CONSONANT-TONE INTERACTION IN OPTIMALITY THEORY

by

SEUNGHUN JULIO LEE

A Dissertation submitted to the

Graduate School-New Brunswick

Rutgers, The State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

Graduate Program in Linguistics

written under the direction of

Professor Akinbiyi Akinlabi

Professor Paul de Lacy

and approved by

____

____

____

____

New Brunswick, New Jersey

October, 2008

ABSTRACT OF THE DISSERTATION

Consonant-Tone Interaction in Optimality Theory

By SEUNGHUN JULIO LEE

Dissertation Directors:

Professor Akinbiyi Akinlabi

Professor Paul de Lacy

This dissertation presents a constraint-based theory of consonant-tone interaction called the 'Extended Tone Bearing Unit Theory (xTBU theory)'. In this presentation, I provide synchronic evidence from a variety of languages that shows how laryngeal features can influence tone. These laryngeal features include voicing, aspiration, glottalization, and voicelessness.

There are three parts to xTBU theory: representation, markedness constraints, and faithfulness constraints. I propose that while tone prefers to associate to moras, tone can also be associated to non-moraic root nodes. I argue that tone directly associated to root nodes acts differently from tone associated to moras due to the interaction of constraints.

The presence and type of directly associated tone is restricted by markedness constraints only. Constraints such as *[+SPREAD GLOTTIS]/L can prevent H tone from spreading over spread glottis consonants; it can also force L tone to change to H, and even force consonants to change their laryngeal features. A significant result is the ability of the constraints to account for apparently unnatural classes of tone-affecting consonants.

An important aspect of the constraint formalism in xTBU theory is that faithfulness constraints only target tone associated to moras; they never target tone associated to non-moraic root-nodes. The lack of faithfulness to directly associated tone means that tone is not contrastive when associated to non-moraic root nodes. Consequently, tone on non-moraic segments is only regulated by markedness constraints.

DEDICATION

To my father Sukhiy Lee and my mother Jaengsook Ser

who taught me how to live a life with wisdom.

ACKNOWLEDGEMENTS

I feel gratitude to the many people who helped me through the dissertation process. I have tried to mention everyone who stood by me during the past six years. If anyone is missing, please regard it as an omission due to my faulty memory.

First, I would like to thank my two supervisors Akinbiyi Akinlabi and Paul de Lacy. Their guidance helped me to develop new ideas and refine analyses. Whenever I needed it, they were ready to give me useful advice based on their expertise and experience.

Many thanks are also due my committee members. Alan Prince helped me to deepen my understanding of the theory, and made me think analytically. I thank Lee Bickmore for his insightful comments, and also his long drive from Albany on the day of my defense.

I also thank the consultants who were willing to share their knowledge of their native language: Khin Maung Gyi and Thuya Maung for Burmese, Yuehua Wei for Zhuang, Pan Huiling for Mulao, and two Western Bade speakers.

I learned a lot about linguistics from the other faculty members at Rutgers. Veneeta Dayal, who was always very supportive, Jane Grimshaw, my teaching advisor, Bruce Tesar, my first QP chair, Mark Baker, my second QP chair, and Young-mee Yu Cho. I also thank Ken Safir for his interesting Syntax classes.

I am also influenced by many linguists. At Seoul National University (SNU), Prof. Yunhan Kim guided me through the interesting aspects of Indo-European linguistics, and Prof. Seungho Nam extended my interests to theoretical linguistics. In fact, Prof. Nam was my first linguistics professor. Prof. Sanghwan Seong has always been supportive and

I also thank Prof. Jongho Jun, Prof. Jaeil Kwon, and Prof. Yangsoo Moon for their time.

I would also like to thank the linguists who gave me constant academic and moral support. In particular, I thank Brian D. McHugh for taking his time to discuss many issues in tone and phonology. I am especially indebted to Jerry Edmondson and Russell Schuh for sharing their valuable data. I also thank Ellen Broselow, Lucien Brown, Charles Chang, Laura Downing, Maia Duguine, Jerry Edmondson, Andres Enrique, Colleen Fitzgerald, Christopher Green, Larry Hyman, Shigeto Kawahara, Minjoo Kim, Meredith Landman, Dongmyung Lee, Hyesook Lee, Peter Manasantivong, Sophie Manus, Hanyong Park, Cedric Patin, Keren Rice, David J. Silva, Dennis Ryan Storoshenko, Katy Tang, Thorsten Traulsen, Nadya Vinokurova, Jonathan Wright, and Shinwon Yoon.

I survived my life as a graduate student because of my dear, fellow graduate students in the department. I was lucky to have the best classmates: Slavica Kochovska, Xiao Li, John Manna, and Jessica Rett. I am indebted to: José Elías-Ulloa, who was always ready to give me the most helpful advice for my life and for doing phonology, James Bruno, whom I always ask for proofreading (and never get a response of ‘no’) and from whom I learned the value of homemade foods in the last two years, Hyunjoo Kim and Heeshin Kwak, with whom I was freely able to share my ideas in Korean. Special thanks go to Paula Houghton and Michael O’Keefe, who proofread this whole dissertation at the last minute. I also thank: Oluseye Adesola, Crystal Akers, Daniel Altshuler, Will Bennett, Adrian Brasoveanu, Aaron Braver, Liping Chen, Vera Dvorak, Carlos Fasola, Graham Horwood, Patrick Houghton, Natalia Kariaeva, Todor Koev, Jinsu Lee, Juyeon Lee, Wei Li, Carlo Linares, Vita Markman, Naz Merchant, Sarah Murray, Jeremy Perkins, Teresa Torres, Willie U. Willie, and Scot Zola. From SNU linguistics, I thank Jinyoung Choi, Woonho Choi, Na-rae Han, Hijo Kang, Kyunghwa Kim, Midam Kim, Yunshin Kim, Seongyeon Ko, Jungyeon Koo, Junkyu Lee, Youngjoo Lee, Hyejoon Yoon, Sooyeon Yoon for their friendships.

My friends from SNU Philharmonic Orchestra and ROK Air Force Academy were always available whenever I need some time outside linguistics: Dongwun Bae, Youngkyung Bae, Hyungyong Choi, Inho Choi, Jaehwa Hong, Euiheon Jung, Seunghoon Jung, Woohyung Jung, Euiyoung Kim, Inhan Kim, Serin Kim, Sungyo Kim, Youngmin Kim, Haktae Lee, Hohyun Lee, Jaeho Lee, Junsung Lee, Sangheon Lee, Sanghoon Lee, Sebeom Paik, Bumseok Seo, Jinwook Seo, Jieun Seong, Seonghwan Yoon, Youngsoo Yu.

At Rutgers, I enjoyed friendships with many people from various backgrounds, which enriched my life. I thank Rob Aters, Yongho Bae, Barbara Mergelsberg, Kwangyong Choi, Daisuke, Kai Diers, Federica Franze, Yoko Ibuka, Atsushi Inoue, Sunyoung Kang, Namhun Kim, Sungeon Kim, Jeongbeom Lee, Jihyun Lee, Jungeun Lee, Sohee Lee, Alexandra Vergara Rodríguez, Phillip Rothwell, Eunkyu Son, and Hyunshin Yoon.

I also thank many friends in different parts of the world who welcomed me, and who generously excused my lack of communication: Hyunsik Joe, Byungjo Jung, Byungsoo Kim, Changhyun Kim, Hyikyun Kim, Jihun Kim, Jongburm Kim, Jose Kim, Kyungho Kim, Sungsu Kim, Jongho Kwak, Jungeun Lim, Chris Perez, Elise Prebin, John Roe, Wonson Ryu, Chris Savva, and Takahiro Kamikawa. I am most thankful to Sunkyung Choi, who always encouraged me and ensured that what I was doing was worthwhile, and John David who was always available to offer support.

My study at Rutgers was generously supported by the Graduate School at Rutgers. I received a Rutgers Fellowship for the first two years and a Rutgers Teaching

Assistantship for the rest of my stay. I deeply thank Teresa Delcorso and the staff at the Chaser program. With their devoted help, I was awarded the University Summer Course Grant from the Deutscher Akademischer Austausch Dienst (DAAD, German Academic Exchange Service).

My dissertation would not have been completed without the help of the Rutgers Interlibrary Loan Service. Whenever I needed books not available at Rutgers, the staff members were always ready to find them. I also thank the staff at the Art Library who endured the numerous check-outs I made. I was also fortunate to have Joanna Stoehr as our department secretary. She knew everything. I had several Korean restaurants to help me satisfy my nostalgia for Korean foods: Edo and Maru.

Finally, I thank my relatives who always believed in me, and supported my journey to this point. There are no words I can use to express my deepest thanks to my father Suk-Hyi Lee, my mother Jeong-Sook Ser, and my brother Seungjoon Lee.

Table of Contents

Abstract.........ii

Dedication.........iv

Acknowledgements.........v

Chapter 1 Introduction......... 1

1.1 Introduction......... 1

1.2 Proposal and consequences......... 3

1.3 Optimality Theory......... 5

1.3.1 Extended Tone Bearing Units (xTBU) theory and OT......... 6

1.3.2 Autosegmental Theory......... 7

1.4 Other assumptions......... 11

1.4.1 Tone......... 11

1.4.2 Laryngeal Features......... 14

1.4.3 The mora: the minimal prosodic unit......... 15

1.5 Organization of this dissertation......... 15

Chapter 2 Description: Consonant-Tone Interaction......... 18

2.1 Introduction......... 18

2.2 Blocking of tone spreading......... 20

2.2.1 Blocking of contour tone formation: H + L H → H + $\widehat{HL}$ H......... 21

2.2.1.1 Tsonga......... 21

2.2.1.2 Ngizim.. 23
2.2.2 Blocking of downstep condition: H + L H → H + H ꜜH 24
2.2.2.1 Bade 24
2.2.2.2 Dagara Wule 25
2.2.3 Blocking of single H tone: H + L H → H + H H.................................... 26
2.2.3.1 Western Bade 26
2.2.3.2 Digo.. 28
2.2.3.3 SiSwati 30
2.2.3.4 Bolanci 31
2.2.4 Blocking of L spreading in Western Bade 32
2.2.5 Zina Kotoko 34
2.2.6 Summary 36
2.3 Tonal neutralization by consonants 37
2.3.1 Neutralization by consonants in onsets... 37
2.3.1.1 Mulao 37
2.3.1.2 Yao language: Aspirates and voiceless nasals 39
2.3.1.3 Zhuang 39
2.3.1.4 Kammu: minor vs. major syllables 40
2.3.1.5 Wujiang (Wu, Chinese) 41
2.3.1.6 Songjiang (Chinese)... 42
2.3.1.7 Korean.. 43
2.3.2 Neutralization by consonants in codas... 44
2.3.2.1 Burmese 44

2.3.2.2 San Martin Itunyoso Trique ... 45

2.3.2.3 Vietnamese: Coda or phonation ... 46

2.3.2.4 Yabem ... 48

2.3.3 Neutralization by consonants in onsets and codas: Thai ... 49

2.4 Change of laryngeal feature by tone ... 56

2.5 Which features affect tone? ... 59

2.5.1 Tsonga ... 60

2.5.2 Yao language ... 60

2.5.3 Burmese ... 62

2.5.4 Thai ... 63

2.6 Conclusion ... 63

Chapter 3 Extended Tone Bearing Unit Theory ... 65

3.1 Introduction ... 65

3.2 Direct association of non-moraic root nodes to tone ... 67

3.3 The role of faithfulness ... 72

3.4 Markedness constraints ... 76

3.5 Phonetic realization ... 86

3.6 Conclusion ... 88

Chapter 4 Effects of consonants on H tone spreading ... 91

4.1 Introduction ... 91

4.1.1 Proposal ... 92

4.2 Blocking tonal spreading by consonants: Tsonga ... 94
4.2.1 H tone spreading across non-depressors ... 95
4.2.1.1 L nouns ... 95
4.2.1.2 LH nouns ... 99
4.2.1.3 Toneless input ... 102
4.2.2 H tone spreading across depressors ... 105
4.2.2.1 Data ... 105
4.2.2.2 LH nouns ... 107
4.2.2.3 L nouns ... 113
4.2.3 Summary ... 113
4.3 Blocking tonal spreading in Western Bade ... 113
4.3.1 High tone blocked by voiced obstruents ... 114
4.3.2 L tone spreading blocked by voiceless consonants ... 119
4.3.3 Summary ... 124
4.4 Conclusion ... 125

Chapter 5 Tone neutralization by consonants ... 127
5.1 Introduction ... 127
5.1.1 xTBU theory ... 129
5.2 Tone neutralization by onsets: Mulao ... 131
5.2.1 Consonants and tone in Mulao ... 133
5.2.1.1 Traditional analyses of Mulao tone ... 135
5.2.3 Analysis: Tone neutralization by onsets ... 136

5.2.4 Summary 143
5.3 Neutralization of tone by codas: Burmese 144
5.3.1 Consonants and tone in Burmese 146
5.3.2 Tone neutralization by codas 147
5.3.3 Glottal stop as a phoneme 152
5.3.4 Tone neutralization by creaky phonation 161
5.3.5 Summary 163
5.4 Neutralization by onsets and codas: Thai 164
5.4.1 Tone neutralization by onsets 169
5.4.2 Tone neutralization by codas 177
5.4.3 Tone neutralization by onsets and by codas 186
5.4.4 Summary 189
5.5 Conclusion 189

Chapter 6 Issues in consonant-tone interaction 191
6.1 Introduction 191
6.2 How the theory produces unnatural classes of depressors 192
6.3 Derived hierarchies in consonant-tone interactions 198
6.4 Directionality of consonant-tone interaction 202
6.5 Tonogenesis and Phonetics 204
6.5.1 Theories of tonogenesis 206
6.5.2 Physiological accounts of tonogenesis 208
6.5.3 Cross-linguistic tonogenesis studies 209

6.5.4 Summary ... 211
6.6 Comparison with other theories of consonant-tone interaction ... 212
6.7 Conclusion ... 218

Chapter 7 Further Discussion ... 220
7.1 Introduction ... 220
7.2 Floating Tone in xTBU theory ... 220
7.3 Morpho-syntactic boundaries in consonant-tone interaction ... 223

References ... 224
Curriculum Vitae ... 240

Chapter 1 Introduction

1.1 Introduction

This dissertation presents a constraint-based theory of consonant-tone interaction called the ‘Extended Tone Bearing Unit Theory’, or xTBU theory for short. The theory is based on two empirical generalizations: certain consonants may affect tone, and only certain segmental features influence tone. These generalizations are shown in (1) with examples of languages.

(1) Empirical generalizations

a. Certain consonants may affect tone

- They may prevent H tones from spreading (Tsonga, Western Bade)
- They may prevent L tones from spreading (Western Bade)
- They may force H tones to become L tones (Burmese, Gurung)
- They may force L tones to become H tones (Mulao)
- They may force H tones to become non-H tones (Songjiang)
- They may force L tones to become non-L tones (Songjiang)

b. Only certain segmental features influence tone

Features	Languages
[+voice]	*Western Bade, Tsonga, Songjiang*
[-voice]	*Western Bade, Songjiang*
[+spread glottis]	*Mulao, Gurung, Tsonga*
[+constricted glottis]	*Burmese, Mulao*
[-spread glottis]	*Thai*
[-constricted glottis]	*unidentified*

There are two novel contributions of this dissertation. The first contribution is the finding that laryngeal features other than voice affect tone. While it is not a new finding that laryngeal features such as [spread glottis] or [constricted glottis] affect tone, this dissertation contributes by demonstrating that the roles of these features in consonant-tone interaction are not marginal phenomena.

Another contribution is that xTBU theory attempts to explain the faithfulness problem in consonant-tone interaction. How is it that consonants affect tone, but tone is not contrastive on consonants? In xTBU theory, I propose that while tone prefers to associate to moras, tone can also be associated to non-moraic root nodes. I also argue that a tone directly associated to a root node acts differently from a tone associated to a mora. An important aspect of the constraint formalism is that faithfulness constraints only target tones associated to a mora, and they never target tones associated to non-moraic root nodes. Thus, the presence and type of directly associated tones is restricted by markedness constraints only.

Current knowledge about voice-tone interaction is extensive. However, outside of tonogenesis, little evidence has been presented for the influence of other features on tone. I provide synchronic evidence from a variety of languages that shows how other laryngeal features can also influence tone, including aspiration, glottalization, lack of aspiration, creaky voice, and voicelessness. These observations are formalized with markedness constraints that target laryngeal features and tone.

In section 1.2, the basics of xTBU theory are presented. An introduction to Optimality Theory (OT) is presented in section 1.3. The proposal is situated in Autosegmental Theory, which is introduced in section 1.3. Assumptions about tone, laryngeal features, and moras are presented in section 1.4. Section 1.5 shows the organization of the rest of the dissertation.

1.2 Proposal and consequences

The theory presented in this dissertation has three main components, laid out in (2). Tone generally associates to moras. However, tones can also associate to a non-moraic root node. There are no faithfulness constraints in the theory that preserve tones underlyingly associated to such consonants. Consonant-tone interaction is restricted by a set of markedness constraints.

(2) Extended Tone Bearing Unit (xTBU) Theory

a.	Tones prefer to associate to moras. However, they can be forced to associate to consonant root nodes when no mora dominates them.	*sec. 3.2*
b.	There are no faithfulness constraints that preserve tones that are underlyingly associated to consonants.	*sec. 3.3*
c.	There is a set of markedness constraints with the form *[LARYNGEALFEATURE]/TONE; these constraints restrict consonant-tone interaction.	*sec. 3.4*

The xTBU theory proposed in (2) has the following implications for consonant-tone interaction. I explain each point in the paragraphs following (3).

(3) Implications of the proposal

a. Laryngeal features always affect tone in the way defined by markedness constraints.
b. Tone associated to consonants can block tonal processes and neutralize tones.
c. Markedness constraints that impose consonant-tone relations can be satisfied by either changing the tone or the laryngeal feature.

First, if a laryngeal feature of a non-moraic consonant restricts tone, it always does so in the way defined by markedness constraints, and never in a contrastive manner. For example, if there is a consonant-tone restriction involving voiced obstruents, L tones will always be preferred. This preference is due both to the markedness constraint *VOICEDOBSTRUENT/H and the *lack* of faithfulness constraints that preserve underlying consonant tone. In terms of Richness of the Base, this means that non-moraic /g̀/ (with L tone), /ǵ/ (with H tone), and /g/ (without tone) must always surface as [g̀] or [g] (depending on the ranking) and never as [ǵ].

Second, consonantal tone may block tonal spreading and neutralize tonal output. In Tsonga (section 4.2), voiced stops block H tone spreading, while in Western Bade L tone spreading is blocked by voiceless stops (section 4.3). Tone neutralization is found in Asian languages; aspirated consonants in onsets force underlying tones to neutralize to H in Mulao (section 5.2), while glottal stop codas neutralize tones to L in Burmese (section 5.3). In Thai, unaspirated stops in both onset and coda positions cannot associate with H tones (section 5.4).

Third, either tone or laryngeal features can change, a point discussed in detail in section 6.3. While most discussion about consonant-tone interaction has been devoted to examining how consonants affect tonal processes, it is also possible to change laryngeal features in order to satisfy consonant-tone restrictions. For example, in Xīnzhài Hmong, an underlying low register tone becomes a high register tone in the output as a result of tone sandhi as in (4).[1] The change of tone on the second syllable induces deaspiration of the onset: /ʦ^{h}/ becomes [ʦ] as in (3a).

(4) Change of laryngeal feature in Xīnzhài (新寨) Hmong
(Xian 1990: 74-75, Niederer 1998: 152)

a.	/tsɑŋ^{55} **ʦ^{h}**ɑ^{343}/	case - chopsticks	→	[tsɑŋ^{55} **ʦ**ɑ^{53}]	chopsticks case
b.	/mi^{11} m^{j}aɯ^{343}/	not - to hear	→	[mi^{11} m^{j}aɯ^{53}]	do not hear

The change of laryngeal features in the tone sandhi context follows because (i) aspirated consonants are not allowed to have high register tone (53 tone); and (ii) no faithfulness constraint preserves H tones associated with the aspirated consonant.

This proposal also aims for a unified account for all consonant-tone interactions, with the discussion focusing on languages spoken in Africa and Asia.

1.3 Optimality Theory

The proposal (xTBU theory) is situated in Optimality Theory (henceforth OT, Prince and Smolensky 1993/2004, P&S) which has three major components: CON, GEN, and EVAL. CON is the universal set of violable constraints, which consists of faithfulness constraints and markedness constraints. GEN generates a set of candidates for each input. The EVAL function "determines the relative Harmony of the candidates, imposing an order on the entire set" (P&S 1993/2004: 6). An optimal candidate is the candidate that "best satisfies the constraint system" (P&S 1993/2004: 6).

---

[1] In Xīnzhài Hmong data, tone is marked with Chao tone letters. The higher the number is, the higher the pitch of the tone. I would like to thank Xiao Li for the translation of Chinese glosses.

Faithfulness constraints evaluate the mapping of inputs to outputs. Markedness constraints evaluate the output properties of candidate forms. An OT grammar aims to provide a mapping from any input to a permissible output; the lack of restriction on input forms is called 'Richness of the Base'.

OT is a well established theory in phonological research. Therefore, no further explanation about the architecture of OT will be presented here. Readers who are interested in OT should refer to other work (McCarthy and Prince 1993, 1995b, 1995a, McCarthy 2002, Gouskova 2003, de Lacy 2006 and references therein). The Rutgers Optimality Archive (ROA, http://roa.rutgers.edu) provides up-to-date resources on OT research.

1.3.1 Extended Tone Bearing Units (xTBU) theory and OT

While xTBU theory is situated in OT, the basic points about TBUs and tone in the proposal potentially have wide applicability, and may find implementation in other theories.

In standard tonal theories, TBUs are limited to prosodic nodes (moras or syllables) because tonal contrasts only occur in prosodic nodes. Vowels display tonal contrasts, and so do some consonants in codas. However, onsets never show tonal contrasts.[2] For example, tone can be contrastive in nasal codas, but tone is never contrastive in nasal onsets.[3] From this asymmetry, it has been assumed that prosodic nodes are tone bearing units, but segments are not (Yip 2002: 72-74).

[2] There are no clear cases of languages that demonstrate tonal contrasts in onsets (p.c. Larry Hyman).

[3] Many theories of syllable weight are based on the same patterns: vowels and coda consonants often contribute to the syllable weight, but onsets do not (Hyman 1985, Hayes 1989, Gordon 2006). However, other lines of research argue that onsets may contribute to syllable weight (Goedemans 1998, Topintzi 2006).

In contrast, xTBU theory allows tone to associate directly to root nodes as long as they are not associated to a mora. In other words, tone prefers to associate to mora (a prosodic node), but under duress, tone can also associate to non-moraic root nodes.

Permitting tone to associate to non-moraic root nodes does not mean that xTBU theory predicts tone to be contrastive on onset consonants. It is important to distinguish the possibility of lexical contrast from the possibility of being a host. For tone to be lexically contrastive in onset position, it is not only necessary for onsets to be able to host tone, but also for faithfulness constraints to preserve tone in that position. In xTBU theory there are no such faithfulness constraints, so while onsets can bear tone, onset tone never distinguishes otherwise identical lexical items from each other.

Throughout the dissertation, autosegmental representations will be adopted to advocate the proposal in the xTBU theory. Section 1.3.2 introduces autosegmental theory.[4]

1.3.2 Autosegmental Theory

The autosegmental representation of tone (Leben 1973, Goldsmith 1976) is adopted in standard constraint-based tonal analyses as in Yip (2002). The autosegmental representation allows us to show the association of tone to prosodic nodes (moras or syllables), and to non-moraic root nodes.

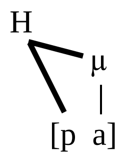
The figure in (5) shows two types of tonal association. As the representation shows, the segments [p] and [a] are associated to H tone. The association of H tone to the segment [a] is via the intermediate mora. This association to the mora is called an

---

[4] There are other theories that represent tone. One is Optimal Domains Theory (Cole and Kisseberth 1994, Cassimjee 1998, Cassimjee and Kisseberth 1998, Volk 2007, Downing 2008), and the other one is Headed Spans Theory (McCarthy 2004, Key 2007). The basics of xTBU theory retains in these theories.

'anchoring' relationship, and the association to the consonant [p] is called a 'dependency' relationship. The properties of these relationships are discussed in detail in section 3.2.

(5) Anchoring and dependency



Tonal faithfulness constraints only target tones associated to a mora ('anchoring relationship') as defined in (6). The correspondence relationships of moras associated with tone are crucial to this definition. For detailed discussion of these faithfulness constraints, see section 3.3.

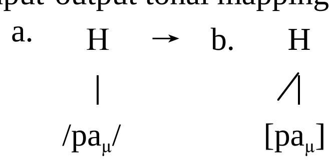
(6) Tonal faithfulness constraints

a.	DEP-T	Every mora *x* in the output has a corresponding mora associated to tone in the input.
b.	IO-IDENT-T	Corresponding segments associated to a mora have identical values for the tonal feature T_F. (If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *x* is [γT_F], then *y* is [γT_F].)
c.	OI-IDENT-T	Corresponding segments associated to a mora have identical values for the tonal feature T_F. (If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *y* is [γT_F], then *x* is [γT_F].)

I propose two types of IDENT-T constraints. These are necessary due to the nature of level tones and contour tones. IO-IDENT-T ensures the identity of tonal features of corresponding prosodic tone bearing units. Thus, an input with low tone /à/ must surface with low tone [à]. If the input maps to an output that has a high tone [á], IO-IDENT-T is violated. However, IO-IDENT-T is not violated if an input with low tone /à/ is realized with a falling contour [â], if we assume that a contour tone is a combination of level tones (cf. Yip 2002: 27-29). As the falling contour tone in the output is a combination of a high tone and a low tone, the input low tone is kept intact. Thus, the contour tone output does not violate IO-IDENT-T. In contrast, the OI-IDENT-T constraint is violated in this situation: the H in the HL contour tone is not present in the input.

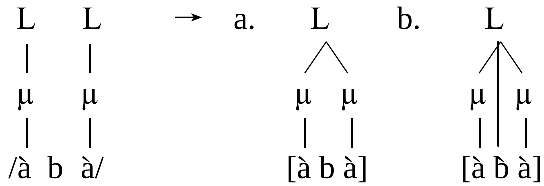
The association of tone to consonantal root nodes is a markedness requirement. Formally, this can be expressed with the markedness constraint ROOTNODE→T, which requires all root nodes to be associated to some tone. The effect of ROOTNODE→T is that every segment must be associated with a tone as demonstrated in (7) (for details see section 3.4).

(7) Input-output tonal mapping (including onsets)



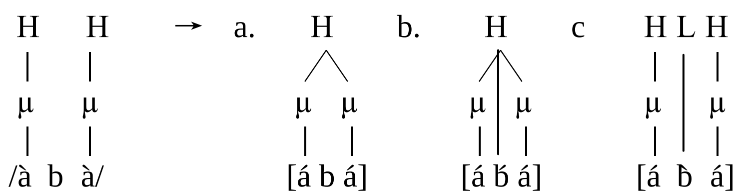
It is the ranking of relevant constraints that determines whether tone is associated to non-moraic root nodes or not. In (8), the input with a voiced stop [b] is surrounded by L tones. The output may not have tonal association to the consonant [b] as in (7a) if ROOTNODE→T is ranked lower than *TBU→T. The output has L tone associated to a consonantal root node as in (7b) if the ranking is reversed (the is, if ROOTNODE→T dominates *TBU/T).

(8) Voiced stop [b] and L tone



If a voiced stop [b] is surrounded by H tones as in (9), there are three possible outputs depending on the constraint ranking. The output may not have tone associated to non-moraic root nodes as in (8a): a language that cannot have consonant-tone interaction. The output may have an H tone associated to the voiced stop [b] as in (8b): a language that has consonant-tone interaction; there are no markedness constraints against H tones associating with [b]. The third possibility is shown in (8c), where the voiced stop [b] must be associated with a L tone; this is a language with consonant-tone interaction.

(9) Voiced stop [b] and H tone



While the representation in this dissertation is rooted in autosegmental theory, association lines have only representational status. Association lines are simply representations that express the relationship between prosodic nodes and tones. As such, there are no constraints targeting association lines: no faithfulness constraints (such as MAX-ASSOCIATION or DEP-ASSOCIATION) and no markedness constraints (such as *ASSOCIATION LINES).

1.4 Other assumptions

This dissertation also has other assumptions made on tone, laryngeal features, and moras. Section 1.4.1 defines what tone is and discusses the related issues. When consonants and tone interact with each other, laryngeal features actively participate in such interaction. The assumptions relevant to laryngeal features appear in section 1.4.2. Finally, in section 1.4.3, issues related to moras are discussed.

1.4.1 Tone

Tone is a phonological concept. It is phonetically realized as manipulations of glottal states that change fundamental frequency (F_0). F_0 is perceived as 'pitch'. Tone can be lexically contrastive in particular phonological positions – i.e., tone can be the sole phonological difference between distinct words (Yip 2002: 1-4). For example, Burmese has a syllable [k^ha]. With a low pitch, [k^hà] means 'to shake', but it means 'be bitter' with a high pitch [k^há]. In the subsections below, I present assumptions about tonal features, tone bearing units, and tonal notations. A short section about the geographical distribution of tone follows at the end of this section.

Tonal Features

For tonal features, I assume a model similar to that of Yip (1989). This model has two tonal features: [±upper] and [±lower]. These features can be deployed to make up to four contrasts of level tone (cf. (Wang 1967, Woo 1969)).[5] Other studies on tonal features

[5] As pointed out by Clements (1983) among others, languages with five level tones are problematic for theories with tonal features [±upper] and [±lower].

and/or tonal geometry can be found in Anderson (1978), Bao (1999: ch. 2), and Duanmu (2000). For the most part, the terms H and L will be used in the following analyses. H is [+upper, -lower] and L is [-upper, +lower], However, in some cases it will be necessary to be explicit about tone features (e.g. Thai in section 5.4).

Tone Bearing Units

In standard theories, tone bearing units (TBUs) are prosodic units to which tones can be associated: usually moras and syllables. Discussions about TBUs have focused on whether moras or syllables are both possible tone bearing units. There is ample evidence from various languages in which either moras or syllables behave as TBUs. Goldsmith (1976) proposes that vowels are TBUs, and Clements and Ford (1979) suggest that syllables are TBUs in Kikuyu. Based on his extensive research on Kimatuumbi, Odden (1996: 195-212) argues for moras alone as TBUs. In later work, after discussing issues of consonant-tone interaction, Odden (1995: 452) leaves the question open as to whether syllables can also be TBUs.

An interesting property borne out from this line of research is that no higher prosodic nodes above syllables (such as feet or prosodic word nodes) can be TBUs.[6] However, the extension of TBUs to nodes like feet or prosodic words could unify the tonal languages with pitch accent languages like Japanese (cf. Hyman 2006).

Cross-linguistic evidence for TBUs is presented in studies such as Yip (1995: 488-490) for East Asian languages, Odden (1995: 448-452) for African languages, and

[6] In Beckman and Pierrehumbert (1986: 271), languages are classified by the distribution of tone with respect to syllables. (a) In Yoruba (a tonal language), every syllable can have 'a distinctive tone' without restrictions on its distribution. (b) In Japanese (a pitch accent language), only one syllable in a prosodic word can be associated to H tone. (c) In English (a non-tonal language), at least one syllable in a prosodic word is associated with 'a starred tone'.

Duanmu (2000: 218-219).

In xTBU theory, tone can associate to non-moraic root nodes as well as moras. Tones can surface with two different relationships: anchoring and dependency. While tones prefer to associate with prosodic units (moras) by an anchoring relationship, they can also associate to a non-moraic root nodes by a dependency relationship. This point is explicated in detail in section 3.2.

Tone: notations

There are many different methods of tone notation (Yip 2007: 231). Throughout this dissertation, tone marking follows the original sources except when it would cause potential confusion. The notational differences of tone in various research traditions are as follows. In African languages, high tone is usually marked with an acute accent (H, ´), and low tone is marked with a grave accent (L, `) respectively. Contour tones are marked with the combination of these two accents: falling tone (HL,ˆ) and rising tone (LH, ˇ).

The Chinese and Southeast Asian notations often adopt Chao tone letters (Chao 1930). In Chao tone letters, the starting point and the end point of pitch are expressed on a number scale. Number 1 is the lowest and 5 is the highest. So, [ma^{55}] means that the tone of the syllable is high from the beginning to the end of the syllable, while [ma^{31}] means that the tone starts from mid level pitch and drops to low pitch within the syllable. For a constructive criticism of Chao letters, see Duanmu (2000: 210-213).

In the Americanist tradition, tone is often marked with single digit numbers, but the value of numbers is the reverse of the Chinese tradition. For example, [ta^{1}] represents high tone, while [ta^5] means low tone.

Tone: geography

Tonal languages are found in Africa, China and Southeast Asia, and Central and North America. The typological differences have been summarized in Odden (1995) and Yip (1995) respectively. While consonant-tone interaction is mainly observed in African and Asian languages, there are also languages spoken in other areas which exhibit such interactions.

1.4.2 Laryngeal Features

Consonants that interact with tone share certain laryngeal features: voicing, aspiration, glottalization, breathiness, and creakiness. In African languages, voiced consonants and/or voiceless consonants interact with tone (Bradshaw 1999, Tang 2007). In Asian languages, tone interacts with consonants that are aspirated or glottal.

In Halle and Stevens (1971), segmental features and suprasegmental features are argued to belong under the same feature system. In contrast, Pulleyblank (1994) argues that segmental root nodes and tonal nodes are sisters of moraic nodes, and Bao (1999) proposes that tonal nodes are dominated by laryngeal nodes. Further discussion of laryngeal features and tonal features can also be found in Yip (2002: 56-61).

The affinity of tone and laryngeal features suggests that tone may in fact associate to the laryngeal node under the root node (in feature geometry terms) as proposed in Bao (1999). Assuming tone association to laryngeal nodes would prevent tone from interacting with place of articulation or manner of articulation. In the rest of the dissertation, following standard theories, tone association to root nodes is regarded as tone association to laryngeal nodes (under the root nodes). Markedness constraints on consonant-tone interaction, therefore, only target laryngeal features and not other sub-segmental features.

1.4.3 The mora: the minimal prosodic unit

Following standard theories, I assume that tone associates to a mora (cf. Pulleyblank 1994). The mora is the minimal unit in the prosodic hierarchy (cf. Hyman 1985). Furthermore, following Hayes (1989) and McCarthy and Prince (1988, 1990), I also assume that vowels are moraic in the input. Consonants are moraic only for prosodic reasons (Morén 1999, Elías-Ulloa 2006), but onset consonants are assumed to be non-moraic (for other proposals, see Topintzi 2006).

1.5 Organization of this dissertation

Chapter 2 presents cross-linguistic patterns of consonant-tone interaction that are discussed and analyzed in later chapters. This chapter aims to be descriptive and atheoretical in two areas: consonants that block tone spreading (section 2.2) and consonants that neutralize tone (section 2.3). This chapter also shows languages that seem to have a change of the laryngeal feature of consonants induced by tone (section 2.4).

In chapter 3, the extended tone bearing unit theory (xTBU theory) is laid out. I propose that tone can directly be associated to non-moraic root nodes. This direct association to tone is defined as a dependency relationship, which demonstrates different properties from an anchoring relationship (between a tone and a mora). Faithfulness constraints only preserve tones that are underlyingly associated to moras. Consonant-tone interaction is an effect of markedness constraints that restrict the dependency relationship between consonants and tone.

The proposed xTBU theory accounts for the blocking of tonal spreading in chapter 4. In Tsonga, high tone spreading is blocked by voiced stops and other consonants (known as depressors). In Western Bade, voiceless consonants block low tone spreading. This blocking results from the active markedness constraints that penalize dependency relationships between laryngealized consonants and tones in the output.

In chapter 5, tonal neutralization by consonants in Mulao, Burmese and Thai is analyzed in the xTBU theory. Different sets of markedness constraints penalize dependency relationships between tones and laryngeal features (for example, [$\pm$spread glottis] and [$\pm$constricted glottis]). In Mulao, onsets neutralize output tones, while codas neutralize output tones in Burmese. On the other hand, consonants in onset and coda positions neutralize tones in Thai. The xTBU theory can account for all these cases.

Other issues in consonant-tone interaction are discussed in chapter 6. The xTBU theory predicts that unnatural classes of depressors arise from different markedness constraints that apply to disjoint sets of consonants. I claim that consonants interacting with tone form natural classes if they are subject to active markedness constraints (à la Flemming 2005). Consonant-tone interactions can also create apparent hierarchy effects. Analysis of Zina Kotoko suggests that the hierarchy of consonant-tone interaction is a result from output-oriented constraints. This chapter also discusses whether tone can affect consonants, citing studies by Maddieson (1974, 1976, 1978). Tonogenesis is a diachronic study of consonant-tone interaction. I claim that constraints on consonant-tone interaction do not motivate such diachronic changes, but that they do define possible synchronic grammars. Previous studies in consonant-tone interaction are introduced and compared to the xTBU theory at the end of chapter 6.

Issues subject to further discussion are shown in chapter 7. Consonant-tone interaction is sensitive to morpho-syntactic boundaries. How can the boundaries be incorporated with the xTBU theory? Additionally, what is the status of floating tone in xTBU theory, assuming the importance of the mora in tonal faithfulness constraints? Discussion of these questions appears in chapter 7, but a deeper understanding will be left for future research.

Chapter 2 Description: Consonant-Tone Interaction

2.1 Introduction

This chapter aims to present extensive data on consonant-tone interactions that support the empirical generalizations in (1). Consonant-tone interaction shows diverse patterns, as observed in various languages spoken in Africa, Southeast Asia, and the Americas. The majority of data comes from secondary sources such as grammars, articles and dictionaries. These sources are cited where appropriate. However, data for several languages came from my own fieldwork or from original recordings. These languages are: Burmese, Mulao, Western Bade, and Zhuang.

(1) Empirical generalizations

a. Certain consonants may affect tone

- They may prevent H tones from spreading	sec. 2.2.1- sec. 2.2.3
- They may prevent L tones from spreading	sec. 2.2.4
- They may force H tones to become L tones	sec. 2.3.2.1
- They may force L tones to become H tones	sec. 2.3.1.1
- They may force H tones to become non-H tones	sec. 2.3.1.6
- They may force L tones to become non-L tones	sec. 2.3.1.6

b. Only certain segmental features influence tone

Features	Languages
[+voice]	*Western Bade, Tsonga, Songjiang*
[-voice]	*Western Bade, Songjiang*
[+spread glottis]	*Mulao, Gurung, Tsonga*
[+constricted glottis]	*Burmese, Mulao*
[-spread glottis]	*Thai*
[-constricted glottis]	*unidentified*

In section 2.2, blocking of tonal spreading by consonants is described. H(igh) tone spreading and L tone spreading can be blocked by consonants. In particular, this section focuses on the pattern in which H tone spreading is blocked when it spreads to LH words. Such a spreading results in a contour tone, a uniform H tone, or a downstep depending on the language. Consonants such as voiced stops block H tone spreading in all three cases. The blocking effect of consonants is analyzed in chapter 4 based on descriptions in this section.

Consonants also force neutralization of tone (section 2.3) as mainly found in Southeast Asian languages. Consonants in onset positions or coda positions restrict the possible tone in a syllable. For example, it is the onset consonants that neutralize tone in Mulao, while it is the coda consonants that neutralize tone in Burmese. In Thai, consonants in both onset and coda positions neutralize tone. Chapter 5 develops analyses of tonal neutralization by consonants.

The properties of consonants that interact with tone are not uniform. For example, in Tsonga, voiced stops, breathy voice, and aspirated consonants block H tone spreading. In Mulao, on the other hand, aspirated stops and glottalized stops neutralize tone. The consonant inventories of languages discussed in this dissertation show how different types of consonants affect tone. Therefore, the consonants are shown in section 2.2 and 2.3 in subsections whenever possible. For an analysis about these characteristics of consonants, see chapter 6.

There are also languages in which tone seems to affect consonants. While Hyman and Schuh (1974) propose that consonant-tone interaction is asymmetric in that tone may not affect consonants, such examples are reported in Maddieson (1978). Section 2.4 summarizes languages that show tone-to-consonant interaction from original sources.

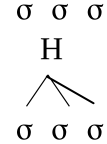
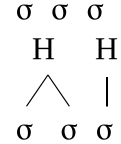
2.2 Blocking of tone spreading

This section presents cross-linguistic data on blocking of H spreading by consonants based on an important work by Bradshaw (1999:32-39). From Bradshaw, I abstract three different types of H tone spreading blocked by consonants. The blocking consonants are called ‘depressors’ (Lanham 1958).

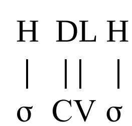
H tone spreading to LH tones **(H + L H)** results in: (2a) a contour tone **(H + H͡L H)**, (2b) a single H tone (**H + H H)**, or (2c) creation of a downstep environment (**H + H ꜜH**). All types of H tone spreading can be blocked by depressors as in (2d).

(2) Patterns of H tone spreading to LH tone

Non-depressors

a.	H + L H	→	H H͡L H	Tsonga	
b.	H + L H	→	H H H	Western Bade	
c.	H + L H	→	H H ꜜH	Dagara	

Depressors

d.	H + DL H	→	H DL H		

In section 2.2.1, blocking of contour tone formation in (2a) is shown based on Tsonga and Ngizim. The blocking of forming a single H tone (or deleting an underlying L tone) in the output is presented in section 2.2.2. Depressors that block the downstep condition are found in Bade and Dagara (wule), which are discussed in section 2.2.3.

2.2.1 Blocking of contour tone formation: H + L H → H + H͡L H

2.2.1.1 Tsonga

Tsonga (S53, Guthrie 1970) is spoken by 3.2 million in the Republic of South Africa, Mozambique and Zimbabwe. Tsonga is also known as Shangaan and Thonga. All Tsonga data are from Baumbach (1987), which is based on the variety of Tsonga spoken in the Republic of South Africa.

When LH nouns are preceded by a H tone prefix, the H tone spreads and surfaces with a falling contour tone (H + LH → H + H͡L H). Examples in (3) show the contour tone in the first syllable of a noun after an H tone copular prefix ([í] in nouns or [ɦí] in pronouns) or an instrumental prefix ([ɦí] in (3d)). The non-tonal blocking initial consonants can be fricatives, voiceless stops, prenasalized stops, and sonorants.

(3) LH tone nouns (Baumbach 1987: 50)

a.	*fricatives*	βòná	→	ɦí **β**ôná	'it is they'
b.	*voiceless stops*	kòmbé	→	í **k**ômbé	'it is an ousted impala'
c.	*nasals*	mìná	→	ɦí **m**îná	'it is me'
d.	*prenasalized stops*	mbìtá	→	ɦí **ᵐb**îtá	'with a pot'

An H tone spreading to a LH noun is blocked by a depressor. Thus, an input such as /H + DLH/ ('D' stands for depressors) becomes [H + D **L**H] and not *[H + D**H͡L**H] with a contour tone.

All examples in (4)-(6) show cases in which depressor consonants at the beginning of LH nouns block H spreading from the copulative prefix [í]. Depressor consonants in Tsonga are breathy voice consonants as in (4), voiced stops as in (5), and aspirated consonants as in (6).

(4) LH nouns with breathy voice depressors (Baumbach 1987: 53)

		H + DLH	→	H + DLH	
a.	[n̤]	n̤àŋgá	→	í **n̤**àŋgá	'it is a hut for unmarried girls'
b.	[r̤]	r̤òβá	→	í **r̤**òβá	'it is a flat cake'
c.	[m̤]	m̤àlá	→	í **m̤à**lá	'it is an impala'
d.	[ŋ̤]	ŋ̤wàrí	→	í **ŋ̤**wàrí	'it is a partridge'
e.	[^{m}b̤]	^{m}b̤ìmbí	→	í **^{m}b̤**ìmbí	'it is a mangosteen tree'
f.	[^{n}d̤^{ɦ}]	^{n}d̤^{ɦ}àmbá	→	í **^{n}d̤**àmbá	'it is a cooking pot'
g.	[^{n}ʥ̤]	^{n}ʥ̤èŋgá	→	í **^{n}ʥ̤**èŋgá	'it is afternoon'
h.	[^{n}g̤]	^{n}g̤òŋg̤wé	→	í **^{n}g̤**òŋg̤wé	'it is an old ousted vervet monkey'
i.	[^{n}dl̤]	^{n}dl̤àzí	→	í **^{n}dl̤**àzí	'it is a mousebird'
j.	[r̤]	r̤òβá	→	í **r̤**òβá	'it is a flat cake'

(5) LH nouns with voiced stop depressors (Baumbach 1987: 54)

		H + DLH	→	H + DLH	
a.	[b]	bùʃá	→	í **b**ùʃá	'it is a hen which eats its own eggs'
b.	[d]	dòɦé	→	í **d**òɦé	'it is an undersized peanut'
c.	[g]	gùdá	→	í **g**ùdá	'it is a small verandah'
d.	[bj]	bjàŋgá	→	í **bj**àŋgá	'it is a beer'
e.	[dj]	djòná	→	í **dj**òná	'it is it'

(6) LH nouns with aspirated depressors (Baumbach 1987: 54)

		H + DLH	→	H + DLH	
a.	[ts^{h}]	ts^{h}ùrí	→	í **ts^{h}**ùrí	'it is a mortar'
b.	[k^{h}]	k^{h}òswá	→	í **k^{h}**òswá	'it is a half portion'
c.	[^{n}tl^{h}]	^{n}tl^{h}àmú	→	í **^{n}tl^{h}**àmú	'it is a trap'
d.	[ʧ^{h}]	ʧ^{h}ìpá	→	í **ʧ^{h}**ìpá	'it is a pensioner'
e.	[t^{h}]	t^{h}ònsí	→	í **t^{h}**ònsí	'it is a drop'
f.	[ɦ]	ɦòmú	→	í **ɦ**òmú	'it is a beast'

The blocking of H tone spreading by depressors is found not only in copulative constructions or instrumental constructions, but also in various other nominal and verbal constructions as well: **a**. an LH object following a H tone verb in imperatives, **b.** an LH noun after the class 2a prefix, which is H tone, **c.** locative constructions, **d.** the first syllable of *mʊ̀ní* 'what kind' (LH tone) after a H tone syllable, and **e**. an LH noun after a possessive concord (cf. Baumbach 1987: 55-56).

2.2.1.2 Ngizim

In Ngizim, a Chadic language spoken in Yobe state, Nigeria[1], H tone spreading is blocked by voiced obstruents. H tone spreads to LH verbs from clitics: a subject marker /ná/ or an imperative marker /á/. The result of spreading is a contour tone on the first syllable of the verb [ná **ɗâ**nkə́-w] as in (7a). Such spreading is blocked when LH verbs begin with voiced obstruents like [b] as in (7b).

(7) Consonant-tone interaction in Ngizim (Schuh 1971)

a. Non-depressor

	H	L H		H H͡LH	
[ɗ]	/ná	ɗànkə́-w/	→	[ná ɗânkə́-w]	'I sewed'
[k]	/ná	kàasú-w/	→	[ná kâasú-w]	'I swept'
[r]	/á	rə̀pcí/	→	[á rə̂pcí]	'open!'

b. Depressor

	H	DL H		H DL H	
[b]	/ná	bàkə́-w/	→	[ná bàkú]	'I burned (it)'

[1] The webpage at *http://www.humnet.ucla.edu/aflang/Ngizim/ngizim.html* includes useful information about Ngizim (extracted on June 30, 2008).

2.2.2 Blocking of downstep condition: H + L H → H + H ꜜH

Spreading a H tone can also create downstep when the H spreading results in two adjacent H tones as in Bade and Dagara-wule. This spreading, however, is blocked when depressors are present. Analysis of this type of spreading appears in section 4.3.

2.2.2.1 Bade

Bade is a Chadic language spoken in Yobe state and Jigawa state in Nigeria. In Bade, a H tone from a subject clitic /nə́n/ spreads to a LH verb /kàtáw/ 'returned' as in (8). The spreading results in a downstep of the second H as in [nə́n káꜜtáw] 'I returned'.

(8) H tone spreading across non-depressors (Schuh 1978: 226)

		H	L H		H HꜜH	
a.	[k]	/nə́n	kàtáw/	→	[nə́n káꜜtáw]	'I returned'
b.	[l]	/nə́n	làwáw/	→	[nə́n láꜜwáw]	'I ran'

The H tone spreading is blocked by depressors in Bade. In (9), the subject clitic /nə́n/ precedes a LH verb that begins with a voiced obstruent [g]. The H tone does not spread, and therefore the downstep does not surface when depressors begin a word.

(9) H tone spreading across depressors (Schuh 1978: 226)

		H	DL H		H DLH	
a.	[g]	/nə́n	gàfáw/	→	[nə́n gàfáw]	'I caught'

2.2.2.2 Dagara Wule

Dagara Wule is a Voltaic language spoken in Burkina Faso and Ghana. When the prefix /ní/ 'a person' is followed by LH verbal adjectives, the H tone in the prefix spreads. So, the LH verbal adjective /fùùdá/ 'be defied' becomes HꜜH [fúúꜜɾá] as in (10). The second column shows consonants that allow such H tone spreading.

(10) H tone spreading in Dagara (Somé 1998: 11-12)

		H	LH		H HꜜH	'person…[2]
a.	[f]	ní	fààdá	→	ní fááꜜɾá	… who must be screwed'
b.	[f]	ní	fùùdá	→	ní fúúꜜɾá	… to be defied'
c.	[kp]	ní	kpààdá	→	ní kpááꜜɾá	… who is hammerable'
d.	[s]	ní	sìɛ̀dá	→	ní síɛꜜdá	… to be sewn'
e.	[f]	ní	fɛ̀ddá	→	ní fɛ́ꜜrá	… to be disturbed'
f.	[w]	ní	wɛ̀ddá	→	ní wɛ́ꜜrá	… to be medically operated'
g.	[ŋ]	ní	ŋàddá	→	ní ŋáꜜrá	… who needs to stand up'
h.	[ɓ]	ní	ɓòddá	→	ní ɓóꜜrá	… to be put in hot water'
i.	[k]	ní	kʊ̀ɔ̀ddá	→	ní kʊ́ɔ́ꜜrá	… to be sold'
j.	[h]	ní	hàbdá	→	ní háwꜜɾá	… to be trapped'
k.	[c]	ní	cɔ̀gdá	→	ní cɔ́wꜜɾá	… to be prickled'
l.	[p]	ní	pɔ̀gdá	→	ní pɔ́wꜜɾá	… who can be confined'
m.	[ʔ]	ní	ʔògdá	→	ní ʔówꜜɾá	… to be separated'
n.	[t]	ní	tɛ̀gdá	→	ní tɛ́wꜜɾá	… who can be exchanged'
o.	[k]	ní	kɔ̀glá	→	ní kɔ́gꜜlá	… to be accompanied'

H tone spreading is blocked if a depressor consonant is present. In (11), the LH verbal adjectives begin with depressors, as shown in the second column. When a depressor is present, there is no tonal change in the LH verbal adjective [zɛ̀lá] following the H tone prefix [ní] 'person'.[3]

---

[2] I am indebted to Maia Duguine who provided me the translation from French.
[3] As in Somé (1998), the discussion in this section does not include segmental changes.

(11) Blocking of H tone spreading in Dagara (Somé 1998: 12)

		H	DLH		H DLH	'person…
a.	[z]	ní	zὲlá	→	ní zὲlá	… to be asked'
b.	[d]	ní	dɔ̀gdá	→	ní dɔ̀wɾá	… who can be given birth'
c.	[ɟ]	ní	ɟɪ̀ὲlá	→	ní ɟɪ̀ὲlá	… to be watched closely'
d.	[g]	ní	gùùdá	→	ní gùùɾá	… who must be kept'
e.	[gb]	ní	gbààdá	→	ní gbààɾá	… who must be won by playing'
f.	[v]	ní	vùùtá	→	ní vùùɾá	… who is worthy of making errors'
g.	[b]	ní	bàngdá	→	ní bɑ̃̀wná	… who must be known'
h.	[ɦ]	ní	ɦììndá	→	ní ɦììnná	… who cries by sighing'

2.2.3 Blocking of single H tone: H + L H → H + H H

The last type of H tone spreading appears when a H tone simply spreads without creating a contour tone or a downstep condition. This type of H tone spreading is found in Western Bade, Digo, SiSwati, and Bolanci. So, an input /H/ followed by /LH/ becomes [H H H] in the output. However, when a LH word begins with a depressor consonant, H tone spreading is blocked.

2.2.3.1 Western Bade

Western Bade is a Chadic language spoken in Nigeria[4]. The language is closely related to Ngizim. Russell Schuh provided me with recordings of two male consultants in their mid forties who are natives of Dagona village, the central Western Bade speaking region. Consultant G was recorded in Gashua, Yobe State, Nigeria on July 22, 2007. Consultant B was recorded twice in Potiskum, Yobe State, Nigeria, first on July 25, 2007 and then on August 8, 2007. These consultants confirmed all the Western Bade data presented below and in chapter 3 and 4.

While voiceless obstruents, glottalized obstruents, and all sonorants allow H tone

[4] The language described here is different from Bade discussed earlier in section 2.2.2.1.

spreading, voiced obstruents in Western Bade block H tone spreading. Western Bade also shows blocking of L tone spreading, a point discussed in section 2.2.4.

H tone spreads to LH verbs across phrase boundaries in Western Bade. In (12a-c), a LLH verb becomes HHH in the output following the first person singular H tone clitic /nə́/. For example, the first two syllables of the LH verb /tə̀nkə̀kú/ 'pressed' become H tone [tə́nkə́kú] after /nə́/ in (12a).

The spreading of H tones is blocked when a depressor consonant is present as in (12d-e). In (12e), the H tone does not spread in the verb /bàzàrtú/ 'shamed' because it begins with a depressor. So, the H tone does not spread to [bàzàrtú]. In (12d), /tə̀mbə̀lú/ 'pushed', the medial syllable of the verbal root is a depressor. So, the H tone only spreads to the first syllable of the verbal root [tə́mbə̀lú].

(12) H tone subject clitic + Verb (Schuh 2002, Handout#4:16)

	H **L** **L** H		H **H** **H** H	
a.	/nə́ tə̀nkə̀kú/	→	[nə́ tə́nkə́kú]	'I pressed'
b.	/nə́ ɗ̀ùwàtlú/	→	[nə́ ɗ́úwátlú]	'I got tired'
c.	/nə́ mə̀skə̀tú/	→	[nə́ mə́skə́tú]	'I turned
	H **L** DL H		H **H** DL H	
d.	/nə́ tə̀mbə̀lú/	→	[nə́ tə́mbə̀lú]	'I pushed'
	H DL DL H		H DL DL H	
e.	/nə́ bàzàrtú/	→	[nə́ bàzàrtú]	'I shamed'

('D' stands for depressors)

After a L tone subject clitic, there is no tonal change. In (13), the same verbs in (12) are presented after a L tone clitic, the first person plural subject marker /jə̀/. Thus, the LLH verb maps faithfully as LLH.

(13) L tone subject clitic + Verb (Schuh 2002, Handout#4:16)

	L L L H		L L L H	
a.	/jə̀ tə̀nkə̀kú/	→	[jə̀ tə̀nkə̀kú]	‘we pressed’
b.	/jə̀ ɗùwàtlú/	→	[jə̀ ɗùwàtlú]	‘we got tired’
c.	/jə̀ mə̀skə̀tú/	→	[jə̀ mə̀skə̀tú]	‘we turned’
d.	/jə̀ tə̀mbə̀lú/	→	[jə̀ tə̀mbə̀lú]	‘we pushed’
e.	/jə̀ bàzàrtú/	→	[jə̀ bàzàrtú]	‘we shamed’

2.2.3.2 Digo

Digo (E73, Guthrie 1970) is a Bantu language spoken in Kenya and Tanzania. In Digo, H tone spreading from a prefix to verbal stems is blocked by depressors. The aim of this section is to show Digo examples in which H tone spreading is blocked, and not to provide a full analysis of stem tone in Digo.

In (14) and (15), verbs in the past tense demonstrate the depressor effect. The past tense in Digo is expressed with *a*-, which introduces a H tone. The H tone surfaces on the L tone verbal stem as in (14). However, when a L tone verb begins with a depressor, the H tone surfaces on the past tense prefix itself as in (15).

(14) Past tense L tone verbs (Kisseberth 1984: 146)

		L L	L H H H͡L	*past*
a.	[ts]	/tsùkùr/	[n-à-tsúkúr-â]	‘I carried’
b.	[w]	/wòchèr/	[n-à-wóchér-â]	‘I received’
c.	[ts]	/tsòr/	[n-à-tsór-â]	‘I picked up’

(15) Past tense L tone verbs with depressors (Kisseberth 1984: 146)

		H D… L͡H H͡L	H D… L͡H H͡L	*past*
a.	[v]	/vùmìkíz/	[n-á-vùmìkíz-à]	‘I agreed’
b.	[v]	/vùgùr/	[n-á-vùgǔr-â]	‘I untied’
c.	[g]	/gùr/	[n-á-gǔr-â]	‘I bought’
d.	[dz]	/dzè^{n}g/	[n-á-dzě^{n}g-â]	‘I built’

Depressors in word-medial position can also affect H tone spreading in Digo as shown in (16). In (16a), the final syllable of the verb with a depressor [z] has a L tone instead of a falling tone (compare this with the final syllables in (14)). In (16b), the penultimate syllable has a depressor [g], so the H tone only spreads to the first syllable of the verbal root [tó]. The penultimate syllable has a rising tone [gǒ] instead of a H tone (compare with (15a-b)).

(16) Past tense L tone verbs with depressors (Kisseberth 1984: 146)

		L H H L	*past*
a.	[z]	[n-à-ró^{n}gó**z-à**]	'I led'
b.	[g]	[n-à-tó**gǒ**r-â]	'I praised'

The past tense of H tone verbs has the same pattern as that of L tone verbs, as demonstrated in (17). If we compare (17a) with (17e), the infinitive, H tone verbs have a rising tone in the penult [kù-pù**pǔ**t-â] 'to beat'. In the past tense forms, H tones appear on the syllables of verbal roots as in (17a-d).

(17) Past tense H tone verb (Kisseberth 1984: 146)

		L H H H͡L	*past*
a.	[p]	[n-à-púpút-â]	'I beat'
b.	[k]	[n-à-kú^{m}búkír-â]	'I remembered'
c.	[t]	[n-à-túrúk-â]	'I went out'
d.	[n]	[n-à-nén-â]	'I spoke'
		L L L͡H H͡L	*infinitive*
e.	[p]	[kù-pùpǔt-â]	'to beat'

When a H tone verb begins with a depressor, the H tone is realized on the past tense prefix as in (18).

(18) Past tense H tone verb with depressors (Kisseberth 1984: 146)

		H D… L͡H H͡L	*past*
a.	[g]	n-á-ga̤ràgǎr-â	'I rolled about in pain'
b.	[vw]	n-á-vwìnǐr-â	'I sang for'
c.	[d]	n-á-dǔⁿg-â	'I pierced'

2.2.3.3 SiSwati

SiSwati (S43, Guthrie 1970) is a Bantu language spoken in Swaziland. The infinitive form in SiSwati demonstrates H tone spreading to LH verbs. In (19a), the LHL verb /khùlúúmà/ following the H tone infinitive prefix /kú/ becomes HHL [kú-khúlúúmà] as a result of H tone spreading. As in Digo, H tone spreads from the prefix without forming a contour tone or downstep.

(19) H tone spreading in SiSwati (Bradshaw 1996, 1999: 35-36)

		H	L H L		H + H H L	
a.	[kh]	kú	khùlúúmà	→	kú-khúlúúmà	'to speak'
b.	[l]	kú	lànyéélа	→	kú-lányéélà	'to plan'
c.	[ɓ]	kú	ɓèkétèèlà	→	kú-ɓékétèèlà	'to be patient'
d.	[tsh]	kú	tshànyéélà	→	kú-tshányéélà	'to sweep'
e.	[ɬ]	kú	ɬùkánììsà	→	kú-ɬúkánììsà	'to make separate'

When the LHL verbal root begins with a depressor [g] as in [gàyííŋà] in (20a), H tone spreading from the infinitive prefix [kú] is blocked. The [kúgàyííŋà] 'to dry roast' faithfully maps the input L tone on [gà] to the output.

(20) Blocking of H tone spreading in SiSwati

		H	DL H L		H + DL H L	
a.	[g]	kú	gàyííŋà	→	kú-gàyííŋà	'to dry roast'
b.	[c]	kú	càndvúúlà	→	kú-càndvùúlà	'to hammer'
c.	[c]	kú	cìndzétèèlà	→	kú-cìndzètéèlà	'to oppress'
d.	[kh]	kú	khàŋéétà	→	kú-khàŋèétà	'to hold out one's hands'
e.	[ɬ]	kú	ɬàŋányèèlà	→	kú-ɬàŋànyéèlà	'to participate'

2.2.3.4 Bolanci

In Bolanci, a Chadic language spoken in Northern Nigeria, depressors block H tone spreading. In (21), genitive constructions show that the H tone of the rising tone (L͡H) in /kǔm/ 'ear' spreads to the first syllable of a following L tone noun. So, the L noun /làawò/ becomes HL tone as in [kǔm **lááwò**] 'ear of the child'.

(21) Genitive constructions with non-depressors (Lukas 1969: 134, 137)

		L͡H	LL(L)		L͡H **H**L(L)	
a.	[l]	kǔm	lààwò	→	kǔm lááwò	'ear of the child'
b.	[m]	kǔm	mòndù	→	kǔm móndù	'ear of the woman'
c.	[s]	kǔm	sààwùrà	→	kǔm sááwùrà	'ear of the falcon'

The H tone spreading from the rising tone noun /kǔm/ 'ear' is blocked when the following L tone noun begins with a voiced obstruent as in /**gàn**dùkì/ 'hare' as in (22).

(22) Genitive constructions with depressors (Lukas 1969: 134, 137)

		L͡H	DL DL L		L͡H DL DL L	
a.	[g]	kǔm	gàndùkì	→	kǔm gàndùkì	'ear of the hare'

Depressor consonants of Bolanci also block H tone spreading in verbs. In perfect or future tense, verbs in Bolanci are followed by a H tone verbal prefix [ká]. When the tone of the verbal root is LH, H tone spreads to the first syllable as in (23). Thus, the verb /kùmáa/ 'to hear' becomes […kúmáa…].

(23) Verbal roots with non-depressors (Lukas 1969: 136-137)

		L H		H H H ….		
a.	[k]	kùmáa	to hear	ká-**kú**máawòoyíi	'you have heard'	(perfect)
b.				ká-**kú**mèeyú		(future)

Such H tone spreading, however, is blocked when the LH verb begins with a voiced obstruent as in (24). The depressor [b] in the LH verb /bàltú/ 'to lock in' blocks the H tone spreading from the H tone verbal prefix [ká].

(24) Verbal roots with depressors (Lukas 1969: 136-137)

		DL H		H DL H ….		
a.	[b]	bàltú	to lock in	ká-**bàl**túwòoyú	'you have locked in'	(perfect)
b.				ká-**bàl**tàayíi	'you will lock in'	(future)

2.2.4 Blocking of L spreading in Western Bade

In Western Bade, voiceless stops block L tone spreading. In (25), LH verbs precede the H noun [kórón] 'donkey'. When the LH verb precedes the H tone direct object, the final H of the verb becomes a L tone; /LH + H/ → [LL + H]. In (25a), the verb /kə̀rə́/ 'stole' is followed by a H tone noun [kórón] ‘donkey’. The final H tone of the verb becomes a L tone in the output as in [kə**rə̀** kórón] ‘stole a donkey’, and not *[kə̀**rə́** kórón].

(25) (L)H Verb + H tone Noun (Schuh 2002, Handout#4:18)[5]

	L **L H H** H		L **L L** **H** H	
a.	/jə̀ kə̀rə́ kórón/	→	[jə̀ kə̀rə̀ kórón]	we stole a donkey
b.	/jə̀ tàɗə́ kórón/	→	[jə̀ tàɗə̀ kórón]	we released a donkey
c.	/jə̀ də̀ɓə́ kórón/	→	[jə̀ də̀ɓə̀ kórón]	we watered a donkey
	L H H H		**L L H** H	
d.	/jə̀-ɗgə́ kórón/	→	[jə̀-ɗgə̀ kórón]	we followed a donkey
	L **L H H** L H		L **L L H** L H	
e.	/jə̀ wànə́ kázàmə́n/	→	[jə̀ wànə̀ kázàmə́n]	we sent a girl
	L **L H H** H		L **L H H** H	
f.	/jə̀ də̀psə́ kórón/	→	[jə̀ də̀psə́ kórón]	we hid a donkey
g.	/jə̀ gàfá kórón/	→	[jə̀ gàfá kórón]	we caught a donkey

However, the spreading of L tone to verb final H tones does not occur when the final syllable has voiceless obstruent onsets as in (25f-g). The LH verb /də̀psə́/ ‘hid’ is followed by the H tone noun [kórón] ‘donkey’ in (26f). The output retains the final H tone as [də̀psə́ kórón] ‘hid a donkey’, and it does not become *[də̀psə̀ kórón] as we would expect.

Contrastively, when the verbs are followed by a L initial noun like /dùwún/ ‘horse’, the lowering of the H tones does not occur at all. The output surfaces with the same tonal patterns of the input as in (26).

---

[5] Verbs in Western Bade are at most two syllables due to morphological restrictions (Russell Schuh, p.c.).

(26) (L)H Verb + L tone Noun (Schuh 2002, Handout#4:18)

	L **L H L** H		L **L H L** H	
a.	/jə̀ kə̀rə́ dùwún/	→	[jə̀ kə̀rə́ dùwún]	we stole a horse
b.	/jə̀ tàɗə́ dùwún/	→	[jə̀ tàɗə́ dùwún]	we released a horse
c.	/jə̀ də̀ɓə́ dùwún/	→	[jə̀ də̀ɓə́ dùwún]	we watered a horse
	L H L H		**L H L** H	
d.	/jə̀-ɗgə́ dùwún/	→	[jə̀-ɗgə́ dùwún]	we followed a horse
	L **L H L** H		L **L LH** H	
e.	/jə̀ wànə́ m̀də́n/	→	[jə̀ wànə̂mdə́n]	we sent a a person
	L **L H L** H		L **L H L** H	
f.	/jə̀ də̀psə́ dùwún/	→	[jə̀ də̀psə́ dùwún]	we hid a horse
g.	/jə̀ gàfá dùwún/	→	[jə̀ gàfá dùwún]	we caught a horse

2.2.5 Zina Kotoko

Zina Kotoko is a language spoken mainly Cameroon, and also in Nigeria and Chad. In Zina Kotoko, the future tense is a circumfix [n^{H}-…-a], where the H tone is realized on the stem syllable, as shown in (27). The high tone is realized faithfully when the stem begins with [h], voiceless stops, and implosives. High tone is marked with an acute accent. Low tone is marked with a grave accent, and mid tone has no marking.

(27) H tone in the future tense (Odden 2002: 17)

a.	[h]	[h]	n-hár-à	*find*	[h]	n-híyar-à	*bite pl.*
		[h]	n-hə́n-à	*burn*	[h]	n-hám-à	*swear*
		[h]	n-hə́rc-à	*slice*	[h]	n-hə́s-à	*throw*
b.	implosives	[ɗ]	n-ɗə́v-à	*put*	[ɗ]	n-ɗám-à	*eat*
		[ɗ]	n-ɗə́h-à	*write*	[ɓ]	m-ɓál-à	*dance*
c.	voiceless obstruents	[s]	n-sáp-à	*chase*	[s]	n-sáb-à	*grow*
		[p]	m-páy-à	*bury*	[c]	n-cíhy-à	*fry*
		[k]	n-káɗ-à	*cross*	[c]	n-cə́nh-à	*be sated*
		[s]	n-sə́my-à	*hear*	[s]	n-sə́k-à	*send*

The high tone of the future tense verbs is lowered to mid when roots begin with sonorants, glottal stops, and voiced obstruents as shown in (28).

(28) H tone lowering to mid in the future tense (Odden 2002: 17-18)

a.	sonorants	[y]	n-yey-à	*call*	[w]	n-wurgy-à	*buy*
		[w]	n-wac-à	*leave*	[w]	n-wasy-à	*cough*
		[w]	n-wuràgy-à	*buy pl.*	[l]	n-lab-à	*tell*
		[l]	n-law-à	*fight*	[l]	n-ləhày-à	*fear*
		[r]	n-raɗ-à	*pull*	[m]	m-mar-à	*die*
		[l]	n-lum-à	*shave*	[l]	n-lakf-à	*bring*
b.	glottal stop	[ʔ]	n-ʔəkf-à	*approach*	[ʔ]	n-ʔək-à	*snatch*
c.	voiced obstruents	[j]	n-jagh-à	*dig*	[gh]	n-ghag-à	*close*
		[z]	n-zəgh-à	*distribute*	[g]	n-gəg-à	*do*
		[b]	m-bagh-à	*split*	[z]	n-zəby-à	*follow*
		[z]	n-zəgl-à	*carry*	[b]	m-bughwr-à	*jump*
		[g]	n-gəɓ-à	*answer*	[b]	m-ban-à	*bathe*
		[j]	n-jary-à	*burp*	[d]	n-dunkw-à	*throw*
		[v]	m-vənàh-à	*vomit*	[g]	n-gulàn-à	*laugh*

While it may seem that Zina Kotoko simply presents a situation of 'unnatural class' behavior, other morphological processes display *different* consonant-tone interactions, as shown in (29). Mid tones become low before voiced obstruents in recent past and imperatives as in (29a). Consonants also affect the following tones. In the progressive, high tone reduplicants surface with mid tone if the reduplicant begins with voiced obstruents or sonorants as in (29b). Similar to (29a), mid tones become low if followed by voiced obstruents, sonorants, implosives, or the glottal stop in remote past and recent past.

(29) Consonant-tone interaction in Zina Kotoko (Odden 2002)

rules	*change*	*before*	*tense*
a. Pre-depressor lowering	**M → L**	**voiced obstruents**	*recent past* (p.21)
	M → M	sonorants ~ [h]	*imperative* (p.28)
	change	*after*	*tense*
b. Reduplicant	**RED = M**	**voiced obstruents ~ sonorants**	*progressive* (p.31)
	RED = H	glottal stop ~ [h]	
c. M lowering	**M → L**	**voiced obstruents ~ implosives**	*recent past* (p.20)
	M → M	voiceless obstruents, [h]	*remote past* (p.26)

The consonant-tone interaction in the future tense in (29) is analyzed in chapter 6. Other various morphological processes can be analyzed in the same way as the future tense.

2.2.6 Summary

In this section, I have presented the blocking of tonal spreading by consonants. When H tone spreads to LH tone words, it can (a) create a contour tone (as in Tsonga), (b) surface with a single H tone domain (as in Western Bade), or (c) form a downstep condition (as in Dagara). If a depressor consonant begins the LH tone words, H tone spreading is blocked. Therefore, (a') no contour tone is formed, (b') no single H tone domain is formed, or (c') a downstep condition is not formed. L tone spreading can be blocked as well, as shown in Western Bade in section 2.2.4.

Detailed analyses of these sets of data appear in chapter 4. The proposed theory (xTBU theory) assumes that consonants can directly associate with tone. Such a tonal association is only restricted by markedness constraints in the absence of faithfulness constraints.

2.3 Tonal neutralization by consonants

In various languages, especially languages spoken in Southeast Asia, consonants limit the number of possible output tones. The tonal restriction can be understood as neutralization by consonants. This section presents cross-linguistic data of such neutralizations. Tonal neutralization is affected by the position of consonants in a syllable. In languages such as Mulao, consonants in onset positions neutralize tone (section 2.3.1). In Burmese, consonants in coda positions neutralize tone (section 2.3.2). There are also languages like Thai in which consonants in both onsets and codas neutralize tone (section 2.3.3). Tonal neutralization by consonants is analyzed in chapter 5.

2.3.1 Neutralization by consonants in onsets

2.3.1.1 Mulao

Mulao (or Mulam 仫佬) is a language spoken in Luocheng County of Guangxi Zhuang Autonomous Region. There are about seventy thousand speakers, and most of them live in Luocheng (based on the 1977 census). Jerry Edmonson provided me with a tape recording of Mulao data. The consultant was Ms. Huiling Pan (潘慧玲), who was recorded in Beijing, China on November 10, 1986. Ms. Pan confirmed all the Mulao data presented below and in chapter 5.

In Mulao, onset consonants restrict the possible tone in a syllable: syllables with onsets that are aspirates, glottals, or voiceless sonorants only surface with a high register tone. In (30), the high tone requirement associated with onset consonants in Mulao is presented. Syllables with consonants in onset positions, in (30), do not occur in low register tone, as shown in (30b). The group of consonants in (30) is called '*elevator* *consonants*'[6] because they favor higher tone (contrasting with 'depressors', which favor lower tone). The subscript H or L marks the tonal register. The numbers in superscript are tone marked in Chao tone letters, in which 1 represents the lowest pitch, and 5 is the highest pitch (Chao 1930).

(30) Onsets ('*elevators*') that require a high tone[7]

		a. *high*		b. *low*
Aspirates	[kʰ]	[**kʰ**ɛːk^{42}]$_H$	'guest'	*[kʰɛːk]$_L$
	[pʰ]	[**pʰ**o^{44}]$_H$	'bed'	*[pʰo]$_L$
Glottals	[ʔ]	[**ʔ**uk^{55}]$_H$	'to exit'	*[ʔuk]$_L$
	[ʔj]	[**ˀj**em^{42}]$_H$	'to borrow'	*[ʔjem]$_L$
Voiceless sonorant	[n̥]	[**n̥**ɔ^{53}]$_H$	'rat, mouse'	*[n̥ɔ]$_L$

In Mulao, syllables with onsets other than the ones in (30) have no tonal restrictions - there is no tonal neutralization. Sonorants or voiceless stops in onset positions can have both high tone and low tone. Example (31) shows the tonal minimal pairs in such syllables. For example, if the glide [j] occurs in onset positions, high tone (e.g. [ja]$_H$ 'cloth') and low tone ([ja]$_L$ 'also') are both possible.

(31) Onsets that do not require a high tone

		a. *high*		b. *low*	
Sonorants	[j]	[**j**a^{42}]$_H$	'cloth'	[**j**a^{11}]$_L$	'also, too'
	[l]	[**l**au^{44}]$_H$	'snail'	[**l**au^{11}]$_L$	'to leak'
Voiceless	[k]	[**k**uŋ^{53}]$_H$	'stalk, stem'	[**k**uŋ^{121}]$_L$	'grasshopper'
	[p]	[**p**aːk^{42}]$_H$	'mouth'	[**p**aːk^{11}]$_L$	'white'
	[t]	[**t**aŋ^{44}]$_H$	'stool'	[**t**aŋ^{24}]$_L$	'to stand'

---

[6] I am indebted to Marc Brunelle and Susan M. Burt for suggesting this term to me.
[7] All data come from Wang and Zheng (1993), which is based on Dayin variety of Mulao.

Tonal neutralization by consonants in onset positions is found in languages other than Mulao, as discussed below. For an interaction that occurs in a prosodic domain bigger than a syllable, see Jun (1996, 1998) in which she reports that aspirates in onset positions of an accentual phrase in Korean only surface with a high pitch.

2.3.1.2 Yao language: Aspirates and voiceless nasals

The Yao language, spoken in Guangxi Zhuang Autonomous Region, has three major dialects: Mjen (or Mien 勉), Pu nu (or Bunu 布努), and Lak kja (or Lakkia 拉珈). In all of these dialects, aspirated and voiceless nasal consonants in onset positions neutralize tone (Mao & Chou 1972: 240).

The consonants that neutralize tone in the Yao language share laryngeal features: aspiration and voiceless nasals. In section 2.5.2, the consonant inventories show that consonants interacting with tone and consonants not interacting with tone do not overlap.

2.3.1.3 Zhuang

In Zhuang, tone is also neutralized if consonants in onset positions have laryngeal features such as glottal, aspirated or unaspirated (Luo 2005: 1217-1218). Zhuang's characteristics also influence Wuming Mandarin (cf. Huang 1997).

In Sanfang Zhuang, it is observed that all (historically) preglottalized onsets surface with a high tone even though the consonants become voiced stops (Wei and Edmondson 1997: 46). For other studies on Zhuang, see Qin (1996), Qin (2004), Wei and Tan (2006) and references therein.

From fall 2007 through summer 2008, I made recordings of a variety of the Zhuang spoken in Du'an, Guangxi Zhuang Autonomous Region with the consultant Yuehua Wei, a male speaker in his 20s. I elicited data to confirm data from secondary sources. However, the characteristics found in the Du'an dialect in comparison with the standard Zhuang spoken in Nanning were greater than expected; so much so that I was unable to include Mr. Wei's data in this dissertation.

2.3.1.4 Kammu: minor vs. major syllables

Kammu is a Mon-Khmer language spoken in Northern Laos. In Kammu, aspirated consonants in certain onset positions neutralize the output tones to high. In Kammu, there are two types of syllables: one with schwa [ə] (called 'minor syllables') and the other one with full vowel contrast (called 'major syllables'). A word in Kammu usually consists of a minor and a major syllable, a property called sesquisyllabicity. Minor syllables with schwa [ə] can surface with a high tone or low tone, except when aspirates are in the onset position; this latter case restricts output tone to high.

An unaspirated stop in the onset position of a minor syllable, as in (32a) and (32d), surfaces with either high tone or low tone. If the onset is a sonorant as in (32c), minor syllables are low. When an onset is aspirated as in (32b), minor syllables (and a following major syllable) only surface with high tone.

(32) Minor-Major syllables (Svantesson and Karlsson 2004: 180)

	minor syllables		tones	example	
a.	unaspirated	p t c k	H-H	[kə́.múul]	'silver'
			L-L	[cə̀.mə̀ʔ]	'rope'
b.	**aspirates**	**s h c^h k^h**	**H-H**	**[sə́.cáaŋ]**	'**elephant**'
c.	sonorants	l r lC rC	L-H	[rə̀.háaŋ]	'bamboo'
			L-L	[lə̀m.pòʔ]	'cow'
d.	unaspirated	pC tC cC kC	H-L	[pə́ŋ.kàʔ]	'to wear by the ear'
			L-H	[kə̀m.múʔ]	'person'
			L-L	[pə̀ŋ.kàʔ]	'shy'
e.	aspirates	sC hC p^hC	H-H	[c^hə́k.ɓɨ̂k]	'expressive for blue'
		t^hC c^hC k^hC	H-L	[hə́m.ràŋ]	'horse'

The requirement of high tone on major syllables is less strict if a minor syllable has a coda consonant, as in (32e), in which a major syllable has a low tone even though a minor syllable has an onset with aspirates.

An experimental study by Svantesson and Karlsson (2004) shows that [+spread glottis] is the feature that determines the output tone in Kammu. See also other work on Kammu for more data and discussions (Smalley 1961, Svantesson 1983, Svantesson and House 2006).

2.3.1.5 Wujiang (Wu, Chinese)

In Wujian, a northern Wu dialect, Chen (2000: 10) reports that the tonal pattern depends on the consonants in onset position. Unaspirated voiceless onsets have the highest pitch, and voiced onsets have the lowest. Aspirated onsets have intermediate pitch as shown in (33). The tonal variants in Wujiang depend on onsets, and each tonal category can have up to three different variants.

(33) Tonal Inventory of Wujiang (Ye 1983: 34)

Onsets		level	falling	falling-rising	CVO
a. voiceless	plain	55	51	412	5
b.	aspirated	33	42	312	3
c. voiced		13	31	212	2

While the possible tonal values in (33) suggest 12 possible tones in Wujiang, phonologically there are three tones: level, falling, and falling-rising. Examples of each tonal value are presented in (34).

(34) Wujiang data spoken in Songling (Ye 1983: 35)[8]

Onsets	level	falling	falling-rising	CVO
voiceless plain	**kã^{55}** ‘firm’	**ʦiəu^{51}** ‘to walk’	**fɑ̃^{412}** ‘to put’	**paʔ^{5}** ‘hundred’
voiceless aspirated	**k^{h}ã^{33}** ‘chaff’	**ʦ^{h}iəu^{42}** ‘3-5 am’	**k^{h}ɑ̃^{312}** ‘to carry’	**p^{h}aʔ^{3}** ‘to tap’
voiced	**zɑ̃^{13}** ‘bed’	**zəu^{31}** ‘to sit’	**mɑ̃^{212}** ‘to watch’	**baʔ^{2}** ‘white’

In Wujiang, consonants in onset positions neutralize tone in the output, so voiced onsets do not surface with H tone (34c), and unaspirated stops do not occur with L tone (34a).

2.3.1.6 Songjiang (Chinese)

Songjiang, spoken in Jiangsu, China, demonstrates similar behavior to Wujiang, but the consonants that neutralize tone are only dependent on voicing as shown in (35). Syllables with voiced consonants in the onset always occur with L tones, and syllables with voiceless consonants always occur with H tones. Data comes from a compendium of Jiangsu dialects, Jiangsusheng he Shanghaishi Fangyan Gaikuang (JSFG 1960).

[8] I would like to thank Xiao Li for the assistance in translating Chinese texts.

(35) Tonal Inventory of Songjiang (JSFG 1960: 11)

Onsets	level	rising	falling	CVO
a. voiceless	44	35	53	5q
b. voiced	22	13	31	3q

2.3.1.7 Korean

In Korean, intonation patterns of accentual phrases (AP) vary according to the phrase-initial consonants. Jun (1996, 1998) observes that accentual phrases have LHLH intonation patterns except when an accentual phrase begins with an aspirate or a tense stop. In the latter case, accentual phrases have HHLH intonation.

Example (36) demonstrates the consonantal effect on the phrasal intonation. In (36a) and (36c), the accentual phrases begin with L because they begin with the sonorant [j]. On the other hand, when the accentual phrases begin with an aspirate [c^h] as in (36b) and (36d), the accentual phrases have H tones.

(36) Standard Korean (Kang 1996)

L LH	H L H	L H	H H L L%
| | |	| | |	| |	| | | |
a. [jəp-maɨl]$_{AP}$	b. [c^həŋnjənɨn]$_{AP}$	c. [jəine]$_{AP}$	d. [c^hinku-jess-ko]$_{AP}$
neighbor village	young man	woman	friend

'The neighbor village young man was the woman's friend.'

Recent studies on the Korean consonants support this view of the tonal differences at the beginning of accentual phrases. Pioneering works by Silva (2006) and Wright (2007) show that the younger generation of Korean speakers (born after 1980) has higher pitch for aspirated stops and tense stops than for lax stops.

2.3.2 Neutralization by consonants in codas

Consonants in coda positions neutralize tone in the output. The languages in (37) show that open syllables (CV) and syllables with a sonorant coda (CVS) have more tonal contrast than syllables with a stop coda (CVO).

(37) Tone neutralization by codas (from Hyman 2007: 1)

	Language		CV, CVS	***sonorant codas***	CVO	***obstruent codas***
a.	Bola	3:2	H, L, HL	m n ŋ	H, HL	p t k ʔ
b.	Maru	3:2	H, M, L	m n ŋ	H, L	p t k ʔ
c.	Tangkhul	3:2	H, M, L	m n ŋ r w y	M, L	p t k
d.	Trung	4:1	H, L, HL, LH	m n ŋ l r	H	p t k ʔ
e.	Jingpho	4:2	H, M, L, HL	m n ŋ	H, L	p t k ʔ
f.	Karen (Pa'o)	4:2	H, M, L, HL	m n ŋ	M, L	p t k ʔ
g.	Xiamen	5:2	44, 24, 22, 21, 53	m n ŋ w y	4, 32	p t k ʔ
h.	Cantonese[9]	6:3	55, 33, 22, 21, 35, 23	m n ŋ w y	5, 4, 3	p t k

The rest of this section discusses Burmese, San Martin Itunyoso Trique and Vietnamese in detail.

2.3.2.1 Burmese

Burmese is a Tibeto-Burman language spoken in Myanmar (Burma). I recorded two Burmese consultants in New York City: Khin Maung Gyi, a male in his 60s from Nyaung Shwe, and Thuya Maung, a male speaker in his 20s from Yangon (Rangoon). These consultants confirmed the Burmese data presented below. Measurements of the data from Khin Maung Gyi are presented in chapter 5.

[9] In Cantonese, CVO syllables with a short vowel can surface with five tones. CVO syllables with a long vowel, however, only surface with 3 tones (Hyman 2007: 1).

Burmese has two phonological tones in the output: high and low. High tones as in (38a) and low tones as in (38b) occur in open syllables and in syllables with a nasal coda. Low tone is marked with a grave accent, and high tone with an acute accent.

(38) Burmese tone[10]

			tone
a.	k^há	be bitter	high
b.	k^hà	to shake	low

Burmese syllables also have a glottal stop coda as in (39a) or creaky phonation as in (39b). Creaky phonation is marked with a tilde under the vowel. These types of syllables only occur with low tones.

(39) Neutralization to L tone in Burmese

a.	k^haʔ	draw off	*glottal stop*
b.	k^ha̰	fee	*creaky voice*

The neutralization effect of glottal stops on tone is similar to the one found in the languages presented in (37). An analysis of tonal neutralization by glottal stops is presented in section 5.4.

2.3.2.2 San Martin Itunyoso Trique

Trique, spoken in San Martin Itunyoso (SMI), Mexico, has four level tones and five contour tones as in (40). In the representation, number 1 means low tone, and number 4 means high tone.

[10] Unlike in Mulao, note that aspirated onsets do not affect tone in Burmese.

(40) Tonal minimal pairs in SMI Trique (DiCanio 2006: PPT#9)

level			falling			rising		
1	[ʧə̄]	eleven	31	[nne]	meat	13	[jeh]	yes
2	[nne]	lie	32	[nne]	water	(4)5	[ʔnih]	corn
3	[nne]	plough	43	[li]	tiny			
4	[ββe]	hair						

The tones in (40) have restrictions based on syllable structure. Level tones can appear with any syllable structure that is marked (√) in (41). When a syllable has a glottal fricative [h] coda, falling tones do not surface, as in (41a). Syllables with a glottal stop coda [ʔ], on the other hand, only surface with a level tone, as in (41b). Open syllables can occur with any of the tones, as shown by the check marks in (41c).

(41) Consonant-tone patterns in SMI Trique (Hyman 2007:1 from DiCanio 2006)

		level				**falling**			**rising**	
		1	2	3	4	31	32	43	13	(4)5[11]
a.	CV[h]	√	√	√	√				√	√
b.	CV[ʔ]	√	√	√	√					
c.	CV:	√	√	√	√	√	√	√	√	√

The surface patterns of tones and consonants in SMI Trique show that coda consonants (such as glottal stops or glottal fricatives) neutralize the tone in the output.

2.3.2.3 Vietnamese: Coda or phonation

Vietnamese has six tones as in (42). There are three tones in both the high and low registers. Each register has a level tone, a rising tone, and a falling-rising tone.

---

[11] While DiCanio (2006) classifies the tone (4)5 as a level tone, Hyman (2007) categorizes it as a rising tone.

(42) Tonal Inventory and Phonation type (Pham 2003: 79, 93, 127)

	Description	*Name*	Register
a.	level	*ngang*	upper
b.	rising	*sắc*	
c.	falling-rising	*hỏi*	
d.	level	*huyền*	lower
e.	falling	*nặng*	
f.	falling-rising	*ngã*	

In CVO syllables, only two tones surface: upper rising tone (sắc, 42b) and lower falling tone (nặng, 42e). The emphatic forms in Vietnamese undergo full reduplication of the tones and segments of a base. In (43a), the base [ɲả:] 'small' has an upper falling-rising tone.[12] The reduplicated form is [ɲả ɲả] which means 'slightly small'. In (43b) and (43c), the CVO syllables surface with *sac* and *nang* tone, and the reduplicant keeps the tone as well as the segmental structure.

(43) Reduplication in Vietnamese

	Upper register					*base tone*
a.	ɲả:	'small'	→	ɲả ɲả	'slightly small'	*hoi*
b.	mét	'pale'	→	mét mét	'rather pale'	*sac*
	Lower register					
c.	sạc	'clean'	→	sạc sạc	'rather clean'	*nang*

Vietnamese also has reduplication patterns in which the reduplicant must have level tone, as in (44). The restriction on tone is that the reduplicant must have an upper (*ngang*) or lower (*huyen*) level tone; these do not allow obstruent consonants in coda. In (44), the

[12] The tone marking in Vietnamese words follows the Vietnamese Orthography.

base with an obstruent coda has a *sac* or *nang* tone. The reduplicant therefore must have a level tone or change the coda consonant of the base to a homorganic nasal of the following consonant.

(44) Reduplicant must be a level tone (Burton 1992: 35)

	Upper register					*base tone*
a.	sóp	'spongy'	→	so<u>m</u> sóp	'rather spongy'	*sac*
b.	má:t	'breezy'	→	ma:<u>n</u> má:t	'a little breezy'	*sac*
	Lower register					
c.	dẹp	'beautiful'	→	dè<u>m</u> dẹp	'rather pretty'	*nang*
d.	xɛ̃:	'soft'	→	xɛ̀: xɛ̃:	'rather soft'	*nga*

Consonant-tone interaction in Vietnamese has been addressed in many previous studies (Earle 1975, Nhán 1984 among others). Tones on CVO syllables can be regarded as separate tones (Pham 2003). Independently, Michaud (2004) examines the phonation change by a stop coda in CVO syllables. Many other studies also suggest the importance of phonation in Vietnamese (See also Alves 1995, Nguyen and Edmondson 1997, Brunelle 2003).

2.3.2.4 Yabem

Yabem is a language spoken in New Guinea (Dempwolff 1939, Zahn 1940). In Yabem, verbs in the third conjugation demonstrate consonant-tone interaction. Voiced obstruents only surface in a low tone syllable (in realis singular), while voiceless obstruents only surface in a high tone syllable (in other forms in the conjugation).

(45) Verbal conjugation III in Yabem (Poser 1981: 484-485)

	realis singular (*low tone*)	all other forms (*high tone*)	
a.	yɔ̀b	yɔ́p	'guard'
b.	yòb	yóp	'whistle'
c.	lòb	lóp	'fly'
d.	mèb	mép	'relieve oneself'
e.	mòb	móp	'decay'

Poser (1981) also suggests the possibility of tone affecting consonants in Yabem which is discussed in detail in section 2.4 (See also Hansson 2004).

2.3.3 Neutralization by consonants in onsets and codas: Thai

In Thai, consonants in both onset and coda positions neutralize tones in the output. The restriction between consonants and tone is that H tone does not surface when unaspirated stops occur in onsets or codas. The data in this section is based on Ruangjaroon (2006) except where noted.

In (46), the consonant inventory of Thai is presented. There are aspirated consonants as in (46a), and sonorants as in (46b). Thai also has unaspirated voiced and voiceless stops as in (46c), which do not surface with a H tone. While all the consonants can appear in onsets, only unaspirated voiceless stops and nasals can occur in coda positions.

(46) Thai consonants (Apiluck Tumtavitikul 1992: 264, Ruangjaroon 2006: 9)

		labial	alveolar	palatal	velar	glottal	
a.	aspirates	p^h, f	t^h, s	$ʧ^h$	k^h	h	
b.	sonorants	m, w	n, l, r	j	ŋ		
c.	unaspirated	p, b	t, d	ʧ	k	ʔ	→ ***no high tone***

Thai has five contrastive tones in stressed syllables as in (47). There are three level tones (mid, low and high) and two contour tones (falling and rising). The five-way tonal contrast appears in open syllables (CV) and in syllables with a sonorant coda (CVS). Examples in (47) demonstrate that aspirates and sonorants do not affect tone in Thai. Tonal marking is as follows: mid tone is unmarked, high tone is marked with an acute accent, and low tone is marked with a grave accent. Circumflex marks falling tone, and a wedge marks rising tone. Sounds in parentheses are optionally realized.

(47) Tonal minimal pairs in Thai (Ruangjaroon 2006: 5, 46)

		Open		Sonorant coda	
a.	low	[pʰɛ̀ː]	'to spread'	[kʰùn]	'muddy'
b.	mid	[pʰɛ̄ː]	'a raft'	[kʰōn]	'person'
c.	high	[pʰɛ́ː]	'to lose'	[kʰón]	'search'
d.	falling	[pʰ(r)ɛ̂ː]	'to broadcast'	[kʰôn]	'thick'
e.	rising	[pʰ(l)ɛ̌ː]	'a wound'	[kʰǒn]	'hair'

When a syllable has an obstruent coda as in (48), only H or L tones surface in the output (Gandour 1975: 170-172, Apiluck Tumtavitkul 1993: 13-14).[13] In other words, in Thai, a CVO syllable cannot surface with mid, falling, or rising tone as in (48c-e).

(48) Neutralization of tonal contrast with obstruent codas (CVO)

a.	low	[pʰìt]	'be wrong'
b.	high	[pʰít]	'poison'
c.	mid	*[pʰīt]	N/A
d.	falling	*[pʰît]	N/A
e.	rising	*[pʰǐt]	N/A

[13] For a discussion and an analysis about this type of data, see Ruangjaroon (2006: 24-25).

Unaspirated onsets do not allow high tone in Thai if all else is equal. Example (49) shows tonal minimal pairs when the onset of a syllable is an aspirate ([pʰ] or [kʰ]) as in (49a) or a sonorant ([l] or [m]) as in (49b). These types of syllables can appear with all five tones in Thai.

(49) Five tones in CV or CVS (Ruangjaroon 2006: 39-48)

	Onsets		**low**	**mid**	**high**	**falling**	**rising**
a.	**aspirates**	CVː	[pʰàː]	[pʰāː]	[pʰáː]	[pʰâː]	[pʰǎː]
			‘cut’	‘take’	‘a knife’	‘clothes’	‘a cliff’
		CVS	[kʰùn]	[kʰūn]	[kʰún]	[kʰôn]	[kʰǔn]
			‘muddy’	‘2nd sg. pers.’	‘familiar’	‘thick’	‘fatten’
b.	**sonorants**	CVː	[lòː]	[lāː]	[láː]	[lâː]	[lǎː]
			‘last’	‘a donkey’	‘exhausted’	‘chase’	‘yard’
		CVS	[màn]	[mān]	[nán]	[mân]	[mǎn]
			‘persistent’	‘greasy’	‘that’	‘engage’	‘sterile’

However, no CVː or CVS syllable has an unaspirated onset and a high tone; only low, mid, falling and rising tones appear. As shown in (50), the voicing of such onsets does not interfere with the tonal restriction; onsets can be voiceless ([k]) as in (50a), or the onsets can be voiced ([b]) as in (50b).

(50) Tone in CV and CVS with an unaspirated onset (Ruangjaroon 2006: 39-48)

	low	**mid**	**high**	**falling**	**rising**
a. CV	[kùː]	[kūː]		[kûː]	[kǔː]
	‘holler’	‘1st sg. pers.’		‘borrow’	‘uncle’
b. CVS	[bòn]	[bōn]		[bân]	[bǔn]
	‘complain’	‘on’		‘a portion’	‘civil’

In Thai, a syllable with an obstruent coda (CVO) allows only H or L tone. Obstruent codas are [p], [t], and [k]. As in (51), syllables with short vowels surface with either L or

H tone, while syllables with long vowels surface with L or falling tone. All examples in (51) have onsets that are aspirates or sonorants, which allow all five tones in open syllables and CVS syllables.

(51) Tone in syllables with obstruent codas (Ruangjaroon 2006: 51-58)

		Onsets	**low**	**mid**	**high**	**falling**	**rising**
a.	**CVO**	aspirates[14]	[sàk] 'tattoo'		[sák] 'wash'		
b.		sonorants	[lòp] 'hide'		[lóp] 'erase'		
c.	**CV:O**	aspirates	[fàːt] 'acidulous'			[fâːt] 'to eat'	
d.		sonorants	[màːk] 'an areca palm'			[mâːk] 'very'	

In obstruent-final syllables with unaspirated onsets (OVO syllables), however, H and falling tones do not surface in the output. As shown in (52), only L tone is allowed in OVO syllables.

(52) Unaspirated onsets and unaspirated codas (Ruangjaroon 2006: 55, 60)

	non-aspirates	**low**	**mid**	**high**	**falling**	**rising**
a.	OVO	[bòk] 'on land'				
b.	OV:O	[pàːt] 'to cut'				

The restricted tonal inventory in CVO syllables is observed in many other Tibeto-

[14] Fricatives are assumed to be specified as [+spread glottis] as proposed in Armenian by Vaux (1998).

Burman languages when an obstruent coda is present (cf. Weidert 1987: Ch. 9)[15]. Because of the tonal restrictions on CVO syllables, CVO syllables have traditionally been called 'checked' syllables, or 'stopped' syllables in Chinese, Tibeto-Burman, and Mon-Khmer studies. By contrast, open syllables or syllables with a sonorant coda are called 'unchecked', or 'smooth' syllables.

Reduplication in Thai

The high tone deference in Thai finds support from partial reduplication [Caʔ] in which the initial consonant of the reduplicant is copied from its base. The reduplicant, which is a CVO syllable, only permits high or low tone. Moreover, if the onset of the reduplicant is an unaspirated stop, only low tone can surface. All the data in this subsection comes from Apiluck Tumtavitkul (1993).

The reduplicant copies the tone of a high-toned base as in (53). In (53a), for example, the high tone base is /ʧít/. The reduplicant copies the onset of the base [ʧ] before the rhyme [aʔ]. The tone of the reduplicant is H, identical to the base tone.

(53) /-aʔ/ in H tone base (Apiluck Tumtavitkul 1993: 23)

	base **H**	RED-base **H - H**		***L - H**
a.	/ʧít/	[ʧáʔ-ʧít]	'come near'	*[ʧàʔ-ʧít]
b.	/k^hɨk/	[k^háʔ-k^hɨk]	'loud noise'	*[k^hàʔ-k^hɨk]

[15] Tibeto-Burman languages are not uniformly tonal as described in Weidert (1987: 1). There are four different types of languages: a) tonal languages, b) non-tonal languages, c) languages that are gaining tonal contrasts (this process is named as 'tonogenesis' by James Matisoff), and d) languages that are losing their tonal contrasts.

c.	/pʰɔ́ːŋ/	[pʰáʔ-pʰɔ́ːŋ]	'agree'	*[pʰàʔ-pʰɔ́ːŋ]
d.	/rík/	[ráʔ-rík]	'laugh'	*[ràʔ-rík]
e.	/rɨ́ːn/	[ráʔ-rɨ́ːn]	'smooth'	*[ràʔ-rɨ́ːn]

The reduplicant of a low tone base surfaces with a low tone as in (54). The reduplicant copies the onset of the low tone base [k]. The rhyme [aʔ] is added to the onset. The tone of the reduplicant is identical to the tone of the base: low tone. Due to the consonant-tone restriction discussed in previous section, H tone does not occur in the reduplicant in (54) because the onset is an unaspirated stop.

(54) /-aʔ/ in L tone base (Apiluck Tumtavitkul 1993: 23)

	base **L**	RED-base **L - L**		***H - L**
a.	/kɔ̀ːŋ/	[kàʔ-kɔ̀ːŋ]	'beautiful'	*[káʔ-kɔ̀ːŋ]

Third, the tone of the reduplicant after mid tone bases can be either high or low, as in (55). The onset consonant of the base determines the tone of the reduplicant in the output. If the onset of a base is an aspirate [pʰ] or a sonorant [l] as in (55a-b), the reduplicant appears with a high tone. If the onset of a base is an unaspirated stop [d] as in (54c), the reduplicant surfaces with low tone.

(55) /-aʔ/ in M tone base (Apiluck Tumtavitkul 1993: 23)

	base **M**	RED-base **H - M**		***L - M**
a.	/pʰāːn/	[pʰáʔ-pʰāːn]	'meet'	*[pʰàʔ-pʰāːn]
b.	/lāːn/	[láʔ-lāːn]	'exited'	*[làʔ-lāːn]
	M	**L - M**		***H - M**
c.	/dān/	[dàʔ-dān]	'push'	*[dáʔ-dān]

Next, the reduplicant of a rising tone base surfaces with a L tone as in (56). In (56a), the onset of the base [s] is copied into the reduplicant followed by the fixed rhyme [aʔ]. The tone of the reduplicant is low.

(56) /-aʔ/ in rising tone base (Apiluck Tumtavitkul 1993: 23)

	base **R**	RED-base **L - R**		***H - R**
a.	/sǎːŋ/	[sàʔ-sǎːŋ]	'untangle'	*[sáʔ-sǎːŋ]
b.	/ʧǎːn/	[ʧàʔ-ʧǎːn]	'witty'	*[ʧáʔ-ʧǎːn]
c.	/sùə́y/	[sàʔ-sùə́y]	'pretty'	*[sáʔ-sùə́y]

The reduplicant of a falling tone base displays a somewhat unexpected pattern. Bases with an affricate onset [ʧ] or a sonorant onset [l] surface with a high tone as in (57a-b), whereas the reduplicant with a voiceless onset [k] in (57c) has a low tone because the unaspirated onset [k] of the reduplicant cannot surface in a high toned syllable.

(57) /-aʔ/ in Falling tone base (Apiluck Tumtavitkul 1993: 23)

	base **F**	RED-base **H - F**		***L - F**
a.	/ʧɔ̂ːŋ/	[ʧáʔ-ʧɔ̂ːŋ]	'hole'	*[ʧàʔ-ʧɔ̂ːŋ]
b.	/lêːn/	[láʔ-lêːn]	'play'	*[làʔ-lêːn]
	F	**L - F**		***H - F**
c.	/krâːw/	[kàʔ-krâːw]	'roar'	*[káʔ-krâːw]

Another pattern appears in (58). The reduplicant with an affricate onset [ʦ] or with an aspirated onset [k^h] in (58a-b) surfaces with a low tone. These onsets can occur with L tone. Even so, it is unclear why falling tone can sometimes surface in the reduplicant as H tone as in (57), or as L tone as in (58).

(58) Exceptions: /-aʔ/ in Falling tone base (Apiluck Tumtavitkul 1993: 23)

	F	L - F		*H - F
a.	/ʦæ̂ːŋ/	[ʦàʔ-ʦæ̂ːŋ]	‘enlightened’	*[ʦáʔ-ʦæ̂ːŋ]
b.	/kʰæ̂ːn/	[kʰàʔ-kʰæ̂ːn]	‘strong’	*[kʰáʔ-kʰæ̂ːn]

2.4 Change of laryngeal feature by tone

This section presents languages that seem to show interaction in which tone affects consonants (from Maddieson 1974, 1976, 1978). Xinzhai Hmong is a language spoken in Southwestern China (Xian 1990, Niederer 1998: 149). In Xinzhai Hmong, laryngeal-tone interaction is found in tone sandhi positions.[16] If a 55 tone becomes a 343 tone as a result of tone sandhi, the onset surfaces with aspirated consonants (59a). If a 343 tone becomes a 53 tone due to tone sandhi, the onset surfaces with unaspirated consonants (60a). Aspiration and deaspiration are not both applied to sonorants in the same environment (59b, 60b).

(59) Emergence of Aspiration

a.	/nɔu^{13} **<u>to</u>**^{55}/	‘day’-‘come’	[nɔu^{13} **<u>tʰo</u>**^{343}]	‘dawn’
b.	/z̧ou^{55} noŋ^{55}/	‘disorganized’-‘eat’	[z̧ou^{55} noŋ^{343}]	‘eat anything’

[16] There is no agreement about whether tone sandhi position is a prominent position or not. For example, Wee (2004) claims that tone sandhi is not a prominent position because it undergoes tonal change. The controversy about tone sandhi will not be discussed in this proposal.

(60) Loss of aspiration

a. /tsaŋ^{55} **<u>tsʰa</u>**^{343}/ ‘tube’-‘chopsticks’ [tsaŋ^{55} **<u>tsa</u>**^{53}] ‘chopsticks case’
b. /mi^{11} mjaɯ^{343}/ NEGATION-‘listen to’ [mi^{11} mjaɯ^{53}] ‘do not listen to’

Most cases reported in Maddieson (1974, 1976, 1978) are quoted below from original sources. Phrases between quotation marks are unaltered citations. There are a number of Asian languages as in (61), in which low tone affects the surface realization of stops. When low tone appears, stops become voiced.

(61) Asian languages

	Language	*Consonants change due to tone*
a.	Tankhur Naga	“the three unaspirated stops, p, t, and k become voiced intervocally, especially before a vowel in low tone” (Bhat 1969: ix)
b.	Central Monpa	“g, j, d, b i.e. the voiced plosives have but indistinct voicing. They are rather softened low tone varieties of k, c, t and p respectively.” (Das Gupta 1968: 1)
c.	Jingpho	“If a syllable beginning with a vocalic [voiced] initial follows a syllable which has the high long pitch, then the initial of the second syllable acquires -h by gemination.” (Maran 1971: 172)
d.	Wu Chinese	“Almost all Wu dialects show … evidence supporting an underlying system composed of four paired tones with one of each pair being a lowered tone in syllables with voiced initials.” (Ballard 1969: 70)
e.	Cham	“In closed syllables, with front vowels i, e, and ɛ before ʔ, h or ŋ, the voiceless oral stops have fortis and lenis allophones, which may co-occur with low and non-low pitch, respectively” (Blood 1967: 8)
f.	Atsi	“/v/ is a voiced labial fricative. … Before /e/, … and before /a/, in high toned syllables, /v/ has bilabial friction as well, …” (Burling 1967: 17)
g.	Chengtu, Sichuan Mandarin	“…with tone 4 /213/ the ending is realized as nasalization of the preceding vowel and a fully articulated [n]; with tones other than tone 4 the ending is realized as nasalization of the preceding vowel and a weakly articulated [n]…” (Malmqvist 1962: 137, 141)

As in Asian languages, low tone can also affect consonants and cause them to become voiced in various African languages as in (62).

(62) African languages

	Language	*Consonants change due to tone*
a.	Kuwaa (Kru)	"When word-initial /k͡p/ is followed by a low tone, then /k͡p/ becomes [g͡b]." (Thompson 1976: 42)
b.	Ọɦ̃ụɦ̃ụ Igbo	"h, ɦ̃, hj, ɦ̃j [Maddieson: glottal fricatives] appear to be partially voiced before low tone vowels" (Dunstan and Igwe 1966: 74)
c.	!Xũ	"When initiating syllables with low tones the laryngeal features of consonants may become vocalised. Thus [ph] > [pɦ]." (Snyman 1970: 36, footnote) *These sounds include voiceless aspirates (such as [th], [tsh], [kh], [h]), and clicks (such as [ǂh], [ǂʔh], [!h], [!ʔh], [//h], [//ʔh], [ŋ/ʔɦ]).*

The languages in (63) are spoken in America. In these languages, low tone can also trigger segmental changes: voiceless consonants become voiced.

(63) American languages

	Language	*Consonants change due to tone*
a.	Tucano	"Voiced vowels have … voiceless variants … when a CV syllable with voiceless consonant onset precedes hV which has higher pitch: /p**à**hīgó/ [p**ḁ̀**hīgóʰ] 'fat woman'…" (West and Welch 1967: 22)
b.	Picuris	"the glottal stop, combined with low tone, has a phonetic effect…: the word for *chokecherry*, /ə̂m'ene/, is phonetically [ʌ̂ᵐb'ɛnɛ]; the /m/ becomes partially denasalized and devoiced and more tense" (Trager 1971: 31) (ˆ marks primary stress combined with low tone)
c.	Kiowa	"… the initial voiced stop of the thematic suffix is devoiced following roots with falling tone." (Watkins 1984: 40) For example, the thematic stem /-be-/ is realized as [há:**-b**è-] 'smoke', but as [hâ:**-p**è-] 'pick up'.

While the examples in (61)-(63) are 'impressionistically observed' according to Maddieson (1978: 327), these examples suggest that tone could affect consonants. A definitive conclusion, however, awaits detailed phonetic and phonological analysis of these languages.

2.5 Which features affect tone?

Based on cross-linguistic data presented in section 2.2 to section 2.4, segmental features that affect tone are summarized below in (64). The features are all related to the status of the larynx: voicing, spread glottis, and constricted glottis. Voiced consonants block H tone spreading, or neutralize H tone to non-high (64a). Voiceless consonants block L tone spreading, or neutralize L tone to non-low (64b). Consonants with a [+spread glottis] feature block H tone spreading, neutralize L tone to H tone, or neutralize H tone to L tone (64c). The [+constricted glottis] feature, if present, neutralizes H tone to L tone, or neutralizes L to H (64d). In Thai, consonants specified with a [-spread glottis] feature neutralize H tone to non-high (64e).

(64) Tone affecting segmental features

	Features	**Effect on tone**	**Languages**
a.	[+voice]	blocks **high** tone spreading	*Western Bade, Tsonga*
		H neutralizes to non-high	*Songjiang*
b.	[-voice]	blocks **low** tone spreading	*Western Bade*
		L neutralizes to non-low	*Songjiang*
c.	[+spread glottis]	L neutralizes to **high** tone	*Mulao*
		H neutralizes to **low** tone	*Gurung*
		blocks **high** tone spreading	*Tsonga*
d.	[+constricted glottis]	H neutralizes to **low** tone	*Burmese*
		L neutralizes to **high** tone	*Mulao*
e.	[-spread glottis]	H neutralizes to **non-high**	*Thai*
g.	[-constricted glottis]	*unidentified*	

From the data I have collected, there is no language that displays changes in tone due to the differences in place of articulation or manner of articulation.

The following subsections show that consonants interacting with tone vary from language to language.

2.5.1 Tsonga

The consonant inventory of Tsonga is shown in (65). The depressor consonants are in a heavy-lined box. The non-depressors are on the right side of the table. All depressor consonants in Tsonga are marked with voicing, aspiration, or breathy voice.

(65) Consonants in Tsonga (Baumbach 1987: 3-16)

			depressors				non-depressors			
stops	voiceless	unaspirated					p	t		k
	voiceless	**aspirated**	**p^h**	**t^h**		**k^h**				
	voiced		**b**	**d**		**g**				
	breathy		**$^{(m)}$b̤**	**$^{(n)}$d̤**		**$^{(ŋ)}$g̈**				
		prenasalized					^{m}b	^{n}d		^{ŋ}g
affricates	voiceless	unaspirated					pf	ʦ	ʧ	
	voiceless	**aspirated**	**pf^h**	**$ʦ^h$**	**$ʧ^h$**					
	voiced	unaspirated					bv	ʣ	ʤ	
	voiced	**aspirated**	**bv^h**	**ʣ̤**	**ʤ̤**					
fricatives	voiceless						ɸ, f	s	ʃ	x
	voiced					ɦ	β, v	z	ʒ	
sonorants	nasal						m	n	ɲ	ŋ
	nasal	**breathy**	**m̤**	**n̤**		**ŋ̈**				
	oral						w	r	l	j
	oral	**breathy**	**w̤**	**r̤**	**l̤**	**j̈**				

2.5.2 Yao language

In Mjen (a variety spoken in Hsing an), syllables with onset consonants in the heavy-lined box in (66) show neutralization to tone in the output: only high tone appears in such syllables. The non-elevators are shown in the right side of the table.

(66) Consonants in Mjen (Mao and Chou 1972: 240)

		elevators				**non-elevators**			
stops	unaspirated					p, b	t, d		k, g
	aspirated	**p^h**	**t^h**		**k^h**				
fricatives						f	s	ɕ	h
affricates	unaspirated						ʦ, ʣ	ʨ, ʥ	
	aspirated		$ʦ^h$	$ʨ^h$					
sonorants	nasals	**m̥**	**n̥**	ɲ̊	ŋ̊	m	n	ɲ	ŋ
	orals		ɬ			w	l	j	

Pu nu (from the Tu an region), another Yao dialect, is mainly spoken in the eastern part of the Guangxi province. As shown in the heavy-lined box in (67), the aspirated consonants (marked with a superscript ‘h’) neutralize the tone of a syllable to high if these consonants appear in an onset.

(67) Consonants in Pu nu (Mao and Chou 1972: 242)[17]

		elevators				**non-elevators**			
stops	plain	**p^h**	**t^h**	**c^h**	**k^h**	p	t	c	k
	pre-nasalized	**$^{m}p^{h}$**	**$^{n}t^{h}$**	$^{ɲ}c^{h}$	$^{ŋ}k^{h}$	^{m}p	^{n}t	^{ɲ}c	^{ŋ}k
fricatives						f, v	θ	ɕ	h
affricates	plain		$ʦ^h$				ʦ		
	pre-nasalized		$^{n}ʦ^{h}$				$^{n}ʦ$		
sonorants	nasals	**m^h**	**n^h**	$ɲ^h$	$ŋ^h$	m	n	ɲ	ŋ
	orals		l^h	j^h		w	l	j	

Third, another Yao dialect, Lak kja (a variety spoken in Ta yao shan), has aspirated onsets and voiceless nasal onsets that surface only with a high register tone. These consonants are in the heavy-lined box in (68).

[17] The retroflex series are omitted from this table.

(68) Consonants in Lak kja (Mao and Chou 1972: 243)

		elevators				**non-elevators**			
stops	voiceless					p	t		k
	voiced					ˀb			
	aspirated	**p^h**	**t^h**		**k^h**				
fricatives						f	θ		h
affricates			**$ʦ^h$**				ʦ		
sonorants	nasals	**m̥**	**n̥**			m	n		ŋ
	orals		**ɬ**			w	l	j	

In all Yao dialects, aspiration crucially plays a role in tone neutralization: H tone is required in syllables with aspirated onsets.

2.5.3 Burmese

In Burmese, the glottal stop and creaky phonation neutralize tone to L tone. The consonant inventory of Burmese presented in (69) shows that the glottal stop is the only consonant with a glottal feature (e.g. [+constricted glottis]) in Burmese.[18]

(69) Consonants in Burmese (Green 2005: 4)

	bilabial	dental	alveolar	palatal	velar	glottal
stop/affricate	p b		t d	ʧ ʤ	k g	ʔ
aspiration	p^h		t^h	$ʧ^h$	k^h	
fricative		θ (ð)	s s^h z	ʃ		h
nasal	m̥ m		n̥ n	ɲ̥ ɲ	ŋ̊ ŋ	
liquid/glide	(w̥) w		ɬ (r) l	j		

[18] Consonants in parentheses are commonly used in loanwords but rarely in native Burmese words (Green 2005: 4).

2.5.4 Thai

In Thai, unaspirated consonants do not co-occur with H tone. The consonant inventory of Thai is presented in (70).

(70) Consonants in Thai (Apiluck Tumtavitikul 1992: 264, Ruangjaroon 2006: 9)

		labial	alveolar	palatal	velar	glottal	
a.	aspirates	pʰ, f	tʰ, s	ʧʰ	kʰ	h	
b.	sonorants	m, w	n, l, r	j	ŋ		
c.	unaspirated	p, b	t, d	ʧ	k	ʔ	→ ***no high tone***

2.6 Conclusion

This chapter has presented extensive data of consonant-tone interactions that will be analyzed in the following chapters. In section 2.2, the blocking of tonal spreading by consonants is described. H(igh) tone spreading can be blocked by voiced stops, and L tone spreading can be blocked by voiceless stops. The blocking effect of consonants is analyzed in chapter 4 based on the descriptions in this section.

Many languages spoken in Southeast Asia show that consonants also force neutralization of tone (section 2.3). Consonants in onset positions or coda positions impose restrictions on the tone in a syllable. For example, it is the onset consonants that neutralize tone in Mulao, while it is the coda consonants that neutralize tone in Burmese. In Thai, consonants in both onset and coda positions neutralize tone. Chapter 5 develops analyses of tonal neutralization by consonants.

There are also languages in which tone seems to affect consonants. While Hyman and Schuh (1974) propose that consonant-tone interaction is asymmetric in that tone may not affect consonants, such examples are reported in Maddieson (1978). Section 2.4 summarizes languages that show tone-to-consonant interaction from original sources.

In section 2.5, consonant inventories of the languages discussed in detail are presented. The section demonstrates that consonant-tone interaction is not limited to voicing, and it also shows that depressors or elevators are not randomly distributed in the inventory, a point further discussed in section 6.2.

Chapter 3 Extended Tone Bearing Unit Theory

3.1 Introduction

This chapter presents the core elements of the Extended Tone-Bearing Unit (xTBU) theory; this theory aims to be an integrated explanation of tone-tone, vowel-tone, and consonant-tone interaction. The core elements of the theory are:

(1) a. Tones prefer to associate to moras. However, they can be forced to associate to consonant root nodes when no mora dominates them.
b. There are no faithfulness constraints that preserve tones that are underlyingly associated to consonants.
c. There is a set of markedness constraints with the form *[LARYNGEAL FEATURE]/TONE; these constraints restrict consonant-tone interaction.

The elements in (1) are implemented within the framework of Optimality Theory (Prince and Smolensky 2004). The effect of the proposal is that consonants can be required to directly bear tone under particular constraint rankings. Evidence for the presence of such tones comes from their influence on surrounding tones and segments. The lack of faithfulness constraints means that tone that is directly associated to consonants is never lexically contrastive, so no language will contrast words like [m̀ā] (low tone on [m]) with [ḿā] (high tone on [m]).

The xTBU theory differs from standard theories of tone in that it allows consonantal root notes to be TBUs; other theories restrict TBUs to moras. It also includes markedness constraints on tone-segment interaction, and more generally places strong restrictions on faithfulness and markedness constraints.

A brief example that will help with the exposition of the xTBU theory is found in Tsonga. In Tsonga, voiced stops block the spreading of high tone. Usually, H spreads and creates a contour tone (e.g., (2b)); however, H is blocked from spreading across a voiced stop [b] (2a).

(2) High tone spreading in Tsonga (Baumbach 1987)

<table>
<tr><td>a.</td><td>L H
| |
bùxá</td><td>→</td><td>H L H
| | |
í bùxá</td><td>
‘it is a hen
which eats its own eggs’</td><td>
H tone does not
spread</td></tr>
<tr><td>b.</td><td>L H L
| | |
mùfánà</td><td>→</td><td>H L H L
|\ | |
í mûfánà</td><td>

‘it is a boy’</td><td>

H tone spreads</td></tr>
</table>

In the xTBU theory, the blocking of H spread in Tsonga is due to two factors, one representational and one constraint-based. The representational requirement is that Tsonga tones must associate to all consonantal root nodes. The constraint that interferes is *VOICEDSTOP/H, which bans H tones associating to voiced stops. In contrast, H can spread across [m] because no active markedness constraint bans this relationship. Importantly, languages can differ from Tsonga; some languages do not require tones to associate to consonantal root nodes – a requirement regulated by constraints; and in some *VOICEDSTOP/H is inactive, with the result that consonants do not interfere with tone in the same way.

The analysis in this dissertation is set within Optimality Theory (OT, Prince and Smolensky 2004, P&S). In OT, the grammar is expressed by the ranking of violable faithfulness and markedness constraints. All tableaux will be in the format of comparative tableaux (Prince 2002) in conjunction with violations expressed by asterisks.

The structure of this chapter is as follows. Section 3.2 proposes mechanisms for direct tone-to-consonant association. The section also discusses the difference between root node TBUs and moraic TBUs. The absence of faithfulness constraints on root node TBUs presented in section 3.3 is crucial to explain the asymmetry in TBUs with respect to tone. Faithfulness constraints do not preserve a direct association between tone and the root node. This results in the importance of markedness constraints with respect to consonant-tone interaction as shown in section 3.4. This section proposes markedness constraints on the grounds of observed consonant-tone interaction in various languages, and shows a schematic ranking and its typology. Non-moraic consonants do not contrast in tone. The phonetic realization of tone in such consonants is discussed in section 3.5.

3.2 Direct association of non-moraic root nodes to tone

In standard OT analyses of tone, GEN ('generator', a function that generates a candidate set for each input, P&S (2004: 5)) does not allow candidates with tones associated to consonant root nodes; only association to a prosodic element (moras, or other prosodic nodes, Pierrehumbert and Beckman 1988 on Japanese) is allowed. In xTBU theory, GEN allows tone to associate to moras and consonant root nodes that do not head a mora.

Underlying forms can be stored with a tone associated to consonant root nodes in the lexicon. On the surface, however, markedness constraints determine whether such an association will surface or not. In xTBU theory, non-faithful mapping of tone associated to consonant root nodes does not incur violations of faithfulness constraints.

I propose here that root nodes - the lowest elements on the prosodic plane - may also be directly associated to tone. However, there are two limitations: (a) not every language allows root nodes to bear tone, and (b) if the root node is dominated by a mora, the mora bears the tone. A root node that is not dominated by a mora will be called a 'non-moraic root node'. The net effect is that onset consonants and non-moraic coda consonants may – but do not have to – bear tone in a particular language.

Tones directly associated with root nodes demonstrate unique properties. These tones may block spreading of other tones, but they may not trigger tonal spreading. These tones may require a specific tone on a higher prosodic unit such as the syllable. In addition to these characteristics, directly associated tones do not contrast in the output. So, a non-moraic root node cannot require a low tone and a high tone in one language. In comparison, only tones anchored to a mora can be lexically contrastive.

Tone bearing units (TBUs) are non-moraic root nodes, moras, or syllables. In general, tonal studies agree that moras are TBUs. While Hyman (1992: 77, fn 2) suggests that only moras can be TBUs, languages like Kikuyu (Clements and Ford 1979) have been argued to have syllables as TBUs. This dissertation will not focus on whether moras and/or syllables can be TBUs; the aim is to argue that non-moraic root nodes can also be TBUs.

It is important to distinguish between two aspects of previous proposals about tone association: anchoring and dependency. The 'anchoring' aspect is how H and L tones are linked to points in the prosodic representation, with effects on the timing of their phonetic realization. The 'dependency' aspect is how tone interacts with other features.

The xTBU proposal is that anchors are preferably prosodic (mora (μ), syllable (σ), etc.), but that under duress anchors can be non-moraic root nodes. Tones are never anchored to sub-segmental features or nodes.

In contrast, dependency – how tone interacts with features – is achieved in the xTBU theory through constraints. For example, the constraint *VOICEDSTOP/H, ranked appropriately, is responsible for the sensitivity of tone to laryngeal features (and vice versa) in many languages. The following chapters will provide many examples.

Many previous theories have attempted to propose a single formal device to account for both the anchoring and dependency aspects of tone. This merger has led to apparent paradoxes. For example, tones are phonetically aligned with prosodic landmarks, indicating that phonological tone should be aligned or associated with prosodic elements. The number of tones in a syllable domain is also often limited to the number of moraic elements in that domain, indicating that there is a representational connection between tone and moras. In contrast, tone interacts with laryngeal features in some languages, motivating several theories in which tone is associated to the laryngeal node (e.g. Bao (1999), Duanmu (1990), Pulleyblank (1994: 350-352), Bradshaw (1999)). In the most detailed theory, Bradshaw (1999) proposes that the dependency between tone and laryngeal results from the feature [L/voice], which may be associated to different anchors. When linked to a prosodic node (mora), [L/voice] makes the prosodic node be realized as a low tone. On the other hand, when linked to a root node, the root node becomes voiced due to [L/voice]. Bradshaw's proposal inadvertently combines the 'anchor' and 'dependency' aspects of consonant-tone interaction. This dissertation differs in claiming that the two aspects have independent accounts: the anchor aspect is expressed through requiring representation to root nodes and prosodic elements, and the dependency aspect is expressed through constraints.

When tone is associated with a consonantal root node, the dependency relationship is situated on the tonal plane like the tone associated with a mora. This relationship between tones, segments, and moras is shown in Fig. 1. All (tonal) association lines shown in Fig. 1 are on the tonal plane (within the solid line) separate from the prosodic plane (within the dotted line).

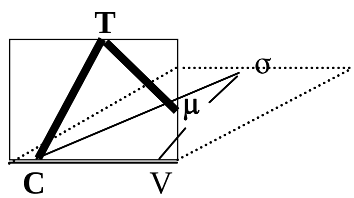
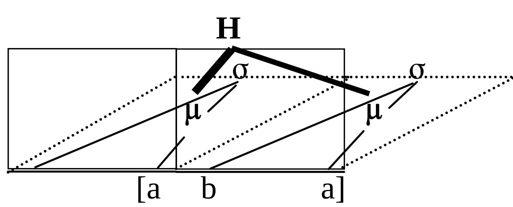


Fig. 1 Direct association to tone
- tone anchors to the area within the dotted line
- tone forms dependencies to area within the solid line

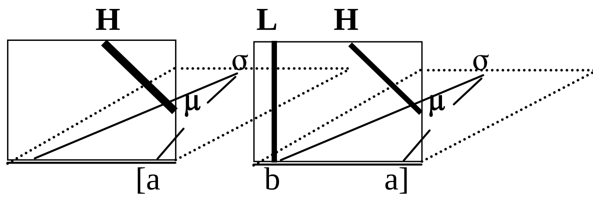
The following forms further exemplify this representation. In (3), [b] is not associated to a tone while the H tone is associated to the moras ([a]). This situation occurs in tonal languages without consonant-tone interaction.

(3) [á.bá]



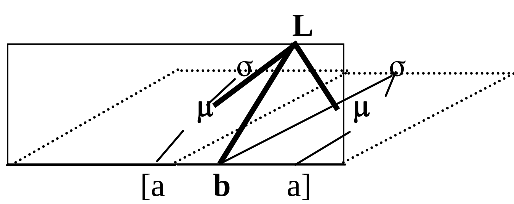
In (4), the consonant root node [b] has a L tone, and the preceding and following vowels [a] have a H tone. The consonant *b* is associated to the L tone (dependency) in the output, and it is not associated to the H tone.

(4) [á.b á]$_H$



In the example (5), all segments in [àbà] share the L tone. The L tone is associated to a mora if a root node is dominated by a mora: the two [a]'s (anchoring). The L tone is associated to the consonant root node [b] if the root node is non-moraic (dependency).

(5) [à.bà]$_L$

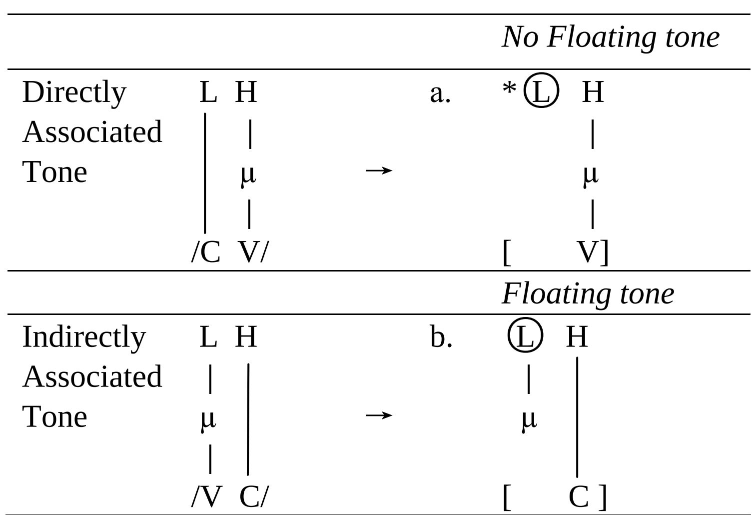


This representation illustrates that tone directly associates to a root node if and only if the root node is not directly dominated by a mora; otherwise it links through a mora. The xTBU proposal is that tone is associated to a minimally available prosodic node (i.e. a mora) (also see Peng 1992).

As expected, tones associated to non-moraic root nodes demonstrate characteristics comparable to other features associated to root nodes. Root nodes have strong dependency relations with the sub-structure because they cannot be deleted without deleting all nodes they dominate (McCarthy 1988, Kaisse 1992: 313). Likewise, consonantal tones seem to be dependent on the nodes they dominate, including root nodes.

In the xTBU theory, when root nodes are deleted tones directly associated to a root node do not surface in the output because tones associated to consonantal root nodes are dependent on the root nodes. The dependency relationship is not contrastive in the output because faithfulness constraints only preserve tone associated with a mora. For example, a tone linked to a root node cannot become a floating tone as in (6a), because no constraints preserve the tone associated to a root node. However, tone associated with a mora in the input as in (6b) may become a floating tone (i.e. tone stability, Goldsmith 1976).

(6) Deletion of root node



Throughout the dissertation, association lines are used to denote the dependency relationship (when associated to a non-moraic root node) and the anchoring relationship (when associated to a mora) (Goldsmith 1976).

3.3 The role of faithfulness

In previous studies on tone, root nodes are explicitly banned from being TBUs. The main motivation for this restriction comes from contrastiveness. Yip (2002: 72-74) and others observe that there is no language that has a tonal contrast on onset segments (e.g. [ḿa] vs. [m̀a]) while languages may have tonal contrast in moraic coda segments (e.g. [áḿ] vs. [ám̀]). The present proposal fully accepts that non-moraic consonants cannot bear tone contrasts; no lexical items ever have contrasting tone in non-moraic consonants.

However, it is not necessarily the case that lack of tone contrast in a position means that the position cannot bear tone. The ability to bear tone and the ability to contrast it are separable. In OT, the ability to contrast in tone depends on faithfulness constraints. Crucially, the separation of being a TBU from being contrastive results from the absence of faithfulness constraints that preserve the tonal contrasts on consonants.

Following Myers (1997) and others, faithfulness constraints on tone evaluate the correspondence relationship of tone in the input and tone in the output. However, in xTBU theory, faithfulness constraints on tone always mention moras. There are no faithfulness constraints that preserve underlying tone on non-moraic root nodes. Tone faithfulness constraints are given in (7).

(7) Faithfulness constraints on tone

a.	DEP-T	Every mora *x* in the output has a correspondent mora associated to tone in the input. (cf. Yip 2002: 83)
b.	IO-IDENT-T	Corresponding segments associated to a mora have identical values for the tonal feature T_F. If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *x* is [γT_F], then *y* is [γT_F].
c.	OI-IDENT-T	Corresponding segments associated to a mora have identical values for the tonal feature T_F. If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *y* is [γT_F], then *x* is [γT_F].

The effect of the absence of faithfulness constraints targeting tones on consonantal TBUs is demonstrated in (8) and (9) using an input /ba/. Note that the faithfulness constraints do not assign violation marks to output candidates that fail to preserve input non-moraic tone specifications. While an underlying tone on a root node is changed from H to L in (8a) and from L to H in (9b), IDENT-T does not assign violation marks to these candidates because these changes are not on tones associated with a prosodic node (i.e. a mora). As above, the association lines in the inputs in (8) and (9) denote the dependency relationship between consonant and tone.

(8) Consonants with underlying H tone[1]

<table>
<tr><td></td><td>H
|
/b a/</td><td>IDENT-T</td><td>*VOICED STOP/H</td><td>DEP-T</td></tr>
<tr><td>a. ☞</td><td>L
/|
μ
|
[b a]</td><td></td><td></td><td>*</td></tr>
<tr><td>b.</td><td>H
/|
μ
|
[b a]</td><td></td><td>W*</td><td>*</td></tr>
</table>

[1] In each comparative tableau, asterisks indicate violation profiles. ‘W’ means that the optimal candidate is the winner under a constraint. ‘L’ means that the optimal candidate loses against other candidates under a constraint. In each row of the tableau, all L’s should be dominated by at least one W. See Prince (2002).

(9) Consonants with underlying L tone

	L | /b a/	IDENT-T	*VOICED STOP/H	DEP-T
a. ☞	L /| μ | [b a]			*
b.	H /| μ | [b a]		W*	*

Consequently, the existence and value of tones associated to root nodes is entirely due to markedness constraints. In (8) and (9), tones on consonants neutralize to a low tone in the output. This is because the markedness constraint *VOICEDSTOP/H disprefers a dependency relationship between a voiced consonant and a high tone, and assigns violation marks to candidates with this relationship in (8b) and (9b).

Tones directly associated with root nodes do not have tonal contrast due to the absence of faithfulness constraints. Now, compare the tableaux above with (10) and (11), respectively. As defined in (7c-d), IDENT-T assigns violation marks when the correspondent tones on a mora are not identical. So, the change of input tone H to output tone L in (10a) and the change of input tone L to output tone H in (11b) incur violations of IDENT-T. As a result, tones associated with a mora may contrast in the output.

(10) Vowels with underlying H tone

	H | μ | /b a/	IDENT-T	*VOICED STOP/H
a.	L ╱| μ | [b a]	W*	L
b. ☞	H ╱| μ | [b a]		*

(11) Vowels with underlying L tone

	L | μ | /b a/	IDENT-T	*VOICED STOP/H
a. ☞	L ╱| μ | [b a]		
b.	H ╱| μ | [b a]	W*	W*

This section has shown that tones linked to a root node do not contrast due to the absence of faithfulness constraints. Therefore, no constraints preserve a relationship between a consonant and a tone.[2] It is the markedness constraints that play a crucial role in this theory. Recall the discussion in (8) and (9). The markedness constraint *VOICEDSTOP/H penalizes candidates with a dependency between a voiced consonant and a high tone, which is the only way to restrict consonant-tone relationships.

3.4 Markedness constraints

This section discusses markedness constraints that crucially determine whether consonant-tone interaction occurs in a particular language. As discussed in section 2.3, tones do not display contrast when associated to a root node. This non-contrastiveness is argued to be the result of the absence of relevant faithfulness constraints. Consonant-tone interaction, therefore, is a markedness-driven phenomenon.

[2] In other words, no faithfulness constraint targets the dependency aspect of tonal association. This differs from Myers (1987), in which faithfulness constraints to dependency relationships are proposed; DEP-ASSOCIATION and MAX-ASSOCIATION.

Markedness constraints such as ROOTNODE→T (cf. SPECIFY-T in Yip 2002), which demands that every segment be associated with a tone, compete with *TBU/T, which bans tone on any kind of TBU. When ROOTNODE→T dominates *TBU/T, all TBUs including consonantal TBUs must be realized with a tone. When *TBU/T dominates ROOTNODE→T, the given grammar will have no tone in the output.

The specifics of markedness constraints determine what kind of direct association is possible in languages. For example, the constraint *VOICEDSTOP/H (seen in Tsonga - section 3.2) bans any voiced stops (called ‘depressors’) from being associated with a H tone. Conversely, this constraint tolerates association of depressor consonants with low tone, which in turn allows the spreading of low tone over depressor consonants. Markedness constraints targeting a direct association in (12) are proposed in this dissertation on the basis of languages with consonant-tone interaction. The third column lists languages that provide evidence for these constraints.

(12) Markedness constraints

a.	General:	*TBU/T[3]		
b.	Voicing:	*VOICEDSTOP/H	***Tsonga***	Ch. 4 (4.2)
		*VOICELESSOBSTR/L	***Western Bade***	Ch. 4 (4.3)
c.	Laryngeal: (consonants)	*[+SPREAD GLOTTIS]/L	***Mulao***	Ch. 5 (5.2)
		*[+CONSTRICTED GLOTTIS]/L	***Mulao, Burmese***	Ch. 5 (5.2, 3)
d.	Phonation: (vowels)	*V̰/L (creaky)	***Burmese***	Ch. 5 (5.3)
		*V̤/H (breathy)	***Tsonga***	Ch. 4 (4.2)

[3] The markedness constraint *TBU/T targets any tone associated to tone bearing units (moras or non-moraic root nodes). While *TBU/T assigns violation marks as *TONE (*T) would do, a question arises in languages like Japanese, which is argued to associate tone to higher prosodic nodes (Pierrehumbert and Beckman 1988). More studies are required to understand the difference between *TBU/T and *T, which is beyond the scope of this dissertation. I defer this inquiry to future research. I am indebted to Alan Prince for raising this point.

These markedness constraints are visible when there is a requirement of tone on all TBUs ('TBU' here stands for the set {root nodes, moras}). The requirement may be satisfied by a general markedness constraint ROOTNODE→T in (13a). However, in order to distinguish root node TBUs from moraic TBUs, a specific constraint on moraic TBUs is necessary: μ→T as in (13b). These two constraints are in competition with *TBU/T in (13c), which prohibits tone bearing units (root nodes or moras) from associating to a tone.

(13) Markedness constraints requiring tone on TBUs

a. ROOTNODE→T (RN→T):	Assign a violation mark to every root node that is not associated to a tone either directly or via a mora.
b. μ→T:	Assign a violation mark to every mora that is not associated to a tone.
c. *TBU/T:	Assign a violation mark to every tone bearing unit associated to a tone.

This proposal is based on the idea that both non-moraic root nodes and moras can be TBUs (cf. Hyman 1992).

In (14a), the candidate satisfies both ROOTNODE→T and μ→T. ROOTNODE→T is not violated by the output root node [a] in candidate (a) because the root node of [a] is *transitively* associated to a tone – [a] is associated to a mora which is associated to a tone. Consequently, ROOTNODE→T is always satisfied when μ→T is satisfied. On the other hand, μ→T is violated in (14b) because the mora is not associated to a tone. While the faithful candidate in (14c) has fewer violation marks under *TBU/T, it crucially violates ROOTNODE→T.

(14) ROOTNODE→T requires all root nodes to have tone

	L μ /b a/	RN→T	μ→T	*TBU/T
a. ☞	L μ [b a]	√	√	**
b.	L μ [b a]	√	W*	**
c.	L μ [b a]	W*	√	L*

This stringency relationship between ROOTNODE→T and μ→T determines the preference for tonal association. When a root node is linked to a mora, tones are always favored on the mora and not on the root node. A hypothetical input such as (15) illustrates this point. There is no faithfulness constraint that preserves the relationship between an input tone and a root-node TBU. The faithful candidate (15b) can never be a winner because it always has more violations under μ→T compared to a candidate that associates the tone to a mora as in (15a). In turn, these constraints always prefer moras as a TBU, when there is a mora.

(15) Tone prefers to associate to a mora

	L μ /b a/	RN→T	μ→T
a. ☞	L μ [b a]	√	√
b.	L μ [b a]	√	W*

As emphasized above, the interaction among markedness constraints is the only factor in consonant-tone interaction in the absence of faithfulness constraints for tones associated with root-node TBUs. Rankings in (16) demonstrate the crucial rankings for possible grammars with respect to consonant-tone interaction. When ROOTNODE→T dominates *TBU/T, languages require tones on consonants as in (16a). The reverse ranking in (16b) bans tones from being associated to a root-node TBU, which are languages that do not have consonantal tone. In (16c), a specific markedness constraint *VOICEDSTOP/H dominates the general markedness constraint *TBU/T. This ranking requires tones on consonants to be the same one, in this case L tone on voiced obstruents. Note that no ranking predicts languages that require tones on consonants only.

(16) *Rankings for consonant-tone interaction*

a. Ranking that requires tones on consonants **RN→T >> *TBU/T**

b. Ranking that bans tones on consonants ***TBU/T >> RN→T**

c. Ranking that requires tones on consonants to be the same one (e.g. no H on voiced stops) ***VOICEDSTOP/H, RN→T >> *TBU/T**

d. No ranking requires tones on consonants only.

Note that the ranking in (16c) is a specific ranking of (16a). When specific markedness constraints such as *VOICEDSTOP/H among others are dominated by the general constraint *TBU/T, the effects of the specific markedness constraints are suppressed. So, languages with consonant-tone interaction demonstrate the interaction, if and only if a specific constraint or multiple specific constraints are ranked higher than the general constraint. In a language in which all specific constraints are dominated, root nodes are required to be associated with a tone, but the effect would be invisible. The rankings mentioned in (16) are examined case by case from (17) to (21).

(17) Ranking that *requires* tone on consonants (see also (14))

	L | μ | /b a/	RN→T	*TBU / T
a. ☞	L ╱ ╲ μ | [b a]	√	**
b.	L | μ | [b a]	W*	L*

Languages require tone on consonants when ROOTNODE → T dominates the markedness constraint *TBU/T. An input with a tone only on a mora does not surface faithfully because the candidate in (17b) violates ROOTNODE→T. The root node [b] is not associated with a tone. The optimal candidate in (17a) satisfies ROOTNODE→T because every TBU is associated with some tone. The optimum, however, has more violations under the lower ranked constraint *TBU/T.

Languages may not show consonant-tone interaction at all. When *TBU/T dominates ROOTNODE → T, the optimum should have fewer violations of *TBU/T. Two relationships should be accounted for under this ranking. An input as in (18) must not have new associations between a tone and a TBU. At the same time, the ranking must ban association lines that are not preserved by faithfulness constraints. In (19), a candidate with no relationship between a consonant and a tone is preferred. Note that a candidate [ba] with no tone in the output is ruled out in both tableaux due to the higher-ranked MAX-T constraint, which only preserves the relationship between a tone and a mora.

<Ranking that *bans* tones on consonants>

(18) Do not create a relationship

	L μ /b a/	*TBU / T	RN→T
a. ☞	L μ [b a]	*	*
b.	L μ [b a]	W**	L√

(19) Do not preserve a relationship

	L μ /b a/	*TBU / T	RN→T
a. ☞	L μ [b a]	*	*
b.	L μ [b a]	W**	L√

When tones are required on consonants, the requirement is limited to a specific tone. For example, Tsonga and many other Nguni languages have voiced consonants that require low tone (and always low tone) in the output. This is due to a specific constraint *VOICEDSTOP/H. This constraint shows effects in the grammar only if it dominates the general constraint *TBU/T. Thus, these constraints are in a Pāṇinian relationship (P&S 2004: 97-99).

(20) Ranking that requires tones on consonants to be the same one

	L | μ | /b a/	*VOICEDSTOP/H	RN→T	*TBU / T
a. ☞	L μ | [b a]	√	√	**
b.	L | μ | [b a]	√	W*	L*
c.	H L | μ | [b a]	W*	√	**

(21) Ranking that requires tones on consonants to be the same one (with DEP-T)

	H μ /b a/	*VOICEDSTOP/H	RT→T	*TBU / T	DEP-T
a. ☞	L H μ [b a]	√	√	**	√
b.	H μ [b a]	W*	√	**	√
c.	H μ [b a]	√	W*	L*	√

In (21), the same ranking requires an input with no tone on a consonant to have a low tone on the voiced consonants because of the higher ranked constraints *VOICEDSTOP/H and RT→T. So, the tableau shows that the grammar permits tones on consonants to be different from the tones on a mora. This is attested in Tsonga (see chapter 4 section 4.2). Note that inserted tones on the consonant in (21a-b) do not incur violations of DEP→T (the last column).

The theory has further implications. The re-ranking of markedness constraints discussed above never predicts a language that has tones only on consonantal TBUs. Recall that no faithfulness constraint preserves a relationship between a consonant and a tone. In (22), four different candidates are examined under the proposed markedness constraints. The candidate that allows tone on consonants (root nodes) in (22a) does violate *TBU/T twice, but it satisfies both μ→T and RT→T. When tone is only on a moraic TBU as in (22b), the candidate satisfies μ→T, and violates both RT→T and *TBU/T once. When no tone is assigned to any TBU as in (22c), the candidate violates the tonal assignment constraints: μ→T and RT→T.

The candidate in (22d) has tone on a consonantal root node TBU. The mora is not associated with any tone. This candidate violates all three markedness constraints. In the absence of faithfulness constraints for tones associated with a root node, this candidate will always be disfavored under these markedness constraints. As a result, there will be no languages that only assign tone on consonantal TBUs because such candidates will always be harmonically bounded by another.

(22) Interaction of Markedness

		μ→T	RN→T	*TBU / T
a.	L μ [b a]	√	√	**
b.	L μ [b a]	√	*	*
c.	[b a]	*	**	√
d.	L μ [b a]	*	*	*

(23) Typology

a. Tonal languages with consonant-tone interaction
μ→T, RN→T >> *TBU / T

b. Tonal languages with no consonant-tone interaction
μ→T, *TBU / T >> RN→T

c. Non-tonal languages
***TBU / T >> μ→T, RN→T**

In (23), the typology resulting from these constraints is shown as three types of languages. Tonal languages that show consonant-tone interaction (23a), tonal languages that do not show consonant-tone interaction (23b), and non-tonal languages (23c). In the subsequent chapters, consonant-tone interaction assumes the ranking in (23a). Thus, the constraints in (23a) will not be shown in subsequent tableaux unless they are crucial to the discussion.

3.5 Phonetic realization

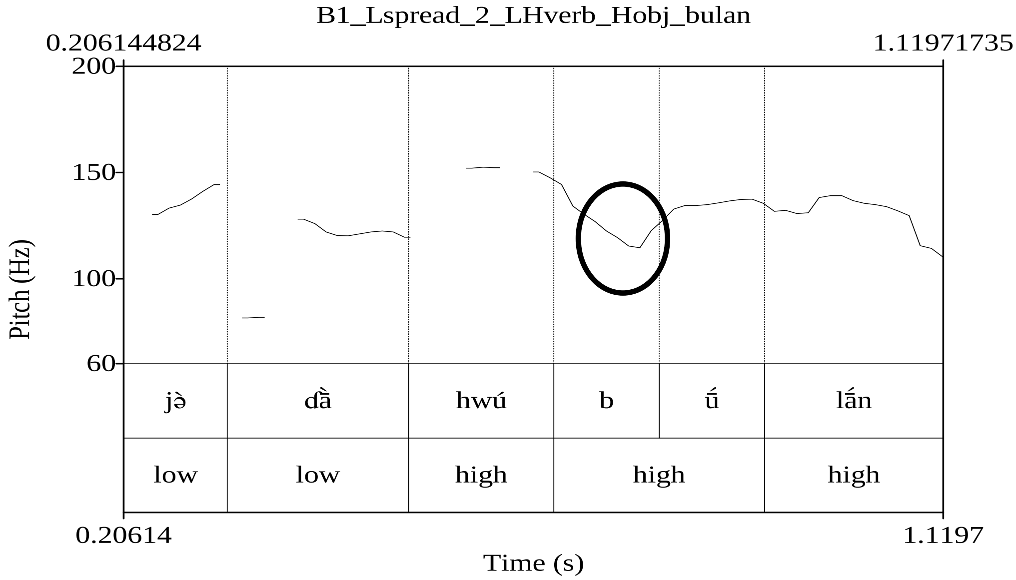
Tone on non-moraic consonants is phonetically realized (cf. Hyman 1973, Hombert et al. 1979, among others). For example, in an output such as [a^H b^L a^H], there is a depression effect in the pitch contour over the [b]. As shown in (24), the [b] (in the circle) between high tones in Western Bade shows lowering of the pitch, which raises after the depressor to high tone. Similarly, pitch depression occurs on [z] between low tones in 0.

To clarify, the pitch depression results from micro-variation in pitch contour caused by certain inherent properties of consonants. For example, voiced obstruents cause pitch depression due to their inherent properties (see section 6.4 for more discussion). However, the pitch depression is inherent and universal; it is not a language-dependent property.

Russell Schuh provided me with recordings of the male consultant in his mid forties in (24). Consultant B was recorded twice in Potiskum, Yobe State, Nigeria, first on July 25, 2007 (B1) and then on August 8, 2007 (B2).

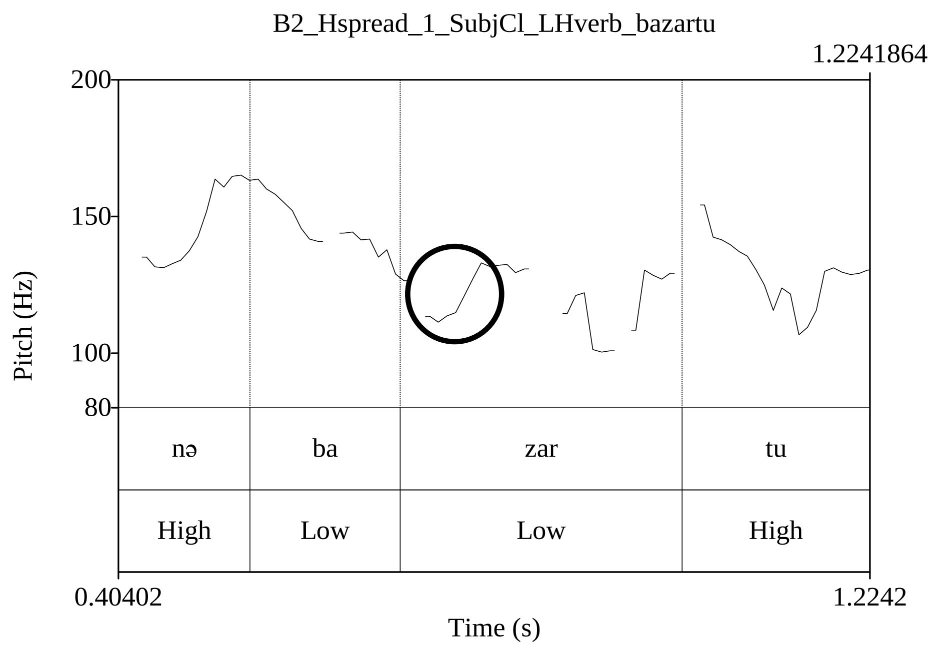
(24) A depressor [b] between high tones in Western Bade[4]

[jə ɗàhwú búlán] ‘We put on a gown.’



(25) A depressor [z] between low tones in Western Bade

[nə́ bàzàrtú] ‘I shamed’



[4] I am indebted to Russell Schuh for sharing the recordings of Western Bade presented here.

It is interesting that tone associated to non-moraic root nodes is phonetically realized. Even so, the phonetic realization of the non-moraic root nodes does not result in phonological tonal contrasts (cf. Tran et al. 2005). This is borne out in the xTBU theory, because tone associated to consonantal root nodes is regulated only by markedness constraints. Furthermore, there is ample phonological evidence that non-moraic root nodes bear H and L tones, presented in the rest of this dissertation.[5]

3.6 Conclusion

Consonant-tone interaction results from the direct association of tone to consonant root nodes coupled with markedness constraints that regulate tone-feature combinations (section 3.2). There are no faithfulness constraints in CON which preserve tones directly associated to a segment (section 3.3). Inputs with tones associated to a root node have association lines that are only evaluated by markedness constraints (section 3.4). Because of this asymmetry on root node TBUs between faithfulness constraints and markedness constraints, tones only contrast when they are associated with a moraic TBU.

The ranking of markedness constraints predicts the following typology in (26). In languages with consonant-tone interaction as in (26a), tonal assignment constraints (μ→T, RN→T) dominate the markedness constraints *TBU/T, which ban tone on any TBU. Tonal languages may not have consonant-tone interaction when tone is required on a mora (μ→T), but not on a root node, following the ranking in (26b). When no tone is

---

[5] Since I propose that inherent properties of consonants affect the pitch of the following vowel, it would be interesting to find out whether there is any difference between tonal languages and non-tonal languages. A study on Kammu suggests that non-tonal languages can have bigger pitch perturbation in the vowel due to the consonants (Svantesson and House 2006). I defer a phonetic investigation to future research. I am thankful to Paul de Lacy for suggesting this point.

allowed on any TBU, the language becomes non-tonal as in (26c). These constraints do not predict a language in which consonants can have tonal contrast, due to the stringency relationship between μ→T and RN→T.

(26) Typology of consonant-tone interaction

a. Tonal languages with consonant-tone interaction
μ→T, RN→T >> *TBU / T
b. Tonal languages with no consonant-tone interaction
μ→T, *TBU / T >> RN→T
c. Non-tonal languages
***TBU / T >> μ→T, RN→T**

The cross-linguistic variation in consonant-tone interaction arises from different markedness constraints such as *VOICEDSTOP/H or *[+CONSTRICTED GLOTTIS]/L. When these constraints dominate the general constraint *TBU/T in (24a), language specific patterns emerge. For example, higher ranked *VOICEDSTOP/H penalizes candidates that have a relationship between a [+voice] feature and a high tone.

In following chapters, several cases of consonant-tone interaction will be presented and analyzed. The proposal on direct association to tone, the absence of faithfulness constraints, and the markedness constraints in (26) will recur.

In chapter 4, blocking of tonal processes by depressor consonants will be discussed. For example, in Tsonga, voiced stops, breathy voice and aspirated consonants block high tone spreading. In Western Bade, voiced obstruents block high tone spreading, while voiceless obstruents block low tone spreading. Chapter 5 mainly discusses tonal neutralization in Asian languages. For instance, in Burmese, glottal stop codas neutralize the tone of a given syllable to low, while in Mulao it is onsets that neutralize tone of a syllable to high. In Thai, onsets and codas independently neutralize tone in the output.

Chapter 4 Effects of consonants on H tone spreading

4.1 Introduction

The xTBU theory allows tones on consonants to interact with other tones. In some cases, this interaction results in blocking of tone spread across particular consonants. In Tsonga, for example, the usual spreading of H tone to words with LH tone does not occur when a depressor consonant is present. This blocking by depressors results from a requirement on dependency between tones and consonantal root nodes as proposed in chapter 3.

Tsonga is analyzed in detail in section 4.2; H tone spreading from a prefix to LH nouns results in a falling contour tone as $\widehat{HL}$ H. Such spreading, however, is blocked by consonants such as voiced stops, breathy voice and aspirates (‘depressors’). The blocking of tonal spreading by consonants is a markedness requirement between tone and depressor consonants.

Section 4.3 discusses blocking of tonal spreading in Bade. H tone spreading is blocked by voiced obstruents, and H tone lowering is blocked by voiceless obstruents. Such a situation shows that the feature [+voice] is not the only factor that plays a role in consonant-tone interaction.

There are three different patterns in which H tone spreads to LH tones (see section 2.2). The H spreading may create a falling contour tone as in (1a); H tone may spread without resulting in a contour tone as in (1b); or H tone spreads and ends up with downstep in the output as in (1c). Depressors can block all three types of spreading as shown in (1d).

(1) Patterns of H tone spreading to LH tone

a. H + L H → H L H (σ σ σ: H linked to the first and second σ, H linked to the third σ) *contour tone* Tsonga

b. H + L H → H (σ σ σ: H linked to all three σ) *single H tone* Western Bade

c. H + L H → H ꜜH (σ σ σ: H linked to the first and second σ, ꜜH linked to the third σ) *downstep* Dagara

Depressors ('D')

d. H + L H → H L H (σ Dσ σ: one tone linked to each σ)

4.1.1 Proposal

As proposed in chapter 3, tone is related to segments in a dependency relationship. The dependency relationship between tone and consonant root nodes is different from the relationship between tone and prosodic tone bearing units (TBUs) such as moras and syllables ('anchor' relationship). The dependency relationship is output oriented, while the anchor relationship is an input-output correspondence relationship. Thus, the dependency relationship is only subject to markedness constraints in the grammar. There are no faithfulness constraints in CON that preserve the relationship between a consonant root node and a tone.

The markedness-driven consonant-tone interaction is an interaction among the general markedness constraints ROOTNODE→T, μ→T and *TBU/T. In (2), the typology predicted by these three constraints is presented.

(2) Typology of consonant-tone interaction

a. Tonal languages with consonant-tone interaction

μ→T, RootNode→T >> *TBU / T

b. Tonal languages with no consonant-tone interaction

μ→T, *TBU / T >> RootNode→T

c. Non-tonal languages

*TBU / T >> μ→T, RootNode→T

This chapter aims to accounts for the blocking of tonal spreading by consonants. In Tsonga, for example, the usual situation is for an H to spread onto a following L-toned syllable, creating a falling tone (3b). However, voiced stops block high tone spreading. In (3a), LH nouns remain as LH after the H tone prefix. Unless stated otherwise, H tone is marked with an acute accent, L tone with a grave, falling with a circumflex.

(3) Blocking of H tone spreading in Tsonga

a.	L H	→	H L H		***Depressor***
	| |		| | |	‘it is a hen	*No spreading*
	bùxá		í bùxá	which eats its own eggs’	
b.	L H L	→	H L H L		***Non-depressor***
	| | |		|⟍ | |		*Spreading*
	mùfánà		í mûfánà	‘it is a boy’	

This blocking is due to a low tone on a voiced stop [b], forced by the markedness constraint *VoicedStop/H. Under this constraint, H tone cannot form a dependency relationship with a voiced stop in the output, so a candidate such as [í bûxá] (L HL H) with a contour tone on [û] is less harmonic than a candidate [í bùxá] under *VoicedStop/H because [b] in [í bûxá] is associated with a high tone. A detailed analysis will be presented in section 4.2.

4.2 Blocking tonal spreading by consonants: Tsonga[1]

Tsonga (S53, Guthrie 1970) is spoken by 3.2 million in the Republic of South Africa, Mozambique and Zimbabwe. Tsonga is also known as Shangaan and Gwamba. All data in this dissertation are from Baumbach (1987), which is based on the variety of Tsonga spoken in the Republic of South Africa.[2]

In (4a), an LH noun with a breathy voice onset surfaces with no tonal change (LH) after a high tone prefix. On the other hand, when an LH noun begins with a non-breathy nasal, the surface form after a high tone prefix has a high-low contour tone as in (4b).

(4) H tone spreading

```
a.  H       L H      →   H   L H                         No H spreading
    |       | |          |   | |
    /í  +  m̤àlá/         [í  m̤àlá]      'it is an impala'
b.  H       L H L    →   H   L H L                       H spreading
    |       | | |        |\  | |
    /í  +  mùfánà/       [í mûfánà]     'it is a boy'
```

Since the surface form in (4a) does not allow the H tone to spread across the intermediate consonant, it is taken that the intervening consonant (i.e. the breathy nasal [**m̤**]) blocking the H tone from spreading. Phonetically, these kinds of consonants lower the pitch of a following vowel (Traill et al. 1987). Because of this phonetic attribute, these consonants are called *depressor consonants* (cf. Lanham 1958). In the sections that

[1] An earlier version of this section was presented at the 38th Annual Conference in African Linguistics. I would like to thank the audience for their insightful and helpful comments.

[2] The data in this chapter is entirely from Baumbach's grammar; I did not phonetically analyze primary data. Even so, Baumbach's grammar is very clear about the patterns relevant here.

follow, this term will be used for consonants that block the high tone phonologically.

Previous phonological studies analyze these types of consonants as being associated to a L tone (cf. Lieber 1987, Bradshaw 1999). Crucially, this dissertation differs from previous research by proposing that these consonants *can* be associated with a L tone. The association between a tone and a consonant arises from the markedness requirement on depressor consonants. There is no faithfulness constraint that preserves a contrast of tone associated to a consonant (or a segment in general) when a mora is present. It is the markedness constraints that prevent depressor consonants from being associated with a high tone.

The aim of this section is two-fold. First, in section 4.2.1, I will present an analysis that shows H tone spreading across non-depressors in L nouns and LH nouns. Second, H tone spreading across depressors in Tsonga will be analyzed in section 4.2.2. Depressors block H tone spreading due to the markedness requirement and constraint interaction proposed in this dissertation.

4.2.1 H tone spreading across non-depressors

4.2.1.1 L nouns

In Tsonga, when a H tone prefix precedes L tone nouns, the H spreads to the penultimate syllable of the root. In (5a-b), disyllabic nouns show this type of spreading, and in (5c-d), trisyllabic nouns show such spreading. The H tone spreading to the penultimate syllable in (5) is due to the requirement that the H tone be aligned as right as possible, and for the H tone to spread to the metrically prominent syllable.

(5) L tone nouns: *H tone spreads* (Baumbach 1987: 46-47)

	L L		H + HL	
a.	rìbjè	→	í **rí**bjè	'it is a stone'
b.	ᵐbìlà	→	í **ᵐbí**là	'it is a xylophone'
	L L L		H + HHL	
c.	ʃìkòsà	→	í **ʃíkó**sà	'it is an old woman'
d.	mìlètì	→	í **mílé**tì	'it is naughtiness'

In (6), H tone spreading is analyzed. The H tone spreading results from the following ranking: NON-FINALITY dominates ALIGN-R, which in turn dominates IO-IDENT-T. The unfaithful mapping in (6a) violates the faithfulness constraint IO-IDENT-T because of the tonal change in the moraic TBU [i] from L tone to H. The candidate in (6b) that is faithful to the input has fewer IO-IDENT-T violations, but it has more violations under the alignment constraint. There are two intervening syllables between the H tone and the right edge. While the candidate in (6c) has no alignment violations, it violates NON-FINALITY because the spread H tone is on the final syllable. The candidate (6c) also violates IO-IDENT-T twice. The definitions of these constraints are presented in (7).

(6) H tone spreading to disyllabic L nouns

	H L | /\\ /í rìbjè/	NONFINALITY	ALIGN-R	IO-IDENT-T
a.☞	H L /\\ | [í rí .bjè]		*	*
b.	H L | /\\ [í rìbjè]		W**	L
c.	H /\\ [í ríbjé]	W*	L	W**

(7) Constraints

a. IO-IDENT-T
Corresponding segments associated to a mora have identical values for the tonal feature T_F. If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *x* is [γT_F], then *y* is [γT_F]. (de Lacy 2002: 10, Yip 2002: 83)[3]

b. ALIGN-H-R (ALIGN-R)
Align the rightmost mora associated to a H tone with the right edge of a prosodic word (Assign one violation mark to each intervening syllable between the syllable associated to H tone and the right edge of a prosodic word).[4] (cf. Yip 2002: 83)

c. NONFINALITY
Assign one violation mark for every H tone spread to the final syllable of a prosodic domain (cf. Prince and Smolensky 1993/2004: 51)

Under this analysis, H tone spreading does not extend to the final syllable because of the NON-FINALITY constraint. Crucial to this analysis is the L tone specification in the input. This assumption is different from some previous studies, in which tones in Bantu languages are proposed to be H tone and toneless. I will defer a discussion about toneless inputs until section 4.2.1.3.

While the analysis above explains why H tone spreads in the first place, it fails to address the issue of why H tone spreads in particular to the penultimate syllable. This is problematic because the candidate in (8b), in which H tone spreads to the final syllable and surfaces with a contour tone, would be more harmonic in terms of alignment.

I will follow the proposals based on extrametricality to account for this candidate (Downing 1990). Extrametricality is expressed by the constraint NON-FINALITY as

---

[3] I propose that the tonal faithfulness constraint IDENT-T be separated into two versions: IO-IDENT-T and OI IDENT-T (see section 3.3). In previous studies IDENT-T was not violated between level and contour tones (cf. Trommer 2005), while in other studies IDENT-T was violated between level and contour tones (cf. Hyman and VanBick 2004: 829).

[4] I assume that the alignment constraint assesses violation marks in a gradient manner unlike a recent proposal in McCarthy (2003) who argues that constraints in Optimality Theory are categorical.

defined in (7c). This analysis assumes that H tone only spreads to metrical positions; that is, footed syllables.[5] Under the extra-metrical analysis, the candidate in (8b) violates NON-FINALITY because the spreading of H tone to the final syllable would mean that the final syllable is parsed as a foot. In other words, NON-FINALITY blocks the H tone from spreading because H tone spreading to the final syllable would result in the creation of a metrical structure (a foot) of the final syllable.

In (8), the optimal candidate has a foot (marked with parentheses) that includes the ante-penultimate syllable and the penultimate syllable.[6] The optimum in (8a) violates ALIGN-R because there is an intervening syllable between the right edge of the foot and the right edge of the prosodic word.[7] In the candidate in (8b), H tone spreads to the final syllable. This candidate does not violate ALIGN-R since there is no intervening syllable between the mora associated to the H tone and the right edge of the prosodic word. However, the candidate in (8b) violates the higher ranked NONFINALITY constraint because the final syllable is parsed associated with the spread H tone.[8]

---

[5] I am indebted to Laura Downing for this suggestion.

[6] In Bantu phonology, a non-iterative single-foot seems to be a common features as proposed in following studies: Nguni languages (Downing 1990), ChiZigula (Kenstowicz and Kisseberth 1990), KiVunjo Chaga (McHugh 1999), Chi-Mwi:ni (Kisseberth and Abasheikh 1974) among others.

[7] In the non-finality analysis, I assume that the foot-head is right aligned within a foot in Tsonga.

[8] An alternative analysis is based on a family of *CONTOUR constraints. In Tsonga, this constraint should be dominated by ALIGN-R because contour tones are allowed when H tone spreads to LH nouns (see section 4.2.1.2). Stipulating a constraint such as *CONTOUR]_{PrWd} does not help. This constraint would ban contour tones on a final syllable in a domain. This constraint is not only ad-hoc in nature, but also the constraint militates against the typological observation made in previous studies (Gordon 2001, Zhang 2002) which have shown that contour-tones are cross-linguistically favored in final position.

(8) Motivation of penultimate spreading[9]

	H L | /\\ /í rìbjè/	NONFINALITY	ALIGN-R
a.☞	H L /\\ | [(í rí)$_{FT}$ bjè]		*
b.	H /\\\\ [í (rí bjé)$_{FT}$]	W*	L

- Feet are marked with parentheses.

The H tone spreading by prominence, which is metrically driven, is advocated in Kenstowicz and Kisseberth (1990), in which they argue that the foot head of a prosodic word in Chizigula is required to be realized with a H tone unless other constraints block it. For an extensive analysis on Nguni languages, see Downing (1990: 267-268) and references therein. For an OT analysis, see a proposal on tone-stress interaction in de Lacy (2002).

In summary, H tone spreads to L tone nouns in Tsonga because the alignment constraint forces the spreading. The spreading stops at the penultimate syllable due to a metrically driven constraint NONFINALITY.

4.2.1.2 LH nouns

In LH nouns, H tone spreads and surfaces with falling contour tone (H + LH → H + $\widehat{HL}$ H). As analyzed in section 4.2.1.1, H tone spreads due to the alignment constraint. The examples in (9) show the contour tone in the first syllable of a noun after a H tone prefix. The initial consonants of these nouns are consonants that are fricatives, voiceless stops,

[9] If ALIGN-R outranks NON-FINALITY the final syllable would surface with a high tone (as observed in Digo (cf. Kisseberth 1984)).

prenasalized stops, and sonorants (nasals, liquids, glides). The H tone prefix [ɦí] in (9a) and (9c) is a copulative prefix for pronouns, while the prefix [ɦí] in (9d) is an instrumental marker.

(9) LH tone nouns (Baumbach 1987: 50)

a.	*fricatives*	βòná	→	ɦí βôná	it is they
b.	*voiceless stops*	kòmbé	→	í **k**ômbé	it is an ousted impala
c.	*nasals*	mìná	→	ɦí **m**îná	it is me
d.	*prenasalized stops*	mbìtá	→	ɦí ^{m}**b**îtá	with a pot

In the tableau in (10), ALIGN-R dominates *CONTOUR (defined in (11)), and thereby allows contour tones. The optimal candidate is (10a), which violates ALIGN-R because there is an intervening syllable between the mora associated with a H_1 tone and the right edge of a prosodic word. It also violates *CONTOUR because of the contour tone created by the spreading. In (10a), the optimal candidate does not violate IO-IDENT-T because the contour tone retains the low tone from the input. However, OI-IDENT-T is violated because a high tone is added to the syllable [ko]. The candidate in (10b) violates the UNIFORMITY-T constraint and the NON-FINALITY constraint, and the candidate in (10c) has two violations due to the gradient nature of ALIGN-R, even though it satisfies *CONTOUR. The candidate in (10d) violates IO-IDENT-T because the tone of the final syllable has changed from a high tone to a low. In (10e), the contour tone is formed in the final syllable, but this candidate has an IO-IDENT-T violation because the L tone of the penultimate syllable changes to a H tone.

(10) LH nouns :

	H_1 L H_2 /í <u>**k**</u>òmbé/	UNIFORMITY-T	NONFINALITY	OCP	ALIGN-R	*CONTOUR	IO-IDENT-T	OI-IDENT-T
a. ☞	H_1 L H_2 [í kô.mbé]				*	*		*
b.	$H_{1,2}$ [í kómbé]	W*	W*		L	L	W*	L
c.	H_1 L H_2 [í kòmbé]				W**	L		L
d.	H_1 H_2 [í kómbé]			W*	*	L	W*	L

(11) Constraints

a. *CONTOUR
Assign one violation mark for every mora that is associated with more than one tone (cf. Yip 2002: 83)

b. UNIFORMITY-T (No coalescence)
Let *input* mora associated to tone = $i_1 i_2 i_3 \ldots i_n$ and *output* mora associated to tone = $o_1 o_2 o_3 \ldots o_m$. Assign one violation mark for every pair i_x and i_y if $i_x \Re o_z$ and $i_y \Re o_z$ (cf. McCarthy 2008: 197)

c. OBLIGATORY CONTOUR PRINCIPLE (OCP)
Assign one violation mark for every two adjacent high tones in the output (cf. Yip 2002: 84)

There is a possible, but rejected, analysis, which proposes a positive markedness constraint that requires non-depressors to be associated with a high tone (e.g. NONDEPRESSOR→H) to account for the H tone spreading. While this constraint could explain the contour tone formation in Tsonga, the constraint predicts that all non-depressors must be associated to high tone in a given language. If this were the case, we would expect languages in which all sonorants (the typical non-depressor) are always required to be associated to a H tone, and even block low tone spreading. Such cases are not attested.

In this section, H tone spreading to LH nouns with no depressors is analyzed. The contour tone is formed as a result of allowing contour tones in the output. The contour tone formation is blocked when depressors are present. The depressor effect is analyzed in section 4.2.2 as the result of markedness requirements.

4.2.1.3 Toneless input

Assuming Richness of the Base, I will consider toneless inputs in this section. The output will be chosen based on the given ranking derived from other Tsonga data. The spreading of H tones stops at the penultimate syllable due to the markedness constraint NONFINALITY.

Under the ranking in which NON-FINALITY dominates ALIGN-R and DEP-T as in (12), the optimal candidate is (12a). All root nodes must have a tone because of the ROOTNODE→T constraint, and H tone spreads to the penultimate syllable; this is the same pattern as in H tone spreading to L nouns (see section 4.2.1.1). The H tone spreading to the final syllable in (12b) violates NONFINALITY. The candidate in (12d) has a root node that is not associated with tone. This candidate has a ROOTNODE→T violation while it has fewer violation marks under *TBU/T that assigns violation marks to TBUs associated to a tone.

(12) Nouns with no input tone

	H | V CV CV	RN→T	μ→T	NON FINALITY	ALIGN-R	DEP-T	*TBU/T
a. ☞	H L [V.CV.CV]				*	**	*****
b.	H [V.CV.CV]			W*	L	**	*****
c.	H | [V.CV.CV]	W****	W**		W**	L	L*
d.	H L | [V.CV.CV]	W *			*	**	L****

Another input to consider is the one in (13), in which the input is only specified with high tone. The difference between the LH noun in (13) and the LH noun in (10) is that low tone is not specified in the input. The established ranking predicts the optimal output to have a contour tone as in (13a). The candidate in (13b) violates the higher ranked UNIFORMITY-T constraint because the input high tones are fused in the output. The faithful output in (13c) violates ALIGN-R due the two intervening syllables between the mora associated to the H tone and the right edge of the prosodic word. It also violates the constraints ROOTNODE→T and μ→T. The candidate in (15d) does not violate *CONTOUR, but it violates OCP because of adjacent high tones in the output.

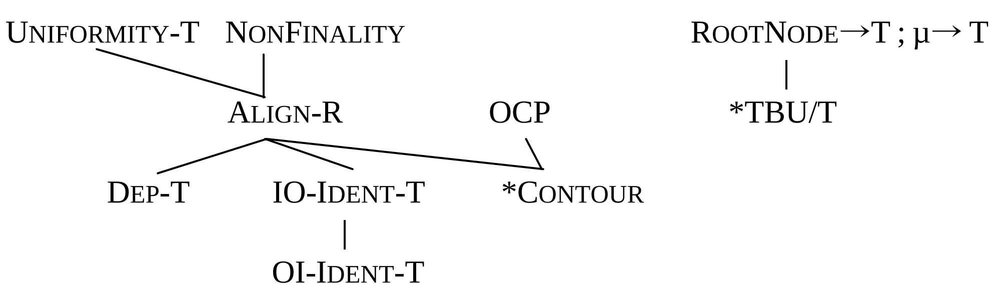
(13) LH Nouns with no input L tone

	H_1 H_2 / í kombé	UNIFORMITY-T	OCP	ALIGN-R	*CONTOUR	DEP-T
a. ☞	H L H / [í kômbé]			*	*	*
b.	$H_{1,2}$ / [í kómbé]	W*		L	L	L
c.	H_1 H_2 / [í kombé]			W**	L	L
d.	H_1 H_2 / [í kómbé]		W*	*	L	*

(14) UNIFORMITY-T (cf. NoFusion, Yip 2002: 83)
Separate underlying tones must stay separate in the output.

This subsection has presented a toneless noun in (12) and a noun with no L tone in (13). Both inputs predict that the optimal output would have a contour tone on the first syllable of a noun. The ranking of constraints that accounts for H tone spreading across non-depressors is shown in (15).

(15) Ranking of H tone spreading in Tsonga (without considering depressors)



The discussion thus far presents the H tone spreading across non-depressors. In section 4.2.2, the influence of depressors in tonal spreading is discussed, and a formal analysis based on the proposal in chapter 3 is presented.

4.2.2 H tone spreading across depressors

In Tsonga, H tone spreading to a LH noun is blocked by a depressor. So, an input such as /H + DLH/ ('D' stands for depressors) becomes [H + D **L**H] and not *[H + D**H͡L**H] with a contour tone. The blocking of depressors is due to the prohibition of certain dependency relationships between tone and segments. As proposed in chapter 3, the dependency relationship is output-oriented. Formally, there are only markedness constraints that regulate this relationship.

For Tsonga, the *VOICEDSTOP/H constraint (and *[+SPREAD GLOTTIS]/H) disallows a dependency between a high tone and a depressor in the output, which in turn results in the blocking of H tone spreading. After presenting data of depressors from Baumbach (1987) in section 4.2.2.1, an analysis based on the proposal is presented in section 4.2.2.2.

4.2.2.1 Data

All examples in (16)-(18) (repeated from chapter 2) show the behavior of depressor consonants, which block H spreading from the copulative prefix. LH nouns following the prefix begin with depressor consonants such as breathy voice consonants as in (16), voiced stops as in (17), and aspirated consonants as in (18).

(16) LH nouns with breathy voice depressors (Baumbach 1987: 53)

	H + LH	→	H + **L**H	
a.	n̤àŋgá	→	í **n̤**àŋgá	it is a hut for unmarried girls

b.	r̤òβá	→	í **r̤**òβá	it is a flat cake
c.	m̤àlá	→	í **m̤à**lá	it is an impala
d.	ŋ̤wàrí	→	í **ŋ̤**wàrí	it is a partridge
e.	^{m}b̤ìmbí	→	í **^{m}b̤**ìmbí	it is a mangosteen tree
f.	^{n}d̤^{ɦ}àmbá	→	í **^{n}d̤**àmbá	it is a cooking pot
g.	^{n}dʑ̤èŋgá	→	í **^{n}dʑ̤**èŋgá	it is afternoon
h.	^{n}g̤òŋg̤wé	→	í **^{n}g̤**òŋg̤wé	it is an old ousted vervet monkey
i.	^{n}dl̤àzí	→	í **^{n}dl̤**àzí	it is a mousebird
j.	r̤òβá	→	í **r̤**òβá	it is a flat cake

(17) LH nouns with voiced stop depressors (Baumbach 1987: 54)

	H + <u>L</u>H	→	H + **<u>L</u>**H	
a.	bùʃá	→	í **b**ùʃá	it is a hen which eats its own eggs
b.	dòɦé	→	í **d**òɦé	it is an undersized peanut
c.	gùdá	→	í **g**ùdá	it is a small verandah
d.	bjàŋgá	→	í **bj**àŋgá	it is a beer
e.	djòná	→	í **dj**òná	it is it

(18) LH nouns with aspirated depressors (Baumbach 1987: 54)

	H + <u>L</u>H	→	H + **<u>L</u>**H	
a.	ts^{h}ùrí	→	í **ts^{h}**ùrí	it is a mortar
b.	k^{h}òswá	→	í **k^{h}**òswá	it is a half portion
c.	^{n}tl^{h}àmú	→	í **^{n}tl^{h}**àmú	it is a trap
d.	ʧ^{h}ìpá	→	í **ʧ^{h}**ìpá	it is a pensioner
e.	t^{h}ònsí	→	í **t^{h}**ònsí	it is a drop
f.	ɦòmú	→	í **ɦ**òmú	it is a beast

As shown in (19), all depressor consonants in Tsonga are laryngeally marked: voiced stops, aspirates, and breathy voice. A detailed discussion on the characteristics of depressor consonants and the complete presentation of Tsonga consonants will be deferred until section 6.2.

(19) Depressor consonants in Tsonga (Baumbach 1987: 3-16)

	laryngeal	labial	alveolar	palatal	velar	glottal
plain	*voiced*	b	d		ɡ	
	aspirated	p^h	t^h		k^h	ɦ
	breathy	$^{(m)}$b̤	$^{(n)}$d̤		$^{(ŋ)}$g̈	
affricate	*aspirated*	pf^h	$ʦ^h$	$ʧ^h$		
	breathy	bv̤	ʣ̤	ʤ̈		
nasal	*breathy*	m̤	n̤		ŋ̈	
liquid	*aspirated*		l^h			
	breathy		l̤, r̤			
glides	*breathy*	w̤		j̈		

4.2.2.2 LH nouns

In LH nouns, H tone does not spread across depressors. In the analysis I am proposing, H tone cannot associate to depressor consonants. The markedness constraint blocks any dependency relationship that associates depressors with a H tone. Even so, they must be associated to some tones because all root nodes (segments) must be associated to a tone in the output.

Non-depressor consonants do not have such a restriction, so they can be associated to H tone or L tone. Out of several markedness constraints on consonant-tone interaction, the active markedness constraints in Tsonga are *VOICEDSTOP/H and *[+SPREAD GLOTTIS]/H (*[+S.G.]/H). These two constraints are ranked over other related constraints in Tsonga, and they ban depressor consonants from being associated to a H tone.

The tonal spreading is blocked if a depressor begins a root as illustrated in (20). The depressor in the optimal candidate in (20a) is associated to a L tone. While the optimum satisfies the markedness constraint *VOICEDSTOP/H and EXPRESS(H), it violates the alignment constraint. The alignment constraint has fewer violations in candidates such as (20b-c). However, the candidate in (20c) has violations of MAX-T, which assigns violations to syllables that delete an underlying tone. The association of H tone to the depressor consonants incurs a violation of *VOICEDSTOP/H. The candidate in (20b) is more harmonic under the alignment constraint. This candidate violates the *VOICEDSTOP/H constraint because the depressor has a dependency relationship with a H tone.

(20) LH nouns with depressors: í ɦòmú ‘it is a beast’

	H_1 L H_2 μ μ μ /í ɦòmú/	*VOICED STOP/H	OCP	ALIGN-R	*CONTOUR	IDENT-T
a. ☞	H_1 L H_2 [í ɦò.mú]			**		
b.	H_1 L H_2 [í. ɦo.mú]	W*		L*	W*	
c.	H_1 H_2 [í.ɦó.mú]	W*	W*	L*		W*

As proposed in chapter 3, there are no faithfulness constraints that preserve the relationship between tone and non-moraic TBUs. If there were such faithfulness constraints, we would expect an unattested language that could have contrastive tones on consonants. Thus, it is the markedness constraints that restrict the relationship between tone and consonants. The H tone from the sponsor in a prefix can spread rightward as long as the association does not violate markedness constraints such as *VOICEDSTOP/H and *[+S.G.]/H.

An alternative means to satisfy *VOICEDSTOP/H is by not forming any other dependent relationships between tone and depressor consonants. This can be represented by having depressors not associated to any tone as in (21b). This candidate would never be chosen as the optimum because the candidate is harmonically bounded under the current ranking due to the ROOTNODE→T constraint. The effect of this ranking is that depressor consonants must be associated to a tone, but the tone should always be a tone other than a high tone (i.e. low tone in Tsonga).

(21) LH nouns with depressors: í ɦòmú ‘it is a beast’

	H L H | | | í ɦòmú	µ→T	RN→T	*VOICEDSTOP/H
a. ☞	H L H | /| /| [í ɦò.mú]			
b.	H L H | | /| [í. ɦo.mú]		W *	

A hypothetical input with H tone on a depressor (assuming Richness of the Base) should never surface with a H tone on the depressor. This is ensured by the lack of faithfulness constraints for the dependency relationship between depressors and tone. So, the faithful candidate could only emerge as the winner if markedness constraints happened to favor it over all other options - i.e. preservation of underlying tone would be incidental, never directly forced for preservation reasons.

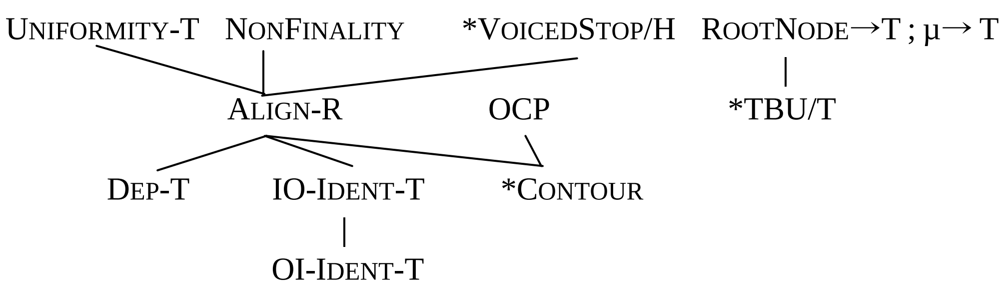
In the tableau below, a candidate with a depressor consonant associated with a L tone in (22a) is better under *VOICEDSTOP/H than a candidate with H tone on a depressor as in (22b). The faithfulness constraint IDENT-T has no violation marks as long as the tones associated with a moraic TBU are not changed.

(22) An input with H tone on depressor

	H H L H |		| /V D V CV/	*VOICEDSTOP/H	IDENT-T
a. ☞	H L H | ╱| ╱| [V. DV.CV]		√
b.	H H L H |		╱| [V. DV.CV]	W*	√

The ranking from the arguments so far is presented in the Hasse Diagram in (23). The markedness constraint *VOICEDSTOP/H crucially dominates ALIGN-R and IO-IDENT-T which explains the spreading of H tone in the first place.

(23) Hasse Diagram: Tsonga depressors and H tone spreading



In xTBU theory, the blocking of H tone spreading is not solely a representational requirement. The blocking is required by markedness constraints in the absence of faithfulness constraints. When depressors are associated with a high tone, a given candidate is always less harmonic than other candidates. It is not the case that the L tone on consonants *blocks* the spreading of H tone. The spreading of H tone does not occur because of the ranking of constraints that do not tolerate a dependency relationship between a depressor consonant and a H tone. This is possible because I crucially assume that root nodes can have a dependency relationship with tone. This could be a contentious claim as TBUs have generally been argued to be moras or syllable nodes (Yip 2002: 72-4). As discussed in section 3.2 in chapter 3, being able to host a tone should be separated from being contrastive on tone.

This analysis differs from representational theories as proposed in Peng (1992) and Bradshaw (1999). In Bradshaw's multi-planar theory, the feature [L/voice] in the representation is crucial to the analysis. As depressor consonants are linked with [L/voice], H tone spreading is blocked because the spreading creates an impossible representation, at least in the tonal tier. As a result, the blocking crucially depends on satisfying the representational requirement, a situation created by the [L/voice].

Bradshaw's theory is illustrated in (24) and (25). In (24), high tone verbs are preceded by a high tone infinitive prefix /kú-/. The high tone from the prefix (H_1) spreads to the root-initial syllable in order to satisfy the adjacency requirement between H tones (Bradshaw 1999: 94). In other words, H tone spreading occurs because the prefix H tone (H_1) must become adjacent to the H tone of the root (H_2).

(24) H tone spreading in SiSwati (Bradshaw 1999: 94)

	H_1 H_2		H_1 H_2	
	| |		|\\ |	
a.	kú + khulúúma	→	kúkhúlúúma	to speak
b.	kú + tshanyééla	→	kutshányééla	to sweep

Such a spreading is blocked if a depressor consonant is present as in (25). The depressor [g], which is voiced, is specified with the [L/voice] feature. Due to the L tone associated with the depressor [g], the spreading of H tone from the prefix is blocked.

(25) Blocking of H tone spreading in SiSwati (Bradshaw 1999: 95)

```
 H      H              H  L  H
 |      |              |  |\ |
kú + gayííŋa    →    kú  gàyííŋa      to dry roast
```

While the multi-planar theory may explain the blocking of H tone spreading in SiSwati, it has shortfalls. By restricting the consonant-tone interactions to voice and tone, the multi-planar theory cannot account for other consonant-tone interactions such as the blocking of L tone spreading by voiceless obstruents in Western Bade (see section 4.3, cf. Tang 2007). Proposing a feature [H/voiceless] would be too restrictive because we would then expect no low tone on syllables with voiceless onsets. While the multi-planar theory provides an insight into consonant-tone interaction in a representational sense, the constraint-based theory is more explanatory.

It is important to have a final note on coda consonants. Codas are argued to be available as tone bearing units. It also has been shown that these consonants contrast in tones. Moreover, several studies have demonstrated that codas can be contextually moraic (Zec 1995 among others, Morén 1999, Elías-Ulloa 2006), unlike onsets (though Topintzi 2006 argues for the existence of moraic onsets). In chapter 5, languages such as Burmese and Thai are presented to show consonant-tone interaction in relation to the onset-coda position.

4.2.2.3 L nouns

This section explores the prediction of the current analysis on the accidental gap in the data; L tone nouns with depressors. The available L tone data from Tsonga all begin with non-depressors. While Baumbach does not provide any data for L nouns beginning with depressors, an independent search of Cuenod's (1967) dictionary shows that Tsonga has depressor-initial L tone nouns. The proposal predicts that the H tone spreading should be blocked by these L tone nouns, the same as in LH nouns.

Analogous to the analysis presented in section 4.2.2.2, the spreading of H tone across depressors to L nouns is not allowed due to the markedness constraint *VOICEDSTOP/H. This part needs further research with a native speaker of Tsonga.

4.2.3 Summary

So far, I have provided an analysis of the blocking of H tone spreading to LH nouns. The proposal about dependency relationships between tone and consonants shows how blocking by depressors can be explained. However, many questions remain. How do Tsonga speakers learn the group of depressor consonants? Most descriptions related to depressor consonants are domain specific. If so, under which conditions do depressors actively interact with tonal processes? I will address these inquiries in subsequent chapters.

4.3 Blocking tonal spreading in Western Bade

In Bade, voiced obstruents block H tone spreading as in Tsonga. Additionally, voiceless obstruents block L tone spreading. This section aims to present an analysis of the blocking of H tonal spreading in Western Bade. Furthermore, it will demonstrate that consonant-tone interaction is not limited to consonants that lower the tone. The main body of data comes from Schuh (2002).[10]

Western Bade is a Chadic language spoken in Nigeria. The language is closely related to Ngizim. Voiced obstruents in this language block H tone spreading while voiceless obstruents, glottalized obstruents, and all sonorants allow such spreading. On the other hand, L tone spreading is blocked by voiceless obstruents, while any voiced segments and glottalized obstruents allow such spreading.

The blocking of H tone spreading is analyzed in section 4.3.1 based on the proposal that depressors are banned from forming a dependency relationship with H tones. The markedness constraint *VOICEDOBSTRUENT/H is ranked in a way so that it penalizes output candidates in which voiced obstruents are associated to a H tone. In section 4.3.2, L tone spreading is analyzed. The L tone spreading is blocked by voiceless obstruents because of the antagonistic markedness constraint *VOICELESSOBSTRUENT/L, which bans voiceless obstruents from being associated to a L tone.

4.3.1 High tone blocked by voiced obstruents

H tone spreads to LH verbs across phrase boundaries in Western Bade. In (26a), a LLH verb becomes HHH in the output after the first person singular H tone clitic /nə́/. The spreading of H tone is blocked when a depressor consonant is present as in (26b-c).

The first two syllables of the LH verb /tə̀nkə̀kú/ ‘pressed’ become H tone [tə́nkə́kú]

[10] For more information, see http://www.humnet.ucla.edu/humnet/aflang/Bade/bade.html (extracted on May 5, 2008). See also Tang (2007) for an analysis of voice-tone interaction in Bade.

after the clitic /nə́/ in (26a). However, in (26c), this tonal change does not occur in the verb /bàzàrtú/ 'shamed', which has a depressor onset. So, the H tone does not spread to [bàzàrtú]. In (26b), /tə̀mbə̀lú/ 'pushed', the medial syllable of the verbal root is a depressor. So, the H tone only spreads to the first syllable of the verbal root [tə́mbə̀lú].

(26) Data: H tone subject clitic + Verb (Schuh 2002, Handout#4:16)

	H **L** **L** H		H **H** **H** H	
a.	/nə́ tə̀nkə̀kú/	→	[nə́ tə́nkə́kú]	'I pressed'
	H **L** DL H		H **H** DL H	
b.	/nə́ tə̀mbə̀lú/	→	[nə́ tə́mbə̀lú]	'I pushed'
	H DL DL H		H DL DL H	
c.	/nə́ bàzàrtú/	→	[nə́ bàzàrtú]	'I shamed'

('D' stands for depressors)

In (27), the same verbs from (26) are shown after a L tone clitic /jə̀/, the first person plural subject marker. There is no tonal change in this construction. Thus, the LLH verbs map faithfully as LLH.

(27) Data: L tone subject clitic + Verb (Schuh 2002, Handout#4:16)

	L L L H		L L L H	
a.	/jə̀ tə̀nkə̀kú/	→	[jə̀ tə̀nkə̀kú]	'we pressed'
b.	/jə̀ tə̀mbə̀lú/	→	[jə̀ tə̀mbə̀lú]	'we pushed'
c.	/jə̀ bàzàrtú/	→	[jə̀ bàzàrtú]	'we shamed'

The generalization of the data in (26) and (27) by Schuh is shown in (28). Depressors block the spreading of H tone if the H tone crosses phrase boundaries.

(28) H tone spreading ('Low tone raising' in Schuh 2002, Handout#4:14)

L → H / H | ____
a. | indicates clitic phrase boundary or phonological phrase boundary
b. ***blocked*** if the L tone syllable begins with a voiced obstruent

The generalization adequately describes the depressor blocking effect in Western Bade. Given this, why is the spreading of H tone from the subject clitics to LH verbs blocked when there are intervening depressor consonants?

H tone spreading to LH tones in Western Bade produces a different result from that in Tsonga. In Tsonga, the H tone to LH tone spreading surfaces with a falling contour tone. However, H tone spreading results in a sequence of H tones in Western Bade.

The ranking in (29) expresses this point. The optimal candidate in (29a) satisfies both ALIGN-R and *CONTOUR, while it has a violation of IDENT-T. The candidate in (29b) violates both *CONTOUR and ALIGN-R. The faithful candidate in (29c) has more violations of ALIGN-R even though it does not violate *CONTOUR and IDENT-T. This candidate shows that ALIGN-R dominates both IDENT-T and UNIFORMITY-T. The candidate in (29d) has a contour tone in the final syllable, which incurs a crucial violation of *CONTOUR. The ranking between IDENT-T and UNIFORMITY-T is shown by candidate (29d). The optimal candidate violates the lower ranked UNIFORMITY-T constraint, which assigns violation marks to tones that coalesce in the output.

(29) H tone spreading in Western Bade

	H_1 L H_2 /nə́ tə̀nkə̀kú/	OCP	*CONTOUR	ALIGN-R	IDENT-T	UNIFORMITY-T
a.☞	$H_{1,2}$ [nə́ tə́n.kə́.kú]$_{H1,2}$				**	*
b.	H_1 L H_2 [nə́ tə́n.kə̂.kú]		W *	W *	L*	L
c.	H_1 L H_2 [nə́ tə̀n.kə̀.kú]			W ***	L	L
d.	H_1 L [nə́ tə́n.kə́.kû]		W *		W***	L
e.	H_1 H_2 [nə́ tə́n.kə́.kú]	W *		W *	**	L

Such H tone spreading in Western Bade is blocked when depressors (voiced obstruents) are present. The depressor effect emerges due to the markedness constraint *VOICEDOBSTRUENT/H, which bans voiced obstruents from associating with H tone. The tableau below shows that the optimal candidate is (30a). Both competing candidates in (30b-c) violate *VOICEDOBSTRUENT/H, even though they have fewer violations under ALIGN-R. As in Tsonga, the candidate in (31d) violates ROOTNODE→T (RN→T) because there are segments not in association to any tone in the output.

(30) Blocking of H tone spreading in Western Bade

	H_1 L H_2 /nə́ bàzàrtú/	RN→T	*CONTOUR	*VOICED OBSTR/H	ALIGN-R	IDENT-T	UNIFORMITY-T
a. ☞	H L H_2 [nə́ bà.zàr.tú]				***		
b.	$H_{1,2}$ [nə́ bá.zár.tú]			W **	L	W **	W *
c.	H_1 L H_2 [nə́ bâ.zàr.tú]		W *	W *	L*		
d.	H_1 L L H_2 [nə́ bà. zàr. tú]	W **			***		

This section has demonstrated that the constraints proposed for the analysis of Tsonga account for the typological differences in Western Bade. Unlike in Tsonga, H tone spreading to a LH tone verb does not result in contour tone; H + LH does not become H +H͡LH but instead it becomes H + H H. The ranking, in which ALIGN-R dominates IDENT-T, which in turn dominates UNIFORMITY-T, ensures that spreading of H tone can be achieved at the expense of changing the tonal values of underlying tone and fusing underlying tone. This spreading is blocked by the markedness constraint *VOICEDOBSTRUENT/H.

The ranking needed for blocking of H tone spreading in Western Bade is shown in (31). The heavy-lined box is the crucial ranking in Western Bade. From the discussion so far, no ranking has been established for other relevant constraints (outside of the heavy-lined box).

(31) Hasse Diagram: Western Bade depressors and H tone spreading

*VoicedObstruent/H
|
Align-R
|
IO-Ident-T
|
Uniformity-T

RootNode→T ; µ→ T
|
*TBU/T

*Contour, OCP

4.3.2 L tone spreading blocked by voiceless consonants

L tone spreading in Western Bade is blocked by voiceless consonants. In (32), the LH verbs are followed by a H noun [kórón] 'donkey'. When these verbs are followed by the H tone direct object, the final H of the verb becomes L tone: /LH + H/ → [LL + H]. The example in (32a) illustrates this phenomenon. In (32a), the verb /kə̀rə́/ 'stole' is followed by [kórón] 'donkey'. The final H tone of the verb becomes a L tone in the output as in [kə̀rə̀ kórón] 'stole a donkey', and not *[kə̀rə́ kórón].

However, L tone spreading to the verb-final H tone does not occur when the final syllable has voiceless obstruent onsets as in (32b). The LH verb /gàfá/ 'caught' is followed by the H tone noun [kórón] 'donkey'. The output retains the final H tone as [gàfá kórón] 'hid a donkey', and it does not become *[gàfà kórón] as we would expect.

(32) Data: (L)H Verb + H tone Noun (Schuh 2002, Handout#4:18)[11]

	L **L H H** H		L **L L H** H	
a.	/jə̀ kə̀rə́ kórón/	→	[jə̀ kə̀rə̀ kórón]	'we stole a donkey'
	L **L H H** H		L **L H H** H	
b.	/jə̀ gàfá kórón/	→	[jə̀ gàfá kórón]	'we caught a donkey'

In contrast, when the verbs are followed by a L tone initial noun like /dùwún/ 'horse', the L tone spreading does not occur at all. The output surfaces with the same tonal patterns as the input, as in (33).

(33) Data: (L)H Verb + L tone Noun (Schuh 2002, Handout#4:18)

	L **L H L** H		L **L H L** H	
a.	/jə̀ kə̀rə́ dùwún/	→	[jə̀ kə̀rə́ dùwún]	'we stole a horse'
	L **L H L** H		L **L H L** H	
b.	/jə̀ gàfá dùwún/	→	[jə̀ gàfá dùwún]	'we caught a horse'

The generalization on L tone spreading is described by Schuh as in (34). The phrasal boundaries are crucial to this generalization, as it was in (28). Spreading of L tone is blocked when the condition in (34b) is satisfied, in which the H tone syllable of a verb begins with a voiceless obstruent.

(34) L tone spreading (Schuh 2002, Handout#4:17)

H → L / L___ | H

a. | indicates complement phrase of phonological phrase boundary

b. ***blocked*** if the H tone syllable begins with a voiceless obstruent[12]

[11] Verbs in Western Bade are at most two syllables due to morphological restrictions (Russell Schuh, p.c.).

[12] In Ngizim, different set of consonants block this rule. High tone lowering is blocked by voiceless and glottalized segments, and allowed by voiced obstruents and sonorants. For further discussion on disparity of consonants applied to a rule among different languages, see chapter 6.

In sum, in (35b), the final syllable of LH verb /kə̀rə́/ ‘stole’ is faithfully mapped with H tone when followed by a L noun ([dùwún] ‘horse’). However, when followed by a H noun ([kórón] ‘donkey’), the final syllable of the LH becomes L tone as in (37a).

(35) L tone spreading

	L L **H H** H		L L **L H** H	
a.	/jə̀ kə̀rə́ kórón/	→	[jə̀ kə̀rə̀ kórón]	‘we stole a donkey’
	L L **H L** H		L L **H L** H	
b.	/jə̀ kə̀rə́ dùwún/	→	[jə̀ kə̀rə́ dùwún]	‘we stole a horse’

First, the L tone spreading before another H tone in (35a) is due to the avoidance of OCP violations. Because the H tones are adjacent in the input, the former one lowers to avoid two adjacent H tones in the output. While the second H tone could lower to resolve the OCP, this might not occur due to a positional faithfulness constraint that preserves the tone on the initial syllable after a boundary. Here, I will analyze the preservation of the H tone of the first syllable in [kórón] ‘donkey’ as being due to IDENT-T-σ_1, which is violated if the tone of the first syllable is changed. The definition of the constraint is below the tableau in (36).

The optimal candidate in (36a) violates the general IDENT-T constraint because of the change of H tone to L tone in the LH verb. The competing candidate in (36b) changes the initial H tone of the H noun, and violates the positional faithfulness constraint IDENT-T-σ_1. The faithful candidate in (36c) satisfies both faithfulness constraints, but it crucially violates the markedness constraint OCP.

(36) L tone spreading due to OCP

	Input	OCP	IDENT-T-σ_1	IDENT-T
	L L H_1 H_2 /jə kərə́ kórón	OCP	IDENT-T-σ_1	IDENT-T
a. ☞	L H_2 [jə̀ kə̀.rə̀ kó.rón]			*
b.	L H_1 L H_2 [jə̀ kə̀.rə́ kò.rón]		W*	*
c.	L H_1 H_2 [jə̀ kə̀.rə́ kórón]	W*		L

(37) IO-IDENT-T-σ_1

Corresponding segments, in the first syllable of a prosodic domain, associated to a mora have identical values for the tonal feature T_F. If x is a mora in the input and y is a mora in the output from $x\Re y$, x is $[\gamma T_F]$, then y is $[\gamma T_F]$.

The L tone spreading, however, is blocked if a H tone syllable begins with a voiceless obstruent. In (38a), the LH verb [gàfá] 'caught' is followed by a H noun [kórón] 'donkey'. Unlike (35a), the final H in the verb is not lowered. Following Schuh's (2002) description, the L tone does not spread because of the voiceless obstruent [f] that begins the H tone syllable.

(38) Blocking of H tone to L tone by voiceless obstruents

	H **H**		**H** **H**	
a.	/jə̀ gàfá kórón/	→	[jə̀ gàfá kórón]	'we caught a donkey'
	H **L**		**H** **L**	
b.	/jə̀ gàfá dùwún/	→	[jə̀ gàfá dùwún]	'we caught a horse'

Formally speaking, the voiceless obstruents are not allowed to have a L tone in the output if the L tone is due to a change from the H tone. There could be the markedness constraint *VOICELESSOBSTRUENT/L, which bans voiceless obstruents from forming a dependency relationship with L tones. The ranking below shows how the competing candidate in (39b) is ruled out by this constraint.

(39) H tone lowering is blocked

	L L H H /jə̀ gàfá <u>kó</u>rón/	*VOICELESS OBSTR/L	IDENT-T-σ_1	OCP	IDENT-T
a. ☞	L H H [jə̀ gà.fá <u>kó</u>.rón]			*	
b.	L H H [jə̀ gà.fá <u>kó</u>.rón]	W*		L	W*
c.	L H L H [jə̀ gà.fá <u>kò</u>.rón]		W*	L	W*

However, the proposed constraint has potential problems. If *VOICELESSOBSTRUENT/L dominates IDENT-T by transitivity (see (36) for OCP dominating IDENT-T), no voiceless obstruents in Bade can occur with L tone, which is not the case. An example like [jə̀ tə̀nkə̀kú] 'we pressed' demonstrates that voiceless obstruents can occur with L tone.

I suggest that the preservation of input L tone can be achieved by faithfulness constraints such as IDENT-[+UPPER] and IDENT-[+LOWER], which target high tone and low tone respectively. Suppose that IDENT-[+LOWER] outranks *VOICELESSOBSTR/L, which in turn outranks IDENT-[+UPPER]. Under such a ranking, the low tone on voiceless obstruents (as underlined) in an input like /jə̀ <u>**tə̀nkə̀**</u>kú/ should be preserved in the output.[13]

The phonetic account will have shortfalls to explain this pattern for the same reasons as above because voiceless obstruents only block L tone when the L tone is derived from a H tone, a phenomenon to which phonetics is not sensitive.

4.3.3 Summary

This section has shown that consonant-tone interaction in Bade has richer patterns than Tsonga. Not only is H tone spreading is blocked by voiced obstruents (depressors), but also L tone spreading is blocked by voiceless obstruents. The blocking by voiced obstruents is due to the high ranked *VOICEDOBSTRUENT/H constraint, which bans voiced obstruents from having a dependency relationship with a H tone in the output. The blocking by voiceless obstruents is analyzed with the *NOVOICEDOBSTRUENT/L, which bans voiceless obstruents from being associated with a L tone in the output.

As for the general case of H tone spreading, Bade does not have falling contour tones when the spreading occurs to LH verbs (unlike Tsonga). This is analyzed with a ranking in which IDENT-T is dominated by ALIGN-R. This ranking allows the change of an underlying tone as well as spreading of H tone. Furthermore, L tone spreading is motivated by the OCP constraint.

The significance of Western Bade lies in the fact that consonant-tone interaction is not limited to the so-called depressor type consonants, which will become more evident when Asian languages are discussed in chapter 5, in which most consonant-tone interaction is found in phonetically pitch-raising consonants (such as glottalized or aspirated consonants), and not phonetically pitch-lowering consonants. Further discussion

[13] I am indebted to Akinbiyi Akinlabi (p.c.) for suggesting this analysis.

of different types of consonants in consonant-tone interaction will be deferred until section 6.2.

4.4 Conclusion

In this chapter, the blocking of H tone spreading in Tsonga and Bade is presented and analyzed. Moreover, cross-linguistic data of depressor blocking are shown. In a formal sense, the blocking of H tone spreading by depressors is due to the markedness requirement of *VOICEDOBSTRUENT/H. This constraint is antagonistic to depressors (e.g. voiced obstruents) that form a dependency relationship with H tones.

Two types of blocking are found in Western Bade. In addition to the blocking of H tone by depressors, voiceless obstruents also block L tone spreading. This illustrates that consonant-tone interaction is not only found in pitch-lowering consonants (depressors), but also in other types of consonants, a point that will be discussed further in chapter 5.

Cross-linguistic data of H tone spreading show that depressors may block contour tone formation (40a), result in a single H tone in the output (40b), or separate H tones in the output (a downstep condition) (40c). When depressors are present, no such spreading occurs as in (40d).

(40) H tone spreading to LH words

a.	H + L H	→	H L H | \ | | σ σ σ	*contour tone*	Tsonga
b.	H + L H	→	H /\ \ σ σ σ	*single H tone*	Western Bade
c.	H + L H	→	H ꜜH /\ | σ σ σ	*separate H tones (downstep)*	Dagara
	Depressors effect				
d.	H + L H	→	H L H | | | σ Dσ σ		

Chapter 5 Tone neutralization by consonants

5.1 Introduction

Chapter 4 showed how consonants can block tonal spreading. Chapter 5 focuses on how consonants can impose restrictions on tone in particular environments. The effect of these restrictions is to neutralize tonal contrast, called 'tone neutralization'. Tone can be neutralized by consonants that are in onsets, in codas, or in both positions.

In Mulao, a language spoken in the Guangxi Zhuang Autonomous Region in southwestern China, syllables with aspirated onsets only occur with high register tone. In (1a), the onset of the syllable is an aspirated stop [p^h]. If such onsets occur in a syllable, the syllable never surfaces with a low register tone, as illustrated in (1b).

(1) Onsets and tone neutralization in Mulao

a. [**<u>p^h</u>**$ó^{44}$]	'bed'	H tone
b. *[**<u>p^h</u>**o]		L tone

Tone can also be restricted by coda consonants. In Burmese, a syllable with a glottal stop coda only occurs with a low tone as shown in (2a). If a glottal stop coda is present, the syllable never surfaces with a high tone as in (2b).[1]

(2) Tone neutralization by codas in Burmese

a. [k^hàʔ̠]	'to draw off'	L tone
b. *[k^háʔ̠]		H tone

[1] Unlike in Mulao, aspirated onsets do not play a role in Burmese. In other words, the constraint, which forces high tone realization in (1a), is violable.

As outlined in chapter 3, this type of consonant-tone interaction is due to requirements in the output with respect to dependency relations between tone and consonants. Tone neutralization by consonants results from markedness constraints that ban such dependency relationships.

The relevant markedness constraints for the languages discussed in this chapter are shown in (3). Tone neutralization by onsets in Mulao is the result of two constraints outranking the faithfulness constraint IDENT-T: (3a) *[+SPREADGLOTTIS]/L and (3b) *[+CONSTRICTEDGLOTTIS]/L. In Burmese, the constraint *[+CONSTRICTEDGLOTTIS]/H in (3c) plays a crucial role in neutralization by codas. The crucial markedness constraint in Thai is *[-SPREADGLOTTIS]/H in (3d). This constraint neutralizes the tone in the output.

(3) Important markedness constraints in this chapter

a. *[+SPREAD GLOTTIS]/L (*[+S.G.]/L) **Mulao** (section 5.2)
   No consonant specified as [+S.G.] associates with a low tone in the output.

b. *[+CONSTRICTED GLOTTIS]/L (*[+C.G.]/L) **Mulao** (section 5.2)
   No consonant specified as [+C.G.] associates with a low tone in the output.

c. *[+CONSTRICTED GLOTTIS]/H (*[+C.G.]/H) **Burmese** (section 5.3)
   No consonant specified as [+C.G.] associates with a high tone in the output.

d. *[-SPREAD GLOTTIS]/H (*[-S.G.]/H) **Thai** (section 5.4)
   No consonant specified as [-S.G.] associates with a low tone in the output.

All constraints in (3) mention a laryngeal feature other than voicing, showing that voicing is not the only feature in consonants that influences tone. Chapter 6 presents a detailed discussion of the relationship between these laryngeal features and tone.

This chapter presents tone neutralization in a wide variety of languages spoken in

Asia. First, Mulao provides evidence for onset-driven neutralization in section 5.2. Second, Burmese shows coda-driven neutralization in section 5.3. Third, Thai will demonstrate a case in which both onset and coda bring the tone neutralization in section 5.4. The rest of this section will briefly summarize the xTBU theory proposed in chapter 3.

5.1.1 xTBU theory

The interaction between consonants and tone follows from the claim that all segments are able to form a dependency relationship with tone (cf. Myers 1997: 851-853). While the claim that consonants are directly associated with a tone is contentious (Bradshaw 1995: 267-269), I argue that consonants and tone form a dependency relationship in the output.

Formally, consonant-tone interaction results from the requirement that all segments in the output must be associated to a tone, which is ensured by the markedness constraint ROOTNODE → T. This constraint assigns violation marks to segments that are not associated to any tone in the output (cf. Yip 2002: 83).

It is crucial to this proposal that there are no faithfulness constraints that preserve the dependency relationship between tones and consonants. The lack of such faithfulness constraints means that tones are never contrastive on laryngealized consonants. So, no language will have a contrast between [p̀ʰà] with low tone on the [pʰ] and [ṕʰà] with high tone on the [pʰ].

Consonant-tone interaction is the result of markedness constraints dominating tonal faithfulness constraints. The consonants marked with [+spread glottis] affect the tone of their syllables due to the markedness constraint *[+SPREADGLOTTIS]/L. This constraint assigns a violation mark to aspirated consonants that form a dependency relationship with a low register tone in the output domain.

The main points of Extended Tone Bearing Unit (xTBU) theory are summarized in (4).

(4) Extended Tone Bearing Unit (xTBU) Theory

a. Tones prefer to associate to moras. However, they can be forced to associate to consonant root nodes when no mora dominates them.

b. There are no faithfulness constraints that preserve tones that are underlyingly associated to consonants.

c. There is a set of markedness constraints with the form *[LARYNGEALFEATURE]/TONE; these constraints restrict consonant-tone interaction. (see (3))

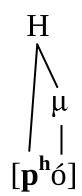
The tonal faithfulness constraints in (5) only target tone associated to prosodic nodes such as moras. In other words, these faithfulness constraints are never violated by tone that forms a dependency relationship with consonants. When the general IDENT-T constraint is used, it refers to both IO-IDENT-T in (5b) and OI-IDENT-T in (5c).

(5) Tonal faithfulness constraints (from chapter 3, section 3.2)

a.	DEP-T	Every mora *x* in the output has a corresponding mora associated to tone in the input.
b.	IO-IDENT-T	Corresponding segments associated to a mora have identical values for the tonal feature T_F. If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *x* is $[\gamma T_F]$, then *y* is $[\gamma T_F]$.
c.	OI-IDENT-T	Corresponding segments associated to a mora have identical values for the tonal feature T_F. If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *y* is $[\gamma T_F]$, then *x* is $[\gamma T_F]$.

The representation for syllables with an aspirated onset is shown in (6). An association line between the tone H and a consonant [p^h] indicates the dependency relationship between the tone and a segment (consonantal root node), while an association line between the tone H and the moraic node μ shows the anchor relationship (cf. Myers 1997).

(6) Representation of tone with respect to root nodes and moras



5.2 Tone neutralization by onsets: Mulao[2]

In Mulao, onset consonants force tone to neutralize on a following mora. Markedness constraints on the consonant-tone relationship require high register tone in syllables with aspirated onsets. I argue that the apparent co-occurrence restriction between an aspirated onset and a low register tone is in fact due to active constraints in the grammar that penalize aspirates from associating to a low tone in the output.

Jerry Edmonson provided me with a tape recording of Mulao data. The consultant was Ms. Huiling Pan (潘慧玲), who was recorded in Beijing, China on November 10, 1986. Ms. Pan confirmed all the Mulao data presented below.

There are other laryngealized onsets that behave in much the same way as aspirates in Mulao. Onset glottals and voiceless sonorants do not co-occur with low register tone, either. In (7), examples of words with such onsets are presented. As shown in the column

[2] An earlier version of this section was presented at the 17th Southeast Asian Linguistics Society. I would like to thank to participants of SEALS 17 for their insightful and helpful comments.

(7b), syllables with these onsets do not occur in low register tone. The laryngealized consonants in (7) will be called ‘*elevator consonants*’[3] because they favor higher tone (contrasting with ‘depressors’, which favor lower tone). H stands for high tone, and L stands for low tone.

(7) Onsets (‘*elevators*’) that require a high tone[4]

		a. high tone		b. low tone
Aspirates	[kʰ]	[**kʰ**ɛːk^{42}]	‘guest’	*[kʰɛːk^{11}]
	[pʰ]	[**pʰ**o^{44}]	‘bed’	*[pʰo^{11}]
Glottals	[ʔ]	[**ʔ**uk^{55}]	‘to exit’	*[ʔuk^{11}]
	[ʔj]	[**ˀj**em^{42}]	‘to borrow’	*[ʔjem^{11}]
Voiceless sonorant	[n̥]	[**n̥**ɔ^{53}]	‘rat, mouse’	*[n̥ɔ^{11}]

Mulao syllables can also have onsets that are sonorants or voiceless stops as in (8). These onsets occur in both high and low tone registers. Each row in (8) shows tonal minimal pairs. For example, the first row shows that the glide [j] can occur with a high tone (e.g. [já] ‘cloth’), or with a low tone ([jà] ‘also’). There is no tonal restriction related to these non-laryngealized consonants.

(8) Onsets that do not require a high tone

		a. high tone		b. low tone	
Sonorants	[j]	[**j**a^{42}]	‘cloth’	[**j**a^{11}]	‘also, too’
	[l]	[**l**au^{44}]	‘snail’	[**l**au^{11}]	‘to leak’
Voiceless	[k]	[**k**uŋ^{53}]	‘stalk, stem’	[**k**uŋ^{121}]	‘grasshopper’
	[p]	[**p**aːk^{42}]	‘mouth’	[**p**aːk^{11}]	‘white’
	[t]	[**t**aŋ^{44}]	‘stool’	[**t**aŋ^{24}]	‘to stand’

[3] I am indebted to Marc Brunelle and Susan M. Burt for suggesting this term to me.
[4] All data come from Wang and Zheng (1993), which is based on the Dayin variety of Mulao. The superscript numbers are tones marked in Chao tone letters, in which number 1 represents the lowest pitch, and number 5 is the highest pitch (Chao 1930).

The consonant-tone restriction in Mulao is not unexpected; the laryngealized consonants in (7) have been shown to have pitch raising properties (cf. Hombert et al. 1979, Jun 1998).

The structure of the rest of this section is as follows. In section 5.2.1, the basic phonology and tonology of Mulao is presented. An analysis of consonant-tone interaction in Mulao is presented in section 5.2.2. It is the markedness constraints *[+SPREADGLOTTIS]/L and *[+CONSTRICTEDGLOTTIS]/L that ban laryngealized consonants in (7) from being associated with low tone. These two constraints outrank the tonal faithfulness constraints.

5.2.1 Consonants and tone in Mulao

In (9), the elevating consonants of Mulao that require H tone in the output are listed. Non-elevating consonants are listed in section 6.2. All other Mulao consonants allow a high-low contrast to follow them. Onsets can also be labialized, palatalized or uvularized in Mulao. The analysis in this section is not affected by these onsets with secondary articulations (see Wang and Zheng 1993 for details).

(9) High tone requiring consonants ('*elevators*') (Wang and Zheng 1993: 4-5)

	labial	alveolar	palatal	velar	glottal
stops	p^h	t^h	c^h	k^h	ʔ
fricatives[5]	f	s	ç		h
affricates		$ʦ^h$			
nasals	m̥	n̥	ɲ̊	ŋ̊	
glides, liquids	ˀw	l̥	ˀj	ˀɣ	

[5] Fricatives assumed to be specified as [+spread glottis]. This follows an independent observation made in Armenian by Vaux (1998), in which fricatives pattern together with aspirates.

Mulao coda consonants do not influence tone. There are six possible codas [p, t, k, m, n, ŋ]. As expected, these consonants do not impose any tonal restrictions: they are not elevators (see (9)). As discussed below, no markedness constraint that drives tone neutralization via these codas outranks the tonal faithfulness constraint (IDENT-T).[6]

Mulao tone

The tonal inventory of Mulao is presented in (10). Mulao has high register tone and low register tone. Each register has a level tone and two types of contour tones. This classification of tone is based on tonal models proposed in Bao (1990) and adopted in Yip (2002). The high level tone may surface with 55 or 44 depending on the presence of an obstruent coda. In syllables with an obstruent coda, the tone is 55. In syllables with no obstruent coda, the tone is 44.

There are two types of contour tones in Mulao. In the high register, there is a high falling tone 53 and a mid falling tone 42 contrast as shown by the minimal pairs in (11a-f). In the low register, contour tones such as mid rising 24 and low rising tone 12 contrast, shown in (11g-i). The following discussion of Mulao will focus solely on register tone, since the sub-register tonal divisions are not influenced by consonants.

[6] In other languages codas may affect tone, such as in Burmese (see section 4.3). Codas, however, interact with tone based on their moraic status. For relevant studies on the interaction between codas and stress, see Elías-Ulloa (2006) for Capanahua and Morén (1999) for Kashmir.

(10) Tonal inventory[7]

register	***level***	***contour (falling)***	
High	55 / 44	53	42
	level	***contour (rising)***	
Low	11	24	12(1)

(11) Tonal minimal pairs - contour tones (Wang and Zheng 1993: 103-132)

	42	(*mid fall*)	**53**	(*high fall*)
a.	[can]	'0.5 kilogram'	[can]	'tight'
b.	[ça]	'thatch grass'	[ça]	'not heavy'
c.	[hui]	'fruit'	[hui]	'to dip out (water)'
d.	[hɣaːu]	'we'	[hɣaːu]	'daughter-in-law'
e.	[jam]	'deep'	[jam]	'to dye'
f.	[ku]	'aunt'	[ku]	'drum'
	121	(*low rise-fall*)	**24**	(*mid rise*)
g.	[la]	'gong'	[la]	'to look for'
h.	[lɔŋ]	'stomach'	[lɔŋ]	'wooden case'
i.	[mu]	'animal's dropping'	[mu]	'aunt'

5.2.1.1 Traditional analyses of Mulao tone

The phonological analysis of Mulao tones differs from traditional analyses, which have proposed the ten tones in (12). The 'odd-numbered' tones in (12a) belong to the high register, and even-numbered tones in (12b) belong to the low register. The highlighted row in the middle shows the phonetic pitch in Chao tone letters (cf. Chao 1930).

[7] Mulao has a falling contour tone in high register, and a rising contour tone in low register. In historical phonology, Ferlus (2006: 11) argues from reconstruction that low pitch is related to raising in vowels, and that high pitch is related to lowering in vowels. This reconstruction results from comparing Southeast Asian languages to Old Chinese.

(12) Description of tones in Mulao (Wang and Zheng 1993: 13)

a.	ODD	1	3	5	7 short	7 long
	pitch	**42**	**53**	**44**	**55**	**42**
	description	mid fall	high fall	mid level	high level	mid fall
b.	EVEN	2	4	6	8 short	8 long
	pitch	**121**	**24**	**11**	**12**	**11**
	description	low rise-fall	mid rise	low level	low rise	low level

Although ten tones were proposed in (12), there are only six contrasts. For example, mid level (44) and high level (55) do not contrast, leading me to posit a single high register level tone. Tone 7 and tone 8 mark tones in syllables with voiceless stop codas (CVO syllables). These syllables allow high tone and low tone. The status of CVO syllables is presented in the discussion about Thai in section 5.4.2.

While phonetic tonal descriptions like those in (12) are an important reference in understanding the tonal inventory, the phonetic tones cannot necessarily be related one-to-one to phonological tones (see Maddieson 1978). Some phonetic tonal divisions do not participate in lexical contrasts, and some are due to incidental pitch perturbations. For example, in his phonological analysis, Chen (2000: 17-19) acknowledges that the phonetics of citation tones in Jianyang is a confounding fact because the phonetic data can result from “the final lowering” or “the undershooting of phonological targets”. Yip (2002: 21-24) also provides relevant discussion.

5.2.3 Analysis: Tone neutralization by onsets

In Mulao, the tone neutralization by elevating consonants (aspirates and glottals, voiceless sonorants and fricatives) in an onset position results from the markedness requirement on a dependency relationship between these consonants and tone in the output.

In (13), crucial points for an analysis of Mulao are illustrated. In the output, syllables with elevator onsets must have a H tone. In other words, an input with an elevator and a high tone as in (13a) and an input with an aspirate and a low tone as in (13b) should always surface with a H tone in the output.

In contrast, non-laryngealized onsets do not have such a requirement. Thus, tone in the input surfaces faithfully in the output. Inputs with high tone have high tone outputs as in (13c), and inputs with low tone have low tone outputs as in (13d).

(13) The analysis should account for:

onsets		*input*			*output*			
laryngealized	a.	/c^{h}v́/	high	→	[ć^{h}v́]	high		[**p^h**o^{44}] 'bed'
	b.	/c^{h}v̀/	low	→	[ć^{h}v́]	***high***		*unattested*
non-laryngealized	c.	/cv́/	high	→	[ćv́]	high		[**j**a^{42}] 'cloth'
	d.	/cv̀/	low	→	[c̀v̀]	low		[**j**a^{11}] 'also'

- 'c' stands for consonants, 'v' for vowels, '^{h}' for aspirates
- acute accent '´' for high tone, grave accent '`' for low tone.

First, onsets that allow both high and low tone as in (13c-d) are analyzed. The output tone remains faithful to the input due to tonal faithfulness constraints that preserve the tone. Second, the neutralization to high tone in syllables with laryngealized onsets as in (13a-b) is analyzed. In the neutralization, markedness constraints on tone and consonants outrank tonal faithfulness constraints.

Faithful realization of tone

In syllables with non-laryngealized onsets H tone inputs surface faithfully with a high tone and L tone inputs surface faithfully with a low tone. The faithful realization of input tones in the output is possible because there are no markedness constraints that block the faithful realization of tone when these onsets are present.

An input with a L tone as in (14) surfaces faithfully because the input tone cannot be changed due to IDENT-T (defined in (5)), and every segment must be associated to a tone because of ROOTNODE-T. An input with a H tone also maps faithfully as in (15) due to these constraints.[8]

(14) L tone input

	L | μ | /jà/ 'also'	IDENT-T	RN→T	*TBU/T
a. ☞	L /| [jà]			**
b.	L | [ja]		W*	L*
c.	H /| [já]	W*		**

[8] In each comparative tableau, asterisks indicate violation profiles. 'W' means that the optimal candidate is the winner under a constraint. 'L' means that the optimal candidate loses against other candidates under a constraint. In each row of the tableau, all L's should be dominated by at least one W. See Prince (2002).

(15) H tone input

	H | μ | /já/ 'cloth'	IDENT-T	RN→T	*TBU/T
a. ☞	H /| [já]			**
b.	H | [ja]		W*	L*
c.	L /| [jà]	W*		**

The faithful realization of input tone in syllables with non-laryngealized onsets is because there is no constraint that restricts the association between these consonants and tone. A hypothetical input /ja/ with no tone must have a tone in the output because ROOTNODE→T outranks *TBU/T as in (16b).

(16) Hypothetical toneless input

	/ja/	DEP-T	RN→T	*TBU/T
a. ☞	L /| [jà]	*		**
b.	L | [ja]	*	W*	L*
c. ☞	H /| [já]	*		**

Further phonological evidence is necessary in order to determine whether L tone (16a) or H tone (16c) would be associated to the toneless input.

Syllables with elevator onsets

Unlike the non-laryngealized onsets, laryngeally marked onsets (‘*elevator onsets*’) in Mulao must be realized with H tone in the output. In other words, inputs with H tone surface faithfully with the H tone in the output, while hypothetical L tone inputs map unfaithfully to a H tone in the output. Thus, the analysis should account for the neutralization to H tone that takes place when inputs have L tone.

I argue that this neutralization is due to the markedness requirement on the elevating consonants, which outranks the tonal faithfulness constraints (such as IDENT-T). An input with H tone will surface faithfully because there is no antagonistic markedness constraint that blocks such an output from being optimal.

First, an input with a low tone will be examined. L tone inputs surface with H tone. The optimum in (17a) has H tone due to the higher ranked constraints: ROOTNODE→T and *[+SPREADGLOTTIS]/L (defined in (18)). The candidate in (17a) violates IDENT-T because the input low tone has changed to high tone in the output. The faithful candidate in (17b) has a violation of the markedness constraint *[+SPREADGLOTTIS]/L. The candidate in which the elevating onset is not associated to tone, as in (17c), violates ROOTNODE→T, which assigns violation marks to segments not associated to tone.

(17) An input with L tone

	L | μ | /pʰò/	RN→T	*[+S.G.]/L	IDENT-T
a. ☞	H [pʰó]			*
b.	L [pʰò]		W*	L
c.	L | [pʰò]	W*		L

(18) *[+SPREADGLOTTIS]/L (*[+S.G.]/L)

No consonant specified as [+SPREADGLOTTIS] associates to L tone in the output.

The constraint ROOTNODE→T must dominate DEP-T (defined in (5)) if we consider an input with no tonal specification as in (19). The optimal output must be in a high tone domain as in (19a). The faithful candidate in (19b) incurs two violations under ROOTNODE→T because no segments in the output belong to any tonal domain. This candidate, however, is more harmonic under DEP-T. The output cannot be a low tone domain as in (19c) because such a candidate violates the markedness constraint *[+SPREADGLOTTIS]/L.

(19) An input with no underlying tone

	/p^ho/	*[+S.G.]/L	DEP-T	RN→T	*TBU/T
a. ☞	H ╱| [$\mathbf{p}^{\mathbf{h}}$ó]		*		**
b.	H | [p^ho]		*	W*	L*
c.	L ╱| [$\mathbf{p}^{\mathbf{h}}$ò]	W*	*		*

Let's consider a hypothetical input with L tone on an elevator onset (it is essential to consider such an input due to Richness of the Base). The input should not surface faithfully. The faithful candidate in (19b) is not the optimum because it violates the higher ranked constraint *[+SPREADGLOTTIS]/L; the laryngeally marked onset is associated to the L tone.

(20) L tone on elevator onsets (a hypothetical input)

	L H | | | μ | | /p̀^{h} ó/	*[+S.G.]/L	IDENT-T
a. ☞	H ╱| [$\mathbf{p}^{\mathbf{h}}$ó]		
b.	L H | | [p^h ó]	W*	

In the candidate (20a), IDENT-T is not violated by the winner even though the dependency relationship between consonants and tone has changed. As proposed and defined in chapter 3, this is because tonal faithfulness constraints do not target tones associated to segments that are not TBUs.

The change of laryngeal specification of onsets or the deletion of an onset in order to satisfy *[+SPREADGLOTTIS]/L are not tolerated either, as shown in (21). The faithfulness constraint IDENT(LAR) is violated if consonants change their laryngeal specification as in (21b). If the onset antagonistic to *[+SPREADGLOTTIS]/L is deleted as in (21c), the faithfulness constraint MAX-SEGMENT is violated.

(21) Faithful to the laryngeal feature

	L | μ | /p^hò/	MAX-SEG	IDENT-LAR	*[+S.G.]/L	IDENT-T
a. ☞	H ╱| [$\mathbf{p^h}$ó]				*
b.	L ╱| [p^hò]			W*	L
c.	L ╱| [pò]		W*		L
d.	L | [ò]	W*			L

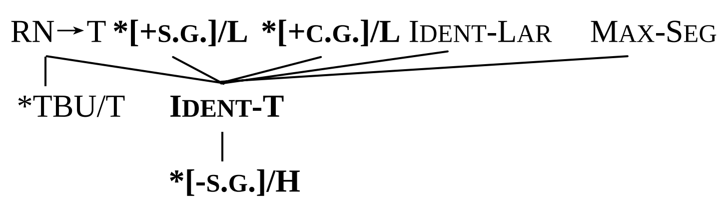
In this subsection, I have presented an analysis of tone neutralization by onsets in Mulao. The crucial ranking is that *[+SPREADGLOTTIS]/L outranks IDENT-T.

5.2.4 Summary

Mulao has laryngealized onsets, and the constraint *[+SPREADGLOTTIS]/L forces them to be associated with H tone; this phenomenon is termed tone neutralization by onsets. The laryngealized onsets are aspirates, voiceless sonorants and fricatives (all [+spread glottis]), and glottals ([+constricted glottis]). This high tone neutralization is argued to be a phonological restriction imposed by constraints that regulate the consonant-tone interaction. Markedness constraints ban laryngealized onsets (dubbed as '*elevators*') from associating to L tone.

The Hasse diagram in (22) shows the ranking discussed so far. The *[+SPREADGLOTTIS]/L constraint and the *[+CONSTRICTEDGLOTTIS]/L constraint disfavor any candidate that has L tone associated with elevating consonants (aspirates and glottals, voiceless sonorants and fricatives). This markedness constraint must dominate the faithfulness constraint IDENT-T. Other constraints also outrank IDENT-T: such as ROOTNODE→T, IDENT-LAR, and MAX-SEG. In Mulao, preserving the underlying tone of a moraic TBU is not the top priority. As a result, Mulao speakers require syllables with an elevator consonant to associate to H tone.

(22) Ranking in Mulao



5.3 Neutralization of tone by codas: Burmese[9]

This section discusses tone mapping restricted by coda consonants. In Burmese, syllables with a glottal stop coda only occur with a L tone. Thus, an input H tone in a syllable with

---

[9] An earlier version of this section was presented at the 43th Chicago Linguistic Society. I would like to thank participants of CLS 43 for their comments. The analysis substantially changed since the presentation.

a glottal stop coda must unfaithfully map to L tone. I will argue that this is due to the markedness constraint *[+CONSTRICTEDGLOTTIS]/H (targeting glottal stops in particular). This constraint is violated if a glottal stop is associated to a H tone.

I recorded two Burmese consultants in New York City: Khin Maung Gyi, a male in his 60s from Nyaung Shwe, and Thuya Maung, a male speaker in his 20s from Yangon (Rangoon). These consultants confirmed the Burmese data presented below. I elicited the data from Khin Maung Gyi and measured it.

The effect of coda consonants (especially the glottal stop) on the tones of the preceding vowel has also been reported in other tonal languages. For example, Lahu, a Lolo-Burmese language, has five tones in open syllables but only two in syllables with a glottal stop coda (Matisoff 2003). San Martín Itunyeso Trique, a Mixtecan language, has only level tones in syllables with a glottal stop coda, while other syllable types allow contour tones (DiCanio 2006). Phonetic studies of Eastern Cham (Brunelle 2005)[10] and a comparative study of Kuki-Chin languages (Hyman 2007) also discuss various issues about the relationship between coda consonants and tone.

The tone neutralization by codas in Burmese is analyzed as a result of the markedness constraint *[+CONSTRICTEDGLOTTIS]/H outranking the tonal faithfulness constraint IDENT-T, which preserves the input tonal specification. Moreover, it will be shown that syllables with creaky phonation also neutralize an input tone. As a result, creaky syllables are required to be associated to L tone by the markedness constraint *[+CONSTRICTEDGLOTTIS]/H.

As presented in section 5.1.1, this analysis crucially assumes that consonants (or

[10] Brunelle (2005), however, suggests that the phonological relationship between codas and tones on Eastern Cham is not as regular as previous work has suggested.

phonation) have a dependency relationship with tone when they are associated to tone, and that no faithfulness constraints preserve such a relationship. Faithfulness constraints such as IDENT-T only target prosodic TBUs (i.e. moras).

This section is organized as follows. In section 5.3.1, the consonant inventory and tonal distribution are presented. Tone neutralization by glottal stop codas and creaky phonation will be analyzed in section 5.3.2. The final section confirms the status of glottal stop codas in Burmese, which has been presented in different ways in previous studies.

5.3.1 Consonants and tone in Burmese

Burmese consonants are presented in (23). Crucial to the subsequent analysis is the fact that it is only the glottal stop that is specified with [+constricted glottis] in Burmese.[11]

(23) Consonants (Green 2005: 4)

	bilabial	dental	alveolar	palatal	velar	glottal
stop/affricate	p b		t d	ʧ ʤ	k g	ʔ
aspiration	pʰ		tʰ	ʧʰ	kʰ	
fricative		θ (ð)	s sʰ z	ʃ		h
nasal	m̥ m		n̥ n	ɲ̥ ɲ	ŋ̊ ŋ	
liquid/glide	(w̥) w		ɬ (r) l	j		

Burmese tone

Burmese has two phonological tones in the output: high and low. High tone as in (24a) and low tone as in (24b) occur in open syllables and in syllables with a nasal coda.

[11] Consonants in parentheses are commonly used in loanwords but rarely in native Burmese words.

Burmese tone has been described to include killed tone (stop tone) as in (24c) and falling tone (creaky tone) as in (24d). Low tone is marked with a grave accent, high tone with an acute accent, and creaky phonation with a tilde under the vowel.

(24) Burmese tone, phonation, and glottal stop (confirmed by Khin Maung Gyi)

			(Okell 1969)	(Watkins 2000)
a.	k^há	'be bitter'	high	high
b.	k^hà	'to shake'	low	low
c.	k^haʔ	'draw off'	killed	stop
d.	k^ha̰	'fee'	falling	creaky

The focus of the current section lies in the examples in (24c) and (24d). In the following section 5.3.2, the stop tone in (24c) is analyzed as tone neutralization induced by a glottal stop coda. In addition to the stop tone, the creaky phonation in (24d) is also analyzed as tone neutralization by the markedness constraint *[+CONSTRICTED GLOTTIS]/H.

5.3.2 Tone neutralization by codas

Burmese has contrastive H and L tone. This contrast is neutralized when a glottal stop coda is present in a syllable. I will represent such syllables as CVO syllables. I argue that the grammar conspires in such a way that CVO syllables only surface with L tone.

The neutralization in CVO syllables results from the markedness constraint *[+CONSTRICTEDGLOTTIS]/H, which bans glottal stops (and creaky vowels) from being associated with H tones in the output.

Faithful realization of H tone and L tone

In Burmese, H tones and L tones must be faithfully mapped in the output. An input with a H tone surfaces with H tone, and an input with a L tone surfaces with L tone. The ranking in (25) shows that IDENT-T and ROOTNODE→T outrank *[+SPREADGLOTTIS]/H, which is violated by a segment specified with [+spread glottis] associating to H tone in the output.

(25) Faithful mapping of H tone

	H | /k^{h}á/	IDENT-T	RN→T	*[+S.G.]/H	*TBU/T
a. ☞	H /| [k^{h}á]			*	**
b.	L /| [k^{h}à]	W*		L	**
c.	H | [k^{h}á]		W*	L	L*

The faithfulness constraint outranks the markedness constraint *[+SPREADGLOTTIS]/H, which was crucial to the analysis of Mulao in section 5.2. If this constraint outranked IDENT-T, Burmese would not allow high tone in syllables with aspirated onsets. However, aspirated onsets can associate to H tone.

Neutralization to L tone before a glottal stop

In syllables with a glottal stop coda (CVO syllables), underlying tone neutralizes to L tone. In other words, input L tone maps faithfully as L tone, whereas input H tone maps unfaithfully as L tone. The unfaithful mapping arises because the markedness constraint

*[+CONSTRICTEDGLOTTIS]/H, which bans a glottal stop from associating to H tone, outranks the tonal faithfulness constraint IDENT-T.

In (26), the ranking for tone neutralization is presented. The optimal candidate in (26a) violates IDENT-T because the input tone is not faithfully mapped in the output. The faithful candidate in (26b) violates *[+CONSTRICTEDGLOTTIS]/H because the glottal stop is associated with H tone. Candidates in (26c) and (26d) do not violate *[+CONSTRICTED GLOTTIS]/H. However, the candidate in (26c) violates MAX-SEGMENT because the input glottal stop is deleted, and the candidate in (26d) violates ROOTNODE→T because the glottal stop does not belong to a tonal domain in the output.

(26) Neutralization to L tone in H tone input

	H | /kʰáʔ/	RN→T	MAX-SEG	*[+C.G.]/H	IDENT-T
a. ☞	L /|\ [kʰàʔ]				*
b.	H /|\ [kʰáʔ]			W*	L
c.	H /| [kʰá]		W*		L
d.	H /| [kʰáʔ]	W*			L

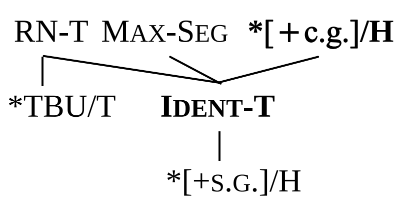
Under this ranking, a CVO syllable in Burmese surfaces with L tone. The neutralization to L tone by glottal stop codas is demonstrated by a hypothetical CVO input with a high tone.

The markedness constraint *[+CONSTRICTEDGLOTTIS]/H has phonetic grounding as well. Watkins (2000) shows that the fundamental frequency of syllables with a glottal stop is realized phonetically with a drastic pitch lowering with in the syllable. While the F0 measured by Watkins demonstrates that the onset of the measured F0 in glottal stop syllables is higher than the high tone, the large F0 drop after the onset shows that glottal stops do not prefer such a high tone. Phonetically, the pitch lowering in glottal stops is probably due to the creaky phonation of the glottal stop.

Ranking: Burmese

In (27), the ranking discussed in this section is presented in a Hasse diagram. In Burmese, the crucial ranking for tone neutralization results from *[+CONSTRICTEDGLOTTIS]/H outranking IDENT-T. The faithfulness constraint dominates the markedness constraint *TBU/T, which bans tone in general.

(27) Ranking of Burmese



Discussion: Tone and syllable type

In Burmese, CVO syllables (syllables with an obstruent coda) neutralize the two-way tonal contrast that exists in open syllables or syllables with a nasal coda. Such an asymmetrical relationships between tone and syllable types have been observed in many Southeast Asian languages such as Vietnamese or Hmong (Chen 2000: 5-6). In these languages, it is common that CVO syllables (so-called *checked syllables*, or *stop syllables*) surface with fewer possible tones than open syllables or syllables with a sonorant coda (so-called *unchecked syllables,* or *smooth syllables*). These tonal contrasts regarding syllable types have been reconstructed for Proto-tone systems in Chinese, Thai, Vietnamese and Hmong (Sagart 1988).

There are at least three theories proposed to account for the asymmetry of the number of tones in CVO syllables: the two-system theory, the underspecification theory and the subset theory (from Hyman 2007).

The two-system theory argues that tones in CVO syllables are different from the rest of the tones. This theory would explain the fact that Burmese has four tones: three tones (low, high, creaky) in CV syllables and a separate low tone in CVO stop syllables (*checked syllables*). The underspecification theory proposed by Weidert (1987: 368) analyzes the asymmetry in a different way. CVO syllables have fewer tones because tone is not specified in such syllables. Under the underspecification theory, the CVO syllables in Burmese have fewer tones because they simply are not specified with any tone. While this theory can explain the two tone system in Burmese, it would be difficult to account for a language that has more than two tones.

The subset theory treats the limited tones in CVO syllables as allotones of tones in other syllables (open syllables or syllables with a sonorant coda). In Burmese, it means that the tone of syllables with glottal stop codas is an allotone of high tone or low tone. In this section, the analysis adopts the subset theory. The tone neutralization in CVO syllables in Burmese supports the preliminary conclusion by Hyman (2007), which suggests the validity of the subset theory in languages that show effects of coda consonants on tone.

5.3.3 Glottal stop as a phoneme

The analysis in section 5.3.2 is based on the assumption that Burmese has a phonemic glottal stop coda. This section shows that glottal stop is in fact a coda, in disagreement with the seminal work on Burmese by Okell (1969) that describes glottal stop as a type of tone. This section also draws upon several crucial works on Burmese including Cornyn (1944), McDavid (1945), Bernot (1963), Allott (1967), Bradley (1982), among others.

Phonological and phonetic evidence supports the claim that glottal stop is a coda: glottal stops assimilate in place with the following onset; they block obstruent voicing; and they are not allowed in syllables with nasal codas. There is also an asymmetry of vowel qualities when a glottal stop coda is present. Furthermore, phonetic studies on the duration of syllables reveal that CVO syllables are shorter than other types of syllables. All these points are introduced in the rest of this section. For detailed discussions, see Lee (2007).

Glottal stop assimilation

A glottal stop becomes a voiceless obstruent that agrees in place and continuancy with a following obstruent.[12] In (28a-b), the final glottal stop /ʔ/ assimilates to the following onset and becomes [k] or [t]. Glottal stop codas can also assimilate to a voiced fricative

[12] A historical study by Maran (1971) shows that final glottal stops in Modern Burmese correspond to obstruent codas in Old Burmese.

/z/ and become a voiceless homorganic fricative [s] as in (28c). Hyphens indicate morpheme boundaries.

(28) Assimilation to onset: obstruents (Okell 1969: 7)

a.	jaʔ	+	kweʔ	→	ja<u>k̚</u>.-kweʔ	‘area, quarter’
b.	seiʔ	+	tʰin	→	sei<u>t̚</u>.-tʰin	‘opinion’
c.	louʔ	+	zaʔ	→	lou<u>s</u>.-zaʔ	‘fictitious story’

Glottal stops become homorganic nasals [m] when followed by a nasal onset /m/ as illustrated in (29a-b).

(29) Assimilation to onset: nasals (Okell 1969: 7)

a.	ʔeiʔ	+	me	→	ʔei<u>m</u>.-me	‘(I) will sleep’
b.	ʔeiʔ	+	meʔ	→	ʔei<u>m</u>.-meʔ	‘dream’

However, glottal stops are deleted when followed by a voiceless nasal /n̥/ or /ɲ̊/ as in (30a-b).

(30) Deletion of a glottal stop: voiceless nasals[13] (Okell 1969: 7)

a.	mjeʔ	+	n̥a	→	mje.-n̥a	‘face’
b.	kauʔ	+	ɲ̊ín	→	kau.-ɲ̊ín	‘sticky rice’

The data above show that glottal stop is an independent output segment in Burmese, and not a tone. If there is a glottal stop segment, accounting for the output [lou<u>s</u>.zaʔ] is straightforward: it is the result of regressive assimilation of place and manner, but not voicing. If glottal stop were really a tone, it would be unclear how to motivate the

[13] Voiceless nasals are probably specified with [+spread glottis] rather than [-voice] because they pattern on par with aspirated consonants in active/passive verbal pairs (Green 2005: 5).

appearance of [s] before a [z]. With an underlying glottal stop segment, it is also clear why it has no output correspondence before voiceless nasals: if /ʔ/ assimilated to a following voiceless nasal it would create a geminate voiceless nasal – a segment type that is banned in the output.

Obstruent voicing

Glottal stop codas also block obstruent voicing that occurs in post-sonorant and intervocalic position. In (31a), a velar stop /k/ becomes voiced to [g] when it occurs after a nasal coda [ŋ]. The aspirated velar stop /kʰ/ becomes voiced to [g] as well. All obstruents undergo voicing regardless of their place of articulation as in (31a-d). Fricatives such as /s, sʰ/ also become voiced to [z] as in (31e). Morpheme boundaries are marked with a hyphen.

(31) Obstruent voicing in Burmese[14] (Okell 1969: 12-13)

a.	Velars:	/k, kʰ/	→	[g]	
	(ə)**k̲**a̰	dance		kəjiŋ-**g̲**a̰	Karen dance
	(ə)**k̲ʰ**a̰	charge		kʰəjí-**g̲**a̰	fare
b.	Alveolars:	/t, tʰ/	→	[d]	
	t̲é	hut		bou-**d̲**é	rest house
	t̲ʰá	native		əɲa-**d̲**á	native of Upper Burma
c.	Labials:	/p, pʰ/	→	[b]	
	p̲oún	can		sʰi-**b̲**oún	oil can
	(ə)**p̲ʰ**oún	cover		səlaúm-**b̲**oún	saucepan lid
d.	Palatals:	/tʃ, tʃʰ/	→	[dʒ]	
	tʃ̲aʔ	rupee		ŋá-**dʒ̲**aʔ	five rupees
	tʃ̲ʰaʔ	flat thing		ŋá-**dʒ̲**aʔ	five flat things
e.	Fricatives:	/s, sʰ/	→	[z]	
	s̲i	each		təkʰṵ-**z̲**i	one each
	s̲ʰi	oil		oún-**z̲**i	coconut oil

[14] The symbol [ə] stands for a toneless syllable.

The examples in (31) show that neither tones nor syllable types are relevant to obstruent voicing. The preceding syllables can have low tone (e.g. boud̰é 'rest house' in 29b) or high tone (e.g. ŋáʤ̰aʔ 'five rupees' in 29d). The syllable can also have creaky phonation as in (32).

(32) Creaky tone and obstruent voicing (Okell 1994: 164)

				/-pa-tɛ/ *'honorifics + 3rd person singular'*
a.	ka̰	'to dance'	ka̰-**b**adɛ	'(he) dances'
b.	ma̰	'to lift'	ma̰-**b**adɛ	'(he) lifts'

However, obstruent voicing does not occur when a preceding syllable has a glottal stop coda. The voicing is blocked, but the glottal stop assimilates to the following onset as shown in (33).

(33) Glottal stop codas block obstruent voicing (Okell 1969: 13)

a.	təjouʔ**k**a̰	*təjouʔ-ɡa̰	[təjouk-**k**a̰]	'Chinese dance'
b.	leʔ**kʰ**a̰	*leʔ-ɡa̰	[lek-**kʰ**a̰]	'wage'
c.	ʧʰauʔʧ̰aʔ	*ʧʰauʔ-ʤ̰aʔ	[ʧʰauʧ-ʧ̰aʔ]	'six rupees'

The presence of a glottal stop blocks obstruent voicing because it destroys the voicing environment – it makes the onset obstruent neither intervocalic nor post-sonorant, which supports the claim that glottal stop is present in that position. If the glottal stop were just a tone, there would be no way to account for this blocking; as (31) shows, no tone blocks voicing.

Co-occurrence restriction of glottal stop

There is also a telling phonotactic restriction involving glottal stop codas: they do not occur when a nasal coda is present. Syllables with nasal codas can have low tone, high tone, or creaky phonation. As shown below in (34), however, no attested syllable has a nasal rhyme in addition to a glottal stop.

(34) Nasal rhymes and glottal stop

a.	Low tone	kʰàn	'to undergo'	(cf. kʰa shake)
b.	High tone	kʰán	'to dry up'	(cf. kʰá be bitter)
c.	Creaky phonation	kʰa̰n	'to appoint'	(cf. kʰa̰ fee)
d.	Glottal stop coda	***kʰaʔn**		(cf. kʰaʔ to draw off)

With a glottal stop segment, there is a straightforward reason for the ban on glottal+nasal codas: Burmese syllables allow only one consonant in the coda. A canonical syllable is C(G)V(V)C (Green 2005), in which G stands for glides. A syllable must have an onset, but a syllable can only have one consonant in the coda. If glottal stops were really a type of tone, it would be mysterious why this tone type cannot occur with a nasal (unlike other tone types).

Vowel Quality

Vowel quality differs depending on whether syllables are open or closed. As expected if glottal stops are segments in Burmese, vowels that have glottal stop codas have the same quality as those that have nasal codas. This section is based on Watkins (2000). He observes that open syllables with low tone, high tone, or creaky voice can occur with tense and lax vowels as shown in (35) and (36).

(35) Open syllables (Watkins 2000:145)

		a. low		**b. high**		**c. creaky**	
tense	**/i/**	miː	*(name)*	míː	*fire*	mḭ	*mother*
	/e/	meː	*May*	méː	*ask*	mḛ	*forget*
	/a/	maː	*hard*	máː	*towering*	ma̰	*female*
	/o/	moː	*heaped*	móː	*sky*	mo̰	*because*
	/u/	muː	*nature*	múː	*drunk*	mṵ	*respect*
lax	**/ɔ/**	mɔː	*look up*	mɔ́ː	*tired*	mɔ̰	*tilt up*
	/ɛ/	mɛː	*mother*	mɛ́ː	*vote*	mɛ̰	*without*

In contrast, vowels in closed syllables are always realized with lax vowels or diphthongs as in (36). In other words, closed syllables cannot occur with a tense vowel.

(36) Closed syllables (Watkins 2000:145)

	Nasal						**Non-nasal**	
	a. low		**b. high**		**c. creaky**		**d. glottal stop**	
/ɪ/	mɪ̃ːn	*fond of*	mɪ̃́ːn	*king*	mɪ̰̃n	*(particle)*	mjɪʔ	*river*
/eɪ/	meɪ̃ːn	*season*	meɪ̃́ːn	*girl*	meɪ̰̃n	*say*	meɪʔ	*friend*
/ɛ/							mɛʔ	*dream*
/aɪ/	maɪ̃ːn	*mile*	maɪ̃́ːn	*mine*	paɪ̰̃n	*pint*	maɪʔ	*stupid*
/a/	mãːn	*plaster*	mã́ːn	*recite*	mã̰n	*jiggle*	maʔ	*March*
/aʊ/	maʊ̃ːn	*younger brother*	maʊ̃́ːn	*drive*	maʊ̰̃n	*wait*	maʊʔ	*haughty*
/oʊ/	moʊ̃ːn	*storm*	moʊ̃́ːn	*hate*	moʊ̰̃n	*flour*	moʊʔ	*pearl*
/ʊ/	mʊ̃ːn	*Mon*	mʊ̃́ːn	*decorate*	tʊ̰̃n	*wrinkle*	mʊʔ	*smooth*

There are two exceptions to the complementary distribution of vowels in Burmese. The front mid lax vowel /ɛ/ occurs in open syllables and syllables with a glottal stop coda. The low vowel /a/ occurs in open syllables and closed syllables.

A detailed phonetic study by Watkins convincingly shows that the quality of these two vowels in closed syllables is different from when they occur in open syllables. When the first formant (F1) and the second formant (F2) are plotted, the vowel /a/ in closed syllables is more closed and front than the vowel /a/ in open syllables. The vowel /ɛ/ before a glottal stop is more open and back than the vowel /ɛ/ in open syllables (Watkins 2000: 147).

The vowel quality depending on syllable structures shows that the glottal stop occurs in syllables with vowels whose quality is the same as in other closed syllables. Thus, glottal stops should be treated as codas.

Duration

Syllable duration also supports the proposal that there is a glottal stop coda. Watkins (2000) conducts phonetic studies on the duration of syllables. The table in (37) shows the duration, the change in fundamental frequency (F0), and the closed quotient[15] change of each category. The results demonstrate that syllables with creaky phonation show great similarities to syllables with a glottal stop.

(37) Comparing Burmese syllables (Watkins 2000)

		glottal stop	**creaky phonation**	**high tone**	**low tone**
a.	duration	*short*	*short*	long	long
b.	F0	*falling*	*falling*	rising	low
c.	closed quotient	*high*	*high*	low	low

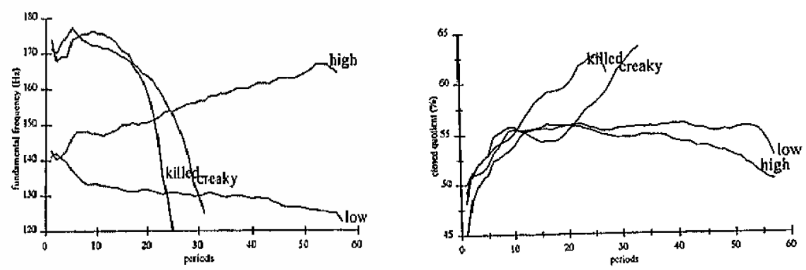
The results of the change in F0 and the closed quotient change are reproduced in (38). Syllables with a glottal stop are marked as ‘killed’, and syllables with creaky phonation are marked with ‘creaky’ in the graphs. The onset of F0 in these syllables is higher than

15 Closed quotient is the percentage of closed glottal phase within one glottal cycle (p.c. Jonathan Wright).

that of high tone syllables. However, F0 drops significantly in syllables with creaky phonation and a glottal stop. Moreover, the closed quotient becomes higher in syllables with creaky phonation and syllables with a glottal stop.[16]

(38) Creaky tone and stop tone (Watkins 2000)[17]

a. Fundamental frequency b. closed quotient



Recordings of Khin Maung Gyi, a male Burmese speaker in his sixties from Nyaung Shwe, confirm Watkins' study. The consultant read each word three times in isolation from Burmese writing to an electret condenser microphone (Sony ECM-F01). The recording was done at a sampling rate of 44,100 Hz. Using Praat 4.5.18 (Boersma and Weenink 2007), the duration was measured using visual cues from spectrograms and waveforms.

The result of the experiment is that the duration of syllables with a glottal stop (or creaky voice) is shorter than other syllables as shown in (39). This result also confirms the duration study by Mehnert and Richter (1976). Syllables with a glottal stop (marked as 'Stop') are always the shortest.

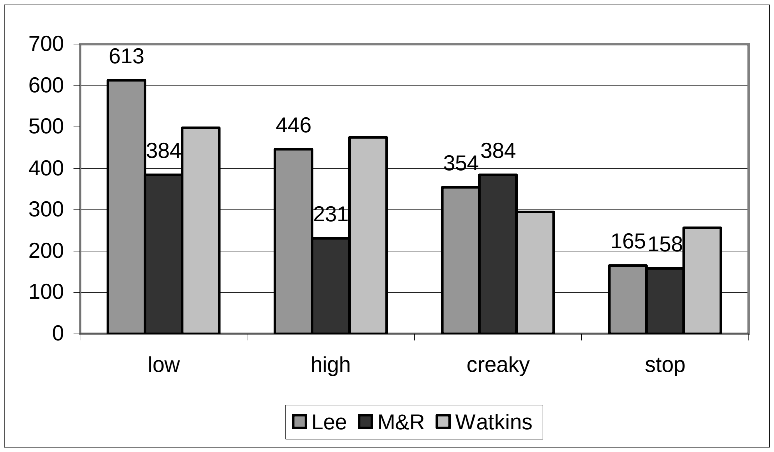
[16] A higher closed quotient means the sound is more creaky, and lower closed quotient means that a sound is more breathy.
[17] I would like to thank Justin Watkins for granting permission to reproduce these graphs.

(39) Comparison of duration

a. Nyang Shwe speaker (left): Low > High > Creaky > Stop

b. Mehnert and Richter (1976: 146): Low, Creaky > High > Stop

c. Watkins (2000:142, right): Low, High > Creaky > Stop

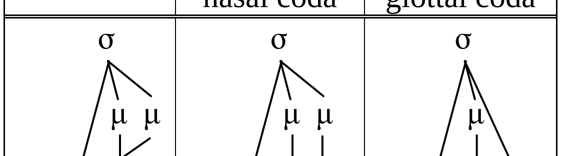


<The mean duration of Burmese syllables>

A phonological account for such short duration in glottal stop syllables is suggested in Hubbard (1994) and Broselow et al. (1997). Both studies argue that a phonological mora contributes to the duration of a syllable. Thus, the presence of a glottal stop should make the duration of syllables shorter. According to this view, syllables with a glottal stop coda have a structure as in (40c). Open syllables as in (40a) or syllables with a nasal coda as in (40b) are longer than syllables with a glottal coda such as (40c), because they have two moras instead of one as confirmed in (39).

(40) Burmese syllable structure (see also Green 2005: 8)

open	closed	
	nasal coda	glottal coda



a. **k^h à**	b. **k^h à ɴ**	c. **k^h a ʔ**

The shortness of syllables with creaky phonation could probably be due to the phonetic effect of creakiness. The creakiness obscures the end of the F0 and results in shorter duration than syllables with high tone or low tone. Based on his findings, Watkins (2000) also suggests that the shortness of syllables with creaky phonation may result from glottal closure. See also Thein Tun (1982) for relevant discussion.

Summary

The evidence presented in this section shows that Burmese permits glottal stops in codas. Glottal stop codas assimilate to the following onset, glottal codas block obstruent voicing, glottal codas cannot co-occur with nasal codas, and vowel quality in syllables with a glottal stop coda follows the pattern found in closed syllables. Moreover, the phonetic experiments support the presence of glottal stops.

It is likely that the disagreement in the literature on Burmese tone is due to the contentious status of final glottal stops and due to the definition of what constitutes a tone. As a result, Burmese has been described as having four tones (Okell 1969, Thein Tun 1982), or three tones (Bernot 1963, Yip 1995). Bradley (1982), on the other hand, proposes that Burmese is a register language. Such disagreement is found because previous research has focused on the phonetic properties of tone to determine the tonal inventory.

5.3.4 Tone neutralization by creaky phonation

Along with glottal stop syllables, the neutralization of tone also occurs in syllables with creaky phonation in Burmese. As shown in (38), syllables with creaky phonation and syllables with a glottal stop show phonetic similarities in fundamental frequency and closed quotient.[18]

In syllables with creaky phonation, the pitch will become lower, as attested in previous phonetic studies. On par with CVO syllables, I propose that high tone is banned in syllables with creaky phonation by the markedness constraint *[+CONSTRICTED GLOTTIS]/H.

The neutralization in syllables with creaky phonation results from constraint interaction between IDENT-T and *[+CONSTRICTEDGLOTTIS]/H. In Burmese, *[+CONSTRICTEDGLOTTIS]/H dominates IDENT-T. A creaky syllable with a H tone in the input /kʰá̰/ will surface with a low tone [kʰà̰] due to this ranking.

Evidence for neutralization of tones in syllables with creaky phonation comes from so-called 'creakable' syllables, in which low or high tones become creaky when they form a word with the following syllable. The examples in (41) show the environment in which creakable syllables acquire creaky phonation. Creaky (or creakable) syllables are in bold. Both low tone syllables in (41a-e) and high tone syllables in (41f-h) become creaky when they are followed by another syllable. Syllables that follow creakable syllables can be any syllable or tonal type observed in Burmese.

[18] Michaud (2004: 137-139) also provides an insightful overview of phonetic distinctions among glottal stop, glottal constriction, and creaky voice. While a glottal stop is defined as "a gesture of closure that has less coarticulatory effects on the voice quality of the surrounding segments", glottal constriction is realized throughout the whole syllable rhyme. Creaky voice is "the irregular, low-frequency vibration of the vocal folds". For example, in Hanoi Vietnamese, glottal constriction and creaky voice are significant in distinguishing tones, while glottal stops and creaky voice are significant in Burmese.

(41) Induced creaky tone (Okell 1969: 18-20)

	Low tone syllable		***becomes creaky***	***before***	
a.	la**de**	(he) came	la**dḛ**lu	*low*	the man who came
b.	θoún**ze**	thirty	θoún**zḛ**ŋá	*high*	thirty-five
c.	**θu**	he	**θṵ**jḛ	*creaky phonation*	his
d.	ŋá**bei**	five feet	ŋá**beḭ** ʧauʔleʔma̰	*glottal stop*	five feet six inches
e.	**pjo**	be happy	mə**pjo̰**təbjo	*toneless*	not very happy

	High tone syllable		***becomes creaky***	***before***	
f.	sə**ká**	word	sə**ga̰**gou	*low*	even a word
g.	pʰə**já**	pagoda	pʰə**ja̰**beí	*high*	the side of the pagoda
h.	**mín**	you	**mḭn**əsá	*toneless*	instead of you

However, syllables with a glottal stop coda and syllables with creaky phonation are not creakable. It is possible that this restriction is in place because the glottal stop coda makes the preceding vowel creaky. Under this condition, the markedness constraint *[+CONSTRICTEDGLOTTIS]/H forces tone neutralization in both creaky vowels and vowels followed by a glottal stop coda.

5.3.5 Summary

This section has shown that Burmese has two tones: high and low. The two-way tonal contrast neutralizes to L tone in syllables with a glottal stop coda due to the markedness constraint *[+CONSTRICTEDGLOTTIS]/H outranking relevant faithfulness constraints (such as IDENT-T). In syllables with creaky phonation, the tonal contrast also neutralizes to L tone because of the markedness constraint *[+CONSTRICTEDGLOTTIS]/H. The neutralization follows the current proposal, in which consonants are TBUs and no faithfulness constraints preserve underlying tones associated with consonants.

Burmese has been shown to have a glottal stop coda based on arguments such as place assimilation, blocking of obstruent voicing, phonotactic restrictions on clusters in the coda, and vowel quality in closed syllables. Moreover, phonetic experiments are shown to support this claim by demonstrating that syllables with a glottal stop have shorter duration.

5.4 Neutralization by onsets and codas: Thai

In Thai, consonants in both onset and coda positions neutralize tone in the output. High tone does not surface when unaspirated stops occur in onsets or codas due to the markedness constraint *[-SPREADGLOTTIS]/H. Consequently, syllables with unaspirated stops in onset and coda positions only occur with a low tone. The data in this section is based on Ruangjaroon (2006) except where noted.

The consonantal effect on tone by onsets is presented in (42). In open syllables (CVV) or syllables with a sonorant coda (CVS, CVVS), there are five contrastive tones when the onset of a syllable is either aspirated or a sonorant as in (42a-b). However, if the onset of a syllable is an unaspirated stop as in (42c-d), the syllable cannot surface with a high tone. The shaded cells in the 'high' tone column indicate ungrammatical forms in Thai. As a result, in syllables with unaspirated stop onsets, only four tones surface in the output.

(42) Open syllables or syllables with sonorant coda (Ruangjaroon 2006: 10)

Onsets			**low**	**mid**	**high**	**falling**	**rising**	
aspirates/ sonorants	a.	CVː	√	√	√	√	√	5 tones
	b.	CV(ː)S	√	√	√	√	√	
unaspirated stops	c.	CVː	√	√		√	√	4 tones
	d.	CV(ː)S	√	√		√	√	

While CV: or CV(:)S syllables surface with five tones, syllables with an unaspirated stop coda [p, t, k] (marked with ‘O’) only surface with two tones as in (43a-b). Short syllables (CVO) have H tone or L tone. However, long syllables (CVVO) can surface with either L tone or a falling tone (cf. Abramson 1962, Morén and Zsiga 2006). In syllables with an unaspirated stop onset and an unaspirated stop coda (OVO or OVVO), only low tone surfaces in the output (43c-d).

(43) Tone of syllables with obstruent coda (Ruangjaroon 2006: 10)

Onsets			**low**	**mid**	**high**	**falling**	**rising**	
aspirates/ sonorants	a	CVO	√		√			2 tones
	b.	CVːO	√			√		
unaspirated stops	c.	OVO	√					1 tone
	d.	OVːO	√					

In section 5.4.2, the high tone in CVO syllables in (43a) is argued to be a phonological HL tone, which is phonetically realized as a H tone. The L tone in HL tone is realized when there is enough room in a syllable (CVːO) for it to appear.

Consonants in Thai

In (44), the consonant inventory of Thai is presented. There are aspirated consonants as in (44a), and sonorants as in (44b). Thai also has unaspirated voiced and voiceless stops as in (44c), which do not surface in a high tone domain. While all the consonants can appear in onsets, only unaspirated voiceless stops and nasals can occur in coda positions.

(44) Thai consonants (Apiluck Tumtavitikul 1992: 264, Ruangjaroon 2006: 9)

		labial	alveolar	palatal	velar	glottal	
a.	aspirates	p^h, f	t^h, s	$ʧ^h$	k^h	h	
b.	sonorants	m, w	n, l, r	j	ŋ		
c.	unaspirated	p, b	t, d	ʧ	k	ʔ	→ *no high tone*

Tones in Thai

In (45), tonal minimal pairs in stressed syllables are presented. There are three level tones (mid, low and high) and two contour tones (falling and rising). Such five-way tonal contrast occurs in open syllables (CV) and in syllables with a sonorant coda (CVS). The examples in (45) demonstrate that aspirates and sonorants are neutral to consonant-tone interaction in Thai. Tonal marking is as follows. Mid tone is marked with a macron. High tone is marked with an acute accent, and low tone with a grave accent. Circumflex marks falling tone, and wedge marks rising tone. Sounds in parentheses are optionally realized.

(45) Tonal minimal pairs in Thai (Ruangjaroon 2006: 5, 46)

		Open		Sonorant coda	
a.	low	[p^hɛ̀ː]	'to spread'	[k^hùn]	'muddy'
b.	mid	[p^hɛ̄ː]	'a raft'	[k^hōn]	'person'
c.	high	[p^hɛ́ː]	'to lose'	[k^hón]	'search'
d.	falling	[p^h(r)ɛ̂ː]	'to broadcast'	[k^hôn]	'thick'
e.	rising	[p^h(l)ɛ̌ː]	'a wound'	[k^hǒn]	'hair'

When a syllable has a short vowel and an obstruent coda as in (46), only (phonetic) high or low tones surface in the output (Gandour 1975: 170-172, Apiluck Tumtavitkul 1993: 13-14).[19] In other words, in Thai, a CVO syllable cannot surface with (phonetic) mid, falling, or rising tone as shown in (46c-e).

[19] For a discussion and an analysis about this type of data, see Ruangjaroon (2006: 24-25).

(46) Neutralization of tonal contrast with obstruent codas

a.	low	[p^hìt]	‘be wrong’
b.	high	[p^hít]	‘poison’
c.	mid	*[p^hīt]	N/A
d.	falling	*[p^hît]	N/A
e.	rising	*[p^hǐt]	N/A

No contour tones with M: Introducing tonal features

An interesting aspect of Thai is that it allows M tone on its own, but not as part of a contour, as in HM, LM, ML, or MH. I propose that these types of contour tones do not surface because of a constraint which bans sequences of tones that are too similar in terms of tonal features. This ban will be a crucial part of the analysis later on.

Thai level tones can be represented with tonal features [±upper] and [±lower]. H is [+upper, -lower], M is [-upper, -lower] and L is [-upper, +lower]. There are two OCP constraints: OCP[upper] and OCP[lower]. OCP[upper] is defined in (47); OCP[lower] is defined in the same way, but for [lower]. Together, the OCP constraints ban contour tones with M in them. HM and MH contours cannot surface because both tones are [-lower]. LM and ML contours cannot surface because both tones are [-upper]. The OCP constraints act together in Thai, so they will be collectively called the ‘OCP’ from now on.

(47) OCP[upper]

Assign a violation mark, if for two moras in the same syllable, both moras are associated to [αupper], and have different values for [lower].

From the introduced tonal features, I propose a group of faithfulness constraints that is the subset of IDENT-T, as in (48). These faithfulness constraints have different violations on tonal identity. IDENT-[+UPPER] is violated when H becomes M or L. IDENT-[-UPPER] is violated when M or L become H. IDENT-[-LOWER] is violated when H or M become L. IDENT-[+LOWER] is violated when L becomes H or M.

(48) Subset constraints of IDENT-T

a.	**IDENT-[+UPPER]**	Corresponding segments associated to a mora have identical values for the tonal feature [+upper]. If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *x* is [+upper], then *y* is [+upper].
b.	**IDENT-[-UPPER]**	Corresponding segments associated to a mora have identical values for the tonal feature [-upper]. If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *x* is [-upper], then *y* is [-upper].
c.	**IDENT-[+LOWER]**	Corresponding segments associated to a mora have identical values for the tonal feature [+lower]. If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *x* is [+lower], then *y* is [+lower].
d.	**IDENT-[-LOWER]**	Corresponding segments associated to a mora have identical values for the tonal feature [-lower]. If *x* is a mora in the input and *y* is a mora in the output from $x\Re y$, *x* is [-lower], then *y* is [-lower].

The rest of this section is organized as follows. In section 5.4.1, neutralization by onsets is analyzed as a requirement to not allow unaspirated stops to associate with H tone by *[-SPREADGLOTTIS]/H. Neutralization by obstruent codas is analyzed in section 5.4.2 as an effect of the same constraint *[-SPREADGLOTTIS]/H. In section 5.4.3, it will be shown how all input tone neutralizes to low tone in syllables with an obstruent coda and unaspirated onsets.

5.4.1 Tone neutralization by onsets

Unaspirated onsets neutralize tone in Thai if everything else is equal. In (49), illustrative examples show the tonal minimal pairs when the onset of a syllable is an aspirate ([p^h] or [k^h]) as in (49a) or a sonorant ([l] or [m]) as in (49b). As presented above, these types of syllables can occur with all five tones in Thai.

(49) Five tones in CV or CVS (Ruangjaroon 2006: 39-48)

	Onsets		**low**	**mid**	**high**	**falling**	**rising**
a.	**aspirates**	CV:	[p^{h}àː] 'cut'	[p^{h}āː] 'take'	[p^{h}áː] 'a knife'	[p^{h}âː] 'a knife'	[p^{h}ǎː] 'a cliff'
		CVS	[k^{h}ùn] 'muddy'	[k^{h}ūn] 2nd sg. pers.	[k^{h}ún] 'familiar'	[k^{h}ôn] 'thick'	[k^{h}ǔn] 'fatten'
b.	**sonorants**	CV:	[lòː] 'last'	[lāː] 'a donkey'	[láː] 'exhausted'	[lâː] 'chase'	[lǎː] 'yard'
		CVS	[màn] 'persistent'	[mān] 'greasy'	[nán] 'that'	[mân] 'engage'	[mǎn] 'sterile'

However, no CV: or CVS syllable has an unaspirated onset and high tone; only low, mid, falling and rising tones are allowed. As shown in (50), the voicing of such onsets does not interfere with the tonal restriction; the onsets can be voiceless ([k]) as in (50a), or the onsets can be voiced ([b]) as in (50a).

(50) Tone in CV and CVS with an unaspirated onset (Ruangjaroon 2006: 39-48)

	low	**mid**	**high**	**falling**	**rising**
a. CV	[kùː] 'holler'	[kūː] 1st sg. pers.		[kûː] 'borrow'	[kǔː] 'uncle'
b. CVS	[bòn] 'complain'	[bōn] 'on'		[bân] 'a portion'	[bǔn] 'civil'

Based on the Thai data discussed so far, an analysis is presented in the following subsections. First, the grammar must allow five-way tonal contrasts in the output: the faithful realization of tone. The contrast results from a ranking in which tonal faithfulness constraints outrank markedness constraints against tones (*TBU/T). Second, the H tone prohibition in syllables with unaspirated stop onsets in (50) is a requirement to block tone, caused by consonants due to the markedness constraint *[-SPREADGLOTTIS]/H.

Faithful realization of tone

The five tones in Thai surface in CVː and CVS syllables. The condition for this five-way contrast is that the onsets of these syllables must be aspirates or sonorants. The tonal contrast surfaces because of the ranking, in which faithfulness constraints on tone outrank the general markedness constraint against tones.

In (51), L tone input maps faithfully in the output. The IDENT[+LOWER] constraint outranks *[+SPREADGLOTTIS]/L, which bans segments specified with [+spread glottis] from associating to L tone (motivated in the analysis of Mulao, section 5.2). The H tone candidate in (51b), the M tone candidate in (51c), the falling tone candidate in (51d), and the rising tone candidate in (51e) all violate IDENT[+LOWER] because the corresponding moras have different tonal features. The toneless candidate in (51f) crucially violates ROOTNODE→T.

(51) Faithful realization of L tone

	L /p^hà à/	RN→T	IDENT [+LOWER]	*[+S.G.]/L	*TBU/T
a. ☞	L [p^hà à]			*	***
b.	H [p^há á]		W **	L	***
c.	M [p^hā ā]		W **	L	***
d.	H L [p^há à]		W *	L	***
e.	L H [p^hà á]		W *	*	***
f.	L [p^hà à]	W *		L	L**

For contour tones, the faithfulness constraint (IDENT-T) must outrank the markedness constraint *CONTOUR. Such a ranking allows the five-way contrast in the output in Thai.

In (52), IDENT[+LOWER] outranks *[+SPREADGLOTTIS]/L, so that syllables with an aspirated onset can be associated to L tone as in (52b). The faithfulness constraint on laryngeal feature IDENT-LAR also dominates *[+SPREADGLOTTIS]/L. Thus, changing of laryngeal feature from aspirated to unaspirated is not allowed, either, as shown in (52c).

(52) Faithful to laryngeal features

	L | /p^{h}àː/	IDENT-LAR	IDENT [+LOWER]	*[+S.G.]/L
a. ☞	L [p^{h}àː]			*
b.	H [p^{h}áː]		W *	L
c.	L [pàː]	W *		L

In this section, the crucial ranking for faithful realization of tone is that the markedness constraints *TBU/T and *[+SPREADGLOTTIS]/L, which bans aspirates from associating to L tone, are outranked by the tonal faithfulness constraint IDENT-T. Consequently, the faithful realization of mid, high, low, falling, and rising tones is possible because there are no opposing markedness constraints dominating these tonal faithfulness constraints. Moreover, in Thai, aspirated consonants do not affect the tonal realization, contra Mulao.

Blocking of H tone by unaspirated stops

When the onset of a syllable is an unaspirated stop, however, only four tones are allowed: mid, low, falling and rising. I propose that the blocking of H tone in syllables with unaspirated onsets is due to the markedness constraint *[-SPREADGLOTTIS]/H, which is violated if an unaspirated stop is associated with a H tone. This markedness constraint outranks the tonal faithfulness constraint IDENT-T. So, H tone is blocked in syllables with unaspirated stops at the expense of changing an input tone. The IDENT-T constraint is also outranked by IDENT-LAR, so that *[-SPREADGLOTTIS]/H cannot be satisfied by changing the laryngeal feature of consonants. This analysis assumes that *[-SPREADGLOTTIS]/H only targets obstruents and not sonorants. This is in accordance with Ruangjaroon's analysis.

While I consider unaspirated stops as [-spread glottis] as in Ruangjaroon (2006), the specifics of the analysis differ from hers, which crucially relies on constraints that target the linearity of laryngealized segments (see Chen (2007) for a critique of Ruangjaroon's analysis).

In the analysis I propose, it is the interaction of constraints that restricts tone when certain consonants are present. The ranking in which *[-SPREADGLOTTIS]/H outranks the faithfulness constraint IDENT[+UPPER] blocks high tone from surfacing on syllables with plain stop onsets, as in (53). An input with a high tone does not surface faithfully because of *[-SPREADGLOTTIS]/H. The faithful candidate in (53b) crucially violates this constraint. Changing the onset to an aspirate as in (53c) incurs a violation of IDENT-LAR. With the subgroup of IDENT-T constraints introduced in (48), we can also explain why an input H tone becomes M in (53). The L tone candidate in (53d) violates IDENT[-LOWER] because L tone is [+lower], while H and M are [-lower]. In this tableau, IDENT[-UPPER] and IDENT[+LOWER] are not violated by any of these candidates.

(53) Blocking of H tone in unaspirated stops

H | /páː/		*[-S.G.]/H	IDENT-LAR	IDENT [-LOWER]	IDENT [+UPPER]
a. ☞	M /| [pāː]				*
b.	H /| [páː]	W *			L
c.	H /| [p^háː]		W *		L
d.	L /| [pàː]			W *	*

As in (49), syllables with unaspirated onsets can surface with contour tones. Following Morén and Zsiga (2006), only one tone is allowed per mora with the representation in (54), a notation briefly introduced in (51).

(54) Thai contour tones (Morén and Zsiga 2006: 114)

```
a. Falling    b. Rising
   H   L         L   H
   |   |         |   |
   μ   μ         μ   μ
[CV   V]      [CV   V]        open syllables
[CV   S]      [CV   S]        CVS syllables with a short vowel
[CV   VS]     [CV   VS]       CVS syllables with a long vowel
```

A rising tone LH input with an unaspirated onset surfaces faithfully as in (55). This is to be expected because the unaspirated onset is not associated to H tone, as can be seen in the representations in (54). The candidates in (55c) and (55d) violate *[-SPREADGLOTTIS]/H because an unaspirated stop cannot surface in a high tone domain.

Candidates (55b), (55c), and (55e) violate IDENT[+UPPER] because all candidates change an underlying H to L or M. The mid tone candidate also violates IDENT[+LOWER] because the input L tone ([+lower]) becomes [-lower] in the output.

(55) Faithful realization of rising contour

<table>
<tr><th></th><th>L H
| |
/pa a/</th><th>*[-S.G.]/H</th><th>IDENT
[+UPPER]</th><th>IDENT
[+LOWER]</th><th>*CONTOUR</th></tr>
<tr><td>a. ☞</td><td>L H
/| |
[pà á]</td><td></td><td></td><td></td><td>*</td></tr>
<tr><td>b.</td><td>L
/\
[pà à]</td><td></td><td>W *</td><td></td><td>L</td></tr>
<tr><td>c.</td><td>H
/\
[pá á]</td><td>W *</td><td></td><td></td><td>L</td></tr>
<tr><td>d.</td><td>H L
/| |
[pá à]</td><td>W *</td><td>W *</td><td>W *</td><td>*</td></tr>
<tr><td>e.</td><td>M
/\
[pā ā]</td><td></td><td>W *</td><td>W **</td><td>L</td></tr>
</table>

In Thai, the falling contour HL also surfaces faithfully with unaspirated onsets. The survival of the HL contour is surprising because it results in an unaspirated onset associated to a H tone. The reason that the unaspirated consonant tolerates a H tone domain here is because every other option is blocked by the OCP (from (47)) and the faithfulness constraint IDENT-[-LOWER]. An underlying H of the falling tone cannot become M because the candidate would violate the OCP as in (56b). An underlying H cannot become L as in (56c) because it would violate IDENT-[-LOWER]. The candidate with rising tone in (56d) also violates IDENT-[-LOWER] because the underlying H becomes

L. If the unaspirated onset [p] is not associated to a tone in the output, the candidate incurs a violation of ROOTNODE→T as in (56e). The candidate with M tone violates IDENT[+LOWER] because the L tone becomes a M tone. The candidate in (56c) violates both OCP and IDENT-[-LOWER]. While violating the markedness constraint *[-SPREADGLOTTIS]/H, the faithful candidate in (56a) has no violations of the higher ranked constraints OCP and IDENT-[-LOWER]. In other words, unaspirated stops can be associated to a H tone if every other option is blocked.

(56) Faithful realization of falling contour

	H L | | /pa a/	RN→T	OCP	IDENT [+LOWER]	IDENT [-LOWER]	*[-S.G.] /H	*CONTOUR
a. ☞	H L /| | [pá à]					*	*
b.	M L /| | [pā à]		W *			L	*
c.	L /|\\ [pà à]		W *		W *	L	L
d.	L H /| | [pà á]			W *	W *	L	*
e.	HL | | [pá à]	W *				L	*
f.	M /|\\ [pà à]			W *		L	L

In this section, I have shown that the blocking of H tone unaspirated stops occurs due to the markedness constraint *[-SPREADGLOTTIS]/H dominating the faithfulness constraint IDENT[+UPPER] (see (53)). An underlying falling tone surfaces with a violation of *[-SPREADGLOTTIS]/H because OCP and IDENT[-LOWER], IDENT[+LOWER] outrank the markedness constraint.

5.4.2 Tone neutralization by codas

In Thai, a syllable with an obstruent coda (CVO) allows only H or L tone. Obstruent codas are [p], [t], and [k]. As in (57), syllables with short vowels surface with L or H tone, while syllables with long vowels surface with L or falling tone. Note that all examples in (57) have onsets that are [+spread glottis] or sonorants. These onsets do not trigger tone neutralization as shown in section 5.4.1.

(57) Tone in syllables with obstruent coda (Ruangjaroon 2006: 51-58)

		Onsets	**low**	**mid**	**high**	**falling**	**rising**
a.	**CVO**	aspirates[20]	[sàk] ‘tattoo’		[sák] ‘wash’		
b.		sonorants	[lòp] ‘hide’		[lóp] ‘erase’		
c.	**CVːO**	aspirates	[fàːt] ‘acidulous’			[fâːt] ‘to eat’	
d.		sonorants	[màːk] ‘an areca palm’			[mâːk] ‘very’	

In obstruent-final syllables with unaspirated onsets (OVO syllables), however, H and falling tone do not surface in the output. As shown in (58), only L tone is allowed in OVO syllables.

[20] I assume that fricatives are [+spread glottis] as well. See (44).

(58) Unaspirated onsets and unaspirated codas (Ruangjaroon 2006: 55, 60)

	non-aspirates	**low**	**mid**	**high**	**falling**	**rising**
a.	OVO	[bòk] 'on land'				
b.	OVːO	[pàːt] 'to cut'				

The restricted tonal inventory in CVO syllables is observed in many other Tibeto-Burman languages when an obstruent coda is present (cf. Weidert 1987: Ch. 9)[21]. Because of the tonal restrictions in CVO syllables, CVO syllables have traditionally been called 'checked' syllables, or 'stopped' syllables in Chinese, Tibeto-Burman, and Mon-Khmer studies. By contrast, open syllables or syllables with a sonorant coda are called 'unchecked', or 'smooth' syllables. Recent studies also show that tone neutralization by stop codas is not restricted to Asia as an areal phenomenon. It is reported that in San Martin Itunyoso Trique, a glottal stop coda neutralizes all contour tones to level tones (DiCanio 2006).

There are several proposals to account for this neutralization process. Weidert (1987: 368) suggests that physiological properties of stop codas cause the restriction of tonal distribution in CVO syllables. On the other hand, based on Kuki Chin data, Hyman (2007) argues for a phonological proposal. In an analysis of Cantonese, Yip (2002: 174-175) argues that tonal constraints induced by codas are responsible for limiting tones in CVO syllables.

Metrical theories have shown that languages may distinguish CVO syllables from CV

[21] Tibeto-Burman languages are not uniformly tonal as described in Weidert (1987: 1). There are four different types of languages: a) tonal languages, b) non-tonal languages, c) languages that are gaining tonal contrasts (this process is named as 'tonogenesis' by James Matisoff), and d) languages that are losing their tonal contrasts.

or CVS syllables. The sonority hierarchy can affect the possibility of codas being moraic (Zec 1995, Morén 2000, Elías-Ulloa 2006). Furthermore, there are also numerous diachronic studies on the tonal restriction in CVO syllables.

Based on the discussion so far, the rest of this section presents an analysis of tone neutralization by obstruent codas.

Faithful realization of tone in CVO syllables

In CVO syllables, H and L tones surface in the output. First, I suggest that every Thai syllable needs at least two moras (cf. Morén and Zsiga 2006). So, CVO syllables have two moras, and every mora can bear a tone. However, *[-SPREADGLOTTIS]/H bans unaspirated stops from associating to H tones. Consequently, the only CVO syllables that can surface faithfully are CVO with L tone and HL tone.

A L tone input in (59) surfaces faithfully with L tone. The candidates in (59b) and (59e) violate *[-SPREADGLOTTIS]/H because an unaspirated stop cannot be associated with H tone. The candidates in (59c) and (59d) violate IDENT-[+LOWER]. The optimal candidate (59a) violates *VOICELESS/L (motivated in chapter 4 on Western Bade, see section 4.3).

(59) L tone input in CVO syllables

	L /\ /l o p/	IDENT-[+LOWER]	*[-S.G.]/H	*VOICELESS/L
a. ☞	L /|\ [lòp]			*
b.	H /|\ [lóp]		W *	L
c.	H L /| | [ló p̀]	W *		*
d.	M /|\ [lōp]	W *		L
e.	L H /| | [lò ṕ]		W *	L

An input with falling tone as in (60) also surfaces faithfully. The H tone candidate in (60b) violates *[-SPREADGLOTTIS]/H. In the L tone candidate in (60c), H becomes L in the output, which violates IDENT[-LOWER]. The change of underlying tones to M tone in (60d) violates IDENT[+LOWER] even though it satisfies the lower ranked constraint *CONTOUR.

(60) HL tone input in CVO syllables

	H L | | /lo p/	IDENT [-LOWER]	IDENT [+LOWER]	*[-S.G.]/H	*CONTOUR
a. ☞	H L /| | [ló p̀]				*
b.	H /|\\ [lóp]		W *	W *	L
c.	L /|\\ [lòp]	W *			L
d.	M /|\\ [lōp]		W *		L

The optimum in (60) has a low tone on the coda consonant, which does not violate the constraints *[-SPREADGLOTTIS]/H and IDENT-[-LOWER]. The optimal candidate in (60a) is realized with H tone because L tone on an unaspirated obstruent is not phonetically realized. So, H and L tones in CVO syllables come from the phonological contrast between [lóp̀] with a L tone on coda [p], and [lòp] with no tone on the coda [p].

It is important to mention the phonetic realization of tone on obstruent codas. Tone cannot be phonetically realized on a coda stop. Consequently, the only tone that is realized is H, making the syllable sound as if it has level H tone rather than falling tone. So, although traditional descriptions have claimed that CVO syllables can bear either L or H tone, they really can bear either L or HL tone. This result explains the apparent difference between CVO and CV:O syllables: CVO have traditionally been described as contrasting L and H tone, while CV:O syllables have been described as bearing L and HL tone. In contrast, I have argued here that both CVO and CV:O syllables can bear L and

HL tone.

Tone neutralization in CVO syllables: H and M against unaspirated codas

The consequence of the proposed analysis is that a H tone input as in (61) surfaces with a HL tone. Phonologically, however, the optimal candidate in (61a) has a L tone associated with the coda consonant. The faithful candidate in (61b) violates *[-SPREADGLOTTIS]/H because the unaspirated coda is associated with H tone. In (61c), changing the H tone to L violates IDENT-[-LOWER], and changing the H tone to M violates IDENT-[+UPPER], as in (61d). While the optimal candidate violates *CONTOUR, it satisfies all the higher ranked constraints: IDENT-[-LOWER], *[-S.G.]/H, and IDENT-[+UPPER] .

(61) Hypothetical H tone input in CVO syllables

	H /ló p/	IDENT- [-LOWER]	*[-S.G.]/H	IDENT- [+UPPER]	*CONTOUR
a. ☞	H L [ló p̀]				*
b.	H [lóp]		W *		L
c.	L [lòp]	W *			L
d.	M [lōp]			W *	L

As shown in (57), M tone cannot be associated to H tone, either. I propose a constraint that bans unaspirated stops in coda positions from associating with M tones because codas are more stringent than onsets.

(62) *[-SPREADGLOTTIS]-CODA/M (*[-S.G.]-CODA/M)

No ***coda*** consonant specified as [-spread glottis] associates to M tone in the output.

The *[-SPREADGLOTTIS]-CODA/M dominates IDENT[-LOWER] as shown by the faithful candidate in (63c). Changing M tone on the coda consonant to L tone as in (63d) incurs a violation of OCP-[upper] because both M and L are [-upper]. The candidate with falling tone in (63b) violates IDENT[-UPPER] even though it has fewer violation marks under IDENT[-LOWER]. The optimal candidate is the L tone candidate in (63a).

(63) Hypothetical M tone input in CVO syllables

	M /lō p/	OCP [UPPER]	*[-S.G.]-CODA/M	IDENT [-UPPER]	IDENT [-LOWER]	*CONTOUR
a. ☞	L [lòp]				**	
b.	H L [ló p̀]			W *	L *	W *
c.	M [lōp]		W *		L	
d.	M L [lō p̀]	W *			L *	W *

The ranking in (64) shows that a toneless input (with two moras) maps unfaithfully to the L tone candidate. Since there is no input tone, no candidates violate IDENT-[-LOWER] (or any other IDENT-T constraints). The candidates (64b) and (64e) violate the markedness constraint *[-SPREADGLOTTIS]/H. The mid tone candidate in (64d) violates the proposed constraint *[-SPREADGLOTTIS]-CODA/M. The L tone candidate in (64a) is the optimum. The competing candidate with HL tone in (64c) violates the lower ranked constraint *CONTOUR. The faithful candidate in (64f) violates the ROOTNODE→T constraint.

(64) Hypothetical toneless input in CVO syllables

	μ μ | | /lo p/	RN→T	*[-S.G.]-CODA/M	*[-S.G.]/H	*CONTOUR
a. ☞	L /|\ [lòp]$_L$				
b.	H /|\ [lóp]$_H$			W *	
c.	H L /| | [ló p̀]				W *
d.	M /|\ [lōp]		W *		
e.	L H /| | [lò ṕ]			W *	W *
f.	[lop]	W ***			

CV:O syllables and tone in Thai

In (57), the CV:O syllables (a long vowel and an obstruent coda) surface with a low tone and a falling tone (see 57c and 57d). Under the ranking established so far, a CV:O input with L tone surfaces faithfully as in (65).

(65) Low tone input in CVːO syllables (from 57d)

	L L | | /ma ak/	IDENT-[+LOWER]	*[-S.G.]/H	*[-VOICE]/L
a. ☞	L [mà àk]			*
b.	H [má ák]		W *	L
c.	H L [má àk]	W *		*
d.	M [mā āk]	W *		L
e.	L H [mà ák]		W *	L

An HL input is faithfully realized as well, as in (66). The difference with CVO syllables is that there is an extra vowel [a], which can realize the L tone. Thus, an underlying HL contour tone surfaces with a falling contour in the output.

(66) HL tone input in CV:O syllables (from 57d)

	H L | | /ma ak/	IDENT-[+LOWER]	*[-S.G.]/H	*CONTOUR
a. ☞	H L [má àk]			*
b.	H [má ák]$_H$	W *	W *	L
c.	L [mà àk]$_L$	W *		L
d.	M [mā āk]$_M$	W *		L
e.	L H [ma ák]$_H$	W **	W *	*

This analysis shows that CVO syllables contrast in L and H, while CV:O syllables contrast in L and HL as shown in (57). In CV:O syllables, H tone and LH tone cannot surface because of *[-SPREADGLOTTIS]/H. M tone does not surface in CV:O syllables because it is banned by *[-SPREADGLOTTIS]-CODA/M.

5.4.3 Tone neutralization by onsets and by codas

In OVO (CVO with an unaspirated onset) and OV:O (CV:O with an unaspirated onset) syllables, only low tone surfaces in the output. Relevant data are presented again in (67).

(67) Unaspirated onsets and obstruent codas (Ruangjaroon 2006: 55, 60)

	non-aspirates	**low**	**mid**	**high**	**falling**	**rising**
a.	short V	[bòk] 'on land'				
b.	long V	[pàːt] 'to cut'				

Analysis: Tone neutralization by onsets AND codas

Following the analysis above, I assume that every syllable in Thai needs two moras, and that every mora can have a tone. Under the ranking so far, OVO syllables with L tone inputs surface faithfully, as in (68). While the optimal candidate violates the lower ranked *VOICELESS/L, all other candidates violate higher ranked constraints.

(68) L input in OVO syllables

	L μ | | /bo k/	*[-S.G.]-CODA/M	IDENT-[+LOWER]	*[-S.G.]/H	*CONTOUR	*[-VOICE]/L
a. ☞	L /|\ [bòk]					*
b.	H /|\ [bók]		W *	W *		L
c.	M /|\ [bōk]	W *	W *			L
d.	H L /| | [bó k̀]		W *		W *	*
e.	L H /| | [bò ḱ]			W *	W *	L

In OVO syllables, HL in input does not surface faithfully in the output. Tone neutralizes to L tone in the output as in (69). The faithful candidate in (69d) violates *[-SPREADGLOTTIS]/H because of the unaspirated onset is associated to H tone. The H tone candidate in (69b) and the LH candidate in (69e) also violate *[-SPREADGLOTTIS]/H because the unaspirated codas are associated to H tone. The M tone candidate in (69c) violates *[-SPREADGLOTTIS]-CODA/M. An underlying H tone cannot become M as in (69f) because the change incurs a violation of OCP.

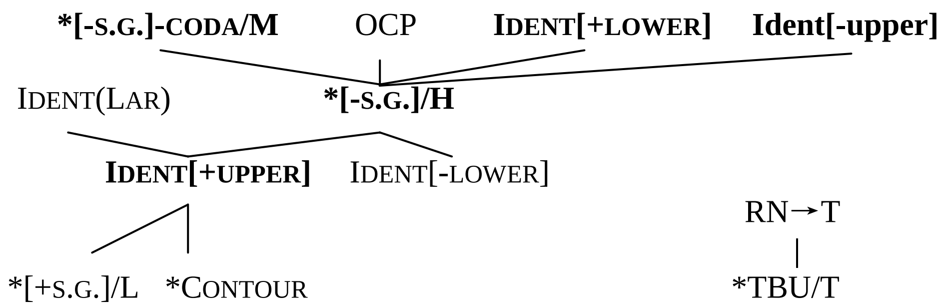
(69) HL input in OVO syllables

	H L | | /bo k/	*[-S.G.]-CODA/M	OCP	*[-S.G.]/H	IDENT-[+UPPER]	*[-VOICE]/L
a. ☞	L /|\\ [bòk]L				*	*
b.	H /|\\ [bók]H			W *	L	L
c.	M /|\\ [bōk]M	W *			*	L
d.	H L /| | [bó k̀]			W *	L	*
e.	L H /| | [bò ḱ]			W *	*	L
f.	M L /| | [bō k̀]L		W *		*	*

Under the ranking so far, input M, H and LH also neutralize tone in the output. The same ranking predicts an equivalent result in OV:O syllables.

In this section, I have presented tone neutralization to low tone in syllables with unaspirated onsets and codas in Thai (OVO and OVːO syllables). The ranking of Thai is presented in (70).

(70) Thai Ranking



5.4.4 Summary

This section has presented consonant-tone interaction in Thai, which shows tone neutralization by onsets and codas. Unaspirated stops in Thai do not occur in a high tone domain. This is analyzed as a crucial ranking, in which *[-S.G.]/H dominates IDENT-[+UPPER]. The neutralization by codas is due to *[-S.G.]/H as well. The OCP constraint on tonal features and the IDENT constraint on tonal features are crucial for the tone neutralization in CVO syllables. In OVO syllables, the tone of a syllable is always low. Neutralization to low tone is due to the interaction of constraints: *[-S.G.]/H and IDENT-[+UPPER].

5.5 Conclusion

This chapter has presented and analyzed how consonants impose restrictions on tone. Such interaction is called tone neutralization by consonants. Consonants in onset positions neutralize tone in Mulao (section 5.2), and consonants in coda positions neutralize tone in Burmese (section 5.3). In Thai, consonants in both onsets and codas neutralize tone in the output.

Following the proposal in chapter 3, the tone neutralization is analyzed as an effect of markedness constraints that regulate the dependency relationship between tone and consonants. There are no faithfulness constraints that target such consonant-tone relationships. The proposed markedness constraints used in discussing Mulao, Burmese and Thai are presented in (71).

(71) Markedness constraints (revisited)

a. *[+SPREADGLOTTIS]/L (*[+S.G.]/L) **Mulao**
No consonant specified as [+S.G.] associates with L tone in the output.

b. *[+CONSTRICTEDGLOTTIS]/L (*[+C.G.]/L) **Mulao**
No consonant specified as [+C.G.] associates with L tone in the output.

c. *[+CONSTRICTEDGLOTTIS]/H (*[+C.G.]/H) **Burmese**
No consonant specified as [+C.G.] associates with H tone in the output.

d. *[-SPREADGLOTTIS]/H (*[-S.G.]/H) **Thai**
No consonant specified as [-S.G.] associates with H tone in the output.

Chapter 6 Issues in consonant-tone interaction

6.1 Introduction

The xTBU theory presented in the preceding chapters has implications for a variety of issues in consonant-tone interaction. The theory predicts that an individual language might have an apparently unnatural set of depressor consonants. In other words, because of the interaction of the consonant-tone constraints the set of consonants that affect tone do not form a group definable as a unified featural class. This issue is discussed in section 6.2.

The theory also predicts that there should be apparent 'hierarchy' effects. The constraints presented in previous chapters can interact to prefer certain segments over others in consonant-tone interaction. Section 6.3 will show that hierarchy effects result from the interaction of constraints, focusing on Zina Kotoko.

In section 6.4, the issue of the directionality of consonant-tone interaction is discussed. The theory predicts that consonants can affect tone and tone can affect consonants. This prediction follows from the ability of markedness constraints on consonant-tone interaction to freely interact with faithfulness constraints on tone and faithfulness constraints on laryngeal features.

The theory and its implications with respect to tonogenesis are discussed in section 6.5. It is the markedness constraints on consonant-tone interaction that allow or block diachronic sound changes, and not simply the re-ranking of constraints.

The theory also has predictions with respect to consonant-tone interaction. Section 6.6 provides a comparison of xTBU theory to previous proposals on consonant-tone interaction.

6.2 How the theory produces unnatural classes of depressors

Chapters 4 and 5 argued that consonants may interact with tone through laryngeal features: [±voice], [±spread glottis], and [±constricted glottis] (see also Li 1980: 2). The influence of these features individually is summarized in table (1).

For example, in Western Bade [+voice] consonants block high tone spreading, while [-voice] consonants block low tone spreading. The blocking of high tone spreading by voiced consonants is observed in Tsonga and other languages as well. Yip (2002: 186) shows that voicing can also force tone neutralization, citing Chen (2000: 8)'s study of Songjiang. The laryngeal feature [±spread glottis] in (1c-d) also interacts with tone. Aspirated consonants ([+spread glottis]) neutralize output tone to high tone (as in Mulao) or low tone (as in Gurung (Glover 1970: 62-63)). The aspirates may also block high tone spreading as discussed in Tsonga. The feature [+constricted glottis] in (1d) neutralizes output tone to low (as in Burmese) or high (as in Mulao). As shown in (1e), the [-spread glottis] feature is active, forcing neutralization of output tone to non-high in Thai.

(1) Laryngeal features in consonant-tone interaction

	Features	**Effect on tone**	**Languages**
a.	[+voice]	blocks **high** tone spreading	*Western Bade, Tsonga*
		H neutralizes to non-high	*Songjiang*
b.	[-voice]	blocks **low** tone spreading	*Western Bade*
		L neutralizes to non-low	*Songjiang*
c.	[+spread glottis]	L neutralizes to **high** tone	*Mulao*
		H neutralizes to **low** tone	*Gurung*
		blocks **high** tone spreading	*Tsonga*
d.	[+constricted glottis]	H neutralizes to **low** tone	*Burmese*
		L neutralizes to **high** tone	*Mulao*
e.	[-spread glottis]	H neutralizes to **non-high**	*Thai*
g.	[-constricted glottis]	*unidentified*	

I have not been able to find a language in which [-constricted glottis] plays a crucial role in consonant-tone interaction. This gap may be an accidental result of the limited number of known cases of consonant-tone interaction.

Evidently, the contrast of consonants in a language matters when the crucial features as in (1) are discussed. For example, if a language does not have contrastive consonants related to glottal constriction ([+constricted glottis]), there would be no consonant-tone interaction involving the feature [+constricted glottis].

The cases cited in table (1) refer to *natural classes* of ‘depressors’ or ‘elevators’ – consonants that influence tone. They are natural classes in the sense that the consonants all share a particular feature value. However, the theory does not demand that a language’s depressors form a natural class. For example, the constraints *[+spread glottis]/L and [+constricted glottis]/L target different sets of consonants. If they are both active in a language, then all these consonants will force neutralization of L tone to H tone, even though aspirated consonants and glottalized consonants don't form a natural class defined by a single feature value or set of values. For example, [t^h] is [+spread glottis, -constricted glottis] and [ˀw] is [-spread glottis, +constricted glottis], but both segments would motivate tone elevation in this situation. In general terms, as discussed in Flemming (2005), a 'natural' class can be defined by the effect of constraints, not just by features.

Mulao provides a clear example. The consonants in Mulao are presented in (2). Syllables with onsets that are in the heavy-lined box neutralize the output tone to high. However, there is no single feature or set of features that defines the class of consonants in the box. Instead, the consonants are the union of two disjoint sets: those that are [+constricted glottis] (circled) and those that are [+spread glottis] (not circled). xTBU theory allows such a non-natural class by having two active markedness constraints: *[+SpreadGlottis]/L and *[+ConstrictedGlottis]/L. Section 5.2 provides a detailed analysis using these constraints.

(2) Mulao consonants (Wang and Zheng 1993: 4-5)

		elevators						non-elevators			
stops	unaspirated							p	t	c	k
	aspirated	**p^h**	**t^h**	**c^h**	**k^h**	**ʔ**	**h**				
affricates	unaspirated								ʦ		
	aspirated		**$ʦ^h$**								
fricatives	**voiceless**	**f**	**s**	**ç**							
	glottalized				**ˀɣ**						
	voiced									ɣ	
sonorants	nasal							m	n	ɲ	ŋ
	voiceless	**m̥**	**n̥**	**ɲ̊**	**ŋ̊**						
	oral							w	l	j	
	laryngealized	ˀw	l̥	ˀj							

In (3), SiSwati depressors are presented in the heavy-lined box, which includes voiced obstruents and clicks. The depressor consonants are actively affected by the markedness constraint *VOICEDOBSTRUENT/H, which includes both *VOICEDSTOP/H and *VOICEDFRICATIVE/H.

(3) SiSwati consonants (Schachter 1976: 213, Bradshaw 2003: 279)

			depressors				non-depressors			
stops	**voiceless**	**unaspirated**	**b**	**d**		**ɡ**				
	voiceless	aspirated					p^h	t^h		k^h
affricates	**voiceless**	**unaspirated**		**ʣ**	**ʤ**					
	voiceless	aspirated					tf^h	ʦ^h		
ejectives							p’	t’	ʧ’	k’
implosive							ɓ[1]			
clicks[2]	voiceless	unaspirated						ǀ		
	voiceless	aspirated						ǀ^h		
	voiced			ᶢǀ						
fricatives	voiceless						f	s	ɬ	h
	voiced		**v**	**z**	**ɮ**	**ɦ**				
sonorants	nasal					ŋ[3]	m	n	ɲ	
	oral						w	l	j	

As shown in (3), depressors in SiSwati do not form a natural class defined by a single feature value. This has prompted previous studies to suggest an account based on sound change (cf. Schachter 1976: 213-214, Rycroft 1980: 10). With the xTBU theory’s constraints, however, SiSwati depressors behave together because all depressors and only

[1] Phonetically, implosives are voiced. However, Bradshaw (2003) points out that the implosive [ɓ] in SiSwati is the only voiced stop without a voiceless counterpart, which arguably suggests that the implosive [ɓ] could phonologically be [-voice]. Implosives are always phonetically voiced for articulatory reasons. For a relevant study on implosives, see Clements and Osu (2002), Storoshenko (2003), and Tang (to appear).

[2] The current IPA symbols for clicks differ from those used in Schachter (1976). Thanks to Will Bennett, who pointed out the difference to me.

[3] Bradshaw (2003) explains that the velar nasal [ŋ], the only nasal depressor in SiSwati, is a reduced form of [ŋɡ] with a voiced stop, so I treat it as a voiced stop here.

depressors are subject to the markedness constraint *VOICEDOBSTRUENT/H.

In Tsonga, yet another set of consonants behave as depressors. As shown in (4), depressors are voiced stops, breathy voice consonants, and aspirates. The aspirates, which are not depressors in SiSwati, are depressors in Tsonga. On the other hand, the voiced fricatives, which are depressors in SiSwati, are not depressors in Tsonga.

Tsonga depressors behave in the same way due to the markedness constraints *VOICEDSTOP/H and *[+SPREAD GLOTTIS]/H. The *VOICEDSTOP/H constraint groups voiced stops, and the *[+SPREAD GLOTTIS]/H constraint targets breathy voice and aspirates (including [ɦ]). This group of depressors differs from Mulao's in that the two definable sets of consonants do intersect: [$^{(m)}$b̤ $^{(n)}$d̤ $^{(ŋ)}$g̈] are both voiced stops and [+spread glottis].

(4) Tsonga consonants (Baumbach 1987: 3-16)

			depressors				non-depressors			
stops	voiceless	unaspirated					p	t		k
	voiceless	**aspirated**	**p^h**	**t^h**		**k^h**				
	voiced		**b**	**d**		**g**				
	breathy		**$^{(m)}$b̤**	**$^{(n)}$d̤**		**$^{(ŋ)}$g̈**				
		prenasalized					^{m}b	^{n}d		^{ŋ}g
affricates	voiceless	unaspirated					pf	ʦ	ʧ	
	voiceless	**aspirated**	**pf^h**	**$ʦ^h$**	**$ʧ^h$**					
	voiced	unaspirated					bv	ʣ	ʤ	
	voiced	**aspirated**	**bv^h**	**ʣ̤**	**ʤ̈**					
fricatives	voiceless						ɸ, f	s	ʃ	x
	voiced					ɦ	β, v	z	ʒ	
sonorants	nasal						m	n	ɲ	ŋ
	nasal	**breathy**	**m̤**	**n̤**		**ŋ̈**				
	oral						w	r	l	j
	oral	**breathy**	**w̤**	**r̤**	**l̤**	**j̈**				

I have argued above that there are two types of ‘natural class’. The traditional concept is that a set of segments is a natural class if all the segments share particular feature values and no segments outside the class have those values – I call this a ‘featural natural class’. However, there is also an output-oriented conception of ‘natural class’: a natural class of segments is all those that undergo or condition a particular process (i.e., unfaithfulness). For example, if the markedness constraints *α/H and *β/H are both active in a language (i.e. outrank appropriate faithfulness constraints), then α and β will both force tone lowering. In this sense, α and β are a natural class, even though α and β may not share any features (as in Mulao).

While many apparently ‘unnatural’ classes of depressors/elevators have been identified, I propose that while they may be *featurally* unnatural classes, they are natural classes in terms of *the effect of constraints*.

In Tsonga, both *VOICEDSTOP/H and *[+S.G.]/H are active, and they both trigger tone lowering. So, although voiced stops and other [+spread glottis] segments do not form a natural class defined by individual features, these consonants are considered to be a natural class because of the output oriented nature of consonant-tone interaction.

There have been other approaches to unnatural classes (Pulleyblank 2003, Mielke 2004, 2005). However, these adopt formal mechanisms in addition to the ones I propose. Mielke, for example, observes that nasals and laterals pattern with non-continuants in one language, and they pattern with continuants in another language. Based on the ‘ambivalent’ nature of the segments, Mielke argues that distinctive features are not necessarily innate. He proposes that distinctive features emerge as a by-product of phonological rules in a synchronic grammar. Since the xTBU constraints can deal with unnatural classes in consonant-tone interaction, the theory does not require such proposals.

In this section, I have shown that consonants interacting with tone form natural classes if they are subject to active markedness constraints; a claim based on the proposal by Flemming (2005). As discussed above, the puzzle can be overcome if a natural class is also defined based on the set of constraints related to phonological processes.

6.3 Derived hierarchies in consonant-tone interactions

When several xTBU constraints are active, they can create apparent hierarchy effects in tone-consonant interaction. An illustrative case is found in Zina Kotoko (Odden 2002).

In Zina Kotoko, the future tense is a circumfix [n^{H}-…-a], where the H tone is realized on the stem syllable, as shown in (5). The high tone is realized faithfully when the stem begins with [h], voiceless stops, and implosives. High tone is marked with an acute accent. Low tone is marked with a grave accent, and mid tone has no marking.

(5) H tone in future tense (Odden 2002: 17)

a.	[h]	[h]	n-hár-à	*find*	[h]	n-híyar-à	*bite pl.*
		[h]	n-hə́n-à	*burn*	[h]	n-hám-à	*swear*
		[h]	n-hə́rc-à	*slice*	[h]	n-hə́s-à	*throw*
b.	implosives	[ɗ]	n-ɗə́v-à	*put*	[ɗ]	n-ɗám-à	*eat*
		[ɗ]	n-ɗə́h-à	*write*	[ɓ]	m-ɓál-à	*dance*
c.	voiceless	[s]	n-sáp-à	*chase*	[s]	n-sáb-à	*grow*
	obstruents	[p]	m-páy-à	*bury*	[c]	n-cíhy-à	*fry*
		[k]	n-káɗ-à	*cross*	[c]	n-cə́nh-à	*be sated*
		[s]	n-sə́my-à	*hear*	[s]	n-sə́k-à	*send*

The high tone of future tense is lowered to mid when roots begin with sonorants, glottal stops, and voiced obstruents, as shown in (6).

(6) H tone lowering to mid in future tense (Odden 2002: 17-18)

a.	sonorants	[y]	n-yey-à	*call*	[w]	n-wurgy-à	*buy*
		[w]	n-wac-à	*leave*	[w]	n-wasy-à	*cough*
		[w]	n-wuràgy-à	*buy pl.*	[l]	n-lab-à	*tell*
		[l]	n-law-à	*fight*	[l]	n-ləhày-à	*fear*
		[r]	n-raɗ-à	*pull*	[m]	m-mar-à	*die*
		[l]	n-lum-à	*shave*	[l]	n-lakf-à	*bring*
b.	glottal stop	[ʔ]	n-ʔəkf-à	*approach*	[ʔ]	n-ʔək-à	*snatch*
c.	voiced obstruents	[j]	n-jagh-à	*dig*	[gh]	n-ghag-à	*close*
		[z]	n-zəgh-à	*distribute*	[g]	n-gəg-à	*do*
		[b]	m-bagh-à	*split*	[z]	n-zəby-à	*follow*
		[z]	n-zəgl-à	*carry*	[b]	m-bughwr-à	*jump*
		[g]	n-gəɓ-à	*answer*	[b]	m-ban-à	*bathe*
		[j]	n-jary-à	*burp*	[d]	n-dunkw-à	*throw*
		[v]	m-vənàh-à	*vomit*	[g]	n-gulàn-à	*laugh*

The theory of natural classes presented in section 6.1 and the xTBU theory's consonant-tone markedness constraints explain the depressor phenomena in the future tense in Zina Kotoko. Markedness constraints prevent high tone from appearing in roots with these consonants. If high tone occurs with voiced obstruents and sonorants, the *VOICED/H (target any voiced consonants including sonorants) constraint is violated. If high tone occurs with a glottal stop onset, *[+CONSTRICTEDGLOTTIS]/H is violated. As a result, mid tone occurs in the root instead of high tone. The consonants in (6) form a natural class because they are subject to the active markedness constraints. Crucially, the onsets in (5) do not violate the markedness constraints *VOICED/H and *[+CONSTRICTEDGLOTTIS]/H.

While it may seem that Zina Kotoko simply presents a situation of 'unnatural class' behavior, other morphological processes display *different* consonant-tone interactions, as shown in (7). Mid tone becomes low before voiced obstruents in recent past and in imperatives as in (7a). Consonants also affect the subsequent tone. In the progressive, high tone reduplicants surface with mid tone if they begin with voiced obstruents or sonorants as in (7b). Similar to (7a), mid tone becomes low if followed by voiced obstruents, sonorants, implosives, or a glottal stop in the remote past and the recent past. The page numbers in the last column indicate the pages in Odden (2002).

(7) Consonant-tone interaction in Zina Kotoko (Odden 2002)

rules	*change*	*before*	*tense*
a. Pre-depressor lowering	**M → L** M → M	**voiced obstruents** sonorants ~ [h]	*recent past* (p.21) *imperative* (p.28)
	change	*after*	*tense*
b. Reduplicant	**RED = M** RED = H	**voiced obstruents ~ sonorants** glottal stop ~ [h]	*progressive* (p.31)
c. M lowering	**M → L** M → M	**voiced obstruents ~ implosives** voiceless obstruents, [h]	*recent past* (p.20) *remote past* (p.26)

The consonant-tone interaction in various morphological processes in (7) can be analyzed in the same way as the future tense. The three morphologically-conditioned consonant-tone interactions result from the ranking of consonant-tone constraints in different ways.

The patterns in Zina Kotoko seem to show that there is a hierarchy of consonant-tone interaction because of the four different tonal lowering processes by consonants. In (8), the apparent hierarchy with the implicational relationship (marked with '>') between consonants and tone is presented. In the hierarchy, consonants to the left (i.e. *voiced obstruents*) have a closer relationship with low tone, and consonants to the right (i.e. *voiceless obstruents*) have an affinity with high tone.[4]

[4] There are other hierarchies in phonology, which combine two scales as the one in (8). For example, the sonority hierarchy combines with moras, and thus provides insights on the analysis of heavy-light syllables

(8) Consonant-tone hierarchy of Zina Kotoko (Odden 2002: 16)

L ←——————————————→ H

voiced obstruents > sonorants > [ʔ] > implosives > voiceless obstruents, [h][5]

↑ a. ↑ b. ↑ c. ↑ d.

This hierarchy describes the consonant-tone interaction in Zina Kotoko. However, it does not explain why and how the grammar results in such an interaction. As pointed out in Odden (2007), such tonal processes suggest that accounts solely based on phonetic representation are not adequate to account for tonal blocking by consonants.

As discussed in section 6.1, consonants can be a natural class if they are subject to active markedness constraints on consonant-tone interaction. In (8), all the arrows mark a certain point sensitive to consonant-tone interaction. The apparent hierarchy in (8) is a result of markedness constraints targeting different sets of consonants in Zina Kotoko.

An earlier proposal of a hierarchy of consonant-tone interaction appears in Hyman and Schuh (1974) as in (9). In this hierarchy, breathy voice consonants show the greatest lowering effect, and implosive consonants are shown as raising consonants.

(9) Consonant-tone hierarchy (Hyman and Schuh 1974: 110)

Tone lowering ←——————————————→ *Tone raising*

breathy voice	voiced obstruent	sonorant	voiceless unaspirated	voiceless aspirated	implosive

The hierarchy in (9) is based on the phonetic effects of consonants on tone, in which

in a given language (Zec 1995, Morén 2003, Elías-Ulloa 2006). Hierarchies also express the markedness relationships in the grammar (Prince and Smolensky 1993/2004, de Lacy 2004, 2006).

[5] The consonants presented here include all the consonants reported in Zina Kotoko (Schmidt et al. 2002: 4).

breathy voice and voiced obstruents lower the pitch of a following vowel, and voiceless obstruents and implosives raise the pitch of a following vowel.

In phonetic studies, the influence of the status of glottals with respect to the phonation types has been proposed as a continuum (Ladefoged 1971, Gordon and Ladefoged 2001: 384), while other studies on glottal status propose a multi-dimensional model of glottals (See Stevens 1977, Esling and Harris 2005, Edmondson and Esling 2006: 159).

In chapter 4 and chapter 5, consonant-tone interaction is argued to be independent of the phonetic effect of consonants to tone. It is the interaction of markedness constraints that regulates the consonants that interact with tone, not the phonetic properties.

In this section, I have shown that the hierarchy of consonant-tone phenomena in Zina Kotoko is not a true hierarchy, but rather a result from output oriented constraints in consonant-tone interaction.

6.4 Directionality of consonant-tone interaction

The theory presented here predicts that not only can consonants can affect tone, but tone could also affect consonants. In other words, a constraint like *[+voice]/H could be satisfied either by changing the tone to L, or devoicing the consonant. It is a controversial claim that tone can affect consonants (see Hyman (1973, 1976), Hyman and Schuh (1974) cf. Maddieson (1974, 1976)). This section will discuss the evidence that tone can affect consonants.

In the xTBU theory, tone can affect consonants and consonants can affect tone because faithfulness constraints on tone and faithfulness constraints on consonants are freely rankable. The consonant-tone markedness constraint can be satisfied by changing the consonants if IDENT-T outranks the constraint IDENT-LAR; the identity of tone must be preserved while laryngeal features of consonants must change.

An example is presented in (10). Let us assume an input that has an aspirated consonant and a low tone. Under the ranking in (10), in which the markedness constraint *[+SPREAD GLOTTIS]/L (*[+S.G.]/L) and the faithfulness constraint IDENT-T outrank IDENT-LAR (and *L), the optimal candidate is (10a), in which the onset is unaspirated. The candidate in (10b), which changes the input tone to high tone, violates the higher ranked faithfulness constraint IDENT-T. The faithful output with an aspirated onset is ruled out by *[+S.G.]/L as in (10c). Therefore, this is a language in which segmental change occurs due to tone.

(10) Hypothetical Mulao - change in laryngeal feature

	L | /pʰàː/	*[+S.G.]/L	IDENT-T	IDENT-LAR
a. ☞	L /| [pàː]			*
b.	H /| [pʰáː]		W *	L
c.	L /| [pʰàː]	W *		L

Maddieson provides a number of examples like Hypothetical Mulao. I have listed them in section 2.4 and provided relevant quotations from the primary sources. In these languages, low tone forces voiceless stops to become voiced in the output. While the examples in section 2.4 are 'impressionistically observed' according to Maddieson (1978:

327), these examples suggest that tone could affect consonants. A definitive conclusion awaits detailed phonetic and phonological analysis.

6.5 Tonogenesis and Phonetics

Tonogenesis is a diachronic process in which a language with laryngeal contrast (and tonal neutralization) changes to a language with tonal contrast (and laryngeal neutralization). Tonogenesis, a term coined by James Matisoff (1970), was first discussed in relation to the origin of Vietnamese tone. Maspero (1912) and Haudricourt (1954) observe that high tone in modern Vietnamese developed from historically voiceless consonants, while low tone comes from voiced consonants. In Vietnamese, the loss of voicing contrast in the onset consonants results in tonal contrast as in (11). The high tone word [kam] is shown in (11a), and the low tone word [kə̌n] is shown in (11b). Note that the corresponding Chinese words have a voicing distinction in their onsets. The Chinese word (from 9-10th century) corresponding to the high tone Vietnamese word in (11a) has a voiceless onset [k], while the Chinese word in (11b) has a voiced onset [g].

(11) Tonogenesis in Vietnamese (Maspero 1912: 20)

	Vietnamese		**Chinese**	**Gloss**	
a.	**k**am	*high*	**k**am	sweet	(甘)
b.	**k**ə̌n	*low*	**g**^{y}iěn	near	(近)

Tonogenesis is also found in Athabaskan languages (Kingston 2005, Krauss 2005). Krauss (2005) shows that different Athabaskan languages have undergone different processes of tonogenesis in addition to segmental changes. As shown in (12), the word *wət' '*belly*' in Proto-Athabaskan becomes high tone in Chipewayan ([bə́r]), while the same word in Gwich'in becomes low tone ([vàd], a phenomenon known as tonal flip-flop; see Kingston and Solnit (1989)). On the other hand, the word *wət' '*belly*' in Proto-Athabaskan has also developed into a toneless word in Hupa ([mət']).

(12) Tonogenesis in Athabaskan languages (Kingston 2005: 144, from Krauss 2005)

	a. Proto-Athabaskan	**b. Chipewayan**	**c. Gwich'in**	**d.Hupa**
marked tone		*high*	*low*	*non-tonal*
belly	*wət'	bə́r	vàd	mət'
fire	*qʊn'	kún	kǫ̀ʔ	xoŋ'
rain	*kʲa·n	ʧą́	tsìn	kʲaŋ
foot	*qeʔ	ké	kʷàjʔ	xeʔ
flour	*ɬeʔʤ	ɬéz	ɬùh	ɬi·ʍ

Such a non-uniform pattern of tonogenesis is also found in various Asian languages. For example, pre-nasalized or fricative onsets in Miao either occur with either high or low tone depending on the dialect (Li et al. 1972). Across languages, aspirated onsets require a low tone in Wuchiang Chinese (spoken in Kiangsu) (Li, Fang Kuei 1980: 6), while aspirated onsets require a high tone in Mulao (see section 5.2). The different tonal developments in tonogenesis are summarized by Fang-Kuei Li (1980: 2) as follows: "… consonantal features … need not influence different tones in the same way." See also Hombert (1975).

6.5.1 Theories of tonogenesis

There are two major theories about how constraints and their rankings influence diachronic changes. One view is that constraints and rankings define possible synchronic grammars but do not motivate diachronic change. Diachronic changes occur from misperception or mispronunciation ('coordination problem' Bermúdez-Otero 2007: 497); constraints merely restrict the grammars that result from such misperception/ mispronunciation.

An alternative theory is that diachronic changes are due to a change in constraint ranking (Reynolds 1994, Zubritskaya 1995: 250-251, Crist 2001 and references therein). In this view, a learner acquires a ranking, but then alters it. For example, if a parent has the ranking IDENT-T » *[+SPREAD GLOTTIS]/L but the child reverses the ranking, the child thereby actuates a process of tone-raising.

A clear difference between the two theories relates to input→output mappings. In the misperception theory, a sound change *α→β does *not* imply that there is a synchronic grammar with the mapping /α/→[β]. If a child misperceives α's as β's, then the child never learns an underlying form with /α/, and so is not forced to create a grammar in which /α/→[β].

In contrast, in the reranking theory of diachronic change, if a child hears α, the child will store it as /α/. Then, to actuate the change *α→β, the child will rerank constraints, resulting in a synchronic mapping of underlying /α/ to output [β].

Consequently, under the reranking theory, every diachronic change must be a possible synchronic input→ouput mapping (it is also possible that every synchronic input →output mapping is also a possible diachronic change (cf. Hyman and Schuh 1974)).

Under the misperception theory, there is no such implication: sound changes through misperception might have no synchronic input→output counterpart (and vice-versa).

The misperception theory is adopted here because there are instances in which a diachronic change does not have a synchronic counterpart. For example, in Hawaiian and other language, a *t diachronically changes to [k]. However, there are no synchronic process that neutralize /t/ to [k] (de Lacy 2006: 352). De Lacy cites Lynch et al. (2002: 54), which notes that "across the languages of the world the sound change *t* to *k* is hugely more common than *k* to *t*". If diachronic changes occur due to the change in synchronic mappings, it is strange that the less common change **k*→*t* has a synchronic counterpart in languages, and not vice versa.

Following de Lacy (2006: 348-355) and many others, I argue that the xTBU theory's constraints *restrict* the possible synchronic grammars resulting from diachronic changes; however, they do not motivate tonogenesis. In Chipewayan, for example, a child would have misperceived a final glottal stop as a high tone. The result is that Chipewayan has a High-Low tone contrast, and it is the xTBU theory's role to define such a grammar. In contrast, the same glottal stop in Gwich'in becomes low tone. However, the result is the same: Gwich'in ends up with a High-Low tone contrast.

Hupa undergoes a different diachronic change because of the synchronic grammar that has the high ranked *TBU/T constraint. When a child of Hupa misperceives a final glottal stop as tone, the tone would not be realized in the output, due to the active markedness constraint *TBU/T in the synchronic grammar.

6.5.2 Physiological accounts of tonogenesis

The misperception/mispronunciation theory of tonogenesis makes crucial reference to physiological and acoustic factors in tone-consonant production and perception.

The physiological motivations of tonogenesis can have different explanations. In Hombert et al. (1979), tone results from "the involuntary act of muscles". It is the pitch-affecting properties of consonants that develop into tone. If speakers misperceive the influence of consonants on the following vowel as tone, a language becomes tonal. By contrast, Kingston's view is that tone can emerge from "the voluntary act of muscles" as demonstrated below.[6]

Athabaskan languages present diverse tonal development. The Proto-Athabaskan word for *fire* *qʊn' surfaces with high tone as [kʊ́n] in Chipewayan, and is realized with low tone as [kǫ̀ʔ] in Gwich'in. In Hupa, however, the corresponding word [xoŋ'] is toneless. Kingston (2005: 150-151) argues that the tonal situation in Athabaskan languages is due to "a stem-final glottal consonant", which results in a high or low tone. Kingston argues that diverse tonal developments such as those observed in Athabaskan languages are due to the physiology of glottals. He argues that it is the variability in vowel constriction that results in high tone or low tone. If creaky voice arose from vowel constriction, low tone would occur because creaky voice lowers the pitch (F0). If tense voice arose from vowel constriction, high tone would emerge because tense voice raises the pitch (F0). Kingston's (2005: 177) argument is based on the observation that vowel constriction can independently occur by either the thyroarytenoid muscles or the

[6] The terms 'the involuntary act of muscles' and 'the voluntary act of muscles' are suggested by Jonathan Wright (p.c.).

cricothyroid muscles.

In an interesting study of Kammu by Svantesson and House (2006), speakers of tonal dialects are shown to make use of pitch (F0) in production and perception, while non-tonal dialect speakers are shown to be not sensitive to pitch. Furthermore, they also demonstrate that the pitch perturbation by onset consonants is smaller in the non-tonal dialect.

6.5.3 Cross-linguistic tonogenesis studies

Tonogenesis has cross-linguistic support as presented in this section. There are many studies that show evidence for tonogenesis in Asian languages, as shown in (13).

(13) Tonogenesis in Asian languages

	Language	*References*
a.	Kam	"Kam shares with most Kadai languages … namely, a lowering of pitch of syllables following original voiced initial consonants, a tonogenetic split…" (Edmondson 1990: 188)
b.	Sui	"… in Sui … [there is] the historical process of developing low tones after voiced initials …" (Edmondson and Yang 1988: 149)
c.	Vietnamese	"H. Maspero has shown that the six tones of Vietnamese were distributed in two series. One series … was tied to old voiceless initials, whereas the other … accompanied the old voiced initials (Haudricourt 1954: 72)[7]" See also Gage (1985), Thurgood(2002).
d.	Kurtoep	"Kurtoep displays high tone following voiceless obstruents and low following voiced obstruents. … there is no voiced palatal fricative [in Kurtoep]. Nearby languages have both voiced and voiceless palatal fricatives and no contrastive tone possible, unlike Kurtoep" (Lowes 2006: 9)
e.	Lahu	"The high-rising tone arose in Lahu through dissimilation in pre-Lahu syllables which both began and ended with a "glottal incident." (Matisoff 1970: 13, 2003)

[7] I thank Carlo Linares Scarcerieau for the assistance with the English translation from French.

f.	Mon-Khmer languages	“Syllables with original voiceless onset consonant … acquired high tone, and those with voiced onset consonant got low tone. … long and short vowels have merged, giving rise to low and high tones respectively.” (Svantesson 2001: 48-49)

Native American languages also demonstrate tonogenesis. Zapotec, Upriver Halkomelem, and Athabaskan languages in this category are shown in (14).

(14) Tonogenesis in Native American languages

	Language	Reference
a.	Zapotec	“Fortis/geminate versus lenis/singleton may be a conditioning environment for tonal contrast. … higher pitch on vowels following geminate/fortis obstruents than when following singleton/lenis obstruents.”(Lowes 2005: 8)
b.	Upriver Halkomelem	“In Upriver Halkomelem, the loss of post-vocalic glottal stops not only raises pitch, but it also lowers it in different environments” (Brown 2004: 7)
c.	Athabaskan	“… a post-vocalic glottal stop … becomes … a phonation type…; this phonation type subsequently evolves into the marked tone in the daughter languages (Leer 1999: 40).” See also works in Hargus & Rice (2005).
d.	Kickapoo	“… Kickapoo … generalized aspiration before the fricatives at some stage prior to the acquisition of low tone before /h/, thus leaving low tone before all fricatives when the aspiration was subsequently lost.” (Gathercole 1983: 75)
e.	Hopi	“… originally voiceless … finals yield … a low tone distinct from the unmarked (high) tone typical of original voiced articulations in the same position.” (Manaster Ramer 1986: 154)

Tonogenesis is also discussed in other languages including Balto-Slavic languages as in (15). In particular, recent studies suggest that there is strong evidence for an ongoing tonogenesis in Seoul Korean. In Korean, the Voice Onset Time (VOT) between plain voiceless stops and aspirated stops is becoming indistinguishable in younger speakers’ speech. Silva’s (2006) insightful study shows that the pitch of the vowels following aspirates is significantly higher than that of those following voiceless stops; this suggests that Seoul Korean might be a case of ongoing tonogenesis.

(15) Tonogenesis in other languages

	Language	Reference
a.	Seoul Korean	"In Korean, it was not the loss of voicing contrasts that gave rise to new tonal distinctions; rather new manner distinctions in the initial consonants arose in Korean (Ramsey 1991, 2001: 40)" For recent works see Silva (2006) and Wright (2007).
b.	Balto-Slavic	"A syllable-final glottal stop can either be lost directly, resulting in a high-pitched short syllable, or give rise to a laryngealized syllable and, finally, a low-pitched long syllable (Slovene)." (Greenberg 2006: 21)
c.	Kwa, Kru, Mande	"Tones in Kwa, Kru and Mande developed from initial prevocalic consonantal perturbations on vowels. Voiceless obstruents correlate with the developments of high tones and voiced obstruents with low tones." (Ahoua 2003: slide#16)
d.	Yabem, Bukawa	"… vowels which followed voiced obstruents acquired low tone and those following voiceless obstruents high tone …" (Ross 1993: 142)
e.	Cèmuhî	"Widespread use of reduplication of initial syllable causes intensification of the stress on this syllable. In some languages, this intensified stress is transformed into a high tone …" (Rivierre 2001: 40)

6.5.4 Summary

The relationship between consonants and tone has been observed in diachronic studies. Tonogenesis is argued to result from the restrictiveness of markedness constraints in the synchronic grammar (see section 6.5.1). If a speaker mispronounces and a listener misperceives a consonant as a tone, tonogenesis occurs, following the ranking of consonant-tone markedness constraints in the synchronic grammar. As shown in Athabaskan languages, the ranking of the markedness constraints can determine the possible tonal outcome.

6.6 Comparison with other theories of consonant-tone interaction

The theory of consonant-tone interaction predicts in essence three types of languages: tonal languages with consonant-tone interaction, tonal languages with no consonant-tone interaction, and non-tonal languages. The xTBU theory's constraints are couched in formalism from Autosegmental Theory (Leben 1973, Goldsmith 1976).

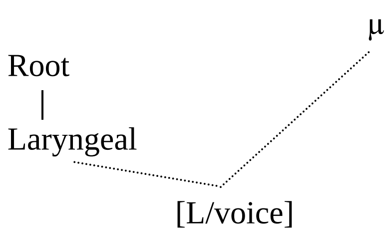
In xTBU theory, moraic segments and non-moraic segments can associate to tone. Tones directly associated to consonants (either onsets or codas) are subject to the markedness constraints targeting consonants and tone. It is crucial that there is no faithfulness constraint that targets the relationship between consonants and tone. This predicts that consonants are not contrastive in terms of tone (see chapter 3).

Consonant-tone interaction results from constraint interaction. In particular, all laryngeal segments in a language can potentially interact with tone depending on the ranking of various markedness constraints. Since constraints are freely rankable, the theory predicts that consonant-tone interaction is bidirectional: tone can affect consonants as consonants can affect tone (see section 6.4).

In terms of voicing, the constraint-based theory predicts that there are no languages in which voiceless consonants block the spreading of high tone, but in which voiced consonants do not block such a spreading (due to the lack of *VOICELESS/H, which is motivated in the analysis of Western Bade, see section 4.3.2). Consequently, any consonants may block the spreading of a high tone, or only voiced consonants can block high tone spreading. Moreover, there are no languages in which non-laryngeal consonants neutralize tone in the output when laryngeal consonants (such as aspirates or glottalized consonants) do not force such neutralization.

Previous studies have emphasized the importance of voicing in consonant-tone interaction. Bradshaw (1999) proposes the feature [L/voice] to account for the observed relationship between voiced consonants and low tone. The feature [L/voice] in the representation is realized as low tone when associated to the suprasegmental tier, but as the [voice] feature when associated to the segmental tier.[8] The multi-planar theory aims to account for the insertion of low tone by depressors, the blocking of high tone spreading by depressors, and the voicing of voiceless obstruents when depressors are present. The representational nature of the multi-planar theory, however, is not explanatory for phenomena such as the blocking of low tone spreading in Western Bade or the tonal neutralization by aspirates or glottalized consonants in Mulao.

(16) [L/voice] in Bradshaw's Multiplanar model (Bradshaw 1999: 51)



Peng (1992), on the other hand, proposes a theory of consonant-tone interaction in the framework of Grounded Phonology (Archangeli and Pulleyblank 1994). Based on Ngizim, Nupe, and Ewe, Peng's proposal attempts to account for the blocking of high tone spreading by voiced consonants, the blocking of low tone spreading by voiceless

[8] Bradshaw (1999) assumes that [voice] is a privative feature.

consonants, and the transparency of sonorants in consonant-tone interaction. In particular, Peng focuses on onsets that interact with tone. His analysis is based on the prosodic hypothesis presented in (17). In addition to this hypothesis, the path conditions in (18) regulate the consonant-tone interaction. The conditions in (18a-d) are about consonants affecting tone, and the conditions in (18 e-h) are about tone affecting consonants.

(17) The prosodic hypothesis of tone-voice interaction (Peng 1992: 27)

a. Tone and voice must be represented on separate autosegmental planes.
b. Tone-voice correlations must be determined by conditions on tone and voice operations

(18) Path conditions of tone-voice (Peng 1992: 202)

a.	HI/VOICING Condition	If +high, then -voiced If +high, then not +voiced
b.	-HI/VOICING Condition	If -high, then +voiced If -high, then not -voiced
c.	LO/VOICING Condition	If +low, then +voiced If +low, then not -voiced
d.	-LO/VOICING Condition	If -low, then -voiced If -low, then not +voiced
e.	UNVOICED/HI Condition	If -voiced, then +high If -voiced, then not -high
f.	UNVOICED/LO Condition	If -voiced, then -low If -voiced, then not +low
g.	VOICED/HI Condition	If +voiced, then -high If +voiced, then not +high
h.	VOICED/LO Condition	If +voiced, then +low If +voiced, then not -low

While Peng, unlike Bradshaw, incorporates voiceless onsets in addition to voiced ones into his analysis, the theory does not address the issue with coda consonants in consonant-tone interaction. As discussed in chapter 5, coda consonants in Burmese and

Thai, among other languages, neutralize tone in the output. If only onset consonants affect tone, we would not expect consonant-tone interaction driven by codas.

Lieber (1987: Ch. 4) proposes a prespecification theory of consonant-tone interaction. Similar to Peng (1992), her theory addresses the issue that voiceless consonants do not block high tone spreading, and voiced consonants do not block low tone spreading. She assumes that features can be specified in multiple tiers (motivated by data on mutation and harmony). So, tonal features are in the suprasegmental tier, and they can be prespecified on consonants in the segmental tier. In Zulu (Laughren 1984) and other Nguni languages (Rycroft 1980), depressor consonants are proposed to be prespecified with tonal features. Tonal spreading is blocked only if the prespecified feature does not allow such a spreading. So, voiced consonants prespecified with low tone allow low tone spreading, but not high tone spreading. Voiceless consonants prespecified with high tone tolerate high tone spreading, but not low tone spreading. Consonants that are not prespecified with tone allow any type of tonal spreading.

In Lieber's theory, consonants affect tone only if there are tonal processes such as spreading. The prespecification theory does not explain the tonal neutralization found in Mulao or Thai (see chapter 5). Even if we assume that an aspirated onset is prespecified with high tone in Mulao, the prespecification theory does not block the following vowel from surfacing with low tone.

Restricted to voicing and tone, these representational approaches are insufficient in explaining consonant-tone interactions shown in Zina Kotoko (Odden 2002), in which glottal stops, implosives and sonorants participate in consonant-tone interaction. Strictly representational theories are also insufficient in providing explanatory accounts for tone interacting with aspirates, breathy voice or glottals. Downing and Gick (2001) observe that depressors in Nambya are phonetically voiceless. In particular, they raise questions about theories that limit the consonant-tone interaction only in voicing. See also Downing (2008).

The relationship between voicing and tone is also proposed in Halle and Stevens (1971). Voiced and low tone are represented as [+slack vocal cords]. Voicelessness and high tone are represented as [+stiff vocal cords]. If we focus on the status of vocal cords, this observation can be extended to other laryngeal segments. Since breathy consonants and vowels as well as creaky consonants and vowels are [+slack vocal cords], these segments behave like voiced consonants with respect to tone; they block the high tone spreading but not the low tone spreading. Aspirates and glottals are represented as [+stiff vocal cords] in Halle and Stevens, which suggests these segments behave like voiceless consonants with respect to tone; they block the low tone spreading but not the high tone spreading. See also Halle (1995).

(19) Features of consonants and tone (Halle and Stevens 1971: 203)

		consonants	***vowels***	***tone***
a.	[+slack vocal cords] [-stiff vocal cords]	voiced [b] breathy voice [bʰ] preglottalized [ˀb]	breathy voice creaky voice	low
b.	[-slack vocal cords] [+stiff vocal cords]	voiceless [p] aspirates [pʰ] ejectives [p’]	glottalized	high
c.	[-slack vocal cords] [-stiff vocal cords]	implosives [ɓ]	voiceless	toneless

Halle and Stevens have an analytical advantage over the representational theories of voicing and tone, and the theory adequately explains the blocking of tonal spreading.

However, their theory does not account for the consonant-tone interaction observed in Thai. In Thai, non-aspirated consonants (both voiced and voiceless) block high tone in their syllables. However, if non-aspirates are [-stiff vocal cords], then voiceless consonants are excluded, and if non-aspirates are [+slack vocal cords], then voiced consonants are excluded. So, a theory relying on the vocal cords feature cannot be adequate to account for the general patterns of consonant-tone interactions reported in chapter 4 and chapter 5.

The xTBU theory in this dissertation does not restrict the consonant-tone interaction to voicing. With the proposed markedness constraints, consonant-tone interaction can occur with any type of laryngeal consonants. Moreover, onsets and codas can both interact with tone as shown in tonal neutralization cases.

There are other proposals of consonant-tone interaction. Strazny (2003), for example, proposes that the effect of depressors is not necessarily tonal. On the phonetic side, Traill et al. (1987) argue that Tsonga depressors are more breathy than non-depressors. Giannini et al. (1988) also demonstrate similar property in Zulu depressors.

A rarely studied area in segment-tone interaction is vowel-tone interaction. Jiang-King (1999) proposes that vowels in Min Chinese (esp. Fuzhou and Fuqing) interact with tone through the prosodic anchoring hypothesis in (20). She provides evidence that vowel-tone interaction is an output-oriented phenomenon. In particular, markedness constraints are crucial to the analysis of vowel-tone interaction.

(20) Prosodic anchor hypothesis (Jiang-King 1999)

a. Representational requirement
Both tone and vowel must directly link to the lowest prosodic anchor on the prosodic hierarchy, that is, the mora.

b. Constraint satisfaction
Optimal linking between the prosodic anchor and tone or vowel is determined by a set of universal output constraints.

Jiang-King observes that the vowel distribution in mono-syllables and vowel reduction in non-prominent syllables (non-final syllables) behave in parallel. She argues that the vowel-tone interaction results from the requirement imposed on mono-moraic syllables and from prominence in metrical structure.

This section has presented the typology of consonant-tone interaction based on the proposed theory. Consonants interact with tone in the output through markedness constraints. Previous theories focus on voicing and its interaction with tone, and they are mostly representational in nature. As shown in this dissertation, other laryngeal consonants such as aspirates or glottals also interact with tone. The constraint-based theory analyzes how different consonants interact with tone in general. Furthermore, the theory predicts that consonants can affect tone, and that tone can affect consonants.

6.7 Conclusion

This chapter discusses a variety of issues which arise from the theory of consonant-tone interaction presented in previous chapters. Consonants that interact with tone do not form a group definable as a unified featural class. I have argued in section 6.2 that the set of consonants forms a natural class because they result in the same kind of output by individual markedness constraints.

The apparent hierarchy effect in consonant-tone interaction is also argued to be the result of constraint interaction in section 6.3. The theory also predicts the bidirectionality in consonant-tone interaction; consonants affect tone, and tone affects consonants. See section 6.4 for detailed discussion.

The theory and its implications to tonogenesis are discussed in section 6.5. Diachronic changes in laryngeal features and tone are argued to result from the markedness constraints on consonant-tone interaction. In section 6.6, predictions borne out from the constraint-based theory are discussed in comparison with previous proposals.

Chapter 7 Further Discussion

7.1 Introduction

In this dissertation, xTBU theory is proposed to account for cross-linguistic consonant-tone interaction. Tone can associate to consonants, and such a relationship (called 'dependency') is targeted by markedness constraints in the absence of faithfulness constraints.

An important aspect of xTBU theory is that tonal faithfulness constraints are exclusively defined based on the correspondence of moras. Tone can be inserted (thereby violating DEP-T) only if a mora associated to tone is in correspondence with a mora in the input. Another proposed faithfulness constraint is IDENT-T, which assigns a violation mark for the change of tonal value on moras that are in correspondence relationships.

In the following two sections, two topics for further discussion are presented. In section 7.2, issues of floating tone in xTBU theory are discussed; for example, are floating tones associated to moras? Consonant-tone interaction is often described in conjunction with certain morpho-syntactic boundaries. In section 7.3, the issue of boundaries is discussed.

7.2 Floating Tone in xTBU theory

In Yip (2002: 76), floating tones are defined as tones that are not associated to a TBU. Floating tones can be morphemes that introduce a meaning, or floating tones can affect adjacent tones as in downstep. The morphemic floating tones associate with a TBU in the output (and thereby incur violation of the faithfulness constraint DEP-T). Downstep incurring floating tones, however, have no association to any TBU in the output.

The presence of morphemic floating tones indicates that tone may be unassociated to a TBU in the input. A tone that is not associated to a mora in the input (marked with Ⓛ) as in (1) does not faithfully map in the output if *FLOATING-T (defined in (2)) outranks the tonal faithfulness constraint DEP-T. The DEP-T constraint is violated because the moras in the correspondence relationship have no tone associated to them in the input, but a tone associated in the output.

(1) An input floating tone associated in the output.

	Ⓛ μ | /C V/	*FLOATING-T	DEP-T
a. ☞	L | μ | /C V/		*
b.	Ⓛ μ | /C V/	W *	L

(2) *FLOATING-T
Assign a violation mark to every tone that is not associated to a TBU in the output.

Since floating tones are not associated to moras, deletion of floating tones does not violate any tonal faithfulness constraints (e.g. MAX-T if it exists in CON).

Tones can remain unassociated in the output if the tonal faithfulness constraint DEP-T outranks the markedness constraint *FLOATING-T as in (3). As Yip (2002: 76) points out, such floating tones do not have any surface realization.

(3) An input floating tone remains unassociated in the output.

	Ⓛ μ | /C V/	DEP-T	*FLOATING-T
a. ☞	Ⓛ μ | /C V/		*
b.	L | μ | /C V/	W *	L

So, floating tones in the output (as in (3a)) may affect other tones. For example, downstep is proposed to be a lowering of the second H tone of two adjacent H tones due to an intervening floating L tone. However, Bickmore (2000) demonstrates that downstep may not necessarily result from a floating L tone.

Since the current discussion crucially relies on the constraint ranking in order to account for the two types of floating tones, it predicts that a language that has morphemic floating tones cannot have downstep induced by floating tones, and vice versa. If we adopt a Bickmorean (2000) view of downstep, a language may have both downstep and morphemic floating tones.

Since floating tones are not associated to a TBU in the input, albeit a mora, no tonal faithfulness constraint targets floating tones following the proposal in xTBU theory. The issue related to floating tones calls for further research on tonal phenomena in OT.

7.3 Morpho-syntactic boundaries in consonant-tone interaction

Descriptions of consonant-tone interaction (esp. the blocking of H tone spreading by depressors) make specific reference to morpho-syntactic boundaries (cf. Bradshaw 1999).

As discussed in chapter 4, the spreading of H tone is blocked in Tsonga when the H tone spreads from a copulative prefix to a verbal root. The blocking also occurs across other morpho-syntactic boundaries as shown in Baumbach (1987): depressors block H tone spreading (i) from H tone verbs to LH object nouns, (ii) from H tone class 2 prefixes to LH nouns, (iii) from H tone locative prefixes to LH nouns, (iv) from H tone instrumental prefixes to LH nouns, and so on. Bradshaw (1999: 8-45) also reports languages in which depressors are sensitive to word-initial positions (Suma, Mulwi) or root-initial positions (Yaka).

The fact that some languages demonstrate a sensitivity to morpho-syntactic boundaries in consonant-tone interaction means that there must be some constraints targeting those boundaries. Since there are no faithfulness constraints on the association between non-moraic root nodes and tones in xTBU theory, it is the markedness constraints that are relativized to the morpho-syntactic boundaries.

The boundary issues in Tsonga are interesting in particular because the boundaries are morphological (between a H tone prefix and a LH noun) as well as syntactic (between a H tone verb and a LH nominal object). A precise understanding awaits further research on this topic.

References

ROA = Rutgers Optimality Archive (http://roa.rutgers.edu)

Abramson, Arthur S. 1962. The vowels and tones of Standard Thai: Acoustical measurements and experiments. *International Journal of American Linguistics (IJAL)* 28.2, Part 2.

Ahoua, Firmin. 2003. Tonogenesis: New evidence from West African languages (Kwa, Kru, Mande), Universität Bielefeld (powerpoint).

Allott, Anna J. 1967. Grammatical tone in modern spoken Burmese. *Wissenschaftliche Zeitschrift der Karl-Marx-Universität Leipzig: Gesellschafts- und Sprachwissenschaftliche Reihe* 16:157-161.

Alves, Mark. 1995. Tonal Features and the Development of Vietnamese Tones. *University of Hawai'i Working Papers in Linguistics* 27:1-13.

Anderson, Stephen R. 1978. Tone features. In: *Tone: A Linguistic Survey*, ed. Victoria Fromkin, New York: Academic Press, 133-176.

Apiluck Tumtavitikul. 1992. Consonant onsets and tones in Thai, Ph. D. Dissertation, University of Texas at Austin.

Apiluck Tumtavitkul. 1993. Perhaps, the tones are in the consonants? *Mon-Khmer Studies* 23:11-41.

Archangeli, Diana, and Pulleyblank, Douglas. 1994. *Grounded Phonology*, Cambridge, MA: MIT Press.

Ballard, W. L. 1969. Phonological History of Wu, Ph. D. Dissertation, University of California.

Bao, Zhi Ming. 1999. *The structure of tone*, Oxford, UK: Oxford University Press.

Bao, Zhiming. 1990. On the Nature of Tone, Ph. D. Dissertation, MIT.Baumbach, E.J.M. 1987. *Analytical Tsonga Grammar*, Pretoria: University of South Africa.

Beckman, Mary, and Pierrehumbert, Janet. 1986. Intonational structure in English and Japanese. *Phonology* 3:255-309.

Bermúdez-Otero, Ricardo. 2007. Diachronic phonology. In: *The Cambridge Handbook of Phonology*, ed. Paul de Lacy, Cambridge University Press, 497-517.

Bernot, Denise. 1963. Esquisse d'une description phonologique du birman. *Bulletin de la Société de Linguistique de Paris* 58.1:164-224.

Bhat, D. N. S. 1969. *Tankhur Naga Vocabulary,* Poona: Deccan College.

Bickmore, Lee. 2000. Downstep and fusion in Namwanga. *Phonology* 17:297-331.

Blood, David L. 1967. Phonological units in Cham. *Anthropological Linguistics* 9.8:15-32.

Boersma, P., and Weenink, D. 2007. Praat: doing phonetics by computer.

Bradley, David. 1982. Register in Burmese. In: *Papers in South-East Asian Linguistics 8: Tonation*, ed. D. Bradley, Canberra: Australia National University, 117-132.

Bradshaw, Mary. 1995. Tone on verbs in Suma. In: *Theoretical Approaches to African Linguistics*, ed. Akinbiyi Akinlabi, Trenton, NJ: Africa World Press, 255-271.

Bradshaw, Mary. 1996. Depressor effects in SiSwati. Paper presented at *ACAL 27*, Gainesville, FL.

Bradshaw, Mary. 1999. A Crosslinguistic Study of Consonant-Tone Interaction, Ph. D. Dissertation, Department of Linguistics, Ohio State University.

Bradshaw, Mary. 2003. Consonant-tone interaction in Siswati. *Studies in Phonetics, Phonology and Morphology* 9.2:277–294.

Broselow, Ellen, Huffman, Marie, and Chen, Su-I. 1997. Syllable weight: Convergence of phonology and phonetics. *Phonology* 14:47-82.

Brown, Jason C. 2004. Some tonogenetic properties of Upriver Halkomelem In: *Proceedings from the Seventh Workshop on American Indigenous Languages*, eds. Lea Harper and Carmen Jany, 40-48.

Brunelle, Marc. 2003. Coarticulation effects in Northern Vietnamese tones. Ms., University of Ottawa, Canada.

Brunelle, Marc. 2005. Register in Eastern Cham: Phonetic, Phonological and Sociolinguistic approaches, Ph. D. Dissertation, Cornell University.

Burling, Robbins. 1967. Proto Lolo-Burmese. *International Journal of American Linguistics (IJAL) Part II* 33.2.

Cassimjee, Farida. 1998. *Isixhosa Tonology: An Optimal Domains Theory Analysis*, München: Lincom Europa.

Cassimjee, Farida, and Kisseberth, Charles W. 1998. Optimal domains theory and Bantu tonology: a case study from Isixhosa and Shingazidja. In: *Theoretical aspects of Bantu tone*, eds. L. Hyman and C.W. Kisseberth, CSLI Publications, 33-

132.[ROA-176]

Chao, Yuen-Ren. 1930. A system of tone letters. *Le Maitre Phonetique* 45:24-27.

Chen, Matthew. 2000. *Tone Sandhi: Patterns across Chinese Dialects* Cambridge University Press

Chen, Tsung-Ying. 2007. Problems of Analyzing Consonant-tone Interaction in Thai: A reply to Ruangjaroon. *Taiwan Journal of Linguistics* 5.2:65-84.

Clements, G. N., and Ford, K. C. 1979. Kikuyu tone shift and its synchronic consequences. *Linguistic Inquiry* 10:179-210.

Clements, G. N. 1983. The hierarchical representation of tone features. In: *Current Approaches to African Linguistics*, ed. I. R. Dihoff, Dordrecht: Foris, 145-176.

Clements, G. N., and Osu, Sylverster. 2002. Explosive, implosives and nonexplosives: The linguistic function of air pressure differences in stops. In: *Laboratory Phonology 7*, eds. Carlos Gussenhoven and Natasha Warner, Berlin: Mouton de Gruyter, 299-350.

Cole, Jennifer, and Kisseberth, Charles. 1994. An Optimal Domains Theory of Harmony. *Studies in the Linguistic Sciences* 24.2:1-13. [ROA-22]

Cornyn, William S. 1944. Outline of Burmese Grammar, Ph. D. Dissertation, Yale University.

Crist, Sean Jacob. 2001. Conspiracy in Historical Phonology, Ph. D. Dissertation, University of Pennsylvania. [ROA-534]

Cuenod, R. 1967. *Tsonga-English Dictionary* Sasavona Publishers & Booksellers.

Das Gupta, K. 1968. *An Introduction to Central Monpa,* Shillong: North-East Frontier Agency.

de Lacy, Paul. 2002. The interaction of tone and stress in Optimality Theory. *Phonology* 19.1:1-32. [ROA-333]

de Lacy, Paul. 2004. Markedness conflation in Optimality Theory. *Phonology* 21:145-199.

de Lacy, Paul. 2006. *Markedness: Reduction and preservation in phonology*, Cambridge: Cambridge University Press.

Dempwolff, Otto. 1939. *Grammatik der Yabêm-Sprache auf Neuguinea*, Hamburg: Friederichsen, De Gruyter & Co.

DiCanio, Christian. 2006. The Phonetics of Consonantal Pitch Perturbation in a Complex Tone System: an Analysis of San Martín Itunyoso Trique. Paper presented at *Conference in Language Complexity, Dynamique du Language*, Lyon, France.

Downing, Laura J. 1990. Local and metrical tone shift in Nguni. *Studies in African Linguistics* 21:261-317.

Downing, Laura J., and Gick, Bryan. 2001. Voiceless Tone Depressors in Nambya and Botswana Kalang'a. In: *Berkeley Linguistics Society 27*, 65-80.

Downing, Laura J. 2008. On pitch lowering not linked to voicing: Nguni and Shona group depressors. Ms., ZAS, Berlin.

Duanmu, San. 1990. A Formal Study of Syllable, Tone, Stress and Domain in Chinese Languages, Ph. D. Dissertation, MIT.

Duanmu, San. 2000. *The phonology of Standard Chinese*, Oxford: Oxford University Press.

Dunstan, E., and Igwe, G. E. 1966. Two views of the phonology of the Ọh̃ụh̃ụ *Journal of West African languages* 3:71-75.

Earle, Michael Allan. 1975. *An Acoustic Phonetic Study of Northern Vietnamese Tones*, Santa Barbara, CA: Speech Communications Research Laboratory, INC.

Edmondson, Jerold A., and Yang, Quan. 1988. Word-initial preconsonants and the history of Kam-Sui resonant initials and tone. In: *Comparative Kadai: Linguistic studies beyond Tai*, eds. Jerold Edmondson and David Solnit, Dallas, TX: Summer Institute of Linguistics and University of Texas at Arlington, 143-166.

Edmondson, Jerold A. 1990. Kam tone splits and the variation of breathiness. In: *Development and Diversity Language Variation across Time and Space: A festschrift for Charles-James N. Bailey*, eds. Jerold A. Edmondson, Crawford Feagin and Peter Mühlhäusler, Dallas, TX: The Summer Institute of Linguistics and University of Texas at Arlington, 187-202.

Edmondson, Jerold A., and Esling, John H. . 2006. The valves of the throat and their functioning in tone, vocal register and stress: laryngoscopic case studies. *Phonology* 23:157-191.

Elías-Ulloa, José A. 2006. Theoretical Aspects of Panoan Metrical Phonology: Disyllabic Footing and Contextual Syllable Weight, Ph. D. Dissertation, Department of Linguistics, Rutgers University. [ROA-804]

Esling, John H., and Harris, Jimmy G. 2005. States of the glottis : an articulatory phonetic model based on laryngoscopic observations. In: *A figure of speech : a*

Festschrift for John Laver, eds. William J. Hardcastle and Janet Mackenzie Beck, Mahwah, NJ: Erlbaum, 347-383.

Ferlus, Michel. 2006. What were the four divisions (deng) of the Middle Chinese. Paper presented at *The 39th International Conference on Sino-Tibetan Language and Linguistics*, University of Washington, Seattle.

Flemming, Edward. 2005. Deriving natural classes in phonology. *Lingua* 115.3:287-309.

Gage, William W. 1985. Glottal Stops and Vietnamese Tonogenesis. In: *For Gordon H. Fairbanks*, eds. V. Z. Acson and R. L. Leed, University of Hawaii Press, 21-36.

Gandour, Jack. 1975. On the Representation of Tone in Siamese. In: *Studies in Tai Linguistics: In Honor of William J. Gedney*, eds. Jimmy G. Harris and James R. Chamberlain, Bangkok: Central Institute of English Language, 170-195.

Gathercole, Geoffrey. 1983. Tonogenesis and the Kickapoo Tonal System. *International Journal of American Linguistics (IJAL)* 49.1:72-76.

Giannini, Antonella, Pettorino, Massimo, and Toscano, Maddalena. 1988. Remarks on Zulu Stops. *Afrikanistische Arbeitspapiere* 13:95-116.

Glover, Warren W. 1970. Gurung Tone and Higher Levels. In: *Occasional Papers of the Wolfenden Society on Tibeto-Burman Linguistics. Volume III* The Center for Asian Studies, University of Illinois, Urbana, 52-73.

Goedemans, Rob. 1998. *Weightless Segments: A phonetic and phonological study concerning the metrical irrelevance of syllable onsets*, The Hague: Holland Academic Graphics.

Goldsmith, John. 1976. Autosegmental Phonology, Ph. D. Dissertation, MIT.

Gordon, M., and Ladefoged, Peter. 2001. Phonation Types: A Cross-Linguistic Overview. *Journal of Phonetics* 29.4:383-406.

Gordon, Matthew. 2001. A typology of contour tone restrictions. *Studies in Language* 25:405-444.

Gordon, Matthew Kelly. 2006. *Syllable Weight: Phonetics, Phonology, Typology*, New York & London: Routledge.

Gouskova, Maria. 2003. Deriving Economy: Syncope in Optimality Theory, Ph. D. Dissertation, University of Massachusetts, Amherst. [ROA-610]

Green, Antony Dubach. 2005. Word, foot, and syllable structure in Burmese. In: *Studies in Burmese linguistics*, ed. Justin Watkins, Pacific Linguistics, Research School of

Pacific and Asian Studies, The Australian National University, 1-25. [ROA-551]

Greenberg, Mark. 2006. Phonetic evidence for the development of the "acute" tone in Slavic. In: *Proceedings volume of International Workshop on Balto-Slavic Accentology (IWoBA)* Zagreb: Institut za hrvatsko jezikoslovlje.

Guthrie, Malcolm. 1970. *Comparative Bantu*.vol. 4, Farnborough, Hants: Gregg.

Halle, Morris, and Stevens, Kenneth. 1971. A note on laryngeal features. *Quarterly Progress Report* 101:198-213.

Halle, Morris. 1995. Feature geometry and feature spreading. *Linguistic Inquiry* 26:1-46.

Hansson, Gunnar Olafur. 2004. Tone and Voicing Agreement in Yabem. In: *WCCFL 23 Proceedings*, eds. B. Schmeiser, A. Kelleher and V. Chand, Cascadilla Press.

Hargus, Sharon, and Rice, Keren. 2005. *Athabaskan Prosody*, Amsterdam/Philadelphia: John Benjamins Publishing company.

Haudricourt, André-G. 1954. De L'origine des tone en viètnamien. *Journal Asiatique* 242:69-82.

Hayes, Bruce. 1989. Compensatory Lengthening in moraic phonology. *Linguistic Inquiry* 20:253-306.

Hombert, Jean-Marie. 1975. Towards a theory of tonogenesis: An empirical, physiologically, and perceptually-based account of the development of tonal contrasts in language, Ph. D. Dissertation, University of California, Berkeley.

Hombert, Jean-Marie, Ohala, John J., and Ewan, William G. 1979. Phonetic explanations for the development of tones. *Language* 55.1:37-58.

Huang, Yuanwei. 1997. The Interaction between Zhuang and the Yue (Cantonese) Dialects. In: *Comparative Kadai: The Tai branch*, eds. Jerold A. Edmondson and David B. Solnit, Dallas: Summer Institute of Linguistics and the University of Texas at Arlington, 57-76.

Hubbard, Kathleen. 1994. Duration in moraic theory, Ph. D. Dissertation, UC Berkeley.

Hyman, Larry. 1973a. Consonant types and tone, Los Angeles: University of Southern California.

Hyman, Larry ed. 1973b. *Consonant types and tone*. *Southern California Occasional Papers in Linguistics 1*. Los Angeles: University of Southern California.

Hyman, Larry, and Schuh, Russell. 1974. Universals of tone rules: Evidence from West

Africa. *Linguistic Inquiry* 5:81-115.

Hyman, Larry. 1976. On some controversial questions in the study of consonant types and tone. *UCLA Working Papers in Linguistics* 33:90-98.

Hyman, Larry. 1985. *A Theory of Phonological Weight*, Dordrecht: Foris.

Hyman, Larry. 1992. Register tone and tonal geometry. In: *The phonology of tone: The representation of tonal register*, eds. Harry van der Hulst and K. Snider, Berlin: Mouton de Gruyter, 75-108.

Hyman, Larry, and VanBick, Kenneth. 2004. Directional Rule Application and Output Problems in Hakha Lai Tone. *Language and Linguistics* 5.4:821-861. [ROA-605]

Hyman, Larry. 2006. Word-prosodic typology. *Phonology* 23:225-257.

Hyman, Larry M. 2007. Coda Constraints on Tone. Paper presented at *Workshop on Segments and Tone*, Amsterdam, the Netherlands.

Jiang-King, Ping. 1999. *Tone-Vowel Interaction in Optimality Theory* Lincom Europa. [ROA-266]

Jiangsusheng he Shanghaishi Fangyan Gaikuang. 1960. *[A Survey of Jiangsu Province and Metropolitan Shanghai]*, Nanjing: Jiangsu Renmin Chubanshe.

Jun, Sun-Ah. 1996. *The Phonetics and Phonology of Korean Prosody: Intonational Phonology and Prosodic Structure* Garland Publishing.

Jun, Sun-Ah. 1998. The Accentual Phrase in the Korean prosodic hierarchy. *Phonology* 15:189-226.

Kaisse, Ellen. 1992. Can [consonantal] spread? *Language* 68:313-332.

Kang, Hyeon-Seok. 1996. Acoustic and Intonational Correlates of the Informational Status of Referring Expressions in Seoul Korean. *Language and Speech* 39.4:307-340.

Kenstowicz, Michael, and Kisseberth, Charles. 1990. Chizigula tonology: the word and beyond. In: *The phonology-syntax connection*, eds. Sharon Inkelas and Draga Zec, Chicago: CSLI, 163-194.

Key, Michael. 2007. Headed Spans and Bantu tonology. In: *Papers in Optimality Theory III*, eds. Adam Werle, Ehren Reilly, Leah Bateman and Michael O'Keefe, Amherst: GLSA University of Massachusetts, 187-208. [ROA-809]

Kingston, John, and Solnit, David. 1989. The Inadequacy of Underspecification. In:

Proceedings of the 19th Meeting of NELS, 264-278.

Kingston, John. 2005. The phonetics of Athabaskan tonogenesis. In: *Athabaskan Prosody*, eds. Sharon Hargus and Keren Rice, Amsterdam: John Benjamins, 137-184.

Kisseberth, Charles. 1984. Digo Tonology. In: *Autosegmental Studies in Bantu Tone*, eds. G. N. Clements and John Goldsmith, Dordrecht: Foris, 105-182.

Kisseberth, Charles W., and Abasheikh, Mohammad Imam. 1974. Vowel length in Chi-Mwi:ni-a case study of the role of grammar in phonology. In: *CLS 10: Parasession on Natural Phonology*, eds. Michael W. LaGaly, Anthony Bruck and Robert A. Fox, Chicago: Chicago Linguistic Society, 193-209.

Krauss, M. 2005. Athabaskan tone. In: *Athabaskan Prosody*, eds. Sharon Hargus and Keren Rice, Amsterdam: John Benjamins, 55-136.

Ladefoged, Peter. 1971. *Preliminaries to Linguistic Phonetics*, Chicago: University of Chicago Press.

Lanham, L. W. 1958. The tonemes of Xhosa. *African Studies* 17.2:65-81.

Laughren, Mary. 1984. Tone in Zulu Nouns. In: *Autosegmental Studies in Bantu Tone*, eds. G. N. Clements and J. Goldsmith, Dordrecht, Holland: Foris Publications, 183-234.

Leben, Will. 1973. Suprasegmental Phonology, Ph. D. Dissertation, MIT.

Lee, Seunghun J. 2007. Glottal stops and tone in Burmese. Paper presented at *The 43rd Chicago Linguistics Society*, Chicago, IL.

Leer, J. 1999. Tonogenesis in Athabaskan. In: *Cross-linguistic Studies of Tonal Phenomena, Tonogenesis, Typology, and Related Topics vol. 1*, ed. S. Kaji, Tokyo: Institute of the Study of the Languages and Cultures of Asia and Africa, Tokyo University of Foreign Studies, 37-66.

Li, Fang Kuei. 1980. Laryngeal features and tone development. *Bulletin of Institute of History and Philology, Academia Sinica* 51.1:1-13.

Li, Yung-sui, Ch'en, K'o-chung, and Ch'en, Ch'i-kuang. 1972. Some problems concerning initials and tones in the Miao language. In: *Miao and Yao Linguistic Studies: Selected Articles in Chinese, Translated by Chang Yü-hung and Chu Kwo-ray*, ed. Herbert C. Purnell, Cornell University Southeast Asia Program, 83-110.

Lieber, Rochelle. 1987. *An integrated theory of autosegmental processes*, Albany, NY: State University of New York Press.

Lowes, Gwendolyn. 2005. Reconstructing Tonogenesis in Zapotec. Paper presented at *Between Stress and Tone*, Leiden University , The Netherlands.

Lowes, Gwendolyn. 2006. Tonogenesis in Progress: a case study with Kurtoep. In *LSA summer meeting*, East Lansing, Michigan.

Lukas, J. 1969. Tonpermeable und Tonimpermeable Konsonanten im Bolanci (Nordnigerien). In: *Ethnological and Linguistic Studies in Honour of N. J. van Warmelo*, ed. The Ethnological Section, Pretoria: The Government Printer, 133-138.

Luo, Liming ed. 2005. *Compilation Commission of Zhuang-Chinese-English Dictionary*. Beijing: Min zu chu ban she.

Lynch, John, Ross, Malcolm, and Crowley, Terry eds. 2002. *The Oceanic Languages*. Richmond, Surrey, UK: Curzon Press.

Maddieson, Ian. 1974. A note on tone and consonants. In: *The Tone Tome: Studies on Tone from the UCLA Tone Project*, ed. Ian Maddieson, Los Angeles: UCLA, 18-27.

Maddieson, Ian. 1976. A further note on tone and consonants. *UCLA Working Papers in Phonetics* 33:131-159.

Maddieson, Ian. 1978a. Tone effects on consonants. *Journal of Phonetics* 6:327-344.

Maddieson, Ian. 1978b. The frequency of tones. *UCLA Working Papers in Phonetics* 41:43-52.

Malmqvist, N. Göran D. 1962. Studies in Western Mandarin phonology. *Bulletin of the Museum of Far Eastern Antiquities* 34:129-192.

Manaster Ramer, Alexis. 1986. Genesis of Hopi Tones [Apr.]. *International Journal of American Linguistics (IJAL). ONT Canada* 52.2:154-160.

Mao, Tsung-wu, and Chou, Tsu-yao. 1972. A brief description of the Yao language. In: *Miao and Yao Linguistic Studies: Selected Articles in Chinese, Translated by Chang Yü-hung and Chu Kwo-ray*, ed. Herbert C. Purnell, Ithaca: Cornell University, 239-255.

Maran, La Raw. 1971. *Burmese and Jingpho: A study of tonal linguistic Processes*, Urbana: The University of Illinois.

Maspero, Henri. 1912. Études sur la phonétique historique de la langue annamite, Les initiales. *Bulletin de l'Ecole Française d'Extrême-Orient* 12:1-126.

Matisoff, James A. 1970. Glottal Dissimilation and the Lahu High-Rising Tone: A Tonogenetic Case-Study. *Journal of the American Oriental Society* 90.1:13-44.

Matisoff, James A. 2003. Lahu. In: *The Sino-Tibetan languages*, eds. Graham Thurgood and Randy J. LaPolla, London & New York: Routledge, 208-221.

McCarthy, John J. 1988. Feature geometry and dependency: A review. *Phonetica* 43:84-108.

McCarthy, John J. 2002. *A Thematic Guide to Optimality Theory*, Cambridge: Cambridge University Press.

McCarthy, John J. 2003. OT constraints are categorical. *Phonology* 20.1:75-138.

McCarthy, John J. 2004. Headed Spans and Autosegmental Spreading. Ms., University of Massachusetts, Amherst. [ROA-685]

McCarthy, John J. 2008. *Doing Optimality Theory: Applying Theory to Data*, Malden, MA: Blackwell Publishing.

McCarthy, John J., and Prince, Alan. 1988. Quantitative transfer in reduplicative and templatic morphology. In: *Linguistics in the Morning Calm*, ed. Linguistic Society of Korea, Seoul: Hanshin Publishing Co, 3-35.

McCarthy, John J., and Prince, Alan. 1990. Prosodic morphology and templatic morphology. In: *Perspectives on Arabic linguistics II: Papers from the Second Annual Symposium on Arabic Linguistics*, eds. Mushira Eid and John J. McCarthy, Amsterdam: John Benjamins, 1-54.

McCarthy, John J., and Prince, Alan. 1993. *Prosodic morphology I: Constraint interaction and satisfaction*, New Brunswick: Rutgers University Center for Cognitive Science. [ROA-482]

McCarthy, John J., and Prince, Alan. 1995a. Prosodic morphology. In: *The Handbook of Phonological Theory*, ed. John A. Goldsmith, Cambridge, Mass., and Oxford, UK: Blackwell, 318-366.

McCarthy, John J., and Prince, Alan. 1995b. Faithfulness and Reduplicative Identity. In: *University of Massachusetts Occasional Papers in Linguistics 18*, eds. Jill Beckman, Laura Walsh Dickey and Suzanne Urbanczyk, Amherst, MA: GLSA Publications, 249-384. [ROA-60]

McDavid, Raven I. 1945. Burmese Phonemics. *Studies in Linguistics* 3.1:6-18.

McHugh, Brian. 1999. *Cyclicity in the Phrasal Phonology of KiVunjo Chaga* Lincom Europa.

Mehnert, Dieter, and Richter, Eberhardt. 1976. Untersuchungen zur Phonetik und Phonologie des modernen Burmesischen: Teil 3. *Zeitschrift für Phonetik, Sprachwissenschaft und Kommunikationsforschung* 29:145-166.

Michaud, Alexis. 2004. Final Consonants and Glottalization: New Perspectives from Hanoi Vietnamese. *Phonetica* 61:119-146.

Mielke, Jeff. 2004. The Emergence of Distinctive Features, Ph.D Dissertation, The Ohio State University.

Mielke, Jeff. 2005. Ambivalence and ambiguity in laterals and nasals. *Phonology* 22.2:169-203.

Morén, Bruce. 1999. Distinctiveness, Coercion and Sonority: A Unified Theory of Weight, Ph. D. Dissertation, University of Maryland. [ROA-346]

Morén, Bruce. 2000. The puzzle of Kashmiri stress :implications for weight theory. *Phonology* 17:365-396. [ROA-273]

Morén, Bruce. 2003. Weight Typology: an Optimality Theoretic Approach. *The Linguistic Review* 20:281-304.

Morén, Bruce, and Zsiga, Elizabeth. 2006. The Lexical and Post-Lexical Phonology of Thai Tones. *Natural Language & Linguistic Theory* 24.1:113-178.

Myers, Scott. 1997. OCP effects in Optimality Theory. *Natural Language and Linguistic Theory* 15.4:847-892.

Nguyen, Van Loi, and Edmondson, Jerold A. 1997. Tones and voice quality in modern northern Vietnamese. *Mon-Khmer Studies* 28:1-18.

Nhán, Ngô Thanh. 1984. The syllabeme and patterns of word formation in Vietnamese, Ph. D. Dissertation, New York University.

Niederer, Barbara. 1998. *Les langues Hmong - Mjen (Miáo–Yáo) - Phonology Historique*, München: Lincom Europa.

Odden, David. 1995. Tone: African languages. In: *Handbook of phonological theory*, ed. John Goldsmith, Oxford: Basil Blackwell, 444-475.

Odden, David. 1996. *The Phonology and Morphology of Kimatuumbi*, Oxford: Clarendon Press.

Odden, David. 2002. The Verbal Tone System of Zina Kotoko. In: *Aspects of Zina Kotoko Grammar*, eds. Bodil Kappel Schmidt, David Odden and Anders Holmberg, Lincom Europa, 15-34.

Odden, David. 2007. The Unnatural Tonology of Zina Kotoko. In: *Tones and Tunes. Volume 1: Typological Studies in Word and Sentence Prosody*, eds. Tomas Riad and Carlos Gussenhoven, Mouton de Gruyter, 63-90.

Okell, John. 1969. *A reference grammar of colloquial Burmese*, London: Oxford University Press.

Okell, John. 1994. *Burmese: An Introduction to the Script* Northern Illinois University Center for Southeast Asian Studies.

Peng, Long. 1992. A unified theory of Tone-Voice, Ph. D. Dissertation, Department of Linguistics, The University of Arizona.

Pham, Andrea Hoa. 2003. *Vietnamese tone: a new analysis*, New York & London: Routledge.

Pierrehumbert, Janet , and Beckman, Mary. 1988. *Japanese Tone Structure*, Cambridge, Mass.: MIT Press.

Poser, William J. 1981. On the directionality of the Tone-Voice correlation. *Linguistic Inquiry* 12.3:483-488.

Prince, Alan. 2000. Comparative tableaux. Ms., New Brunswick, NJ: Rutgers University.

Prince, Alan. 2002. Arguing optimality. In: *Papers in Optimality Theory II*, eds. Andries W. Coetzee, Angela C. Carpenter and Paul de Lacy, Amherst, MA: GLSA, 269-304. [ROA-562]

Prince, Alan, and Smolensky, Paul. 1993/2004. *Optimality Theory: Constraint interaction in generative grammar*, Oxford: Basil Blackwell. [ROA-537]

Pulleyblank, Douglas. 1994. Underlying Mora Structure. *Linguistic Inquiry* 25.2:344-353.

Pulleyblank, Douglas. 2003. Covert feature effects. In: *WCCFL 22: Proceedings of the 22nd West Coast Conference on Formal Linguistics*, eds. Gina Garding and Mimu Tsujimura, Somerville, MA: Cascadilla Press, 398-422.

Qin, Guosheng. 1996. *Zhuang yu fang yan gai lun (An introduction to dialects of Zhuang language)*, Nanning shi: Guangxi min zu chu ban she.

Qin, Xiaohang. 2004. *Zhuang lexicology : a study on Zhuang words and an attached Zhuang-English vocabulary*, Beijing Shi: Ethnic Pub. House.

Ramsey, S. Robert. 1991. Proto-korean and the origin of korean accent. In: *Studies in the historical phonology of asian languages*, eds. William G. Boltz and Michael C. Shapiro, John Benjamins, 215-238.

Ramsey, S. Robert. 2001. Tonogenesis in Korean. In: *Proceedings of the Symposium Cross-linguistic Studies of Tonal Phenomena: Tonogenesis, Japanese Accentology, and Other Topics*, ed. Shigeki Kaji, Institute for the Study of Languages and Cultures of Asia and Africa (ILCAA), Tokyo University of Foreign Studies, 3-17.

Reynolds, William Thomas. 1994. Variation and Phonological Theory, Ph. D. Dissertation, University of Pennsylvania.

Rivierre, J.-C. 2001. Tonogenesis and Evolution of the Tonal Systems in New Caledonia, the example of Cèmuhî. In: *Proceedings of the Symposium Cross-linguistic Studies of Tonal Phenomena: Tonogenesis, Japanese Accentology, and Other Topics*, ed. Shigeki Kaji, Institute for the Study of Languages and Cultures of Asia and Africa (ILCAA), Tokyo University of Foreign Studies, 23-42.

Ross, Malcolm D. 1993. Tonogenesis in the North Huon Gulf Chain. In: *Tonality in Austronesian languages*, eds. Jerold A. Edmondson and Kenneth J. Gregerson, Honolulu: University of Hawaii Press, 133-153.

Ruangjaroon, Sugunya. 2006. Consonant-Tone Interaction in Thai: An OT Analysis. *Taiwan Journal of Linguistics* 4.2:1-66.

Rycroft, D. K. 1980. *The depression feature in Nguni languages and its interaction with tone*, Grahamstown: Rhodes University, Department of African Languages.

Sagart, Laurent. 1988. Glottalised Tones in China and South-East Asia. In: *Prosodic Analysis and Asian Linguistics: To Honour R.K. Sprigg*, eds. David Bradley, Eugénie J. A. Henderson and Martine Mazaudon, Canberra: Australian National University, 83-93.

Schachter, Paul. 1976. An Unnatural Class of Consonants in SiSwati. *Studies in African Linguistics* Supplement 6:211-220.

Schmidt, Bodil Kappel, Odden, David, and Holmberg, Anders eds. 2002. *Aspects of Zina Kotoko Grammar*: Lincom Europa.

Schuh, Russell. 1971. Verb Forms and Verb Aspects in Ngizim. *Journal of African Languages* 10.1971:47-60.

Schuh, Russell. 1978. Tone rules. In: *Tone: A Linguistic Survey*, ed. Victoria Fromkin, New York: Academic Press, 221-256.

Schuh, Russell. 2002. Bade /Ngizim Phonology and Morphology. Ms. *UCLA Linguistics 252, Winter Quarter 2002*.

Silva, David James. 2006. Acoustic evidence for the emergence of tonal contrast in contemporary Korean. *Phonology* 23.2:287-308.

Smalley, William A. 1961. *Outline of Khmu? Structure*, New Haven, Connecticut: American Oriental Society.

Snyman, J. W. 1970. *An Introduction to the !Xũ language*, Cape Town: Balkema.

Somé, Penou-Achille. 1998. L'influence des consonnes sur les tons en Dagara, langue Voltaïque du Burkina Faso. *Studies in African Linguistics* 27.1:3-47.

Stevens, Kenneth N. 1977. Physics of Laryngeal Behavior and Larynx Modes. *Phonetica* 34:264-279.

Storoshenko, Dennis Ryan. 2003. Why Glottalisation and Voice are the Same: A Study of Implosives in Phonemic Inventories. Ms., Simon Fraser University, Vancouver, BC, Canada.

Strazny, Philipp. 2003. Depression in Zulu: tonal effects of segmental features. In: *The phonological spectrum*, eds. Jeroen Van de Weijer, Vincent J. Heuven and Harry Van der Hulst, John Benjamins, 223-239.

Svantesson, Jan-Olof. 1983. *Kammu phonology and morphology*, Malmö, Sweden: CWK Gleerup.

Svantesson, Jan-Olof. 2001. Tonogenesis in Southeast Asia - Mon-Khmer and beyond. In: *Proceedings of the Symposium Cross-linguistic Studies of Tonal Phenomena: Tonogenesis, Japanese Accentology, and Other Topics*, ed. Shigeki Kaji, Institute for the Study of Languages and Cultures of Asia and Africa (ILCAA), Tokyo University of Foreign Studies, 45-58.

Svantesson, Jan-Olof, and Karlsson, Anastasia Mukhanova. 2004. Minor Syllable Tones in Kammu. In *International Symposium on Tonal Aspects of Languages: With Emphasis on Tone Languages*, Beijing, China, 177-180.

Svantesson, Jan-Olof, and House, David. 2006. Tone production, tone perception and Kammu tonogenesis. *Phonology* 23:309-333.

Tang, Katrina Schack. 2007. Voice-Tone Interaction in Bade. Ms. UCLA.

Tang, Katrina Schack. to appear. The Variable Nature of Implosives in Consonant-Tone Interaction. In: *Proceedings of NELS*.

Thein Tun, U. 1982. Some acoustic properties of tones in Burmese. In: *Papers in South-East Asian Linguistics 8: Tonation*, ed. D. Bradley, Canberra: Australian National University, 77-116.

Thompson, Richard B. 1976. A Phonology of Kuwaa, MA Thesis, San Jose State University.

Thurgood, Graham. 2002. Vietnamese and tonogenesis: revising the model and the analysis. Ms., California State University, Chico.

Topintzi, Nina. 2006. Moraic Onsets, Doctoral Dissertation, University College London.

Trager, Felicia Harben. 1971. The phonology of Picuris. *International Journal of American Linguistics (IJAL)* 37:29-33.

Traill, A., Khumalo, J. S. M., and Fridhon, P. 1987. Depressing facts about Zulu. *Journal of African Studies* 46:255-274.

Tran, Do Dat, Castelli, Eric, Serignat, Jean-François, Trinh, Van Loan, and Le, Xuan Hung. 2005. Influence of F0 on Vietnamese syllable perception. In *INTERSPEECH-2005*, 1697-1700.

Trommer, Jochen. 2005. Polar Tone in Kanuri. Ms., University of Leipzig.

Vaux, Bert. 1998. *The phonology of Armenian*, Oxford: Clarendon Press.

Volk, Erez. 2007. High, low and in between: Giryama tonology, MA Thesis, Tel Aviv University.

Wang, Jun, and Zheng, Guoqiao. 1993. *An outline grammar of Mulao ['Mulauyü chienchi' translated from Chinese by Luo Yongxian]*, Canberra: National Thai Studies Centre, The Australian National University.

Wang, William S.-Y. 1967. Phonological features of tone. *International Journal of American Linguistics* 33:93-105.

Watkins, Justin. 2000. Notes on creaky and killed tone in Burmese. *SOAS Working Papers in Linguistics* 10:139-149.

Watkins, Laurel J. 1984. *A grammar of Kiowa*, Nebraska: University of Nebraska Press.

Wee, Lian Hee. 2004. Inter-tier Correspondence Theory, PhD dissertation, Linguistics Department, Rutgers University.

Wei, Feng, and Edmondson, Jerold A. 1997. The Tonal Cylinder in Sanfang Zhuang. In: *Comparative Kadai: The Tai Branch*, eds. Jerold A. Edmondson and David B. Solnit, The Summer Institute of Linguistics and University of Texas at Arlington.

Wei, Jingyun, and Tan, Xiaohang. 2006. *Zhuang yu tong lun*, Beijing Shi: Zhong yang min zu da xue chu ban she.

Weidert, Alfons. 1987. *Tibeto-Burman Tonology,* Amsterdam: John Benjamins.

West, Birdie, and Welch, Betty. 1967. Phonemic system of Tucano. In: *Phonemic Systems of Colombian Languages,* ed. Viola Waterhouse, Norman, OK: University of Oklahoma, 11-24.

Woo, Nancy. 1969. Prosody and Phonology, Ph. D. Dissertation, MIT.

Wright, Jonathan. 2007. Laryngeal Contrast in Seoul Korean, Ph. D. Dissertation, University of Pennsylvania.

Xian, Songkui. 1990. Guizhou Ziyun Shuijingping Miaoyu he Wangmo Xinzhai Miaoyu de liandu biandiao [Tone sandhi in the Hmong language of Shuijingping of the Ziyun district and Xinzhai of the Wangmo district of Guizhou]. *Minzu Yuwen* 3:71-77.

Ye, Xiangling. 1983. Wujiang Fangyan Shengdiao Zai Diaocha [Tones of the Wujiang Dialect]. *Fangyan* 1983.1:32-35.

Yip, Moira. 1989. Contour tones. *Phonology* 6:149-174.

Yip, Moira. 1995. Tone in East Asian languages. In: *The Handbook of Phonological Theory*, ed. John A. Goldsmith, Cambridge, Mass., and Oxford, UK: Blackwell, 476-494.

Yip, Moira. 2002. *Tone*, Cambridge, United Kingdom: Cambridge University Press.

Yip, Moira. 2007. Tone. In: *The Cambridge Handbook of Phonology*, ed. Paul de Lacy, Cambridge University Press, 229-251.

Zahn, Heinrich. 1940. *Lehrbuch der Jabêm-Sprache (Deutsch-Neuginea)*, Berlin: Reimer.

Zec, Draga. 1995. Sonority constraints on syllable structure. *Phonology* 12:85-129.

Zhang, Jie. 2002. *The effects of duration and sonority on contour tone distribution: typological survey and formal analysis*, New York: Routledge. [ROA-452]

Zubritskaya, Katya. 1995. Markedness and sound change in OT. In: *Proceedings of the North East Linguistic Society 25*, ed. Jill Beckman, Amherst, Mass.: GLSA Publications, 249-264.

Curriculum Vita

Seunghun Julio Lee

Education

2002-2008	Ph.D. Linguistics, Rutgers University
1999-2002	Full-time Lecturer (German), Republic of Korea Air Force Academy
1997-1999	M.A. Linguistics, Seoul National University
1993-1997	B.A. German Education, Seoul National University

Publications

submitted — Neutralization to high tone by consonants in Mulao, in the *Proceedings of the 17th Southeast Asian Linguistics Society*.

submitted — Effects of glottal stops on tone in Burmese, in the *Proceedings of the 43rd Chicago Linguistics Society*.

to appear — H tone, depressors and downstep in Tsonga, in: (eds.) Masangu Matondo, Fiona McLaughlin, and Eric Potsdam, the *Selected Proceedings of the 38th Annual Conference on African Linguistics*. Cascadilla Proceedings Project, Somerville, MA.

to appear — On the status of schwa in Korean, *Harvard Studies in Korean Linguistics XII*. (with Brian D. McHugh)

2007a — A structure in the Tonal Tier, in: (eds.) Leah Bateman, Adam Werle, Michael O'Keefe, and Ehren Reilly, *University of Massachusetts Occasional Papers in Linguistics 33: Papers in Optimality Theory 3*. Amherst, MA: GLSA, p.209-222.

2007b — On the phonetic representation of ‘ㅓ’ in Korean, *Proceedings of Association for Korean Studies in Europe 30th Anniversary Conference (Dourdan, France)*, p.149-152. (with Brian D. McHugh)

2006a — Predicting Ibibio Vowel Distribution, *Journal of West African Languages 33.2*: p. 43-60. (with Akinbiyi Akinlabi)

2006b — Tonal Complex: Building Structures around H tone, *Harvard Studies in Korean Linguistics XI*, p.224-236.

2006c Positional markedness and Tatar vowel harmony: The markedness of feature HIGH, *Proceedings of the 2006 Joint Conference on Linguistics (Jeju island, Korea)*, p. 27-40.

2006d Na-Rae Han, Shijong Ryu, Sook-Hee Chae, Seung-yun Yang, Seunghun Lee, and Martha Palmer "Korean Treebank Annotations Version 2.0" Linguistic Data Consortium (LDC), Philadelphia.

2004 A-templatic reduplication in Korean, in: (eds.) Sang-Oak Lee, Seok-Hoon You, Jae-Young Han & Mahmut Ertan Gökmen, *Inquiries into Korean Linguistics I*, Thaehaksa, p.159-167.

2002 Review on the typological proposal of Vennemann, *Journal of KAFA*, No.49.