spreading that could possibly be defined in terms of the morphological category 'noun' and the phonological category 'voiceless obstruent'. Thus, there are problems with this approach. It entails prefixes and suffixes with no semantic content to account for phonological realizations that are merely lexically regular in some way. It also requires rules that refer to features like [+Noun]. These problems can be avoided in an approach that allows initial tones, whether floating or associated to the initial vowel in VCV nouns, to be lexically marked and allows final H tones to be lexically marked as part of the underlying tone pattern. In this sort of ap-

proach, the lexical entries for *àgbàá* 'plate' and *àkpāá* 'fish' would be the same as their surface forms except that the tone after the voiced obstruent in *plate* need not be underlyingly present because an independently needed rule of L Spread would easily account for it. This approach, which I adopt, resolves the problems of anomalous consonant-tone interaction because the tones that are tied to the presence of an obstruent vs. a sonorant are statically distributed in the lexicon and not derived in the grammar.

More explicitly, I assume the underlying patterns for monosyllabic nouns and their surface derivations as presented in (29). Two operations are needed: L Spread, discussed in the next section, and default fill in of M tone on tonally unspecified moras.

(29)	voiced obstruents	voiceless obstruents	sonorants
nonhigh:	$\backslash cv \rightarrow c\grave{v}$ $\backslash vc\grave{v} \rightarrow \grave{v}c\grave{v}$	$\backslash c\bar{v}$ $\backslash vc\bar{v} \rightarrow \grave{v}c\bar{v}$	$cv \rightarrow c\bar{v}$ $vcv \rightarrow \bar{v}c\bar{v}$
high:		$\backslash c\acute{v}$ $\backslash vc\acute{v} \rightarrow \grave{v}c\acute{v}$	$c\acute{v}$ $vc\acute{v} \rightarrow \bar{v}c\acute{v}$
contour:	$\backslash cv\acute{v} \rightarrow c\bar{v}\acute{v}$ $\backslash vc\acute{v} \rightarrow \grave{v}c\bar{v}\acute{v}$	$\backslash c\bar{v}\acute{v}$ $\backslash vc\bar{v}\acute{v} \rightarrow \grave{v}c\bar{v}\acute{v}$	$cv\acute{v} \rightarrow c\bar{v}\acute{v}$ $vcv\acute{v} \rightarrow \bar{v}c\bar{v}\acute{v}$

5.4.2.3. L Spread

L Spread is a phrasal phenomenon in Ewe in which a L spreads in both directions until it reaches a H tone or a voiceless obstruent. If it were any voiceless obstruent that blocked L spread then this might constitute a case of voiceless obstruents blocking tone spread, something which would provide counterevidence to a privative theory of [voice] which is a central assumption in the Multiplanar approach. However, the voiceless obstruents that appear to block L spread are a very limited group.

L Spread is bidirectional. In the data in (30), L spreads leftwards over voiced obstruents and sonorants. In (30c), L spreads to the vowel after the voiceless obstruent in *fi* 'steal'. This is expected since verbs are toneless and take on the tones of following nouns.

(30) L Spread (leftward)

- a. ame ève → à-mè èvè 'two people'
people two
b. awu gèdè → à-wù gèdè 'many dresses'
dresses many
c. ame fi àzi lá → àmè fi àzi lá 'a person stole the egg'
person steal egg the
d. ame wu àfi lá → àmè wù àfi lá 'a person killed the mouse'
person kill mouse the
(Stahlke 1971)

When L spreads to the right, there is no difference in its behavior. In (31), L spreads to all toneless moras, including that following the voiceless obstruent of *fi* 'steal'.

(31) L Spread (rightward)

- àdò fi alá → àdò fi alá 'a squirrel stole the meat'
squirrel steal meat the

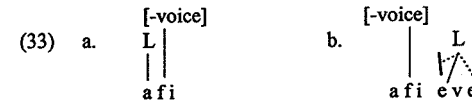
Despite the behavior of voiceless obstruents in verbs, nouns appear to block the spread of L. In (32), L is blocked from spreading to the vowel following the voiceless obstruent in *àfi* 'mouse', despite the presence of a L tone on the following word. Elsewhere in the sentences, L spreads as expected. Apparently the blocking of L Spread is only reported by Stahlke and the only examples he gives, all reproduced here, involve the word *àfi*. Still the implication in Stahlke that at least in the Kpando dialect, this behavior is characteristic of all monosyllabic nouns with an initial voiceless obstruent.

(32) Failure of L Spread

- a. ame wu àfi lá → àmè wù àfi lá 'a person killed the mouse'
person kill mice the
b. àfi fi àzi lá → àfi fi àzi lá 'a mouse stole the egg'
mouse steal egg the
c. àfi ève → àfi èvè 'two mice'
mice two

There are two significant points to be made about the apparent blocking of L Spread by voiceless obstruents. This blocking only occurs in nouns, and yet the process is a phrasal one. Furthermore, the blocking occurs even when there's no intervening voice-

less obstruent since a M tone following *f* does not lower before a following L. This is illustrated in (33).



If it were indeed the case that voiceless obstruents were blocking L spread, then one way of explaining the blocking by a non-intervening voiceless obstruent would be in terms of the spread of a tone from the consonant to the following vowel. In this case, we would have to consider M tone the counterpart of voicelessness. However, there is no reason, crosslinguistically or phonetically, to think that that is the case. On the other hand, the idea that the presence of a M tone on the relevant nouns blocks the spread of L tone is the most sensible account of the blocking effect, although the M tone need not be related to the presence of the voiceless obstruent in any active sense. We already have evidence that there are underlying M tones in Ewe. It is not illogical to assume, and the most sensible interpretation of the data supports the assumption, that nouns with voiceless obstruents have underlying M tones. This explains the failure of L to spread to these sites in all situations, and it accounts for the fact that voiceless obstruents in verbs, which are underlyingly either toneless or high in tone, never block L spread.

CHAPTER 6

PHONETIC EFFECTS OF CONSONANTS ON TONE AND IMPLICATIONS FOR THE FEATURE [L/VOICE]

6.1 INTRODUCTION

This chapter focuses on the phonetic effects of consonants on pitch. The primary effect, the best documented and the most prevalent, is one of consonant voicing on pitch. Other consonantal effects have been postulated and will be mentioned, but they are not substantially documented. There is some documentation of the effect of breathy voicing being more pronounced than that of plain voicing.

Consonants affect pitch either by raising or lowering the pitch of a following vowel. The effect of a given consonant on pitch is determined by the laryngeal properties of the consonant. For example, raising is caused by voiceless obstruents, while lowering is caused by voiced obstruents. The importance of laryngeal factors is a straightforward result of the fact that the larynx constitutes a common articulator for both consonant phonation and pitch. The classic consonants involved in pitch effects are voiced and voiceless obstruents, but we might also expect phonetic effects involving breathy voiced consonants and creaky voiced consonants as well as some kind of contrast between aspirated and unaspirated consonants. In addition, the laryngeal consonants *ʔ* and *h* interact with pitch on a phonetic level. An interesting challenge is posed by implosives, which are phonetically voiced but have an effect similar to that of voiceless obstruents.

In view of the importance of voicing in determining the pitch effects, an examination of the concept of voicing, especially in terms of what phonetic parameters correspond to the phonological notion of a voiced segment, is relevant. Traditionally, the definition of phonological voicing has identified vibration of the vocal folds as the primary phonetic correlate. This definition can readily be found in the literature. For example, Fant 1973 defines the feature *voice* simply as 'vocal fold vibrations' (p. 26). Clark & Yallop 1990 summarize definitions of the feature *voice* in their Appendix 2. Their summary of the Jakobson and Halle 1956 definition of *voice* gives the articulatory (in contrast with acoustic) description as 'vocal cord vibration' (p. 364). Their summary of the Chomsky & Halle 1964 definition of *voice* reads 'vocal cord vibration (induced by appropriate glottal opening and airflow)' p. 366. The inadequacy of such a definition has been widely recognized and is made clear when careful definitions are given which take into account the resistance of stop consonants to phonetic voicing. From a perspective that takes into account consonant-tone interaction, phonological voicing is better defined in terms of a laryngeal configuration which may or may not entail vocal fold vibration during the consonant but does produce an effect on the following vowel.

Armed with the knowledge that consonants do have predictable effects on pitch, we need to understand the reason for the interaction observed. To this end, three major theories are considered which address the mechanisms by which pitch effects are produced and how these are related to the laryngeal configurations needed for the consonants.

6.2 PHONETIC EFFECTS OF CONSONANT VOICING ON FUNDAMENTAL FREQUENCY

As in the phonology, the phonetic effects of consonants on pitch are related to their laryngeal qualities rather than to consonantal characteristics of place and manner. Phonetically, voiced obstruents are correlated with lowered pitch and voiceless obstruents are correlated with raised pitch. The phonetic effects of obstruents on pitch suggest that voiced and voiceless obstruents should both cause phonological effects. Sonorants, which

tend to remain neutral in their phonological and historical effect on vowel pitch, may also have a consistent phonetic effect on the fundamental frequency of a following vowel. All of these effects occur in both tonal and nontonal languages; the difference being that the consonant-induced perturbations are shorter in duration in tone languages. Gandour 1974 finds that the consonant-induced perturbations extend for 30-50 ms. into the vowel in Thai and Hombert 1978 finds that they extend for 40-60 ms. in Yoruba compared to a duration of approximately 100 ms. for English.

Early studies indicate that vowels after voiced obstruents have a lower average frequency than vowels after voiceless obstruents. The results of three studies in which the average fundamental frequency (in Hz.) of vowels is measured after voiced and voiceless consonants, in (1), demonstrate the correlation of voiced obstruents with lowered pitch and voiceless obstruents with raised pitch.

(1) Fundamental Frequencies (in Hz) of Vowels as a Function of the Preceding Consonant as Determined by Three Studies (from Hombert 1978)

	<i>p</i>	<i>t</i>	<i>k</i>	<i>b</i>	<i>d</i>	<i>g</i>
a. House & Fairbanks 1953	127.9	127.1	127.2	120.9	120.6	122.8
b. Lehiste & Peterson 1961	175	176	176	165	163	163
c. Mohr 1968	130.7	129.8	131.1	125.1	124.8	125

House & Fairbanks 1953 use nonsense syllables with English-speaking males. In their results, voiced fricatives and nasals (2) pattern with voiced obstruents (1a) in their effect on the fundamental frequency of following vowels. All of the voiced consonants are followed by a vowel with average fundamental frequency between 120.6 and 123.2 Hz. Note the overlap between the voiced stops with *g* at 122.8 Hz. and the voiced non-stops (i.e. *v*, *z*, *n*). There is no overlap with voiceless stops, which cause a pitch effect on the vowel between 127.1 and 127.9 Hz. Voiceless fricatives are intermediate in their effect, with fundamental frequency values from 124.3 to 126.1 Hz. House & Fairbanks point out that the values for fundamental frequency of vowels after all voiceless consonants (with the exception of *f*) are higher than the values after all voiced consonants.

(2)	<i>v</i>	<i>z</i>	<i>m</i>	<i>n</i>	<i>f</i>	<i>s</i>
	122.2	122.6	123.2	121.8	124.3	126.1

House & Fairbanks find that voicing affected not only fundamental frequency but also duration and relative power (another term for intensity/amplitude; measured in dB). Voiced consonants are followed by vowels that have lower fundamental frequency, longer duration and greater relative power.

Lehiste & Peterson 1961 use CVC words with six speakers of American English (one speaker was the main subject, the other 5 served as controls with a smaller corpus). As in House & Fairbanks 1953, voiced fricatives and nasals with values from 155 to 169 Hz. pattern with voiced stops with values from 163 to 165 Hz. But in this study, voiceless fricatives with values from 173 to 175 Hz. pattern more closely with voiceless stops with values from 175 to 176 Hz., as in (3).

(3)	Stops	<i>b</i>	<i>d</i>	<i>g</i>	<i>p</i>	<i>t</i>	<i>k</i>
		165	163	163	175	176	176
	Fricatives	<i>v</i>	<i>z</i>		<i>f</i>	<i>s</i>	
		155	169		173	175	
	Sonorants	<i>m</i>	<i>n</i>	<i>r</i>	<i>l</i>	<i>y</i>	<i>w</i>
		162	161	166	164	164	167

Lehiste & Peterson also conclude that consonants have no consistent effect on the fundamental frequency of a preceding vowel.

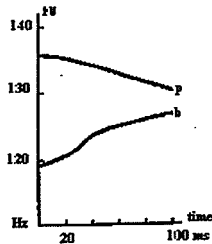
Where the early studies measure the pitch of the entire following vowel, later studies focus on the initial portion. Hombert 1978 shows that the initial portion is where the effect of preceding consonants is most prominent. This effect is that fundamental frequency starts low and rises at the onset of vowels following voiced obstruents and starts high and falls following voiceless obstruents. The phonetic data in Hombert 1978 suggests that sonorants pattern with voiced stops, which would not be surprising if phonetic voicing were the determining factor in the pitch effect. However, it is not clear whether the pitch after sonorants is affected by the consonant or whether it is merely the expected

low pitch effect at the beginning of an utterance. For the most part, no phonetic effect of sonorants is recognized (but see Maddieson 1984 for an opposing view). Since sonorants sometimes pattern with voiced obstruents in phonological consonant-tone interaction, the question of whether sonorants actually interact phonetically with pitch is an interesting one that has not been answered definitively.

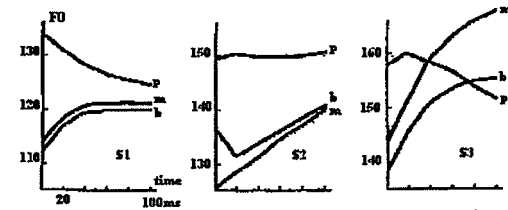
The effects of onset consonants on the pitch of following vowels is in some ways compatible with the phonological consonant-tone effects. That is, like the phonetic data shows, voiced and voiceless obstruents differ in their phonological effect on tone. Like the phonetic data, voiced obstruents are associated with lower pitch, voiceless obstruents are associated with higher pitch. There are other ways, however, in which the phonetic data is less compatible. For example, the phonetic data might suggest that voiced and voiceless obstruents would have an equal impact phonologically on tone. This is not the case, as we have seen, and this will be discussed in more detail in the next chapter.

Hombert 1978, working with speakers of English, illustrates the differences between the effects of differentially voiced obstruents with the charts of average fundamental frequency after voiced and voiceless obstruents shown in (4) and (5). In these charts, *p* represents all voiceless obstruents, *b* all voiced obstruents and *m* all sonorants. There is a significant rise from a low frequency after voiced obstruents and a significant fall from a high frequency after voiceless obstruents.

(4) Pitch Traces: Averages for 3 speakers (Hombert 1978)



(5) Individual Pitch Traces: Averages by speaker (Hombert 1978)



In a separate experiment, also reported in Hombert 1978, a Yoruba speaker was asked to say words with different tones and differing onset consonants. The results once again show a fall after voiceless obstruents, regardless of lexical tone, and a rise after voiced obstruents.

Lea 1973 reports the same results for English: rises after voiced obstruents and falls after voiceless obstruents. Lea also emphasizes that the pitch effects of consonants are only one factor affecting the pitch contour of vowels in nontonal languages. Other factors include intonation contours, the pitch effects of constituency, and the pitch effects of stress. The figure in (6) shows the pitch effects of the different factors. In (d), consonant-induced pitch effects are figured in. This makes it clear that consonantal effects can sometimes be masked.

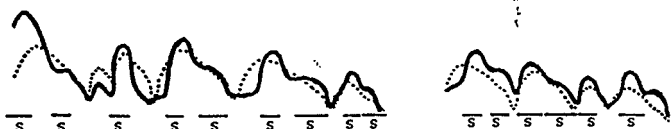
(6)



(a) Overall Sentence Intonation Contour for Two-Clause Sentence.



(b) Archetype F_0 Contours of Constituents Riding on the Overall Sentence Contour.



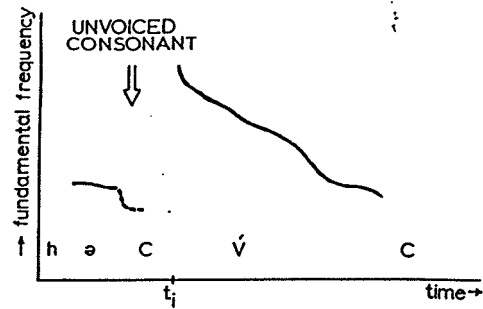
(c) Local Increases in F_0 Assigned Where Stressed Syllables (S) Occur, All Riding on Contours of the Constituents.



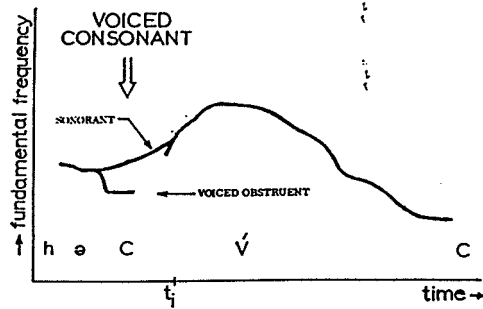
(d) F_0 Variations Due to Phonetic Contents Superimposed on Contours that Incorporate Stress, Constituent Structure, and Sentence Intonation Influences on F_0 Contours.

Lea recorded utterances with varying medial consonants using nonsense words of the form $h\alpha CVC$ with a final stressed syllable. He claims that the consonantal effect on F_0 is more salient in a stressed syllable. In medial position, sonorants pattern similarly to voiced obstruents, but again it is not clear whether the effects after sonorants are consonant-related or stress-related. Since raised pitch is a correlate of stress in English, a stressless syllable will be lower in pitch than a stressed syllable regardless of adjacent consonants. But even if the sonorant effects are stress-related and represent the interpolation from a stressless syllable with lower pitch to a primary stressed syllable with higher pitch, there remains some question as to whether the voiced obstruent effects are significantly different from the sonorant effects. There can be no question but that they are grossly different from the voiceless obstruent effects. The real question is whether the phonetic effects are primarily voiceless obstruent effects in contrast to the phonological effects which are primarily voiced obstruent effects.

(7)



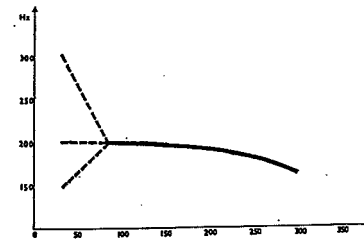
(a) F_0 Contour with Unvoiced Consonants.



(b) F_0 Contour with Voiced Consonants.

The importance of the difference between the pitch effects of voiceless and voiced obstruents is reinforced by the perceptual study in Haggard, Ambler and Cohen 1970, which provides evidence that the relevant pitch effects are actually perceived by the language user. As illustrated in (8), three pitch traces with the same vowel frequency but with three different onsets (rising, falling, level) were synthesized. The synthesized syllable was ambiguous between *bi* and *pi*. The pitch tracing with a falling onset was more often identified as *pi*, the one with the rising onset more often as *bi* and the one with the level onset was identified inconsistently. This indicates that onset pitch following an obstruent is a significant cue in identifying its voicing.

(8) Pitch Salience in a Perceptual Study (Haggard, Ambler & Callow 1970)



In summary, voiced and voiceless obstruents are both characterized by consistent pitch effects realized on the following vowel. These pitch effects are cues to the voicing of the obstruents.

6.3 CAUSES OF VOICING EFFECTS ON VOWEL FUNDAMENTAL FREQUENCY

There are at least three different theories for why obstruent voicing influences fundamental frequency on vowels. These are labelled by Hombert, Ohala and Ewan 1979 as the aerodynamic hypothesis and the vocal cord tension hypothesis, the latter being divided into the Halle-Stevens version (referred to here as the horizontal tension version) and the vertical tension version.

6.3.1 The Aerodynamic Hypothesis

The aerodynamic hypothesis emphasizes the importance of the air pressure differential across the vocal folds. According to this hypothesis, a high rate of glottal airflow at the release of voiceless stops and fricatives leads to a higher than usual Bernoulli effect which, in turn, results in forcible and rapid adduction of the vocal folds. The tight adduction causes the vocal cords to vibrate faster, producing higher pitch. As the laryngeal gesture is modified for normal vowel phonation, the adduction is relaxed and the rate of vibration slows, resulting in a fall in pitch on the vowel. With voiced obstruents, the vocal cords are not abducted, and a blockage is created in the oral cavity which affects air pressure across the glottis. The air pressure builds up in the oral cavity making it more difficult to keep the vocal cords vibrating. This results in a slowing of the rate of vibration, and a lowering of pitch. When the obstruction is released, at the release of the consonant, the initially low pitch and slow vibration returns quickly to normal, resulting in a rise of pitch on the vowel.

Lofqvist & McGowan 1992 assesses the influence of the consonantal environment on the aerodynamics of the voicing mechanism and, in doing so, provide data relevant to the claims of this theory. In this study, it is shown that with voiceless stops and fricatives (excluding ? and ejectives), the vocal cords are abducted during the consonant and adducted for the following vowel as expected. However, the measurement of airflow at consonantal release is not entirely consistent with the aerodynamic hypothesis. In the airflow traces for intervocalic consonants, the rate of glottal airflow at the release of the consonant is quite high for *p*, which is apparently aspirated, but there is little difference between the air flow rates for *b* and *s*. Yet *s* would normally act as a pitch raiser, while *b* would act as a pitch depressor. There does appear to be a more rapid fall in airflow after the peak at the release for *s* than *b*, and this fall in airflow is consistent with the other voiceless obstruents. However, this rapid fall is not relevant to what we are looking for as confirmation for the aerodynamic hypothesis, since what we are looking for is a high rate of airflow.

It is not possible to show that there are no aerodynamic factors involved in producing the pitch effects associated with obstruents, and it is quite likely that aerodynamics are not totally irrelevant. But no study demonstrates that aerodynamics play an important role. Lofqvist & McGowan 1992 show that there is an increase in oral pressure during voiced obstruents, but this fact does not prove that the result of this pressure is slower vibration of the vocal folds. It is interesting to consider sonorants in this regard. They result in less oral pressure than voiceless fricatives and so might be expected to have the opposite effect from voiced obstruents. However, contrary to expectations, it is the voiceless obstruents which have the opposite effect, while sonorants pattern similarly to voiced obstruents, or neutrally.

Another criticism of the aerodynamic hypothesis, given in Hombert, Ohala & Ewan 1979, is that it cannot account for the duration of the pitch effects found after consonants. Hombert 1978 finds that there are effects even 100 ms. after vowel onset. Similarly, consonantally induced pitch effects of long duration are obtained in Shryock 1995.¹ The aerodynamic factors relied on in this hypothesis are very short in duration, no more than 10-15 ms. according to Hombert, Ohala & Ewan 1979.

6.3.2 The Halle & Stevens (1971) Vocal Cord Tension Hypothesis

The vocal cord tension hypotheses are based on the idea that the distinction between voiced and voiceless stops is made by varying the tension of the vocal cords and the differences in tension have a fortuitous effect on the fundamental frequency of adjacent vowels. The Halle and Stevens (1971) version focuses on the horizontal, or longitudinal, tension of the vocal cords. They propose that in voiceless obstruents the vocal cords are stiff, a condition that inhibits voicing and increases the vibratory frequency should-voicing occur. In voiced obstruents, on the other hand, the vocal cords are slack, a condition that facilitates voicing and lowers vibratory frequency relative to that of stiff

¹ Although Shryock does not treat the relevant consonants as voiced obstruents, I argue for that analysis later in this chapter.

vocal cords. This longitudinal tension is achieved through the actions of the thyroarytenoid and cricothyroid muscles.

Support for this hypothesis comes from Lofqvist et al 1989, where the cricothyroid muscle activity was measured and found to increase for voiceless consonants relative to voiced consonants. This increased activity apparently extends into the following vowel. Since the cricothyroid also seems to be active in producing high pitch, it is not unreasonable to suppose that its increased activity could have a pitch-raising effect. However, Lofqvist et al conclude that the activity of the cricothyroid in producing voicelessness is not essential to the devoicing mechanism, although it occurs frequently. For example, one of their three subjects showed no significant difference in cricothyroid activity between voiced and voiceless affricates. (This subject also showed less pitch difference after voiced and voiceless affricates than might be expected, but the pitch effect was still present.) If we consider the pitch effects to be automatic and the cricothyroid activity differences to be optional, then this doesn't look like a very promising explanation. Other studies of laryngeal muscle activity, cited in Hombert, Ohala and Ewan 1979, show inconsistent patterns of activity, suggesting again that increased cricothyroid activity is optional.

In addition to the optionality of the correlation between cricothyroid activity and pitch effects, this hypothesis faces the problem of leading to an incorrect prediction about the direction of a consonant's effect on pitch. The muscle activity which produces the longitudinal tension of the vocal folds can be expected to affect vowels both preceding and following the consonants. However, the historical, phonological and phonetic effects of voiced and voiceless obstruents on pitch are consistently observed to be realized on following and not on preceding vowels. This hypothesis incorrectly predicts that the effects would be on both following and preceding vowels.

6.3.3 The Vertical Vocal Cord Tension Hypothesis

The vertical tension version of the vocal cord tension hypothesis, an approach favored by Hombert, Ohala and Ewan (1979), focuses on larynx height distinctions between voiced and voiceless obstruents. A raised larynx correlates with voiceless obstruents and raised pitch, while a lowered larynx correlates with voiced obstruents and lowered pitch. This hypothesis shares with that of Halle & Stevens an agreement on the importance of the stiffness or slackness of the vocal folds for voiceless and voiced obstruents respectively, but differs in its identification of the factor that affects pitch, i.e. the height of the larynx instead of laryngeal musculature.

Many studies have shown that larynx height follows pitch. For example, Ohala & Ewan 1973 found a strong correlation between pitch raising and larynx raising and between pitch lowering and larynx lowering using the thyroumbrometer. Larynx height also correlates with voicing in obstruents. Ewan & Krones 1974 (cited in Hombert, Ohala & Ewan 1979) found that voiceless consonants in French, English and Thai are produced with a higher larynx than voiced consonants. Most importantly, the height difference characteristic of voiced and voiceless obstruents occurs after stop closure and continues into the following vowel. The larynx raising and lowering, then, occur precisely at the time that the pitch effects are found. Therefore, this is the only hypothesis that accounts plausibly for the fact that the pitch effects of obstruents affect the pitch of the following but not the preceding vowel. Thus, this hypothesis has substantially more credibility than either the Halle & Stevens hypothesis or the aerodynamic hypothesis.

6.4 PHONETIC FACTORS INVOLVING OTHER CONSONANTS

Although voiced and voiceless obstruents account for most of the phonological and a large portion of the historical consonant-tone interactions, other consonants have also been implicated in interactions with tone. Implosives have been seen to pattern with voiceless obstruents in Ngizim. Laryngeal consonants are postulated to have caused rising tones in Vietnamese (Haudricourt 1954, Matisoff 1973) and H tones in Burmese (Maran

1970). Breathy voiced obstruents have also been associated with tonal effects historically and possibly phonologically. The phonetic factors relevant to pitch effects involving these consonants have been less studied and are less clear than those for voiced and voiceless obstruents.

Studies of breathy voiced consonants, cited in Hombert, Ohala & Ewan 1979, show that glottal airflow is high at the consonantal release. Although in the aerodynamic hypothesis a high rate of airflow leads to pitch raising in voiceless obstruents, it is the tight adduction of the vocal folds that is the direct cause of pitch raising. The fact that the vocal cords are not tightly adducted for breathy voiced consonants results in a lower rate of vibration than for voiceless obstruents. This may not lead to a lower rate than for voiced obstruents, however. While historical and phonological studies do not make a clear case that breathy voiced obstruents have greater pitch lowering effects than voiced obstruents, some phonetic studies of Hindi consonants and their effects on pitch do make such a case (Kagaya & Hirose 1975, Ohala 1974). Furthermore, it has been argued that breathy voicing itself can be used as a strategy for lowering tone (Traill 1990), which suggests an integral phonetic relationship between breathiness and low pitch, which is not matched by other laryngeal features. This does not mitigate the importance of voicing alone however, since the vowels on which the pitch effects are manifested are already phonetically voiced. The point is that to further increase the lowering effect, breathiness in concert with the voicing can be added. Pitch raising effects, in contrast, do not ever appear to entail turning off voicing or adding aspiration (the parallel breathy effect minus the voicing).

The phonetic effects of implosives on pitch has not received much coverage in the literature, though based on phonological patterns, one would expect that they behave analogously to voiceless obstruents. Demolin 1995 states that in Lendu, a language with a contrast between voiced and voiceless stops and between voiced and voiceless implosives, he found that voiced obstruents and voiced implosives are followed by the lowest fundamental frequency; voiceless implosives are followed by higher fundamental fre-

quency and voiceless stops are followed by the highest fundamental frequency. This does little to contribute to our understanding of the behavior of implosives phonologically, especially since voiceless implosives are so rare. Despite Demolin's findings that fundamental frequency is low following voiced implosives, he presents data indicating that voiced implosives have led to tone raising effects historically. Phonologically, it is clear that implosives pattern with voiceless obstruents in failing to participate in depressor effects or in participating in the blocking of L spread. There is a contradiction, however, between what is expected from the phonological data on consonant-tone interaction and what is known about implosives phonetically. Phonetically, implosives are very similar to voiced obstruents. Apparently the main phonetic difference between them is the rate at which the oral cavity expands, being faster for implosives. Otherwise, they are so similar they could be expected to have the same effect on pitch. The fact that the larynx is lowered during the production of an implosive also suggests that implosives should have a pitch lowering effect, according to the vertical vocal cord tension hypothesis. However, it is not clear whether the absolute height of the larynx is as low as that of voiced obstruents. It is possible that the larynx is relatively high when an implosive is articulated, and then it is lowered to a position that is still higher than that of a voiced obstruent. Moreover, timing of the laryngeal raising and lowering is important, as noted for voiced and voiceless obstruents. Interestingly, Demolin 1995 observed that although the larynx is lowered during voiceless implosives in Lendu, it raises quite rapidly to its normal position at the time of the release of the consonant. This could be expected to have a pitch raising effect. In contrast, the larynx is still low well into the vowel articulation with voiced obstruents.

The laryngeal consonants *ʔ* and *h* differ from other consonants in having an effect on the preceding rather than the following vowel. In Guelavia Zapotec (Jones & Knudsen 1977), for example, a higher allotone of one of the 3 phonemic tones occurs on vowels preceding glottal stops. Glottal stop has a pitch raising effect historically, while *h* has a pitch lowering effect. Phonetic support comes from Hombert 1976 (cited in Hombert,

Ohala & Ewan 1979) in which 2 Arabic speakers produced consistently rising pitch before ? and falling pitch before *h*. Hombert 1978 found that the pitch contours of ? and *h* can be perceptually differentiated as long as they consist of at least a 20 Hz difference in endpoint pitch and the duration of the contour lasts for at least 40 ms. However, explanations for these acoustic and perceptual observations are lacking.

When we consider the full range of obstruents and their effects on pitch, many questions remain unanswered. Consonants that lower pitch include voiced and breathy voiced consonants and *h*. These cannot even be said to share phonetic voicing since not only *h* but also phonologically voiced obstruents, like those in English, are commonly free of vocal fold vibration in initial position. Nevertheless they produce phonetic pitch effects. Thus, it is clear that phonetic voicing in and of itself is not a consistent phonetic correlate of either pitch-raising or pitch-lowering consonants.

6.5 THE PHONETIC CORRELATE OF [L/VOICE]

It has been argued in this work that L tone and phonological voicing should be represented by a single feature, [L/voice]. This proposal for a modification in feature geometry necessitates an examination of the phonetic correlates of the modified feature in order to determine if the correlation remains intact. As it turns out, the original feature [voice] was somewhat problematic in terms of phonetic correlates. It is impossible to discuss phonetic correlates without also considering the issue of abstractness. It is specifically the relationship between a phonetic correlate and its phonological feature that is of interest. I take the position that it will not avail us to instrumentally measure every segment we wish to describe as voiced in order to determine if some predetermined phonetic correlate is present or not. On the other hand, I do not wish to take the position that we can whimsically decide to represent any segment we choose as voiced. The phonetic correlates of [voice] that are most commonly referred to in the literature are vocal fold vibration, VOT and duration of a preceding vowel. These are inadequate for characterizing [voice] because they are often entirely lacking and at best constitute a laundry list of pos-

sible correlates rather than a unifying phonetic correlate. The challenge in dealing with this issue is in finding a way to allow a degree of phonological autonomy while maintaining the benefits of a stable phonetic correlate. In fact, a laundry list of phonetic correlates is one possible solution. Another is to allow for cases where the phonetic correlate may be missing in a subset of the segments under discussion. An example of this is found in the Siswati language where the voiced stops are not phonetically voiced. If there are independent arguments for considering segments such as Siswati's voiced stops to be characterized for some feature, then these arguments may supersede the absence of the expected phonetic correlates. However, another case arises, that of the Musey language, in which none of the traditional phonetic correlates for [voice] are found to be contrastive within the entire set of segments which patterns as voiced obstruents. Considering this case, the need for an improved specification of the phonetic correlate of [voice] is addressed and a modification is proposed which allows for a more stable phonetic characterization of the feature which is consistent with the added function of [voice] as the feature which specifies L tone. To this end, I redefine the phonetic correlate of [voice] as a laryngeal setting, probably involving larynx height, that results in lowered fundamental frequency on a vowel.

6.5.1 Abstractness of Features

An examination of the phonetic correlate of L/voice brings up questions about the degree of abstractness between phonological features and their phonetic realization. The relationship between a phonological feature and its phonetic realization might be characterized as fully abstract, fully specified, or somewhere between these two extremes, as illustrated by the line in (9). For example, the feature [voice] might be equivalent to a feature-[X] which is nothing more than an alphabetic notation for some abstract element. Alternatively, the feature [voice] might represent some specific number of glottal pulses of vocal fold vibration. Between these two extremes, [voice] might represent the presence of vocal fold vibration, or even the intention of producing vocal fold vibration.

Although there is a tendency to equate [voice] with vocal fold vibration, it has long been recognized that a segment with no vocal fold vibration can be specified contrastively for the feature [voice]. Chomsky & Halle (1968) consider [voice] to consist of a laryngeal configuration in which vocal fold vibration will occur given sufficient airflow. In other words, they characterize [voice] in terms of the potential for vocal fold vibration. The definition of [voice] in these terms remains especially vague because it is unclear whether any laryngeal configuration exists which would not result in vocal fold vibration given sufficient airflow. The somewhat disturbing fact that sonorants are predominantly produced with vocal fold vibration and yet do not pattern as phonologically voiced segments is addressed by Chomsky & Halle also. They take the position that there are important differences between 'spontaneous' (ie. sonorant) and 'nonspontaneous' (ie. obstruent) voicing in terms of vocal fold position, size of glottal opening, manner of vibration, and air flow.² Nevertheless, no attempt is made to define [voice] in such a way that sonorants are excluded.

Another definition in terms of a laryngeal configuration which is less abstract than that of Chomsky & Halle 1968 is that of Ladefoged 1982 in which [voice] is correlated with the distance between the arytenoid cartilages. This approach depicts [constricted glottis], [spread glottis] and [voice] as a continuum along the same phonetic dimension. If this approach were to be pursued, then we might expect a representation of laryngeal features similar to the representation of vowel height features in Clement 1991 or Parkinson 1996. However, if we have reason to consider [voice] as a privative or binary feature separate from [c.g.] and [s.g.], then this approach will not be tenable.

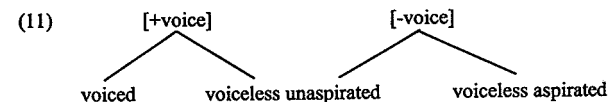
Other definitions of the phonetic correlate of [voice] have focused on measurable phonetic parameters. Based on the studies of Lisker and Abramson 1964, Lieberman 1977 and others, Keating 1984 proposes that VOT correlates with [voice] in a somewhat complex way. Lisker and Abramson 1964 claim that no more than three categories of

² Peter Avery proposes a phonological feature, Sonorant Voice, that contrasts with the feature [voice] that characterizes voiced obstruents.

VOT contrast in any language, and the categories of VOT are roughly the same across languages and even in studies of animal perception, which suggests that there is a perceptual basis for the categories. The three categories can be referred to as lead VOT (with values of -20 ms. or less), short lag VOT (with values of between +20 and -20 ms.) and long lag VOT (with values greater than +20 ms.). More commonly, they are referred to as voiced obstruents, voiceless unaspirated obstruents and voiceless aspirated obstruents.

Keating proposes that the correlates of [voice] can consist of a limited number of different correlates which can be defined according to context. She distinguishes three levels of representation: phonological, major phonetic category and pseudo-physical (i.e. phonetic detail). In Keating 1990, she further divides the pseudo-physical level into acoustic and articulatory parameters and redefines the major phonetic category level as the output of the phonology.

There is a fair amount of indeterminacy in the mapping between the phonological level and the major phonetic category level. For English, she accounts for the observation that a phonologically voiced obstruent can be realized as either a voiced obstruent or as a voiceless unaspirated obstruent, while a phonologically voiceless obstruent can be realized as either a voiceless unaspirated or as a voiceless aspirated obstruent by the mapping in (11) between the phonological feature and the major phonetic category.



Contrast is maintained according to context and Keating apparently intends that Lieberman's approach be incorporated into her model such that the contrast between voiced and voiceless obstruents in any context involves voiced obstruents having a shorter VOT than voiceless obstruents. This works for English where the contrast word-initially is between unaspirated and aspirated and word-medially where the contrast is between phonetically

voiced and voiceless. But this approach presupposes that VOT in some form always correlates to a phonological voicing contrast and that does not seem to be the case for at least several languages, which are discussed below. In Siswati, for example, phonologically voiceless stops can be slightly ejective and they contrast with aspirated voiceless. They would fall into the major phonetic category of short lag VOT. Phonologically voiced obstruents are phonetically voiceless and the following vowel is characterized by breathiness. Again VOT is of the short lag variety. Thus, the contrast between these categories cannot be attributed to VOT.

Keating 1990, while maintaining many aspects of her 1984 approach, makes significant changes in her approach to voicing in obstruents. She adopts Steriade's aperture theory and uses [spread glottis] as an integral part of the definition. It would be somewhat strange if two laryngeal features, [voice] and [spread glottis] were both entirely defined by VOT. However, this is beyond the scope of this thesis because my focus is on the definition of [L/voice] rather on the features relevant to distinguish voiced and voiceless obstruents. Nevertheless, it is clear to me that the distinction can be made on the basis of the feature [L/voice] alone.

In addition to vocal fold vibration and VOT, another phonetic correlate of voicing is frequently cited, i.e. duration of the vowel preceding the obstruent. A vowel is found to be longer before a voiced segment than before a voiceless segment (House & Fairbanks 1953, Peterson & Lehiste 1960, Chen 1970, Klatt 1973, 1976, Umeda 1975, Mack 1982). This is not consistent across languages as some, such as Arabic (Flege 1979) and Polish (Keating 1979) do not display this characteristic. These durational differences, where they exist, are also context driven since not all voiced obstruents are preceded by vowels. Clearly, this definition of [voice] is only meant to show that there is a contrast even in a position where the phonetic correlates of vocal fold vibration and VOT are lacking, but it is not meant to be a stable phonetic correlate that is generally relevant.

We could take Keating's idea that the mapping of a phonological feature to a major phonetic category might involve the choice of a limited number of options a step

further and allow the options not to refer in the case of [voice] to three possible VOT values but instead to refer to a number of dimensions along which contrast can be maintained. Thus, a feature would involve the combination of a limited number of phonetic correlates. This hypothetical approach, which I'll refer to as the laundry list approach, is depicted in (12).

(12) Laundry list approach



The approaches to defining the feature [voice] described above turn out to be either inadequate or inferior in dealing with the range of phenomena associated with phonologically voiced segments. Most fail to satisfy the need for a phonetic correlate which not only characterizes the quality of obstruents which we refer to as 'phonologically voiced' but also characterizes a L tone. Most are context dependent within any given language, distinguishing a voiced segment in a particular position, but not across contexts. Preference should be given to a phonetic correlate that is stable crosslinguistically (and within a single language) in characterizing [voice], if such a correlate can be found. Furthermore, the phonetic correlate should be applicable to cases which pose a problem for traditional notions of [voice]. Such cases are described in the following sections.

6.5.3 The Abstractness of [voice] in Siswati

Siswati, as shown in chapter 3, is a language with extensive interaction between voiced obstruents and tone. However, there is a discrepancy between Siswati's phonemically voiced obstruents and their actual phonetic realization. Siswati provides a case in which the phonetic correlates of [voice] are missing in a subset of the natural class of voiced obstruents, and thus it provides a case where [voice] is somewhat abstract.

The phonemic inventory of the consonants of Siswati is given in (13). Obstruents include stops, fricatives, affricates and clicks. There is a contrast in stops between a voiced series, a plain voiceless series, an aspirated series, and an implosive series represented only by the bilabial implosive.

(13) Stops:	b	d		g	
	p	t		k	
	ph	th		kh	
	ɓ				
Fricatives:	v	z	ʒ	ʒ̥	fi
	f	s	ʃ	ʃ̥	h
Affricates:		dz (dv)	dʒ		
	tsh (tf)	tʃ		kx	
Clicks:		c, ch, nc			
		gc, ngc			
Sonorants:	m, w	n, l	y	ŋ	

The depressor consonants are extracted from the consonant inventory and presented in (14). Note that when any of the voiced series is in a nasal + stop cluster, it continues to act as a depressor, which accounts for the depressor status of *ŋ* which is a reduced form of the cluster *ŋg*.

(14) Depressors:	b (mb)	d (nd)		g, ŋ	
	v	z, ʒ	ʒ̥	fi	
		dz (dv)	dʒ		
		gc, ngc			

Phonemically, the depressor consonants form a natural class of segments sharing the feature [voice], as listed in (15). They contrast with the segments which are not so specified. This leads to the conclusion that in Siswati, as in other languages, [voice] is the critical feature in depressor effects.

(15) Natural class of depressor consonants: b, d, g, v, z, ʒ, ʒ̥, gc, ngc, dz, dʒ, fi
In Contrast With: ɓ, p, t, k, ph, th, kh, f, s, ʃ, ʃ̥, c, ch, nc, tsh, tʃ, h, m, n, l, w, y, kx

However, there is a disparity between the phonemic representation and the phonetic form of these consonants, as illustrated in (16). The stops *b, d, g* are phonetically realized as voiceless unaspirated *p, t, k*, as pointed out by Schachter 1975, Rycroft 19xx, and others. These consonants are followed by vowels with breathy voicing and it has sometimes been claimed that they are breathy voiced consonants. But it is not clear that the breathiness is an attribute of the consonant rather than a phonetic strategy realized on the vowel and unrelated to the consonant. It has been argued by Traill 1990 that breathiness is an accompaniment to lowered pitch in Siswati. In addition, the so-called implosive is actually pronounced as a fully voiced *b* and not as an implosive.

(16) Phonetic disparity	
depressor:	b, d, g = p(ɓ), t(ɓ), k(ɓ)
nondepressor:	ɓ = b

Phonetically speaking, then, we are left with an unnatural class of depressor consonants, listed in (17), which includes voiceless stops, voiced fricatives, voiced clicks and voiced affricates. This unnatural set contrasts with a set which includes a voiced stop and voiceless obstruents in addition to sonorants.

(17) Unnatural class of depressors: p(ɓ), t(ɓ), k(ɓ), v, z, ʒ, ʒ̥, gc, ngc, dz, dʒ, fi
In Unnatural Contrast With: b, p, t, k, ph, th, kh, f, s, ʃ, ʃ̥, c, ch, nc, tsh, tʃ, h, m, n, l, w, y, kx

If we concentrate on the labials (18), which illustrate the problem most clearly, there is a phonemic contrast between the voiced obstruents *b* and *v* and the set which is not phonologically voiced, i.e. implosive *ɓ*, plain voiceless *p*, voiceless aspirated *p^h*, *f* and *m*. Phonetically, however, the set of depressors includes *p* and *v* in contrast to voiced *b*, plain *p*, aspirated *p^h*, etc.

(18) in Labials
a. Phonemically: Natural Class of depressor: b, v
In Contrast with: ɓ, p, ph, f, m

b. Phonetically: Unnatural Class of depressors: p(h), v
 In contrast with: b, p, ph, f, m

How do we know that the phoneme *b* is phonologically a voiced obstruent and that the phoneme *β* is not? The answer to this question does not come from an examination of any obvious phonetic correlate of [voice]. That is, it does not come from an examination of vocal fold vibration, VOT or duration of a preceding vowel. Vocal fold vibration does not characterize the stops in Siswati, as we've noted so far. VOT is also not relevant since there can only be a three way contrast in VOT in any language corresponding to the phonetic categories, voiced, voiceless unaspirated and voiceless aspirated (Keating 1984, Lisker and Abramson 1964). Note that a three way contrast must involve one set of phonetically voiced obstruents (i.e. lead VOT). Since that is exactly what is missing in Siswati, we conclude that VOT does not serve as a phonetic correlate here. Duration of a final vowel is also not useful because of the many contexts lacking such a vowel. This phonetic property is only useful, as in English, when the contrast is maintained by other means in other contexts.

Since the phonetic correlates do not help us in defining a natural class of segments which participate in depressor effects in Siswati, we must look for arguments elsewhere. The extent to which we find them may indicate the extent to which phonological features can be extracted away from some phonetic correlate. First, we should consider the possibility that no natural class exists and that the depressor effect analysis is wrong. The alternative analysis would be that L tone is present underlyingly after the relevant consonants. This analysis fails however because of the fact that there are tonal processes to which the depressor consonants are transparent and these processes precede (in derivational terms) the processes in which depressor consonants are opaque.

The relevant processes are illustrated in (19). The process in (19a), Antepenult Shift, shifts an initial H tone to the antepenultimate syllable. The intervening depressor consonant, notated 'd', does not block the shifting of H. If there were an underlying L tone, this would be expected to block the shift. The process in (19b), Local Shift, is evi-

dent in words of three syllables where Antepenult Shift applies vacuously since the H is already situated on the antepenult. Here H shifts once to the right, over a depressor consonant if one is present³. If the L tone were underlying, we would expect the blocking of Local Shift as well.

- (19) a. Antepenult Shift: cǃdvvcvvcv → cvdvvcvvcv *cǃdvvcvvcv
 b. Local Shift: cǃdvvcv → cvdvvcv → cvdvvcv → cvdǃvcv *cǃdvvcv

Since the alternative hypothesis fails, we find that we do need to define a set of consonants. One point to note is that the phonetic disparity only involves voiced stops; the rest of the depressor consonants are contrastively voiced based on the presence of vocal fold vibration. So voiced fricatives, which act as depressors, contrast with voiceless fricatives, as expected. The fact that the stops pattern with other segments which are clearly contrastive for [voice] motivates us to specify them as voiced also, despite the lack of an obvious phonetic correlate within the stops themselves. Further motivation for the characterization of Siswati [*b d g*] as voiced obstruents comes from a process of palatalization which occurs with morphemes like the locative and diminutive suffixes. Labials become palatals, and the only phonological change is in Place features.

In phonemic terms, the segment *b* is realized as *dʒ* (20a) and implosive *β* is realized as *tʃ* (20b). This is a straightforward operation given the proper phonemic analysis. An analysis based on the phonetic surface values of these segments involves unprincipled mappings. Phonetically, a voiceless *p* becomes voiced *dʒ*, while a voiced *b* becomes voiceless ejective *tʃ*. How would we explain the loss of voicing in the latter case and the insertion of voicing in the former case? How do we account for the insertion of constricted glottis?

³ The careful reader will recall from chapter 2 that Depressor Induced H Tone Shift is blocked in the same environment.

(20) Palatalization: Phonemically: $b \rightarrow d\zeta$ Phonetically: $p(\text{fi}) \rightarrow d\zeta$
 Phonemically: $\delta \rightarrow t\zeta$ $b \rightarrow t\zeta$

- a. $\text{sig}\ddot{u}\text{b}\ddot{u} + \text{ini} \rightarrow \text{sigud}\zeta\text{iini}$ 'in the calabash'
 $\text{sigubu} + \text{ana} \rightarrow \text{sigud}\zeta\text{aana}$ 'little calabash'
- b. $\text{imb}\ddot{o}\delta\ddot{o} + \text{ini} \rightarrow \text{imbot}\zeta\text{eeni}$ 'in the hole'
 $\text{imb}\ddot{o}\delta\ddot{o} + \text{ana} \rightarrow \text{imbot}\zeta\text{aana}$ 'little hole'

Palatalization constitutes a strong argument for the underlying specification of [voice] in phonemic b and the lack of such specification in phonemic δ . Basically, the latent voicing or latent voicelessness is actually allowed to surface when palatalization takes place. We can conclude that even without a phonetic correlate for [voice], there is support for the importance of the feature [voice] in depressor effects in Siswati. Thus, we have seen that it is possible to justify the use of the feature [voice] to characterize segments in a language despite the absence of a relevant phonetic correlate when there are other reasons for doing so. In Siswati, not only do the stops [b, d, g] participate in depressor effects, but also in so doing they pattern with other segments which are contrastively voiced in a phonetically real fashion. Thus, the voiced stops constitute a phonetically aberrant subset of a phonetically (and phonologically) well-behaved natural class. Moreover, in this case, there is added support for the phonological voicing of the relevant stops which comes from the process of palatalization in which alternation reveals the latent voicing of the stops. The absence of a phonetic correlate, then, is not conclusive evidence for the absence of the related feature.

6.5.4 Musey

In contrast to a language like Siswati where a distinct subset of the phonologically voiced segments are missing a phonetic correlate for [voice], Musey poses a situation in which an entire set of phonologically contrastive obstruents is lacking the usual phonetic correlates of any of the standard features that serve to contrast series of obstruents.

Moreover, because of depressor effects, there is reason to believe that the phonological contrast should be represented in terms of [voice]. If there is no phonetic correlate for [voice], it is difficult to justify the use of the feature. However, a redefinition of the phonetic correlate of [voice] may provide a solution to this problem.

Shryock 1995 describes Musey as a language with 2 contrasting series of voiceless obstruents in word-initial position. The contrast is phonological and he seeks to identify its phonetic correlate.

The consonantal inventory of Musey is given in (19). Note that the consonants of interest are identified as Class A and Class B. Although the consonants designated as Class B are written as voiced obstruents, Shryock cautions that "This choice of symbols must not be taken as indicating that the class B consonants are phonetically voiced. Both series of obstruents are phonetically voiceless (p.4)." The class A [h] and Class B [fi], as it turns out, are both phonetically voiced.

(21) Musey Consonantal Inventory

Class A	p	t	tʃ	k	
Class B	b	d	dʒ	g	
	ɸ	dʰ			
	mb	nd	ndʒ	ŋg	
Class A	f	s	t̚		h
Class B	v	z	ʃ̚		fi
	m	n		ŋ	
		l			
	w	r	y		

Putting aside for a moment the question of whether the class B consonants are voiced in any phonetic sense, phonological processes support the analysis of class B consonants as voiced obstruents in a phonological sense. Depressor effects, characteristic of voiced obstruents are found, as illustrated in (22). In nouns, L tones are assigned to initial toneless moras after class B consonants, and M tones are otherwise assigned. Initial toneless moras occur only in nouns of more than one mora, since there is an underlying

tone which is assigned to the rightmost mora. Nouns of more than one mora have a L tone after word-initial class B consonants, as in *bùzùr* 'blood'. These nouns have a M tone after any other initial consonant. So in *kùlùf* 'fish', with an initial class A consonant, the initial tone is M.

(22) Tone assignment in nouns in Musey (adapted from Shryock 1995, p. 6)

	<i>Lexical tone</i>		<i>Tone Assignment</i>		
Voiced obstruent:	L buzur	→	L / \ buzur	→	[bùzùr] 'blood'
Other:	L kuluf	→	M L kuluf	→	[kùlùf] 'fish'

When monomoraic nouns get an extra mora by the addition of a clitic, the ensuing tone patterns match those of disyllabic nouns, as in (23a). That is, when the initial consonant is a class B consonant, the immediately following tone is L (*hù nà* 'goat'), and when the initial consonant is not of class B, the immediately following tone is M (*sā nà* 'person'). Shryock also finds this effect in the subjunctive form of verbs, as in (23b).

(23)	<i>Voiced obstruent initial</i>		<i>Other</i>
a.	fù + na → fù nà 'goat'		sà + na → sà nà 'person'
b.	do + m → dò m 'pick it'		to + m → tō m 'sweep it'

Because of the depressor effects associated with class B consonants and because there is some sort of contrast between the class A and class B series, it seems safe to say that there is a set of voiced and a set of voiceless obstruents in Musey. When Shryock explores the phonetic differences between class A and class B consonants, however, he finds no evidence of contrast along the dimensions usually cited as phonetic correlates for [voice]. Looking for a contrast in vocal fold vibration, he finds that the majority of all class A and B obstruent tokens (excluding *h* and *h̃*) are completely voiceless. In fact, only one subject ever completely voiced any class A or B obstruent. Likewise, differences in

VOT values do not account for the phonological contrast. Although on average the class A consonants have consistently larger VOT values than the class B consonants, the difference in these values has not been found to be perceptible. Lisker and Abramson 1964, in a perceptual experiment, found that VOT differences of at least 20 ms. are necessary in order to be perceived.

(24)	VOT:	p 24 ms.	t 22 ms.	k 39 ms.	Class A 29 ms.
		b 17 ms.	d 15 ms.	g 24 ms.	Class B 19 ms.

Even if VOT differences had turned out to be a useful phonetic correlate for [voice] in Musey, it would only be relevant in the case of stops. Usually, fricatives and affricates contrast in actual vocal fold vibration, but in Musey they do not.

Duration differences that might be expected to signal voiced vs. voiceless obstruents include both duration of a preceding vowel and duration of the consonant itself. Shryock finds no significant differences in the duration of a preceding vowel. As for the duration of the consonant itself, he finds no significant difference for labial and alveolar stops and affricates, but the difference between velar obstruents is statistically significant. The latter point must be considered a statistical anomaly given that place of articulation should not make a difference. As it happens, the actual average durational difference between *k* and *g* is a matter of 6 ms. That small a difference, even if constant, is probably not perceptible, and may be due to other differences that might serve as the basis of a more direct phonetic correlate of [voice]. The difference in fricative duration is also not statistically significant except for the pairs [*s z*] and [*h h̃*].

Shryock does find measurable phonetic contrast between the two series of obstruents when he examines their spectral properties. Class A consonants, as compared to class B consonants, show significantly greater amplitude of the consonant, greater burst amplitude, greater spectral tilt of the following vowel, and greater fundamental frequency of the following vowel.

(25) Spectral differences:

Class A: greater amplitude of consonant
 greater burst amplitude
 greater spectral tilt in following vowel
 greater fundamental frequency of following vowel

Shryock concludes that the phonetic correlate of the phonological contrast between class A and class B obstruents involves a difference in "longitudinal vocal fold tension. There is also strong motivation for positing a distinction at the segmental level in the regulation of subglottal pressure." He also argues that the contrast in Musey is not comparable to that described between obstruents in any other language.

Given the depressor effects and the generalization that I have argued for that these effects can be accounted for in terms of the feature [voice], how do we account for the failure of any phonetic correlate of [voice] to be relevant for Musey? We can add phonetic correlates to our laundry list and expect to find even more. Alternatively, we can redefine the phonetic correlate of [voice] in such a way that it is more consistently relevant across languages and perhaps even within languages.

6.6 REDEFINING THE PHONETIC CORRELATE OF [VOICE]

In conclusion, there is some benefit to be derived and ample precedence for the notion that the phonetic correlate of [voice] is a laryngeal configuration. More precisely, I propose that the phonetic correlate of [voice] is a laryngeal configuration, probably involving larynx height, that results in lowered fundamental frequency on a vowel. Larynx height is thought to be involved because of the arguments in Hombert et al 1979 that the F0 perturbations are due to larynx height.

The actual realization of lowered fundamental frequency on a vowel differs according to whether the feature [voice] is linked to a mora or the laryngeal node of a consonant, and it also differs according to whether there is a following vowel in the latter case. If a following vowel is present, the laryngeal configuration is such that a consonant specified for voice will result in lowered fundamental frequency at the onset of the fol-

lowing vowel. If no following vowel is present, the laryngeal configuration is still such that it would produce lowered fundamental frequency. That is, the potential is latent. If [voice] is linked to a mora, the vowel that is also linked to that mora will be realized with lowered fundamental frequency.

The idea that vocal fold vibration is a central characteristic of the feature [voice] is not superseded by this definition. Any definition that crucially involves fundamental frequency necessarily involves vocal fold vibration. Thus, the definition of the phonetic correlate of [voice] proposed here includes the notion that [voice] refers to vocal fold vibration.

Implosives are interesting to consider in light of this definition. It is the case that the presence of the phonetic correlates of any given phonological feature does not entail that the phonological feature is present. However, what do we do with the case of a segment which always has the phonetic correlate and never has the phonological feature? If vocal fold vibration is a primary phonetic correlate of voice and if it is almost invariably present on implosives, to the extent that is not uncommon for them to evolve into voiced plosives diachronically, then there is a discordant note in the fact that implosives show no sign of being phonologically voiced. However, if we redefine the feature L/voice in terms of f0 perturbations on the vowel, implosives are routinely excluded from the set of voiced segments and this matches the actual situation.

CHAPTER 7

A PHONETICS/PHONOLOGY MISMATCH

7.1 INTRODUCTION

Chapter 6 presented a phonetic perspective of consonant-tone interaction. A serious look at this topic leads to the discovery of a puzzling mismatch between the phonetics and the phonology which is relevant to a discussion of the role that phonetics plays in phonology. Clearly phonetics plays some role in the phonology, but is this role merely one in which phonetics 'informs' the phonology or is it something stronger? For example, Ohala (1990) argues, 'For true explanations for speech sound behavior, phonetics now outstrips autonomous phonology'. Ohala insists that phonology must be integrated with phonetics and cannot be independent from it. If this were true, then all phonological observations about synchronically active operations should be deduceable from phonetics. If however the phonetics merely 'informs' the phonology, and we expect only a degree of consistency between phonetics and phonology, then there could arise cases where phonology makes a different prediction than phonetics, and the phonological prediction is the correct one. Such a case arises in the framework of consonant-tone interaction.

This chapter presents a mismatch in consonant-tone interaction between predictions based on considerations of phonetic naturalness and those based on phonological theory. The resolution of this mismatch is in favor of the phonological predictions, which prove to be more accurate with respect to phonological patterning. The case in question

involves the interaction of voicing and tone. Phonetic studies indicate that both voiced and voiceless obstruents have a significant and crosslinguistically consistent effect on the pitch of the following vowel, leading to a prediction that both voiced and voiceless obstruents will interact with tone with approximately the same frequency. Contrary to expectations, the consonant-tone interaction that is active in the phonology crosslinguistically involves only voiced obstruents, and this can be attributed to phonological factors, i.e. the privative nature of the feature [voice].

The patterning of the interaction between consonant and pitch at the phonetic level is different than the patterning of consonant and tone at the phonological level. At the phonetic level, voiceless obstruents are characterized by a pitch trace at the onset of the vowel that starts high and falls to the intrinsic vowel pitch. In contrast, voiced obstruents are characterized by a pitch trace that starts low and rises to the intrinsic vowel pitch. Experimental data mentioned in chapter 6 confirms that the onset pitch is salient in both cases and is used by speakers of English in identifying whether an obstruent is voiced or voiceless. Extrapolating from observations at the phonetic level, there are at least two phonetically driven predictions that can be made about what will occur at the phonological level. The weak phonetic prediction is that voiceless obstruents should have an effect equal to that of voiced obstruents in the phonology. The strong phonetic prediction is that voiceless obstruents should have a greater effect than voiced obstruents. Observations of consonant-tone alternations at the phonological level, however, is incompatible with either of the phonetic predictions.

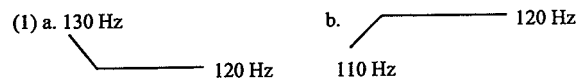
7.2 MARKEDNESS OF RISING PITCH

One of the reasons that there is a phonetic prediction that voiceless obstruents will have a greater effect on tone in the phonology than voiced obstruents is that the rising tone which occurs after voiced obstruents is a more marked pitch contour, both perceptually and articulatorily.

There are a number of indications that rising pitch is systematically disfavored. From the phonological perspective, we find that falling tones are more common in tonal inventories of languages. Cheng 1973 compares 737 Chinese dialect locations with a total of 3433 individual tones. He finds that falling tones are the most common type of tone, followed by level tones and then rising tones. There are 1 1/2 times more falling tones than rising tones (1125 compared to 790).

There is also an implicational relationship between rising and falling tones such that the presence of rising tones entails the presence of falling tones. If a language has phonologically contrastive rising tones, it will always have falling tones. The converse is not true. If a language has falling tones, it may or may not have rising tones. Thus, there are languages with falls but no rises, such as Hausa, Kikamba, Holoholo, Chichopi, Gitunga, Bukusu, and Efik, but there appear to be no languages with rises and no falls.

Perceptual and articulatory studies contribute to our understanding of why rises may be marked. Hombert 1978 reports on an experiment which demonstrates that perception of falling pitch is better than perception of rising pitch. Vowels were synthesized that had a steady state pitch of 120 Hz. but which differed in onset frequency, as in (1). One vowel fell in pitch at the onset from 130 Hz. (1a) and the other raised from 110 Hz. (1b).

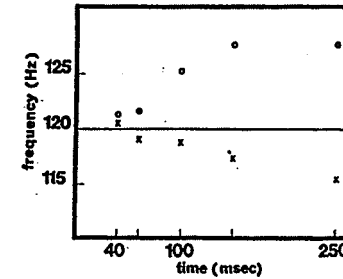


The duration of these onsets was manipulated so that they included durations of 40, 60, 100, 150 and 250 ms. Subjects were asked to match the beginning pitch of the sound.

Although the subjects were never able to correctly identify the beginning pitch of the sound, the perceived pitch was always closer to the actual pitch when the onset had a falling contour rather than a rising contour. Subjects also performed better when the con-

toured portion was longer, but this need not concern us here. Their relative success is illustrated in (3).

(2) Perception Experiment (Hombert 1978)



Hombert concludes that rising pitch tends to be perceived more in terms of its end point than in terms of its beginning. In other words, rising pitch is more difficult to perceive.

What Hombert's experiment did in terms of perception, other experiments did in terms of production. Ohala & Ewan 1973 and Sundberg 1973 demonstrate that a falling pitch can be produced much faster than a rising pitch over the same pitch interval, suggesting that a rising pitch is more difficult to produce.

Based on studies such as the ones cited here, Ohala 1978 concludes that falling tones are probably perceptually more salient than rising tones. Therefore, the voiceless obstruent effect is more likely to be phonologized because it consists of a falling rather than a rising pitch contour.

7.3 PHONETIC EFFECTS OF SONORANTS ON VOWEL PITCH

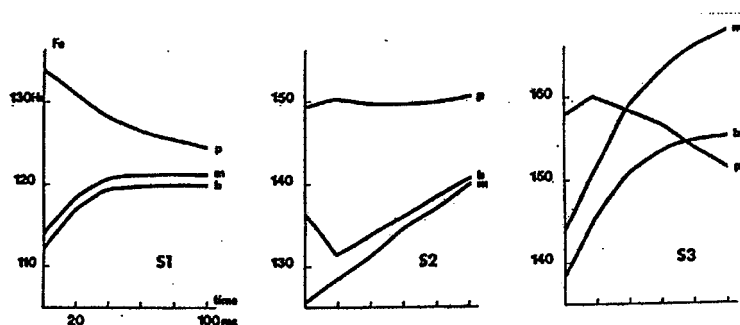
Another reason why voiceless obstruents are more salient than voiced obstruents involves certain similarities shared by the latter with sonorants. Sonorants are phonologically neutral to voice-tone interactions in most cases. It is also the conventional wisdom that they are neutral phonetically, though this is not obvious and there is some disagree-

ment on this point (Maddieson 1984). Nevertheless, it has been remarked that the pitch traces after sonorants resemble those after voiced obstruents. Comparing sonorants to obstruents in (3), this resemblance is clear. In these studies, the fundamental frequency of vowels after sonorants falls in or near the range of fundamental frequency values found after voiced obstruents, and outside the range found after voiceless obstruents.

(3)	a.	House & Fairbanks 1953							
		<i>m</i>	<i>n</i>	<i>voiced obstruents</i>	<i>voiceless obstruents</i>				
		123.2	121.8	120.6-122.8	124.3-127.9				
	b.	Lehiste & Peterson 1961							
		<i>m</i>	<i>n</i>	<i>r</i>	<i>l</i>	<i>y</i>	<i>w</i>	<i>voiced obstruents</i>	<i>voiceless obstruents</i>
		162	161	166	164	164	167	155-169	173-176

Similarly, the chart in (4), repeated from chapter 6 shows the resemblance of the averaged pitch trace for sonorants marked *m* with that of the voiced obstruents marked *b*.

(4) Individual Pitch Traces: Averages by speaker (Hombert 1978)



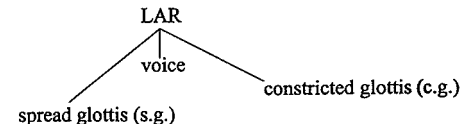
There are two possible interpretations of the sonorant data, either sonorants have a distinctive pitch effect or they have no pitch effect and the pitch traces we see are a default effect, determined by stress or utterance-initial position. In either case, the voiced obstruents resemble the sonorants, which makes them less distinctive than the voiceless

obstruents, which stand apart from both voiced obstruents and sonorants. This leads to the conclusion that the pitch effect of voiceless obstruents must be more salient. This in turn leads to the prediction that voiceless obstruents should be more often involved in phonologized consonant-pitch interactions than voiced obstruents.

7.4 PHONOLOGICAL MOTIVATION FOR THE MISMATCH: THE ROLE OF [L/VOICE]

The phonetics-phonology mismatch with respect to consonant-tone interaction can be motivated by the existence of a privative feature [L/voice]. The privative nature of the feature [voice] has been argued for by Mester & Ito 1989 and Lombardi 1994. The feature [voice] is one of several privative laryngeal features, which also include [constricted glottis] and [spread glottis], as in (5).¹

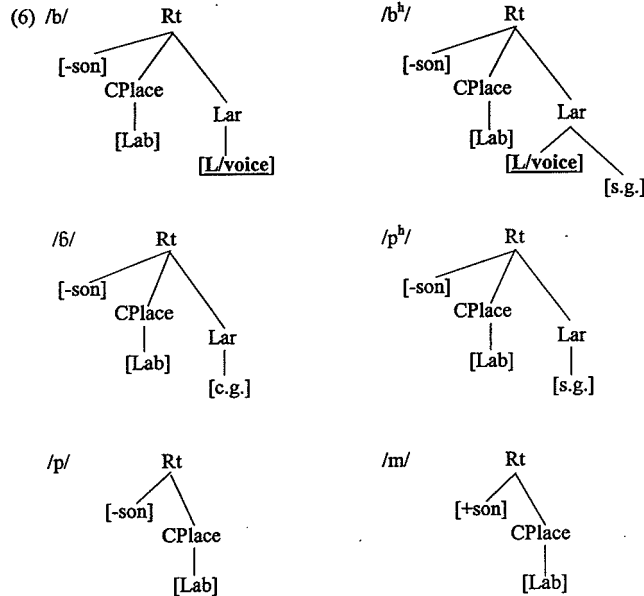
(5) Representation of laryngeal node with privative features:



The use of these features to specify different consonant types is shown in (6). Voiced oral obstruents are exemplified by a representation of *b*, with a laryngeal specification only for [L/voice]. Breathy voiced obstruents are exemplified with a representation of *b^h*, which is specified for both [L/voice] and [spread glottis] under the laryngeal node. These are the only consonants normally specified for [L/voice] and the only types of consonants involved in consonant-tone interactions. The other consonants illustrated include implosives, aspirated voiceless obstruents, plain voiceless obstruents and sonorants. None are specified for [L/voice]. The sonorants and plain voiceless obstruents normally have no laryngeal specifications. They differ in that sonorants can receive a specification for [L/voice], while voiceless obstruents are never so specified. This difference is based on

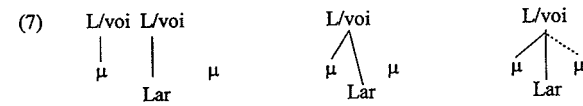
¹ Note that this does not constitute a claim that all features are privative.

the fact that sonorants, unlike voiceless obstruents are not contrastive in their voicing. Thus, they are usually underspecified for the feature [L/voice]. Phonological patterning can reveal whether they are unspecified or not. Voiceless obstruents, if specified for [L/voice], become voiced obstruents. This does occur, as we've seen in the cases of Yabem and Jingpho. So when sonorants are specified for [L/voice], they remain sonorants, while voiceless obstruents become voiced obstruents.



Assuming these laryngeal specifications and the key role of voicing, it is predicted that only voiced oral obstruents and breathy voiced obstruents will participate in regular consonant-tone interactions. The motivation for this prediction is phonological in contrast to the phonetically-motivated predictions outlined previously.

The cases of Ngizim and Nupe, discussed in Chapter 2, where voiceless obstruents seems to interact with tone are a potential problem for a privative voicing feature. The data from these languages can, however, be reanalyzed so that voiceless obstruents are not the conditioning factor in the phonology. In Ngizim, a process of L spread appears to be blocked by voiceless obstruents and implosives. Assuming that voiceless obstruents and implosives are not specified for voicing, the process of L spread can be described as in (7) where spreading is conditioned by the presence of a voiced consonant. More specifically, I propose that this is a process in which the L/voice features which are adjacent on the same tier fuse together and then the multiply linked L/voice spreads to the following mora.



The alternative approach in which L spreading is treated as a blocking phenomenon fails to explain why voiceless obstruents and implosives pattern together. Using a constraint to block L spread across a consonant specified as [-voice], as in (8), fails to deal with the behavior of implosives as blockers.



A reanalysis of the Nupe data would follow the same lines as that of the Ngizim data.

More support for the view that consonant-tone interaction is governed by the existence of a privative voicing feature and not by phonetic factors comes from the behavior of breathy voiced obstruents. Phonetic studies such as Ohala 1974 and Kagaya & Hirose

1975 suggest that breathy consonants depress tone more than other consonants. Ohala 1974 shows fundamental frequency traces for nonsense words spoken by a female native speaker of Hindi. The onset frequency after *bh* is much lower than that after *b*, which is lower than that after *ph* and *p*. If we can assume that these results are typical, then we might expect that breathy consonants will interact with tone even more frequently than voiced obstruents do. In contrast, the phonological prediction is that breathy voiced obstruents will fail to pattern separately from plain voiced obstruents, given that both types of consonants are specified for [L/voice]. There is, in fact, no evidence that breathy voiced obstruents ever act independently of plain voiced obstruents in phonological tone-voice interactions.

If we consider possible counterexamples to the above claim, we find that they have no substance. Hyman & Schuh 1974 claim that in the Tibeto-Burman languages of Nepal breathy voiced consonants change M to L and H to a rising tone while 'voiced obstruents have no perceptible effect' (p. 110). They cite only Glover 1970 which contains a description of the Tibeto-Burman language, Gurung. However, the tone situation in Gurung presented in Glover 1970 (and Hale 1970) makes it clear it is the breathiness of vowels that is distinctive rather than the breathiness of consonants. Hale 1970 gives the obstruent inventory of Gurung as consisting of a series of plain voiceless, a series of voiceless aspirated and a series of plain voiced stops, as well as the fricative *s*. He goes on to explain that vowels contrast in whether they are breathy or clear voiced. Glover 1970n makes the situation even clearer by giving examples of words with breathy voicing. This occurs primarily in initial syllables and can occur with either plain voiced or plain voiceless obstruents, with sonorants or with onsetless syllables, as shown in (9), where an *h* after a vowel indicates breathy voicing.

(9) Gurung (Glover 1970)

ahlad	[ə ^h lād]	'don't do that!'
ahprihd	[ə ^h pri ^h d]	'don't write!'
yaahrba	[y ^h ə ^h rbə]	'to bark'

mehq	[m ^h ɛ ^h]	'cow'
yuql tuhm	[y ^h ul t ^h u ^h m]	'must come'
dlhqr	[d ^h l ^h ɪ]	'in the house'

Therefore any conditioning of tone by breathiness in Gurung is an example of vowel-tone interaction and not one of consonant-tone interaction.

Siswati is a tone language that is sometimes described as having breathy voiced stops, and as such might provide a counterexample to the generalization that [L/voice] is the only segmental feature that crucially interacts with tone. Although I have argued that Siswati's voiced stops are not phonologically breathy, even if we accept analyses in which they are postulated to be breathy, this does not constitute a counterexample. The stops in question pattern with other voiced obstruents, including the fricatives, which are never analyzed as breathy voiced. Thus, it is the voicing that is important phonologically and not the breathiness.

7.5 SUMMARY

Phonetic studies predict either (a) voiced and voiceless obstruents should have equal effects on consonant-tone interaction in the phonology, or (b) voiceless obstruents should have a greater effect. This is because these studies indicate that both voiced and voiceless obstruents have an effect on the pitch of the following vowel. Furthermore, in terms of salience, phonetic studies suggest that voiceless obstruent effects have an advantage because they involve a falling rather than the more difficult to perceive rising tone and because they contrast with both voiced obstruents and sonorants phonetically.

Phonologically, it is the case that voiced obstruents participate to the exclusion of voiceless obstruents. This is supported by a survey of phonological interactions between consonant and tone. The two cases involving potential voiceless obstruent effects can be reanalyzed in such a way that there is no need to refer to voiceless obstruents in the phonology. The case from Ngizim in which voiceless obstruents seem to block the spread of L can be reanalyzed as a case in which only consonants with a specification for [voice]

allow the spread of L. The related case from Nupe can be reanalyzed as a case in which H is phonetically, but not phonologically, present after a voiceless obstruent. In contrast, the voiced obstruent effects, presented in over 25 languages in this work, cannot be reanalyzed in this fashion. In these languages, the effects are clearly phonological rather than phonetic. Moreover, any attempt to handle blocking by placing conditions on the spread of H so that only voiced obstruents are excluded will not account for the fact that the segments which allow this spread do not form a natural class.

Based on the examination of the phonetic and phonological information available, it is clear that there is a phonetics-phonology mismatch. This mismatch can be explained by the existence of the feature [L/voice] which is the crucial element in determining consonant-tone interaction phonologically.

7.6 CONCLUSIONS

It has sometimes been suggested that phonology is narrowly determined by phonetic considerations. It has also been implied that phonology is little more than a notational variant of phonetics, as in Ohala 1979 and Ohala & Lorentz 1977. Phonology-phonetics mismatches, such as the one shown here, provide evidence that phonology is governed by principles that can act independently of the phonetics. Thus, in answer to the question of what role phonetics plays in the phonology, it cannot be correct to say that phonology can be fully explained by phonetic considerations. On the other hand, phonetics does 'inform' the phonology since phonology is governed by principles that are related to, as well as separate from, phonetics. The phonological realization of voice-tone interaction is tied to phonetics in that voiced obstruents have a phonetic lowering effect on pitch that is consistent with their effect on tone, but the bigger picture of consonant-pitch effects demonstrates that phonological principles govern how the phonetic effects will be manifested in the phonology. The actual manifestation of some phonetic effects in the phonology to the virtual exclusion of others argues for a real and significant difference between phonetic and phonological considerations. It also argues that, within the

phonological component, phonological forces outweigh phonetic forces when these two conflict.

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