TONE SYSTEMS OF DIMASA AND RABHA: A PHONETIC AND PHONOLOGICAL STUDY

By

PRIYANKOO SARMAH

A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

2009

To my parents and friends

ACKNOWLEDGMENTS

The hardships and challenges encountered while writing this dissertation and while being in the PhD program are no way unlike anything experienced by other Ph.D. earners. However, what matters at the end of the day is the set of people who made things easier for me in the four years of my life as a Ph.D. student.

My sincere gratitude goes to my advisor, Dr. Caroline Wiltshire, without whom I would not have even dreamt of going to another grad school to do a Ph.D. She has been a great mentor to me. Working with her for the dissertation and for several projects broadened my intellectual horizon and all the drawbacks in me and my research are purely due my own markedness constraint, *INTELLECTUAL.

I am grateful to my co-chair, Dr. Ratree Wayland. Her knowledge and sharpness made me see phonetics with a new perspective. Not much unlike the immortal Sherlock Holmes I could often hear her echo: One's ideas must be as broad as Nature if they are to interpret Nature.

I am indebted to my committee member Dr. Andrea Pham for the time she spent closely reading my dissertation draft and then meticulously commenting on it. Another committee member, Dr. Jimmy Harnsberger spent hours personally supervising the statistics and experimental parts of my dissertation.

The teaching faculty at the linguistics program of the University of Florida has always been very kind to me. I will always remember the contribution of Dr. Fiona McLaughlin, Dr. Ann Wehmeyer, Dr. Edith Kaan, Dr. Jules Glieche, Dr. M.J. Hardman, Dr. Virginia LoCastro, Dr. Gary Miller, and Dr. Diana Boxer in broadening my understanding of linguistics and academia in general.

Helping me overcome all the stressful times in my PhD program were my fellow lab-rats: Dr. Mohammed Al-Khaiiry, Dr. Bin Li, Dr. Bao Mingzhen, Chris Barkley, Dr. Andrea Dallas. Linguistics has been fun fun and fun with all of them around.

Outside Turlington, my home in Gainesville was Belle's house and my family was Apple, Nan, Tony and many other Thai friends. They readily provided any academic or personal help I needed in Gainesville.

My sincere gratitude goes to my Assamese friends in Gainesville who literally made me feel at home during various parts of my four years of stay in Gainesville- Chandan Talukdar, Sakib Rahman Saikia, Siddrat Taufik Saikia, Randeep Khaund, Ananya Bhuyan and Dr. Prabir Barooah- thank you all.

My heartiest thanks go to my study buddy Eva (Zheng Weihua) for her constant persuasions whenever she felt I am slowing down in my work- I owe you big time! Thanks to Sean (Sangyeon Park) for the great company during the time of writing this dissertation.

My heartiest thanks go to the other two members of the 2004 trio Jimmy and Mutsuo. Thanks to my first and close friend in Gainesville, Jimmy (Huang Chun) for putting up with me all these years. Thanks Mutsuo, for never saying no to anything that I demanded!

I would like to express my gratitude to all the beautiful people in the city of Gainesville, Florida who made my four years in the city a memorable experience.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

TONE SYSTEMS OF DIMASA AND RABHA: A PHONETIC AND PHONOLOGICAL STUDY

By

Priyankoo Sarmah

May 2009

Chair: Caroline R Wiltshire
Cochair: Ratree P Wayland
Major: Linguistics

This study explores the tone systems of two languages spoken in the northeast part of India: Dimasa and Rabha. This study involves acoustic analysis of data from the two languages collected from extensive fieldwork. The focus of this study is to determine the lexical tonal inventory of Dimasa and Rabha and the assignment of tones in various morphological domains.

In the available literature on Dimasa and Rabha, there are multitudes of conflicting views about their tone systems and its functions. This study resolves these views and confirms that Dimasa and Rabha have three tones each in their tonal inventory namely, rising, mid-level and falling tones that can be assigned to any lexical word. It also confirms that only one tone can be assigned to each underived lexical word regardless of its syllable size. It is also concluded that in case of derived suffixed words, Dimasa retains the tone of both the root and the suffix whereas Rabha retains only the tone of the suffix assigning a default mid tone to the root. This study also provides an optimality theoretical (OT) account of the tonal phenomena in Dimasa and Rabha.

CHAPTER 1
INTRODUCTION

Research Questions

This study aims at investigating the tonal phonetics and phonology of two Tibeto-Burman languages spoken in the North-Eastern part of India namely, Dimasa and Rabha. It provides a definitive phonetic account of the inventory of tones in the two languages and their assignment in underived monosyllables, underived disyllables and derived polysyllables. Also, this study aims at providing an optimality theoretical account of the tonal phenomena in the two languages in this study. More specifically, this study aims at providing answers to the following research questions:

- How many lexical tones do Dimasa and Rabha have?
- How are lexical tones assigned in underived monosyllables, underived disyllables and derived polysyllables?
- Do the related languages follow the tone assignment pattern as reported in Sarmah (2004) for Bodo?

It is worth mentioning at this point that studies on tones in these two languages are very limited and largely inconclusive. Moreover, until now, there has been no acoustic investigation into the tone systems of Dimasa and Rabha. Even though Singha (2001) describes the tone systems of Dimasa and Joseph and Burling (2001) and Joseph and Burling (2007) describe the tone systems of Rabha, their findings do not correspond to the findings of Resource Centre for Indian Languages Technology Solutions (RCILTS), Guwahati[1] for Dimasa and Basumatary (2004) for Rabha. Moreover, almost next to nothing is known about the tone assignment pattern of these two languages in derivations.

[1] Retrieved from http://www.iitg.ernet.in/rcilts/dimasa.htm on March 20th, 2008

Hence, this study is designed to explore Dimasa and Rabha tone systems and arrive at definitive conclusions about the tone systems and tone assignment in the two languages. The next section provides an overview of the two languages in this study, including the consonantal and vowel inventory of the two languages. It also provides a brief overview of the syllable structures in Dimasa and Rabha. The following sections discuss the goals of the current study and give an overview on tone languages and their distribution around the world. The latter section specifically talks about the observed tonal phenomena in the Tibeto-Burman languages and the final section gives an overview of the organization of this dissertation.

Languages of the Present Study

In the current study, two languages of the Assam-Burmese family of languages are studied (Figure 1-1). In alternative accounts, this language family is also described as Kamarupan (Matisoff 1991, 1999, 2000) and Jingpho-Konyak-Bodo.[2] In this study, the latter classification of the language family is adopted as it is more widely accepted as a standard classification. On the other hand Matisoff (1991)'s classification has faced severe criticism resulting in a defense of the Kamrupan family in Matisoff (1999). In Figure 1-2, the geographical distribution of the languages of interest in this study is demonstrated. In the subsections to follow, descriptions of Dimasa and Rabha are provided.

The Dimasa Language

Dimasa is a language spoken by an ethnically minority community in Assam, India. Dimasa is spoken by 88,543 speakers as a first language.[3] According to the RCILTS website of Indian Institute of Technology, Guwahati, Assam, Dimasa has two lexical tones[4] namely, high and level unmarked tone.[5]

[2] Source: http://www.ethnologue.com, retrieved on June 10, 2008

[3] Source: http://www.censusindia.net/, as retrieved on June 10, 2008

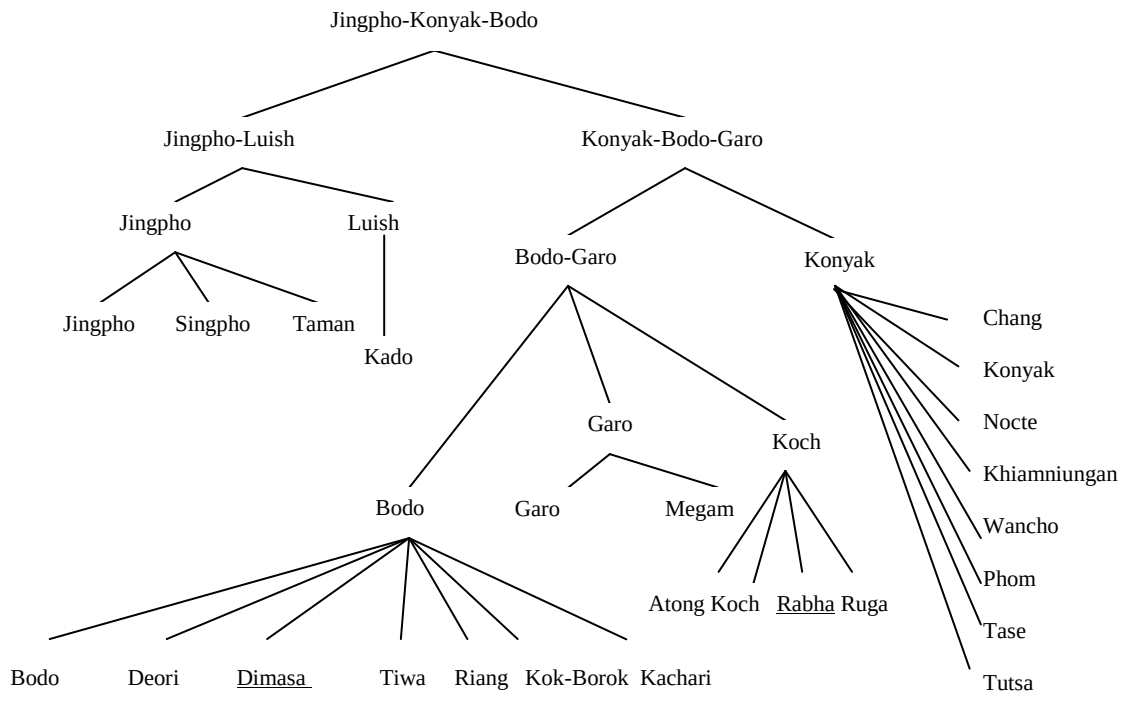


Figure 1-1. The Jingpho-Konyak-Bodo subfamily

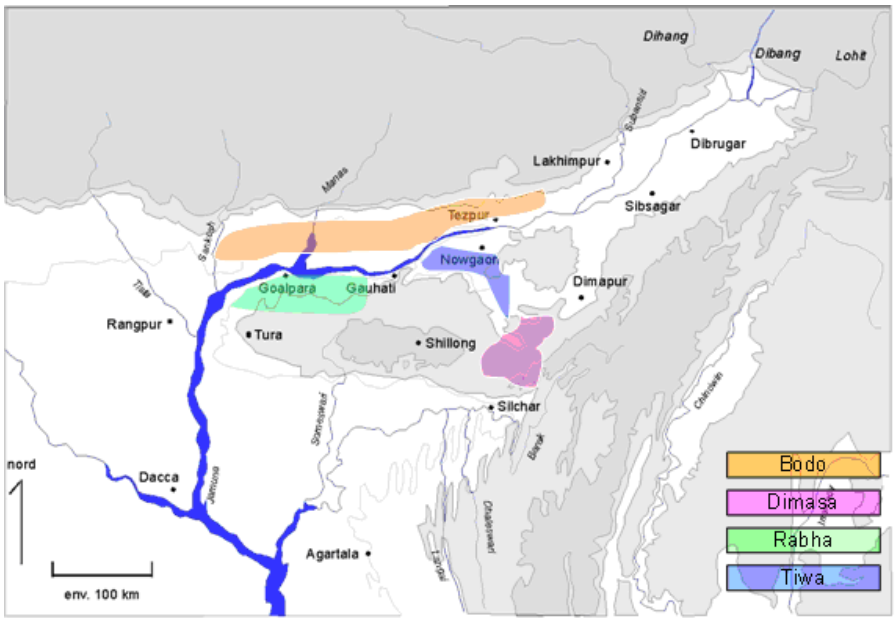


Figure 1-2. Distribution of languages of the Bodo-Garo family

[4] Source: http://www.iitg.ernet.in/rcilts/dimasa.htm, as retrieved on June 10, 2008

[5] It is not clear what they categorize as 'level unmarked tone'. The website provides no description or data related to their claim.

Singha (2001) sheds some light on Dimasa phonology and morphology and, regarding tones in Dimasa, he claims that there are three register tones:[6] high, low, and mid/level, with the mid/level tone being an 'unmarked' tone. Singha (2001) claims that the high and low tones in Dimasa are assigned rising and falling pitch contours respectively in their phonetic realizations.

A preliminary investigation of tones of the Dimasa language (Sarmah and Wiltshire, in press) has led to the conclusion that the language has three phonological tones namely, high, mid and low. However, the high and the low tones in the language have phonetically rising and falling pitch contours. The mid tone is a register tone. Sarmah and Wiltshire (in press) also describe the phonetic properties associated with the production of the three tones in Dimasa.

According to Singha (2001) Dimasa has 6 vowels and 16 consonants. However, this list does not contain the diphthongs that exist in the Dimasa language. The consonantal inventory of Dimasa is described in Singha (2001) at length and is represented in this work (Table 1-1). Singha (2001) also describes the vowels of Dimasa (Figure 1-3). These inventories shows that the segmental inventory of Dimasa is very similar to the segmental inventory of other languages in the Bodo-Garo family such as Bodo, Tiwa and Rabha (Joseph and Burling, 2001).

Table 1-1. Consonants in Dimasa

	Bilabial	Dental	Alveolar	Palatal	Velar	Uvular	Glottal
Plosive	pʰ b	t̪ʰ d̪			k g		
Nasal	m		n		ŋ		
Fricative			s z				h
Tap							
Approximant			ɹ	j	w		
Lateral Approximant			l				

[6] The term 'register' is used by Singha (2003) to refer to level tones.

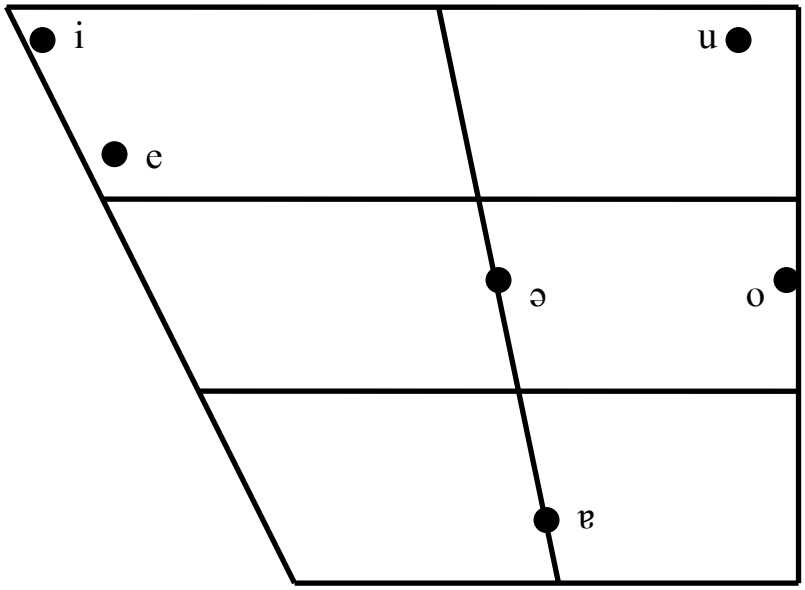


Figure 1-3. Vowels in Dimasa

The Rabha Language

Rabha is spoken by about 139,365 people in Assam and Meghalaya[7] and considered to be a language of an ethnic minority community. The Rabha segmental phonological inventory is very similar to the other languages in the Bodo-Garo subfamily. As Joseph and Burling (2007) notes, Rabha is closer to Tiwa in terms of consonant inventory.

According to Joseph and Burling (2007), like most of the languages of the Bodo Garo family, Rabha also has two tones. These two tones are high and 'less clearly falling than a falling tone' which they accept as a low tone. In an extensive study Basumatary (2004) compares Bodo and Rabha language and comes to the conclusion that Rabha has two phonological tones.

According to Basumatary (2004) Rabha has 20 consonants (Table 1-2) and 6 vowels (Figure 1.4). Similar to Dimasa, the segmental inventory of Rabha differs in the existence of the voiced counterparts of the plosive sounds.

[7] Source: http://www.censusindia.net, as retrieved on June 10, 2008

Table 1-2. Consonants in Rabha

	Bilabial	Dental	Alveolar	Palatal	Velar	Uvular	Glottal
Plosive	p b p^h		t d t^h	c	k g k^h		
Nasal	m		n		ŋ		
Fricative			s z				h
Tap							
Approximant			ɹ	j	w		
Lateral Approximant			l				

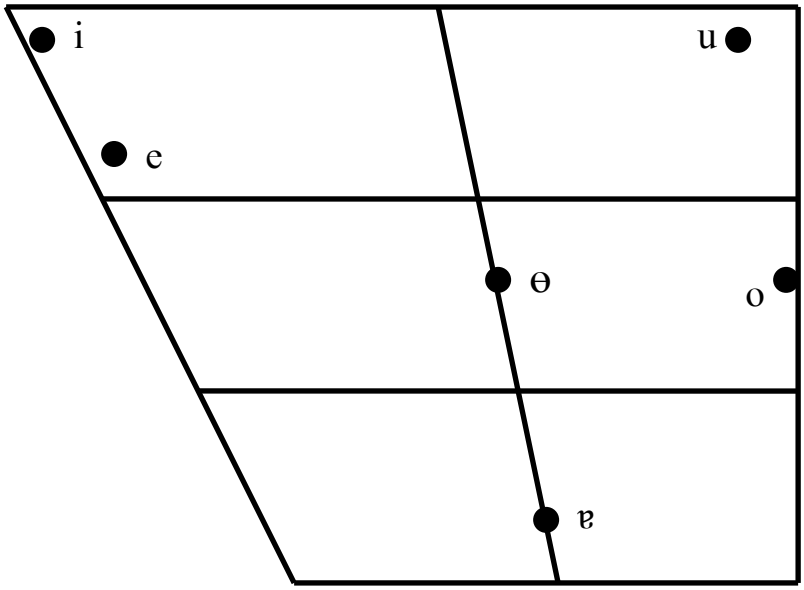


Figure 1-4. Vowels in Rabha

Dimasa and Rabha Morphological Structures

Singha (2001) also discusses the morphology of Dimasa to some extent. He mentions that Dimasa nouns can have gender, number and case as affixes. Even though the occurrence of prefixes is limited to numerals and pronouns, suffixes are allowed for various purposes. As far as the prefixes are concerned, the classifier *ma-* can be optionally attached to a cardinal number. Multiplicative numerals are also formed by adding a prefix to the cardinal numbers. Demonstrative pronouns are formed by adding prefixes to the third person pronoun. However,

suffixation is allowed for both nouns and verbs for a wide variety of usage such as pluralization, causativization etc. As in other Tibeto-Burman languages, Dimasa uses many verbal nouns produced by adding the suffix *–ba* to a verb. Similarly, adverbs can be also derived from adjectives using the suffixes *–sisi* and *–lolo*. Pluralization is achieved by using the plural suffixes *–rao* and *but*^{h}*u*. Apart from these Dimasa also allows echo formation where the echo word changes the vowel or the consonant or both. Echo words in Dimasa add the meaning 'etcetera' or 'similar to' to the base form. In case of reduplication, Singha (2001) points out that Dimasa has two types of reduplication a) class changing and b) class maintaining. The class changing reduplications necessarily change a word to an adverb.

Dimasa allows a variety of syllable structures. As this work discusses the monosyllables and disyllables of Dimasa, it is pertinent to discuss the syllable inventory of Dimasa in underived monosyllables and disyllables. According to Singha (2001), Dimasa allows a wide variety of syllable types in monosyllables and disyllables (Table 1-3).

Table 1-3. Syllable structures of Dimasa

Monosyllables	Disyllables
VC, CV	VCV
CVC, CVV, CVC, CVV, CCV	VCCV, VCVV, CVCV, VCVC
CCVV, CVVC, CCVC	CVCCV, CVVCV, CVCVV, CVCVC, CVCVC, CVCVC
	CVCCVV, CVVCCV, CCVCCV, CVCCVV, CVCCVC, CVVCVC

According to Basumatary (2004), Rabha can adopt to the use of affixes for derivation and inflection. Like Dimasa, Rabha also demonstrates more number of suffixes than prefixes. Rabha uses a variety of nominative suffixes to create nouns from verbs. Similarly, pluralization is also achieved by adding suffixes like *–bizan* or *–taŋ* in Rabha. One of the few instances where prefixes are used is while causativizing a verb. Rabha uses reduplication to pluralize nouns. In case of interrogative sentences, the pronoun can also be reduplicated to refer to a group of

people. Again, adjectives are reduplicated in order to add a plural sense to the noun that the adjectives modify. Not much is known about the syllable structure in Rabha. However, Basumatary (2004) provides an inventory of syllable types for underived monosyllables and disyllables in Rabha (Table 1.4).

Table 1-4. Syllable structures of Rabha

Monosyllables	Disyllables
V, VV, CV, VC CVV, CVC CCVV	VCC CVCV CVCVC CVCCVC

The Current Study

The current study aims to conduct an exhaustive investigation on the tones and their behaviors in the two languages. As mentioned earlier in this chapter, there is no acoustic study on the tones of Dimasa and Rabha available. Moreover, there is no agreement among the available literature on the number, types and behavior of tones in the two languages. Hence, the current study aims filling these gaps in the literature. This study also aims at shedding light on tone assignment in underived monosyllables, underived disyllable and derived polysyllables in Dimasa and Rabha.

This study involves systematic collection of data using digital devices, acoustic and statistical analyses and an optimality theoretical account based on the results obtained from the acoustic analyses (Chapter 2 for more details).

In the available literature on tones, the generalizations about tonal phenomena across languages are derived mainly from data collected from the African, East Asian and Southeast Asian languages, whereas Tibeto-Burman languages have hardly found a place in tone studies. It is expected that the proposed study will help in filling an existing gap in the literature on tone studies. Hence, the objective of this study is to conduct a typological investigation into the tone

assignment pattern of two languages of the Bodo-Garo subfamily of the Tibeto-Burman language family namely, Dimasa and Rabha. In the sections to follow, specific objectives of this study are discussed.

Tonal Inventory of Dimasa and Rabha

According to Benedict (1972) and Mazaudon (1985), Proto Tibeto-Burman has a tonal inventory of only two tones and most of the languages of the family mirror this in terms of their tonal inventories. In this research it will be investigated if the daughter languages of the Bodo-Garo subfamily demonstrate evidence for the claims of Benedict (1972) and Mazaudon (1985). It will also be investigated if the third tone (the mid tone) found in many Tibeto-Burman languages is an unmarked tone which surfaces only when a tone bearing unit is not assigned any tone due to phonological restrictions prevailing in the languages. The motivation for this part of our investigation primarily arises due to the familiarity with the available literature on the Bodo-Garo languages. In case of Bodo it is claimed that it has only two lexical tones (e.g. Burling 1959, Joseph and Burling 2001, Sarmah 2004) as opposed to the previous views that they have a larger tonal inventory with Bhattacharya (1977) claiming that it has four tones and Halvorsrud (1959) claiming Bodo to be a three tone system.

In this study phonetic analysis is used to identify the pattern and types of tones for phonological analysis. With the help of instrumental analysis designed to capture the pitch pattern of the data from the languages, it is expected that a definitive answer about the number and phonetic and phonological nature of tones in the language in the present study can be achieved.

Morphophonemics of Dimasa and Rabha

In this study the interaction between tone and morphology is also investigated. Morphotonological interactions have been noticed in Bodo as demonstrated in Bhattacharya

(1977) and Sarmah (2004). Similarly, an interaction in morphological derivations in terms of tones is expected in Dimasa and Rabha.

The present study is an investigation in the domain of tone languages. Hence, the following section provides a general introduction to tone languages and provides an overview of tones in world languages. This section also talks about the characteristics of the tone languages of the two major regions of the world: Asia and Africa, where most of the tone languages of the world can be found.

Overview of Tone Languages

A pertinent question to ask at this point is, "What is a tone language?" Yip (2002) regards languages as 'Tone Languages' if the pitch of the word results in the change of the meaning of the word. The basis of tone is the pitch of the sound. Pitch is the perceived fundamental frequency or the rate of vibration of the vocal folds (measured by the number of cycles per second- Hz) of a sound.

Hyman (2001) gave a plausible definition of a tone language: "A language with tone is one in which an indication of pitch enters into the lexical realization of at least some morphemes" (pp. 1367-1380).

Hyman's definition is quite ambiguous as it does not draw a distinction between a tone and a stress language. However, while defining tone languages, Yip mentions that it is only a thin line that separates stress languages from tone languages. She tries to make this distinction clearer by noting that in stress languages pitch does not stay constant on the lexical items whereas in tone languages it does. Moreover in a stress language, stress is not lexically marked.

If the pitch of a word can change the meaning of a word, that language is called a tone language. The pitch not only changes the nuances of the words but also changes the core meaning of the words.

Pike (1948) says that the tone languages should have lexically significant, contrastive but relative pitch on each syllable. However, some scholars do not support this view. Welmer (1959), Schachter and Fromkin (1968) and Woo (1969) describe tones in the lines of classical generative phonology, which regards tones as a property of segments. In autosegmental phonology, the same stand is assumed where the tone bearing unit is considered as an element on the segmental tier capable of being associated with an element on the tonal tier (Goldsmith, 1976).

Sapir (1925) and Trubetzkoy (1939) try to associate tones with the mora. Their argument was based on the relationship between the tonal complexity and the vowel length or the syllable quality. There is a possibility of a relationship between tones and the vocalic nucleus of the syllable and the consonants of the relative margin. Tones can normally be realized on voiced segments. Therefore the TBU is most of the time a voiced vowel. However the possibility of a relationship between a tone and a consonant is also not ruled out.

To substantiate Yip (2002)'s definition of tones resulting from pitch change one can look at an example from Cantonese, where the syllable [yau] can be produced in six different pitches, which has six different meanings as shown in Example 1-1.

[yau]		(1-1)
high level	'worry'	
high rising	'paint (noun)'	
mid level	'thin'	
low level	'again'	
very low level	'oil'	
low rising	'have'	(Yip, 2002)

However, in some languages, tonal distinctions in polysyllabic words are obtained by contrastive positioning of restricted tones in different syllables. In Dagaare, a Gur language spoken in Ghana, a disyllabic word can be specified H(igh) and L(ow) as in Example 1-2.

σ σ (1-2)
| |
L H

σ σ
| |
H L
(Yip, 2002)

In case of a disyllabic entry [yuori], a tonal distinction is found as in Example 1-3.

LH [yuori]	'penis'	(1-3)
HL [yuori]	'name'	(Yip, 2002)

In many other languages, the positioning of the lexical tone does not matter much. It may appear anywhere in the lexical entry. The exact location of the tone may change according to the morphological or phonological environment.

The study of tonal languages achieved its due recognition with the publishing of Pike (1948). In the 20th century, the arrival of western missionaries trained in linguistics, in the far flung places of Asia and Africa, exposed western philologists to a large database of tonal languages. Even though 67% of world's languages are tone languages (Yip, 2002) not much has been known about many tone languages and the behaviors of tones in many languages. This deficiency in typology has prevented linguists from offering a general theory of tones and their functions in the world's languages. Even a general tone representational system is also far from being achieved. For example, Gruber (1964) and Wang (1967) consider contour tones to be distinguished from one another as single units. Woo (1969) argues that all contour tones should be analyzed into levels. She says that as contour tones are long, therefore, the syllables bearing them must be bimoraic or trimoraic. Similarly, Leben (1973) argues that owing to the limitations in the number of suprasegmental tonal melodies, contour tones should be analyzed as tonal melodies. Leben (1978) strengthens this argument by showing that Mende contour tones are

actually sequences of H(igh) and L(ow) tone features. Similarly, Goldsmith (1976 a, b) accommodated the H and L tone features on a separate tonal tier.

Other scholars however did not support the view that contour tones should be decomposed into levels. However, later Yip (2002) argues that contour tones do need to be represented as combinations of level tones. This multiplicity of views can only be resolved if typological data empirically supports a particular view over another. Therefore, this study aims at adding data that can bear on these issues.

Tone Languages of the World

Asia and Africa are home to most of the tone languages of the world. Considering the typological evidence gathered from tone languages, Woo (1969) suggests that languages can be categorized in terms of their prosodic qualities. Towards that goal, Woo suggests that languages be divided into the following groups according to their tonality:

A. Lexical tone languages, where the pitch contour of a lexical formative is specified for pitch on every vowel.

B. Tone harmony languages, where a diacritic is associated with each lexical formative and where the diacritic is later interpreted to give the pitch contour of the formative.

C. Non-tone languages, where the lexicon contains no prosodic features associated in any way with formatives.

Woo combines Type A and Type B as ‘tone languages’, distinct from Type C. Considering the arguments put forth by these scholars, languages can be categorized in a system where the feature [Tone] refers to lexical tones and [Accent] refers to relative emphasis given to a particular syllable in a word by varying duration, intensity or pitch (Table 1-5).

Table 1-5. Language categorized according to tonality

[Tone]	[Accent]	Examples
+	+	Mandarin, Zulu, Swedish
+	-	Cantonese, Hausa
-	+	English, Spanish, Japanese
-	-	French

Table 1-6. Elaborate categorization of languages according their tonality

Language Type	Tone	Accent	Accent Type	Examples
I. Non-Accentual tone-languages	YES	NO	---	Cantonese, Huasa
II. Accentual Tone-languages	YES	YES	Stress	Mandarin, Zulu
III. Tonal Accent Languages	YES	YES	Stress	Swedish
IV. Pitch Accent languages	NO	YES	Pitch	Japanese
V. Stress accent languages	NO	YES	Stress	English, Spanish
VI. Non-accentual languages	NO	NO	---	French

Table 1-7. Tonal systems

Free Tone	Restricted Tone, including tone pitch accent
Chinese Ewe	Mende Japanese Tonga Haya
Metrical Accent System	
Stress-Accent	Metrical pitch accent
English Latin Modern Greek Chinese	Vedic Sanskrit Ancient Greek Malayalam

African Tone Languages

African languages are complex in their tone systems. The most striking feature of African tone languages is their tone mobility. It is seen that the tone in a particular morpheme spreads to an adjacent morphological unit both inside and outside the morpheme boundary. This feature is true of Bantu, a major language of this family. Tonal phenomenon like spreading, deletion and metatheses are also found in the African languages. Some also term these languages as accentual languages considering the almost predictable tonal distribution of these languages.

Another factor that creates a problem for the labeling of these languages is their limited tone inventory. In many cases these languages have only one marked tone (H), phonologically

speaking. The L tone is considered to be a default tone and it associates itself with any toneless syllable.

However there are languages in Africa which have up to five tones (e.g. Gimira, Wobe, Dan and Ashuku). Though contour tones are rare in African tone languages, the Khoisan languages do have contour tones. The distribution of contour tones in most of the languages is quite predictable. Usually in African languages the word final TBUs or TBUs with heavy syllables are assigned contour tones. The contour tones in African languages can be analyzed as sequences of two level tones. However there are cases where a prime contour tone is noticed. In some of the languages even a preference for a contour tone over a level tone is noticed. The TBUs in African languages can both be syllables and moras.

Tonal complexity is further increased in African languages by phenomena such as downstep or downdrift. In many African languages, a high tone appearing after a low tone is lower than the high tone preceding the low tone. This phenomenon is called downstep or downdrift. In many languages upstep is also found, where a low tone following a high tone is higher than the one preceding the high tone. Also interaction of segmental and tonal features is also widely observed. Consonantal effects are observed in the lowering of tones in African tone languages. A set of voiced consonants usually lower the tones. Polarity is another feature of the African languages that sets them apart from the tone languages of the other parts of the world. In this case the tones of the affixes are the opposite of the tone of the root.

Asian Tone Languages

Asian languages are rich in tones. The Chinese language family, Tibeto Burman, Tai-Kadai, Vietnamese, the Papuan languages have languages with rich tone inventories. However the Indo-Aryan languages of the Indian subcontinent do not have tone languages (with the sure exception of Punjabi and a possible exception of Rajasthani). Even the Austro-Asiatic languages

are mainly non-tonal (except Vietnamese, some dialects of Khmer and possibly Garo). In comparison to the African languages, the Asian languages have a larger tone inventory with contrasts between level and contour tones. The Asian languages have a simple syllabic structure like the African languages; however unlike the African languages they have a simple morphology. The fairly small set of syllables in these languages is enlarged by incorporating tonal contrasts. For example Mandarin has 406 segmentally distinct syllables; however it increases to 1256 when tonal contrasts are included (Yip, 2002).

In some cases, as in African languages, Asian languages too show consonantal interference in the realization of a tone. Experiments show that in many languages the pitch of vowels following voiceless consonants is higher than following a voiced consonant (Hombert *et al*, 1979). These sorts of characteristics do not have any specific phonological significance, but they may become significant in a number of ways. There may be a limitation of certain tones after certain consonant sounds. Ladefoged (1964) describes the Ewe tones, which have lower tones in syllables beginning with certain voiced consonants. Accounts showing closer links between tone and initial consonants can be found in the historical developments in the South East Asian tone languages. They result in the extension of the tone system and even the development of tones in originally non-tone languages. Tonogenesis in Vietnamese is shown by Haudricourt (1954, 1961). He claims that Vietnamese was actually a non-tone language, like its other counterparts of the Mon-Khmer language group. The tonal distinction in Vietnamese arose due to the loss of a few consonantal distinctions. Three tones developed due to the loss of the final consonants and each of the tones split into two through the loss of initial voiced/voiceless distinction. Other languages also show similar developments. In Sgaw-Karen, a two-tone system split into four-tone system-high and low-level tones, high and low falling tones. The high tone developed after

voiceless and glottalized plosives and voiceless or aspirated nasals and laterals, whereas the low tones developed after voiced plosives, voiced laterals and voiced nasals. The phenomenon is not as simple as that. According to Henderson (1979), in Bwe Karen the two-way split appears to be a three-way contrast due to the loss of voicing (high, mid and low). According to Haudicourt (1961), in Tung and Mak another level of difficulty is noticed. There is a three way split that occurs following the merger of voiced, aspirated, and glottalized initial consonants. Thus the three tones in Tung become nine. But again similar processes did not result in that sort of complex systems in languages such as Thai or Lao. In most of the cases, the loss of the initial consonant distinction results in the two-way split in the tone system.

As the Asian languages are primarily monosyllabic, they form a lot of compound words. The tonal patterns of these compound words are of considerable interest to tonologists as they demonstrate the interaction between morphology and phonology in these languages. In Asian languages when morphemes are combined into words or phrases one or more of the following might happen:

A. No tonal change to either syllable
B. Limited tonal changes when certain tones are adjacent to each other.
C. Loss or major reduction of tonal contrasts on all non-initial syllables.
D. Loss or major reduction of tonal contrasts on all non-final syllables.
E. Spreading of tones to a toneless syllable.
F. Chain shifting of each tone to another tone in the system, usually on the non final syllable

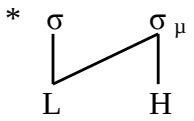
The Tibeto-Burman subfamily of languages is a part of the Sino-Tibetan language family. However, unlike the Asian tone systems, the Tibeto-Burman tone systems are comparatively simpler as far as number of tones and complex phenomenon like tone sandhi is concerned. The following section gives an overview of the features of the Tibeto-Burman tone languages.

Tones in Tibeto-Burman Languages

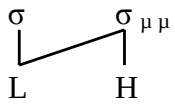
The Tibeto-Burman (TB) subgroup of languages falls within the Sino-Tibetan language family. Lhasa Tibetan, Burmese, Jingpho and Bai are some of the languages which fall within the TB group. However, according to the Linguistic Survey of India (1903), even TB languages can be divided into three categories: Tibetan, Himalayan and Assam-Burmese. The Tibetan languages may or may not be tonal.

Tibetan Languages

Aba Tibetan, for example is a non-tonal language, while Lhasa Tibetan is a tonal language (Yip, 2002). Historically, tones arose in these languages due to the devoicing of the initial voiced obstruents. Deletion or debabuccalization of the final codas also produce contours in these languages. In polysyllabic words the tones of the first syllable is spread to the other syllables. The underlying contour tone is divided into two distinct tones on a longer domain. However if the final syllable is long then the contour tone survives. Hence Example 1-4 is not possible however, Example 1-5 is.



(1-4)



(1-5)

(Yip, 2002)

Jingpho, another Tibeto-Burman language, has a contrastive voice quality co-existing with contrastive tones. It has three tones and each can occur with either tense or lax voiced quality in the onset position. Lax is more breathy and it initially induces a low tone in vowels. Hence in Jingpho we see that pat “stop up” and pat “with a whip” make a minimal pair in terms of voice

quality even though they are assigned the same tone, i.e. 55. Here in this example "_" denotes a tense voiced quality. Historically these breathy voiced words actually started with a voiced consonant.

Compared to Jingpho, Burmese shows a contrastive phenomenon. In Burmese, the tonal and segmental distinctions do not overlap. In other words lexical items are either distinguished in terms of tones or voice quality, but not both at the same time. Apart from a HIGH and a LOW tone, Burmese has a creaky and a constricted glottis type of phonation. Some researchers (Bradley 1982, Watkins 2000) are of the view that Burmese tones are not at all phonological and they want to categorize Burmese as a register language. Their argument for categorizing Burmese as a non tonal language comes from their claim that tones in Burmese are utterly predictable by the vowels and phonation used. On the other hand there is a school of thought that Burmese is a tone language. Green (1994) argues that the H and L tones, creakiness, constricted glottis are all laryngeal features of Burmese and each syllable in Burmese can have one and only one of these features. Though the feature constricted glottis moves to the coda position of a syllable, the other features are always constant in the assigned syllables.

Assam-Burmese

Most of the languages of the North East India are classified in the Assam-Burmese group of languages. Again there are both tonal and non-tonal languages in this sub-group. For example, languages like Missing and Deori are non tonal, whereas languages like Ao, Angami and Bodo are tonal. This area shows interesting tone phenomena as it is an area where the Tibeto-Burman and Indo-Aryan language speaking populations overlap. This effect can be seen from the fact that as one moves from west to east in this area, tonal complexity increases, in terms of number of tones and their assignment pattern. The westernmost language in this area, Bodo has only two tones (Sarmah 2004, Joseph and Burling 2001), whereas one of the languages in the eastern

boundaries of this area, Mizo, has as many as four tones (Lalrindikii 1989, Chhangte 1986, 1993).

Bodo, a language spoken in Assam of the North East India, has two tones, high and low. It also has a default mid tone which is not lexical. Every word is assigned with one and only one lexical tone in this language. The rightmost syllable is assigned with the lexical tone and the rest of the syllables in the word are assigned with a default mid tone. Even in derivations, Bodo tries to maintain the same tonal assignment pattern (Sarmah, 2004).

Garo, another language closely associated with Bodo, does not have any phonological tone. Comparing certain similar lexical items of the two languages reveal that in Garo a glottal stop is usually associated with a high pitch. The high pitch does not otherwise surface in the language. Considering the high pitch association with glottal stops in Garo, Weidert (1987) wanted to associate the high tone in Bodo with the occurrence of a glottal stop. But later research revealed that the surfacing of glottal stops in Bodo is idiosyncratic and cannot be associated with the emergence of any particular tone (Sarmah, 2004).

Ao, another language spoken in this area has three tones. Temsunungsang and Sanyal (2004) argue that the Chungli dialect of Ao has only level tones (High, Low and Mid) and it does not have any contour tones as previously claimed by Gowda (1975). A further claim that Temsunungsang wants to advance (personal correspondence) is that the tonal complexity is higher in Ao (Chungli) verbs than in the nouns; as verbs in this language are minimally bimoraic and the TBU is not a syllable but a mora.

Like Ao, languages like Sema, Angami and Thaadou languages of this area have three tones each (Shreedhar 1976, Ravindran 1974, Thirumalai 1972). However, further detailed tonological studies on these languages are yet to be conducted.

The Manipuri or Meiteilon language of this area shares some features with many other South East Asian languages in terms of the interaction between voice quality and tones. Primary study has revealed that tonal inventory of this language can be classified as rising, falling and level (Chelliah 1997).

Structure of the Study

The chapters of this dissertation are organized in the following manner. Chapter 2 describes the methodology adopted in the dissertation. It also gives an overview of the data collection process and the rationale behind the selection of the language varieties and speakers of Dimasa and Rabha in this study. Chapter 3 reports the findings on the assignment of tones in the monosyllabic entries in Dimasa and Rabha. It also discusses the segmental effects on pitch and possible methodology to minimize such effects in analyzing pitch. Chapter 4 discusses the assignment of tones in disyllables in Dimasa and Rabha. Chapter 5 discusses the tone assignment in the derived polysyllables in Dimasa and Rabha. Chapter 6 provides an optimality theoretical account of the tonal phenomena in Dimasa and Rabha. Finally, Chapter 7 concludes the findings of the current study and discusses the scope for further research in the area.

CHAPTER 2
METHODOLOGY

This chapter describes the methodology of collecting data, digitizing them and acoustically and statistically analyzing them. In the first section of this chapter the methods of data collection are described and the following section describes the methodology adopted in the acoustic analysis of the speech data. The third section describes the statistical methodology adopted and the final section discusses the theoretical framework adopted in this study.

Data Collection

In the current study, data was collected with the aim of capturing the basic tonal inventory of the languages under research. Differences in phonetic pitch will form the basis of classification of different tones in this study. The pitch on the rhyme in a syllable will be regarded as the indicator of tone in the languages under study. In order to avoid phonetic variations arising due to speaker and gender difference, the data will be normalized before conducting analyses on them.

Participants

Before recruiting participants for the production test, I determined the geographical areas from which the participants should come. Areal features and language variations complicate the choice of data collection area and participants. Bhattacharya (1977) and Basumatary (2004) observe that Bodo and Rabha both have distinct varieties and hence, tonal variation in these varieties is not ruled out. Therefore, data is collected from the varieties considered as ‘standard’ by the speakers of the languages in this study. Geographical position of these varieties is also taken into consideration as it is undesirable that the speakers of these languages come into a high degree of contact with other languages of the geographical area. These considerations resulted in collecting data from the areas carefully chosen to avoid any type of impure data (Table 2-1).

After determining the areas and varieties of the two languages, 8 native speakers (4 male and 4 female) from each language area and variety were recruited for the production experiment. The age of the participants was maintained between 18 and 40 years in order to make sure that

Table 2-1. Languages and spoken areas/varieties in this study

Language	Areas/Varieties
Dimasa	The Hasaw variety spoken in the Cachar area. The Cachar area is geographically isolated making them less vulnerable to influences of other languages.
Rabha	The Rangdani variety spoken in the Tilapara area as this variety is considered to be the standard variety of Rabha (Basumatary 2004). Data was collected from the Tilapara as this area is geographically isolated ensuring minimal influence of a second language.

they speak the synchronic variety of the language. Moreover, it also makes sure that the participants do not have any vocal-physiological anomaly arising due to underage or old age. The average age of the participants was 28 years at the time of data collection. Their educational background varied from elementary school to undergraduate degree. None of them reported any history of problems in hearing or listening impairment. Each session of data collection lasted from 30 to 60 minutes and the participants were compensated with 200 Indian Rupees (approximately $4).

Materials

This study required that the participants read a list of segmentally homophonic words of their respective languages, with the meanings written along the words. The participants were asked to produce the words with appropriate tones in order to pronounce the semantic differences among the group of segmentally homophonous words clearly. The participants were required to produce the words within a sentence frame where the target word was situated in the sentence medial position. This ensured that the intonational interference on the target words was uniform and hence predictable. Moreover, using the same sentence frame also ensured that the target

word was not influenced by differing segmental properties of the preceding and the following words. The participants were asked to repeat each word four times. However, only the first three iterations were admitted for analysis. This was done to avoid the possibility of the appearance of listing intonations in the F0 of the target words.

In most cases the participants had enough reading ability to read the list of the words given to them. However, in some cases the experimenter had to prompt them with the meaning of the word and provide cues leading to the production of the target lexical items and tones.

The lists of words were constructed with the aim of capturing the tonal inventories of the languages and the morpho-tonology of the languages. The word lists consisted of both CV and CVC type of syllables.[8] As many types of initial consonants as possible were included so that consonantal effects on pitch can be determined from the collected data. For morpho-tonological analysis a set of data for each language was constructed having various suffixes so that tone assignment on suffixes in their phonetic forms can be determined.

The lists were constructed using previous literature and substantial inputs from the native speakers of the languages in this study. For Dimasa, a Dimasa speaker initially identified various segmentally homophonous words with three different tones and produced them for the investigator. A word list was constructed using the words provided by the native speaker with supposed tonal contrasts. Later, the speaker provided the investigator with a copy of the Anglo-Dimasa dictionary (Dundas 1908) which was used to identify more segmentally homophonous words which are potential distinct tone carriers to be added to the word list. For Rabha an initial set of data was constructed using Basumatary (2005), which has a large vocabulary of both Bodo and Rabha with the tones marked on the words. Later, during the field trip to the Rabha speaking

8 According to Singha (2004), Dimasa allows VC, CV, CVC, CVV, CVC, CVV, CCV, CCVV, CVVC and CCVC syllable types in monosyllables.

villages, a native speaker confirmed the tonal contrasts on the list of words created by the investigator. Additionally, the native speaker also provided four sets of segmentally homophonous words that differed in terms of pitch from each other.

Recording

All the recordings in this study were conducted in the field in the quietest possible environments. Data was recorded on a Marantz PMD660 solid state recorder. Audio signals were captured using an Audio-Technica AT4041 hand-held microphone. The microphone was held about 25mm away from the participants' mouth. The experimenter listened to the speech being recorded, in real time, so that optimal audio quality could be assured. Special care was taken to avoid direct turbulent airflow to the microphone.

The Marantz PMD660 recorder stored audio data to a compact flash card with a 48 KHz sampling frequency (equal to a DAT recorder). After each session, participants' data was transferred from the compact flash card to a portable PC using a USB cable.

Data Analysis

Segmentation of Speech

Both wide band spectrograms and waveform displays were used to segment the recorded speech in this study. Initially, each iteration of the target word was separated and saved as an individual sound file. Afterwards, each individual sound file was segmented with the intention of isolating the tone bearing units from the rest of the speech signal.

This was done by visually locating the point of initiation (P*i*) and the point of termination (P*t*) of the fundamental frequency or the pitch of the syllables in the target words. The time indices of P*t* and P*d* were written on a corresponding PRAAT Textgrid file. This file makes

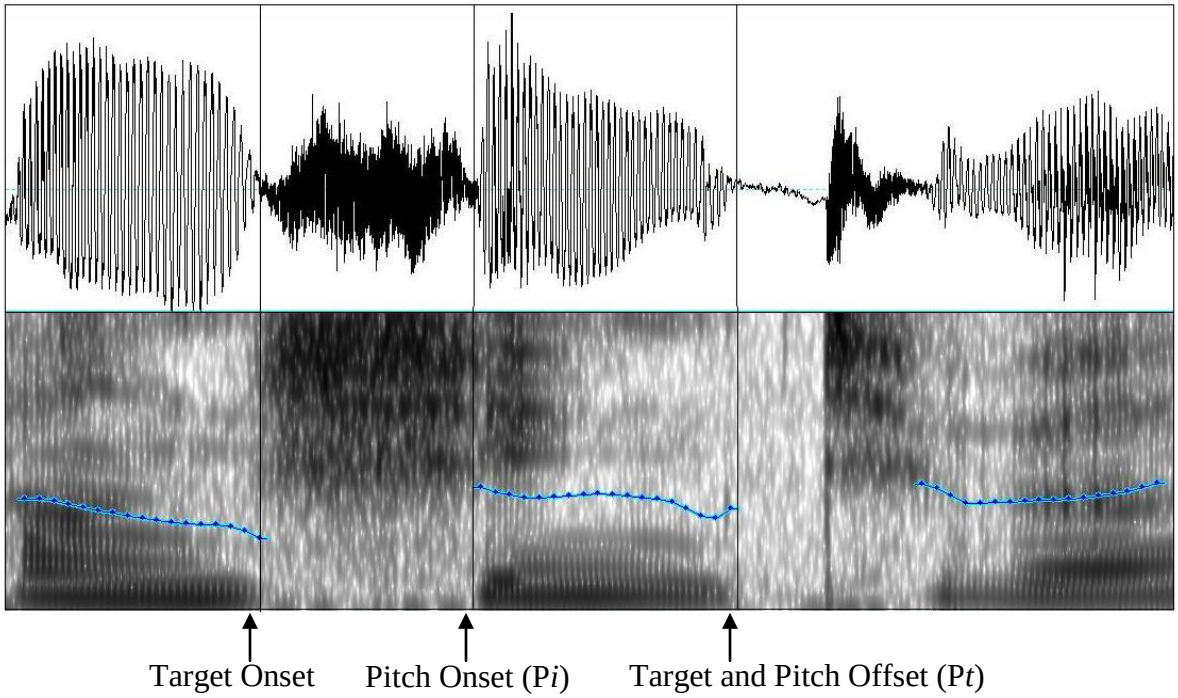


Figure 2-1. An example of segmentation of speech signals

it easier to extract an array of information from the sound files (viz. duration, intensity, F0 etc) in the course of analysis (Figure 2-1).

Acoustic Analyses

PRAAT 5.0.26 (Boersma and Weenink, 2007) was used to conduct both manual and automatic acoustic analysis on the speech data. All the measurements were obtained using various scripts written by the author for PRAAT.

Extracting non-normalized pitch values

Initially, in the time domain from P*i* to P*t*, the total duration (P*d*) of the pitch signal was extracted using a script. Subsequently, the pitch contour was extracted with a pitch floor of 75 Hz and pitch ceiling of 600 Hz with a default time step of 100 milliseconds. The extracted pitch contour was subjected to further analyses as described in the following paragraph. Average intensity (INT) of the time domain from P*i* to P*t* was extracted with minimum pitch being 100 Hz and time step of 100ms.

Using the same script, pitch was extracted from the pitch contour at every 2% (P*n*) of P*d* or the total duration of the target (Figure 2-2). Also, using a 100 ms time step, average pitch (F0) of the pitch contour was also calculated. The values of duration, average pitch, average intensity, pitch on every 2% etc. were written to a spreadsheet by the script. However, it was noticed in Sarmah and Wiltshire (in press) that consonantal effects are prominent in Dimasa into 20% from the onset of the pitch contour.[9] Similarly, the final 20% of a pitch contour also showed significant influence of the following consonant. Hence, in order to avoid consonantal influences, the initial 20% and the final 20% of the pitch contour were not considered for further statistical analysis.

The P*n* values were plotted as a line graph to observe the direction of the pitch contours so that they can be categorized into separate tonal categories such as level (high, mid or low) or contour (rising and falling).

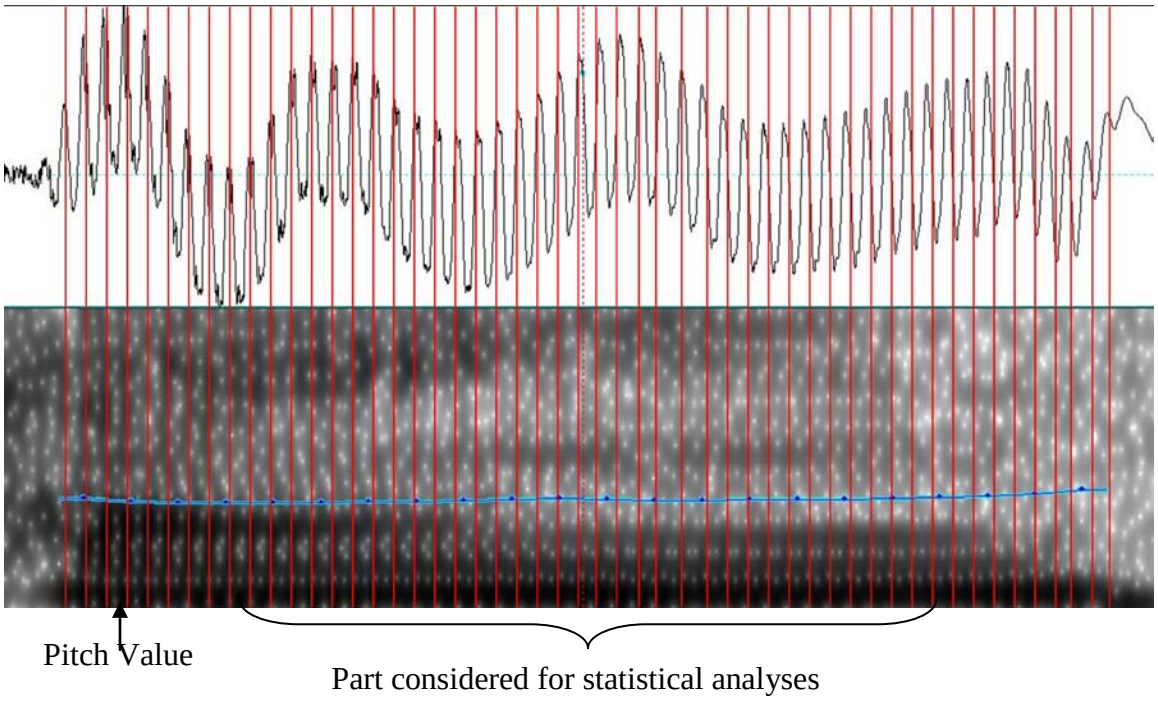


Figure 2-2. Extraction of pitch points (P*n*) at every 2% of the total duration

[9] Please see Section 3.1.2 for discussion on this.

Extracting normalized pitch values

The extracted non-normalized data showed a large significant difference of fundamental frequency among the male and female speakers, especially in case of the Rabha language. On average the Rabha male speakers' average fundamental frequency was almost 150 Hz lower than the female speakers. Hence, to avoid between-speaker differences, the z-score normalization (Disner 1980, Rose 1987, Rose 1991, Ishihara 1999 etc.) procedure was adopted. Rose (1991) reports this method to be superior in normalizing fundamental frequency.

The z-score procedure adopted in this study is NP*n*= (F0i-x)/SD, where NP*n* is the normalized z-score of a sampling point, F0i is the sampling point, x is the average F0 of all sampling points and SD is the standard deviation of the average of all the sampling points. As the PRAAT program can automatically calculate the standard deviation (SD) and the average F0 of the sampling points, a PRAAT script was written in a way so that it can automatically obtain the z-score values (NP*n*) and collate them to a spreadsheet.

Statistical Analysis

A descriptive statistical analysis of F0*d* was conducted for this study using ANOVA and Bonferroni tests. F0*d* is the difference between the 39th point (78%) and the 11th point (22%)[10] of an extracted pitch track that indicates the direction of the pitch contour. As both Dimasa and Rabha have contour tones, it would not have been suitable to compare the average values of pitch contours. In other words, considering a case where one of the languages has both a rising and a falling tone, both falling or rising in the same degree, the average value of the pitch would not show any significant differences, even though in terms of direction of fall and rise there are two different tones. Hence, to address this issue, it was decided that not the average F0 but the

[10] As mentioned in the previous section the initial 20% and the final 20% of the pitch track were not included for analysis due to possible consonantal perturbation.

F0*d* of each of the iterations will be compared. The ANOVA test was conducted to see if there were any significant differences between the acoustically visible tone groups. Similarly, a Bonferroni post-hoc test was conducted to see if the tone groups are significantly different from each other in terms of their F0*d* values.

Theoretical Framework

In providing a theoretical analysis of the languages in this study, an Optimality Theory (OT) framework is applied (Prince and Smolensky 1993, McCarthy and Prince 1993). It has been noticed that some morpho-phonological phenomena in tone languages can be better explained with the help of OT (McCarthy and Prince 1994, Yip 2002). Economy and simplicity are two main reasons for using OT for theoretical analysis of the languages. It is expected that both Rabha and Dimasa tonal phenomena can be explained by the same set of tonal constraints varying only in their ranking. Further, this analysis may be extended to other languages of the Bodo-Garo subfamily to capture the tonal correspondence among them.

CHAPTER 3
TONES IN MONOSYLLABLES

This chapter describes the tones and tone assignment in monosyllables of the Dimasa and Rabha languages. Even though there has been considerable interest in the languages of the Bodo-Garo subfamily, not much is available on tones of these two languages except Joseph and Burling (2001), Joseph and Burling (2007), Singha (2001), Basumatary (2004) and Sarmah and Wiltshire (in press). Apart from Sarmah and Wiltshire (in press) for Dimasa, there is no instrumental study of these two languages available. Hence, in this chapter our goal is to determine the tonal inventories of the two languages and provide a description of tone assignment in monosyllables with the help of instrumental acoustic data. It is argued in this chapter that both Dimasa and Rabha demonstrate three way phonological tonal distinctions. In both languages a rising, falling and mid-level tones appear to be the three phonological tones. In the latter parts of this chapter the claims are supported by statistical analyses on the acoustic data to demonstrate that in the two languages change over a pitch contour is the primary cue for discriminating tones. Hence, direction of pitch is more important than average pitch in categorizing tones.

Dimasa Monosyllables

The earliest known grammatical work on Dimasa (Dundas 1908) does not comment on tones and tonal phenomena at all. Singha (2001) sheds some light on Dimasa phonology and morphology and, regarding its tones, he claims that there are three register tones:[11] high, low, and mid/level, with the mid/level tone an 'unmarked' tone. From the 13 examples of words with contrasting tones that Singha (2001) provides, it is noticed that every Dimasa syllable must be assigned one of the three tones. In Singha (2001) this also holds true for disyllables. However,

[11] The term 'register' is used by Singha (2003) to refer to level tones.

according to online resources on Dimasa, available at RCILTS, IIT Guwahati,[12] Dimasa has only two tones: high and unmarked level. Neither Singha nor the RCILTS website provides any further description of how the unmarked tone operates, nor do they offer an acoustic phonetic description of any of the tones. As mentioned before, the first goal is determine the number of tones, describe their phonetic realization in Dimasa, and test the analyses by conducting statistical analyses on the acoustic data.

Data Collection

For Dimasa, eight Dimasa speakers, 4 male and 4 female, were recorded reading a list (see Appendix A) of target words in a sentence frame. All the speakers were between 20 and 25 years old at the time of data collection and spoke Dimasa as their first language. In addition to Dimasa, the participants also speak Assamese, Hindi and English. Among the four varieties of Dimasa namely Demra, Dijua, Hasaw and Hawar**,** all speakers spoke the Hasaw variety spoken primarily in the North Cachar hills area, in and around Haflong (see Figure 3-1).

Figure 3-1. Map of Assam showing the areas of origin of the speakers in this study as

[12] This information is retrieved from http://www.iitg.ernet.in/rcilts/dimasa.htm on March 20th, 2008; however, RCILTS does not confirm the source of this piece of information.

The target words were a list of segmentally homophonous words, constructed using data from a native speaker of Dimasa. The wordlist was re-examined using Dundas (1908) where the words appeared sans their tonal specifications. Their order in the list was randomized, and they were produced in a sentence frame, as in Example 3-1.[13]

ang^{R}	*X*	*thi*^{F}*-ba*^{F}	(3-1)
I	target	say-PST.1	
'I said X'			

A sentence frame is required in near-natural production of target words. If the speakers are to produce the target words in a bare word list, there is a possibility that the target words induce effects on the pitch contour due to listing intonation, initiation and termination of word production. The rationale behind choosing the sentence frame in Example 3-1 is two-fold. Firstly, the final syllable of the pre-target part of the sentence frame is a sonorant and it is unlikely that it affects the pitch of the following target word. The post-target part of the sentence frame begins with a stop consonant. The stopped part of the consonant makes segmentation easy and reduces the possibility of any anticipatory affect on the pitch of the preceding target word. Secondly, the sentence frame is very colloquial as far as its usage is concerned and hence, it is expected that the speakers will not find the sentence frame unnatural and thus affecting the natural production of the target word. Each sentence was repeated four times by the speakers, but only the first three iterations were included in the analysis to avoid a listing effect, which might affect the intonation and thus the pitch.

Acoustic Analysis

The set of target words read by the speakers included segmentally homophonous pairs, some of which are listed in Example 3-2 without any tone markings (see Appendix A). The first task was

[13] The superscripted R and F denote a rising and a falling tone respectively on the preceding and the following syllables.

to determine which of these words were distinguished by distinct tones:

zao	'to puncture'	zao	'to row'	zao	'to winnow'	(3-2)
khu	'to serve'	khu	'to dig'	khu	'face'	
t^hu	'deep'	t^hu	'sleep'	t^hu	'spit'	

Pitch was calculated at 50 points across the duration of each TBU (every 2%) for each speaker. The values were averaged across the three iterations of each speaker individually. Data from all the speakers were averaged. The averaged values were plotted on a graph using a spreadsheet to reconstruct the pitch track. The plotted pitch tracks revealed that for some pairs or triplets, the pitch tracks were identical, indicating that they are likely pronounced with the same tone. However, several pairs or triplets showed distinct pitch tracks, revealing a potential three way contrast in Dimasa tones. The /zao/ and / t^hu/ (Figure 3-2 and Figure 3-3) sets of syllables were identified as potential carrier of three distinct tones in Dimasa.

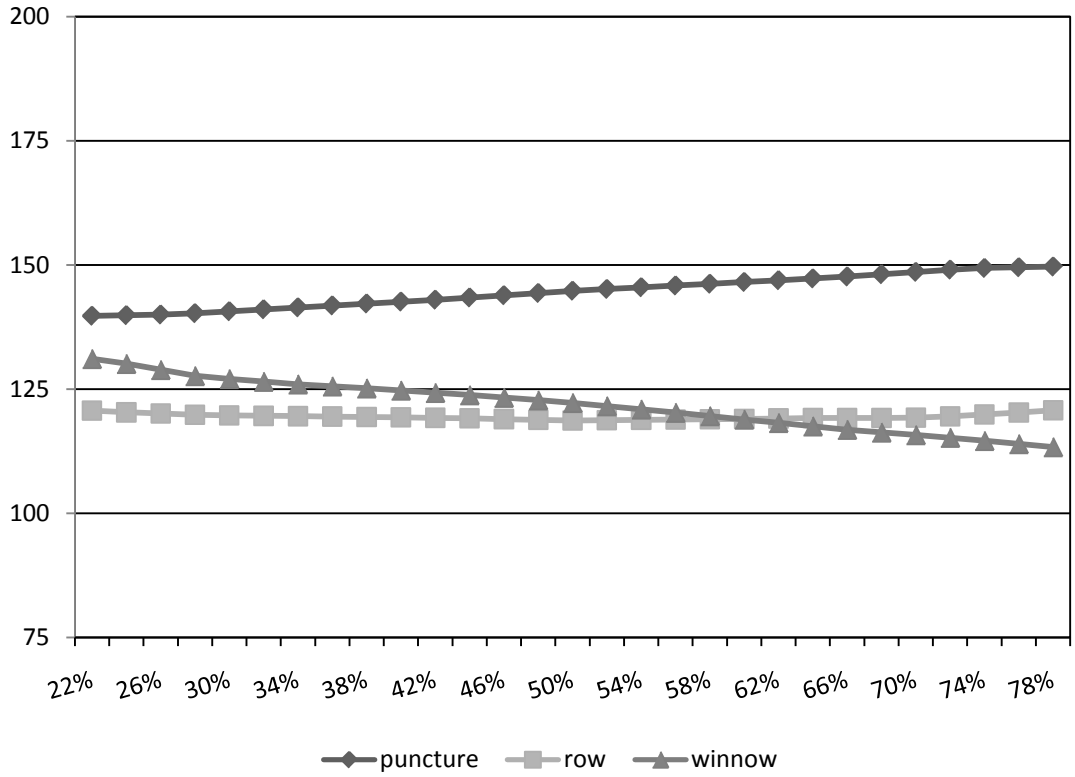


Figure 3-2. Pitch track for /zao/ by speaker PJ

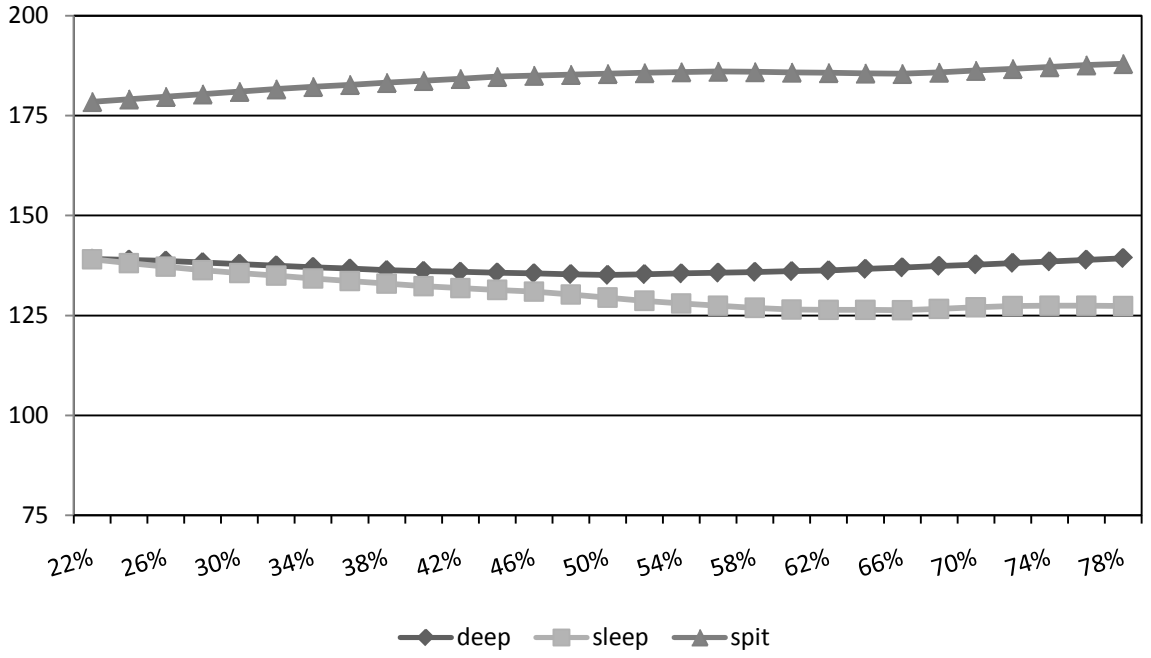


Figure 3-3. Pitch track for /t^hu/ of speaker PJ

There are three distinct pitch levels observed on the plotted graph of F0 in terms of the direction of the pitch tracks in Dimasa (Figures 3-2 and 3-3). However, in Dimasa a segmentally homophonous word pair, despite of having three-way semantic distinction does not necessarily imply that it would also have three distinct tones. Results from this production test shows that some segmentally homophonous triplets are realized with three distinct pitch contours, whereas some triplets are not.

For example, the /k^hu/ set of words have three way semantic distinctions, whereas two of the meanings can be mapped to a single tone group (Figure 3-4). Hence, the lexical items for *face* and *serve* in Dimasa are not only segmentally homophonous, but also homophonous in terms of their underlying tonal representations.

The set of /bai/ words in Dimasa further supported the claims about the three tonal distinctions in Dimasa. The segmentally homophonic /bai/ words have six distinct meanings.Their pitch tracks were plotted on a graph that showed three distinct patterns of tones pitches (Figure 3-5).

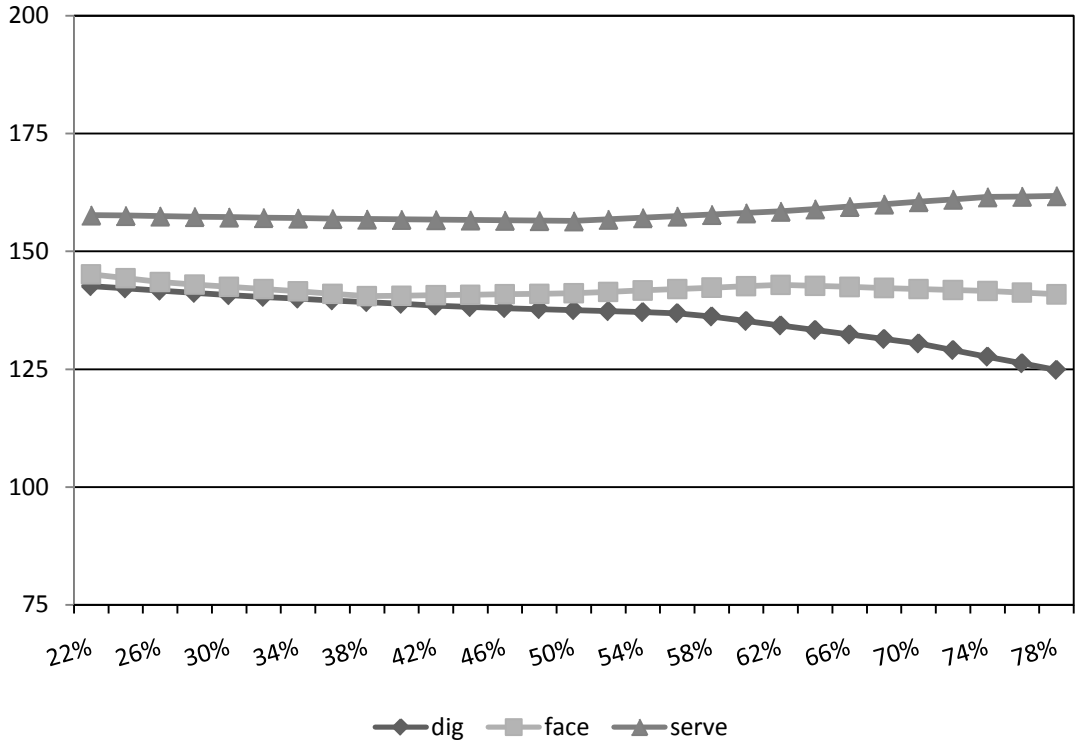


Figure 3-4. Pitch track for /k^{h}u/ of speaker PJ

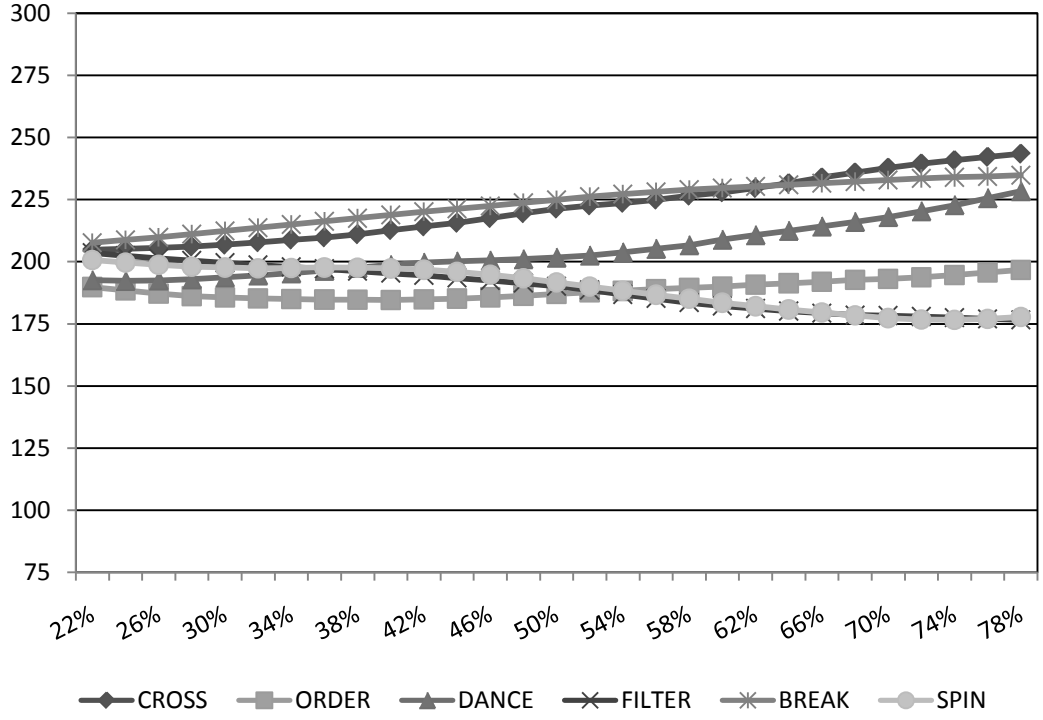


Figure 3-5. Pitch tracks for /bai/ produced by speaker BB

Acoustic analyses reveal that the words for *cross*, *dance* and *break* clearly show a rising pitch (Figure 3-5). On the other hand the word for *order* follows a level pitch contour. However, the words for *filter* and *spin* show a falling pitch contour.

The 53 monosyllables of Dimasa were categorized into three tonal categories namely rising, mid and falling, after visually examining their pitch contours. The normalized pitch contours of each tonal category were averaged and plotted on a graph (Figure 3-6). However, it is noticed in the sections to follow that syllables with the onsets /ʃ/ and /t^h/ have their effect throughout the pitch contour resulting in an allotone for the rising tone in Dimasa that phonetically surface as a tone with a high level contour (Figure 3-6). The allotone of the rising tone is shown as R (ʃ, t^h).

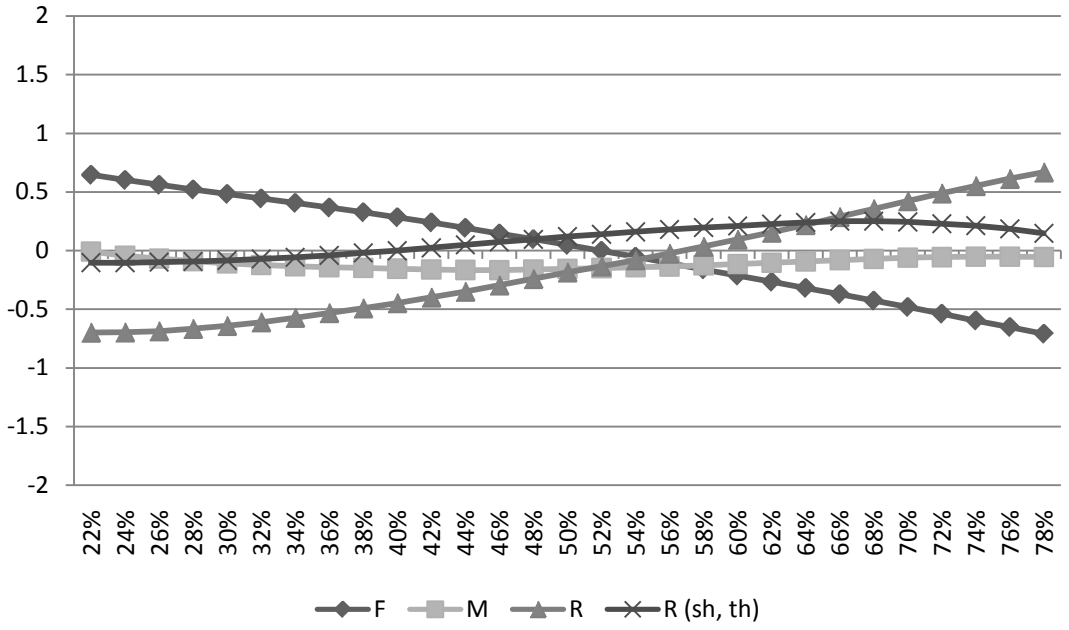


Figure 3-6. Normalized average rising, mid, and falling tones in Dimasa

Ignoring the first 20% of the TBU, the rising tone in Dimasa shows a rising contour, the falling tone shows a falling contour while the mid-tone stays relatively level. Thus speakers of Dimasa have a set of three lexical tones that are distinct in terms of contour.

Effect of Onset and Coda on Pitch

Onset consonant effects on F0 are well attested in the literature (Hombert *et al* 1979, Xu 2001, 2003). In this study the consonantal effect of the onsets on the following pitch contour is also investigated. The primary aim here is to see how far into the duration of a following pitch contour do the consonantal effects permeate. In order to do that, we conducted a visual examination of the F0 contours following various types of consonants in Dimasa. It was confirmed by visual examination that the effects are primarily seen within the first 20% of the pitch contour. Therefore, pitch contours of the mid-level tone in Dimasa in various onset contexts were collected. The pitch contour was divided into five parts from the point of initiation of the F0 till the point of termination. Average F0 of each part of the pitch contour was statistically compared with the following part to see if they differed from each other significantly. Hence, the average F0 of the group 0%-20% was compared with the average F0 of the following group of 22%-40% and so on. The methodology used here followed the one described in Coupe (2003).

An ANOVA was conducted on the data and was supplemented by a Bonferroni post-hoc test. The one-way ANOVA test showed that the average pitch of the five groups interacted significantly [F (4, 2200) = 4.16, $p < 0.05$] and subsequent Bonferroni *post-hoc* tests confirmed that only the first 20% of the pitch contour of a mid-level tone differs significantly from the second 20% of the pitch contour ($p < 0.005$) (Appendix D, Table D-3, Table D-4). However, the other groups of the pitch contours did not show any statistical significance in terms of their average pitch. Hence, it can be concluded that this significant difference between the 0-20% group and 22-40% group occurs due to the consonantal affects perturbed into the F0.

A subsequent univariate ANOVA test confirmed that the voiced and voiceless consonants vary significantly in terms of their effect on the F0. Similarly sonorants, obstruents and fricatives

also have different effects on the F0. The results of this ANOVA univariate test are summarized (Table 3-1).

Table 3-1. Effects of different consonant types on F0

	Mean Difference	Significance
Voiceless- Voiced	37	0.000
Fricatives-Laterals	39	0.000
Fricatives-Stops	-6	0.06
Stops-Laterals	45	0.000

It is demonstrated that a voiceless consonant induces higher pitch into the F0 than the voiced consonant. Similarly both fricatives and stops induce significantly higher pitch into the F0 than the laterals. Even though stops induce slightly higher pitch than the fricatives, this difference is not statistically significant.

From the discussion above it can be safely concluded that throughout the initial 20% of the F0, effects of the onset consonants are significant enough and therefore that the initial 20% may not be relevant while trying to arrive at the phonological representation of a tone. Sarmah and Wiltshire (2006) came to similar conclusions about Mizo, regarding onset effects on the F0. Hence, in the current study, the initial 20% of the pitch contour will be ignored for statistical tests.

Statistical Analyses

The first goal of the statistical analyses is to see if the difference between the three tonal categories suggested by the visual inspection of spectrographs are significantly different or not. In order to confirm such interactions a one way ANOVA is usually preferred. However, as two of the three Dimasa tones have a falling and rising contours, ANOVA tests that compare the average pitch values may not be fully reliable. Even though a rising tone and a falling tone differ significantly in terms of the direction of the contour, it is possible that the average pitches of the two slopes are very similar. Hence, in this study the difference (F0d) between the 39th point

(78%) and the 11th point (22%) was calculated for each token, so that the directional characteristics of the contour tones are captured. The F0d is expected to be of positive value in case of a rising tone, negative for a falling tone and near zero for a register tone. As expected, mean F0d values are correspond to the tonal categories in Dimasa where the rising tone has an F0d value in positive numbers, the falling tone has an F0d value in negative numbers and the mid tone has an F0d value that is near 0 (Table3-2).

Table 3-2. Mean F0d for each tonal category

Group	Mean F0d
Rising	16.77
Mid-level	-1.38
Falling	-20.68

Further, a one way ANOVA with a Bonferroni post-hoc test was conducted to see if the F0d values differed significantly according to the tonal categories. The ANOVA test confirmed that the three tone types are significantly different from one another [F (2, 1070) = 701.98, p <0.05]. A subsequent Bonferroni *post-hoc* test confirmed that all the three tone groups are significantly different from each other in terms of their F0d values (Bonferroni adjusted p <0.017). The results of the ANOVA test are presented in Table D-5 and the results of the Bonferroni test are presented in Table D-6 of Appendix D.

The results of an ANOVA test where F0d is the dependent variable and tone type is the independent variable demonstrate that the Dimasa tone types are significantly different from each other. Hence, it can be concluded that the three tones in Dimasa the rising, the mid-level and the falling tones do not interact with each other.

This lack of interaction between tone types and corresponding F0d is also evident in case of individual speakers. The results of the statistical tests conducted on individual speakers where tone types is the factor and F0d is the dependent variable, are reported in Appendix C of this

dissertation. The results in Appendix C shows that each individual Dimasa speaker produces three distinct categories of tones and each category is significantly different from the other.

Normalization of Data

In order to avoid differences between individual pitch ranges of speakers and further to avoid differences among the tokens produced by each speaker, each pitch track derived from each speaker was normalized. The pitch tracks were normalized by means of their z-scores (see Chapter 2). After normalizing the data, the derived values were plotted on a graph to demonstrate the tonal categories each word belongs to sans speaker effects, listing effects and consonantal effects.

The normalized pitch tracks for /ri/ and /lai/ syllables demonstrate two of the three tone types in Dimasa[14] namely, the rising and the falling tones (Figure 3-7 and 3-8). The /ri/ and /lai/ for 'cloth' and 'page' respectively, have rising pitch contours and the /ri/ and /lai/ for 'give' and 'easy' respectively, have falling pitch contours (Figure 3-7 and 3-8).

However, for the /t^hu/ and /ʃu/ set of syllables the rising tones in the words for /t^hu/ as in 'spit' and for /ʃu/ as in 'beat' occur as a high level tone (Figures 3-9 and 3-10). Similar representations of the rising tone are noticed in all the syllables that have /ʃ/ and /t^h/ as onsets.

Hence, we conclude that the higher resonance frequency of the /ʃ/ and /t^h/ type of onsets embody their high frequencies on the following pitch track, resulting in a high level pitch contour for the rising tones. The rising tone with a high, level pitch contour is hence regarded as an allophonic variant of the rising tone in Dimasa, a variation that has been phonologized in the language. Therefore, it is also imperative that syllables which have /ʃ/ and /t^h/ as onsets be

[14] These two types of onsets were chosen as they are known not to affect the pitch of the following TBU.

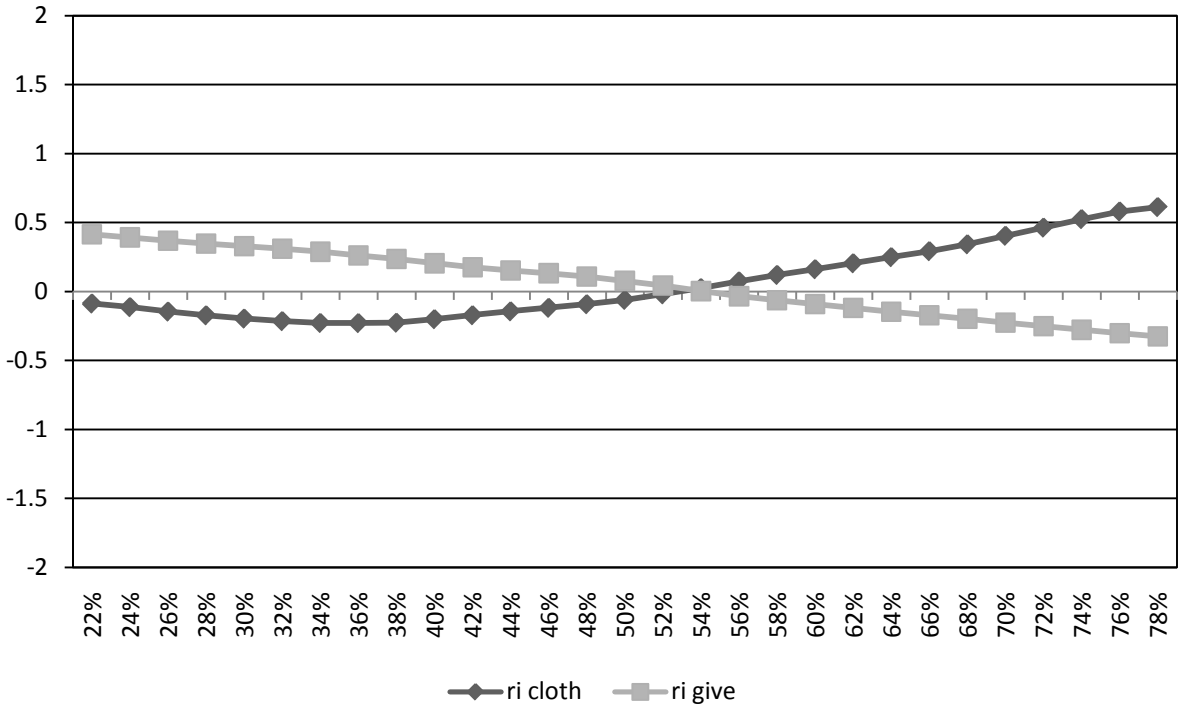


Figure 3-7. Normalized pitch track for /ri/

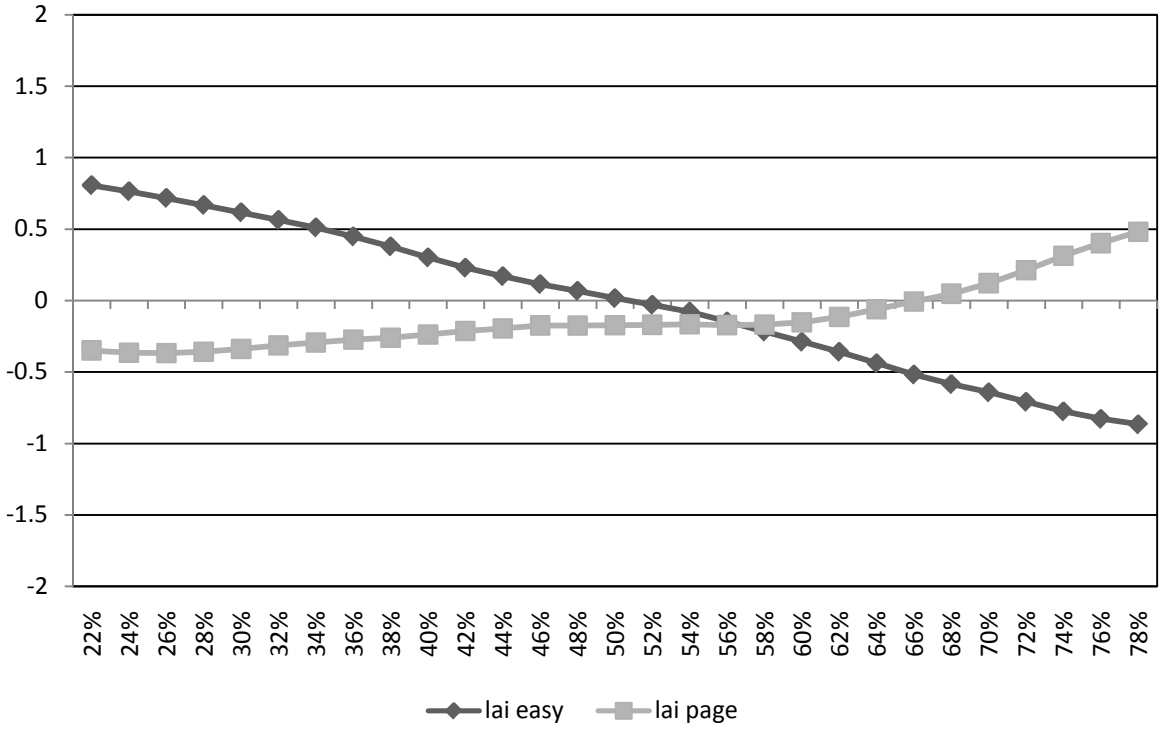


Figure 3-8. Normalized pitch track for /lai/

analyzed separately from the rest of the data for a more accurate representation of the tones in Dimasa syllables. The normalized pitch tracks for the three Dimasa tones (Figures 3-11) are represented with an additional pitch track. As syllables with /ʃ/ and /t^h/ onsets render distinct pitch tracks for the rising tone, their pitch tracks are shown separately. Nevertheless, the tone with the high level pitch contour should be treated as an allophonic variant of the rising tone in Dimasa that is conditioned by onset conditions containing /ʃ/ and/t^h/. It is well attested in the literature that voicesless and sonorant onsets may raise the pitch of the following TBU. In case of Dimasa that is exactly what is happening. The inherent property of the aspirated voiceless consonants to raise the pitch has resulted in an already raised F0 onset for the rising tones in Dimasa. It should also born in mind that in this analysis the initial 20% of the signal is ignored and not considered for analysis..

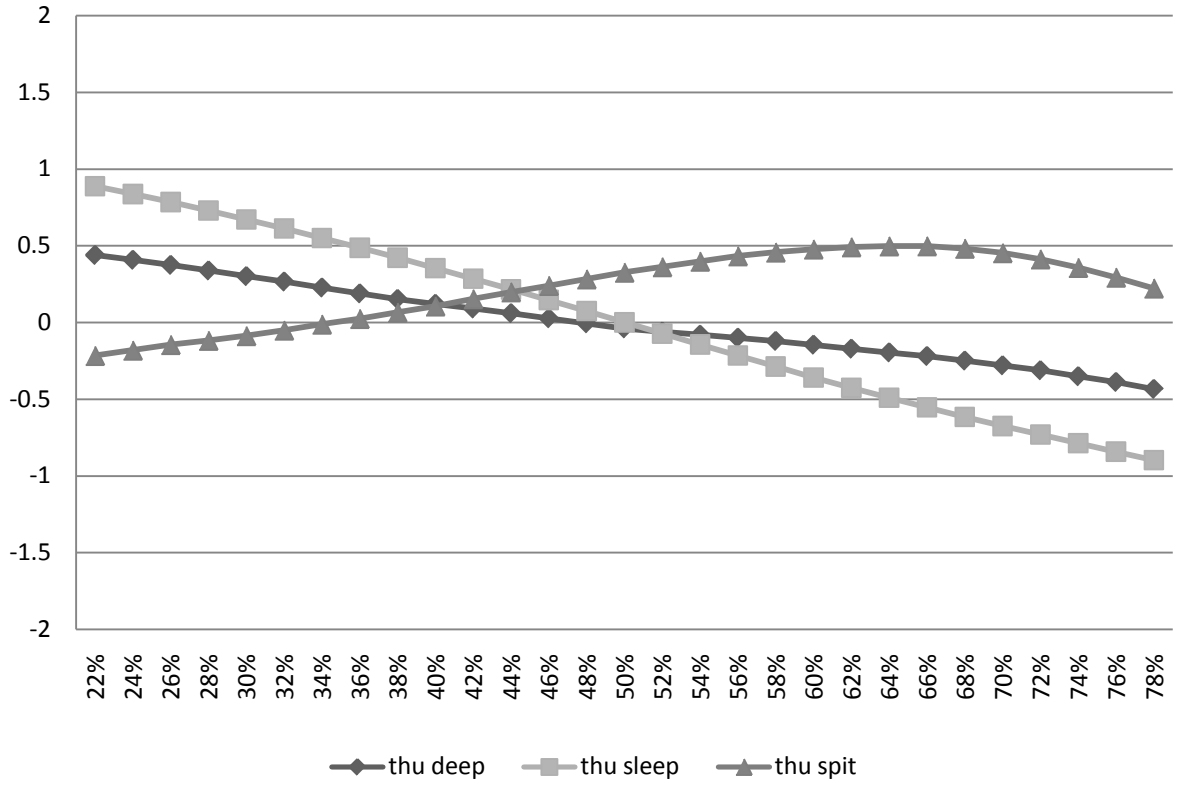


Figure 3-9. Normalized pitch track of the /t^hu/ syllable for all speakers

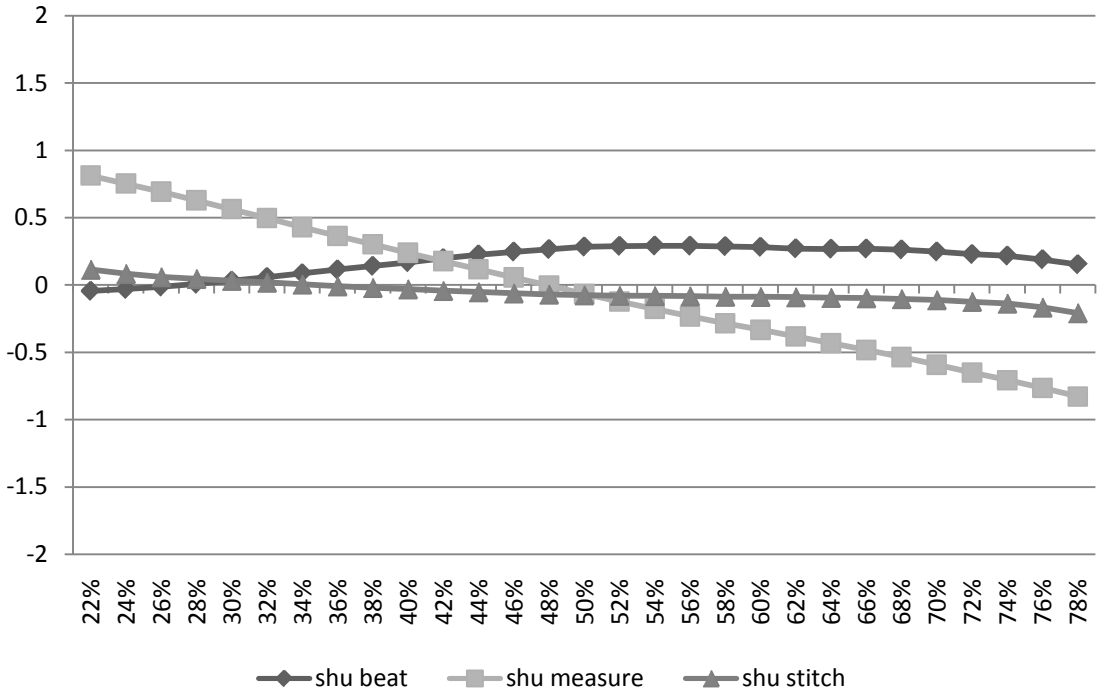


Figure 3-10. Normalized pitch track of /ʃu/ syllables for all speakers

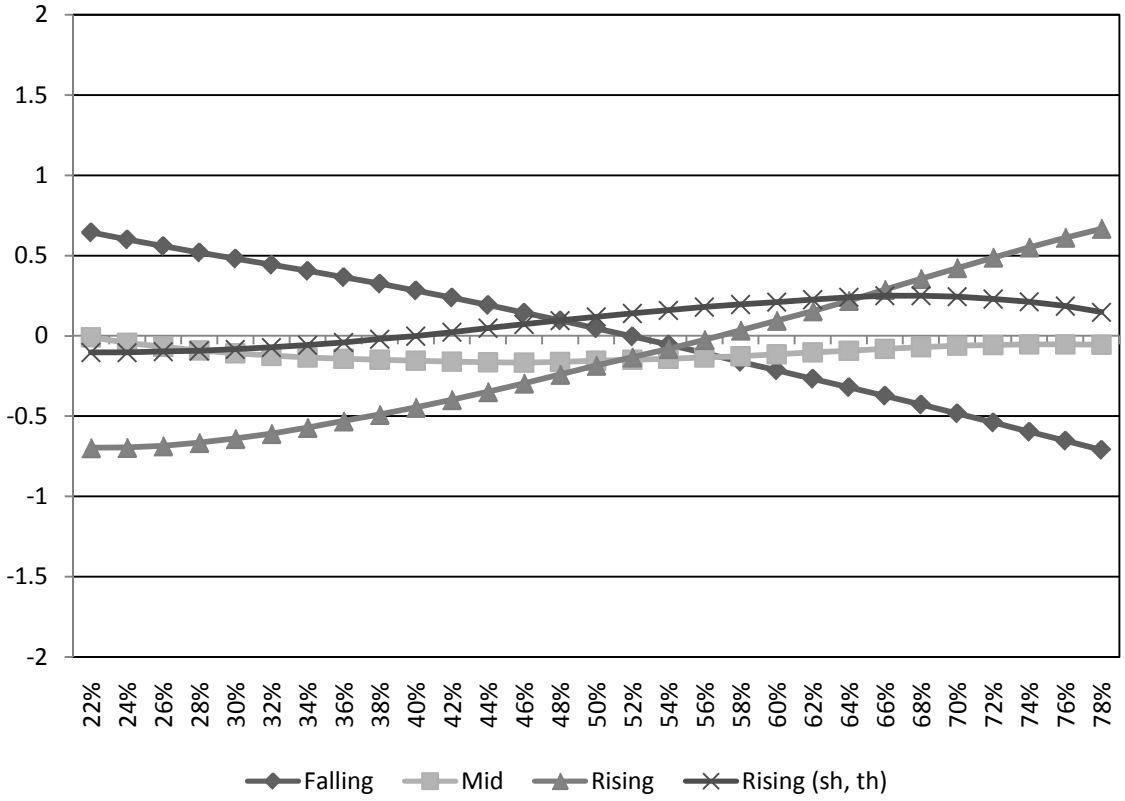


Figure 3-11. Average normalized values of the three tones in Dimasa

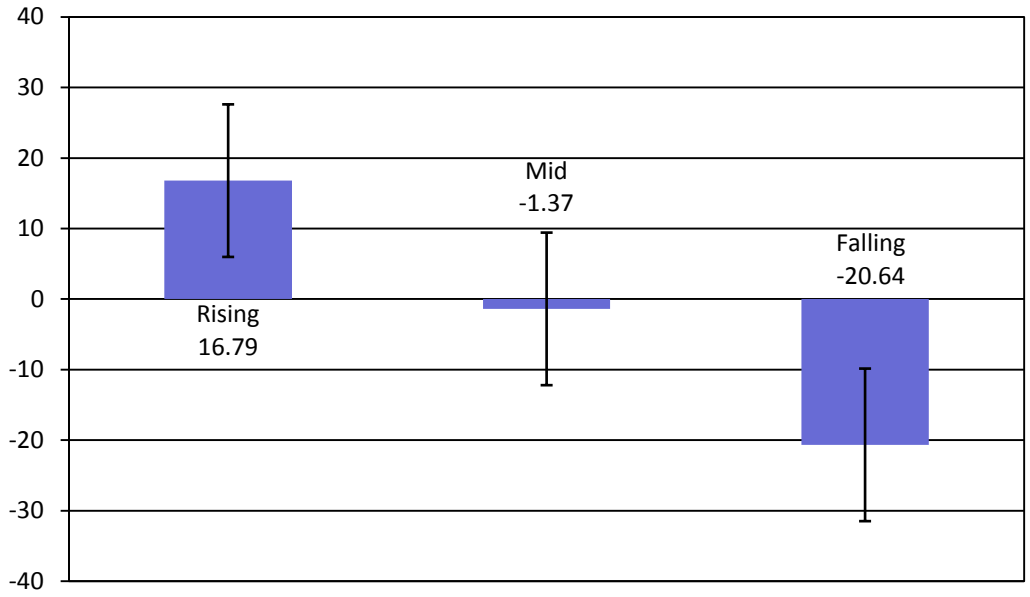


Figure 3-12. Means of F0d for non-normalized pitch tracks with standard error bars

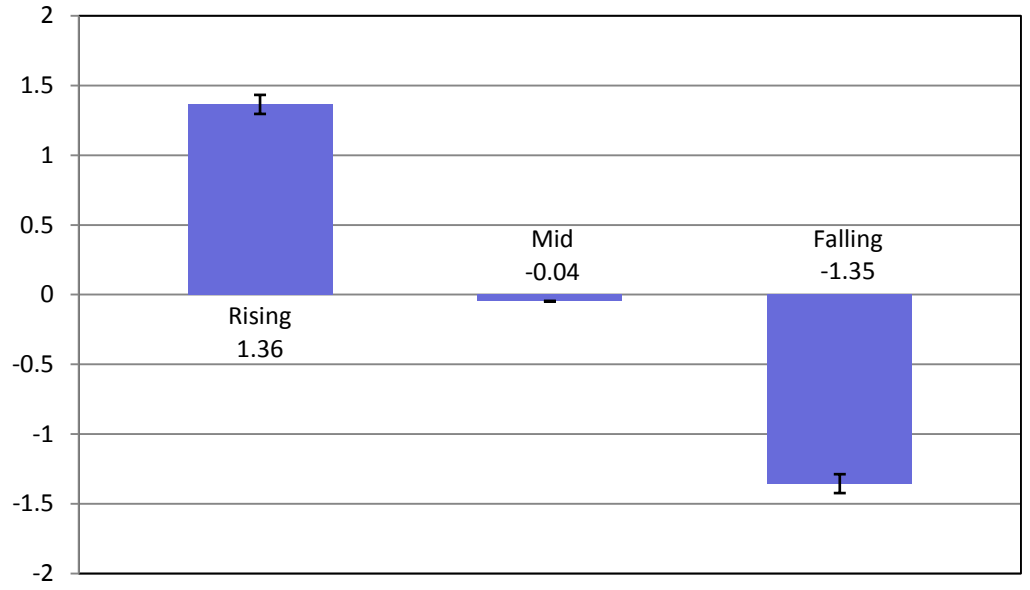


Figure 3-13. Means of F0d for normalized pitch tracks with standard error bars

The average normalized F0d values for different tones were further tested for statistical significance by conducting an ANOVA and a Bonferroni *post-hoc* test. An ANOVA test was conducted where F0d was the dependent variable and tone types were factors. The ANOVA test showed significance among all the tone groups compared where [F (2, 1070) = 328.74, $p < 0.05$].

Further, a Bonferroni *post-hoc* test was conducted on the same set of data with an adjusted $\alpha = 0.017$. Tone type wise comparisons of F0d demonstrated that all the three tone types were significantly different (Bonferroni adjusted $p < 0.017$) from each other in terms of their average F0d (see Table D-7 and D-8, Appendix D).

Perception Test

As a part of this study, a pilot study was conducted to confirm if Dimasa speakers perceive the differences between the three tones in Dimasa or not. However, this study has some serious limitations. Firstly, the conditions in which the perception tests were conducted were not ideal perceptual study settings and secondly, a very small number of participants participated in the perception test making the results underprovided for statistical analyses.

In the aforementioned perception test two female Dimasa speakers participated. Using a laptop computer and a pair of headphones, they listened to real speech data of Dimasa in the consistent sentence frame mentioned before. They were asked to choose one of the three options on the laptop screen that best represents the meaning of the target word that the participant heard. On the laptop screen, the real meaning of the word appeared along with a meaning of the target word, if spoken in a contrastive tone. Each word was repeated randomly on four different occasions.

Among the data presented to the participants were the /t^hi/ and /t^hu/ sets of syllables. The results of the perception test collected from two Dimasa speakers (Figure D-1, Appendix D). The results demonstrate that both the participants could correctly categorize all the iterations of the /t^hi/ set of syllables (Figure D-1). However, one participant wrongly identified one of the repetitions of the /t^hu/ sets of syllables, resulting in overall two occasions of inaccurate identification. Nevertheless, this small perception test further strengthens the argument that there are three lexical tones in Dimasa and they are perceived categorically by its native speakers.

Rabha Monosyllables

Rabha is one of the lesser studied languages among the Tibeto-Burman languages of the North-East India. Until recently, Rabha was considered to be merely a dialect of Bodo owing to its lexical similarity with the Bodo language. However, recently there has been some interest in the language demonstrating that despite its being related to the Bodo language, it is not merely a dialect of Bodo. Basumatary (2004) compared the Bodo and Rabha languages where tonal similarities among the two languages were also taken into consideration.

According to Basumatary (2004), Rabha has two underlying tones- high and unmarked low tones. He however, does not explain why the low tone is considered unmarked in the language. On the other hand, personal communication with many Rabha scholars indicated that Rabha has one more tone leading to a three way contrast among tones in the language. In the following sections using acoustical analyses it is shown that Rabha, like Dimasa, has three lexical tones, and the claims are further supported using statistical analyses.

Data Collection

A set of 54 monosyllables read from a word list (see Appendix B) were recorded from eight Rabha speakers (4 male and 4 female) who belong to the 25-40 age group. All eight speakers were from the Tilapara village of Goalpara district in Assam, and they spoke the Rangdani variety of Rabha, which is considered to be the standard variety. Five speakers were monolingual in Rabha, and while eliciting data from those speakers, a bilingual speaker speaking Assamese and Rabha facilitated the conversations between the speakers and the researcher. Three speakers spoke Assamese apart from speaking Rabha as their first language. The target word list was constructed from Basumatary (2004) and was complemented in consultation with a native speaker of Rabha (see Appendix B). The words in the list were randomized and the speakers were asked to produce them in a sentence as in Example 3-3.

ang^{F} X a^{M}-na^{R} [15] (3-3)
I X say-*past*
'I said X'

Each word was repeated four times by the speakers, however, only the first three iterations were considered for analyses to avoid listing intonation affecting the pitch.

Acoustic Analysis

The target words were read by the Rabha speakers without any tone marking, and the objective of this production test was to see how many levels of pitch were distinguished in the production of the Rabha data. Among the Rabha speakers, the average pitch ranges of the male and the female speakers were significantly different from each other. While the average pitch of the male speakers was 180 Hz, the average pitch of the female speakers was 275 Hz. Hence, the analyses for Rabha was based upon pitch values normalized using z-scores so that individual differences among speakers and tokens can be taken care of.

Similar to the Dimasa analyses in the previous section, pitch points were calculated across 50 points on the pitch track, each point representing 2% of the total length of the pitch track. However, assuming onset and coda consonantal effects to be prevailing up to 20% of the pitch track, pitch points in the initial 20% and the final 20% of the pitch track were not considered for analysis.

In the following sections two way contrasts in pitch in Rabha are discussed for the words 'kho' and 'bia'. In this analysis, initially it was attempted to recognize the tonal contrasts by conducting visual examination of the pitch tracks of Rabha. However, after identifying the tonal categories with the aid of visual analysis, statististical tests will be conducted to verify the validy of the outcome.

[15] The superscripted R denotes a rising tone, the superscripted M denotes a mid-level tone and the superscripted F denoted a falling tone.

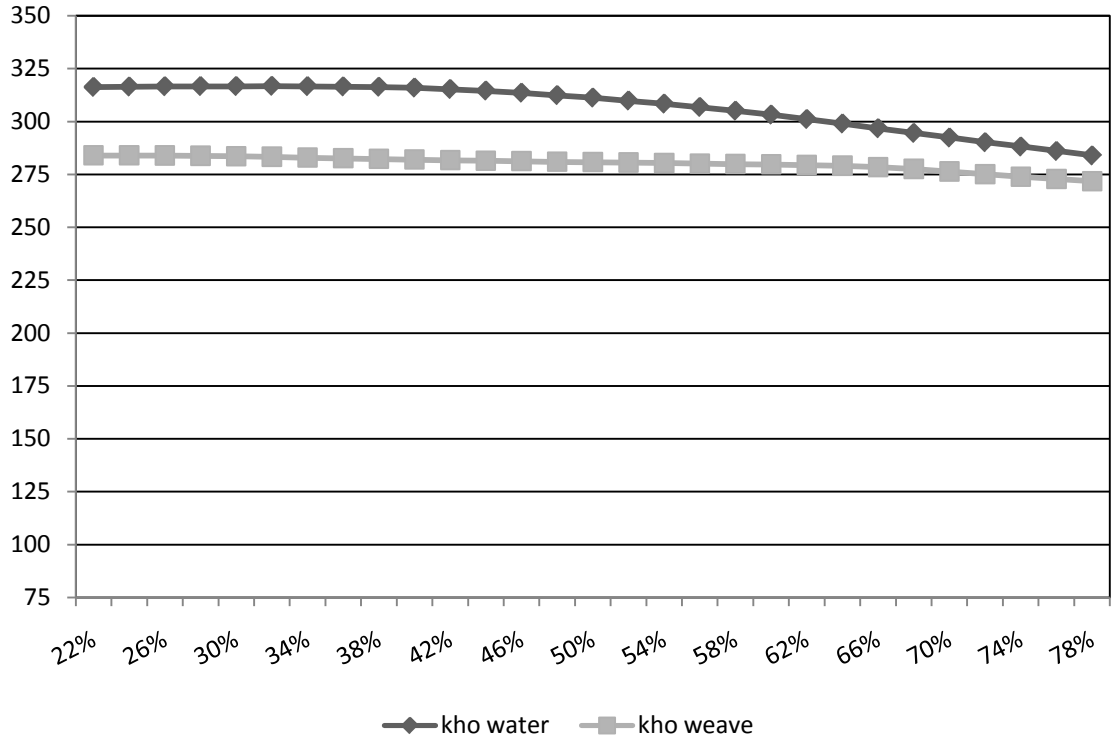


Figure 3-14. Pitch track for /k^{h}o/ for female speakers

The pitch ranges of Rabha speakers' speech vary significantly depending on the gender of the speaker (Figure 3-14 and Figure 3-15). The pitch tracks of /k^{h}o/ demonstrate evidence of two tones in Rabha (Figure 3-16). While /k^{h}o/ 'water' is assigned a falling tone, the /k^{h}o/ for 'weave' is assigned a mid-level tone. Similar two-way tone assignment of a falling and mid-level tones is also demonstrated in the /so/ and the /tʃua/ sets of monosyllables in Rabha.

However, the direction of tones in Rabha is not limited only to level and falling. The analysis of the /bia/set of syllables also provides evidence for a third type of tone contour in Rabha. In case of the /bia/ sets of syllables, two types of tones are assigned to each meaning of the syllable (Figure 3-17 and Figure 3-18). The word /bia/ for 'marriage' is assigned a mid-level tone whereas; the word /bia/ for 'break' is assigned a rising tone. It is worth noting that the /bia/ for 'marriage' is a borrowing from Assamese- an Indo-European language spoken in the proximity of the Rabha speaking areas.

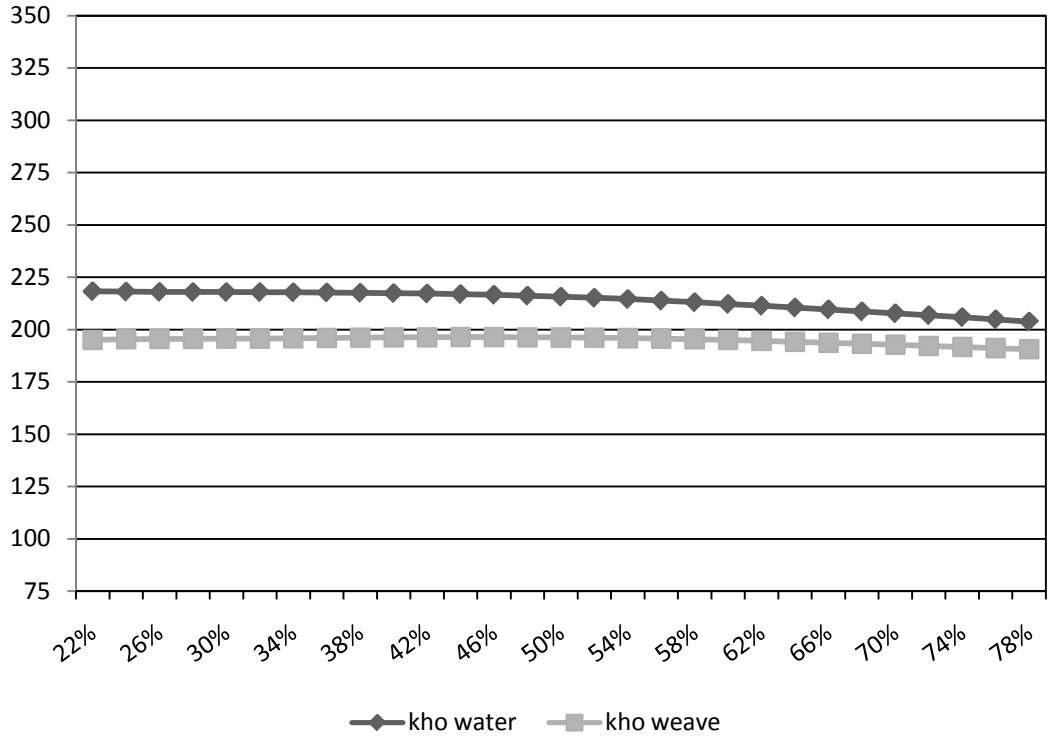


Figure 3-15. Pitch Track for /k^{h}o/ for male speakers

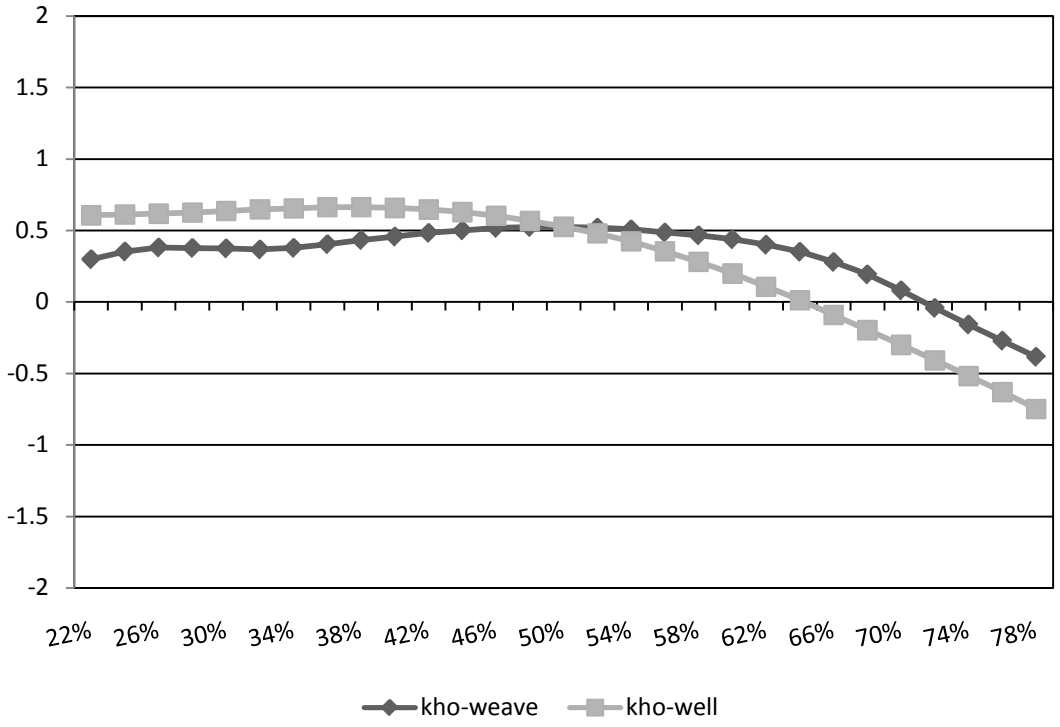


Figure 3-16. Normalized pitch track for /kho/ for all speakers of Rabha

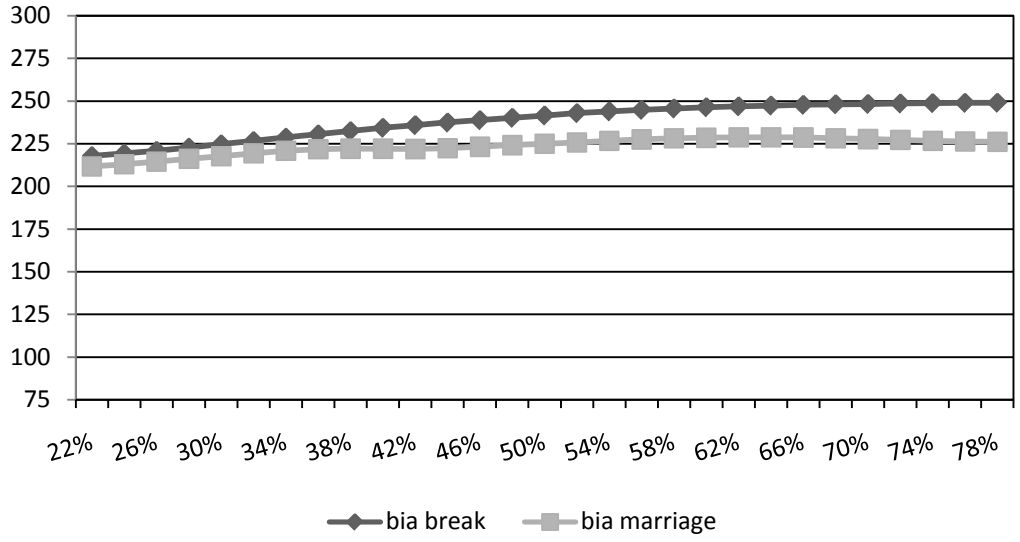


Figure 3-17. Pitch track for /bia/ for female speakers

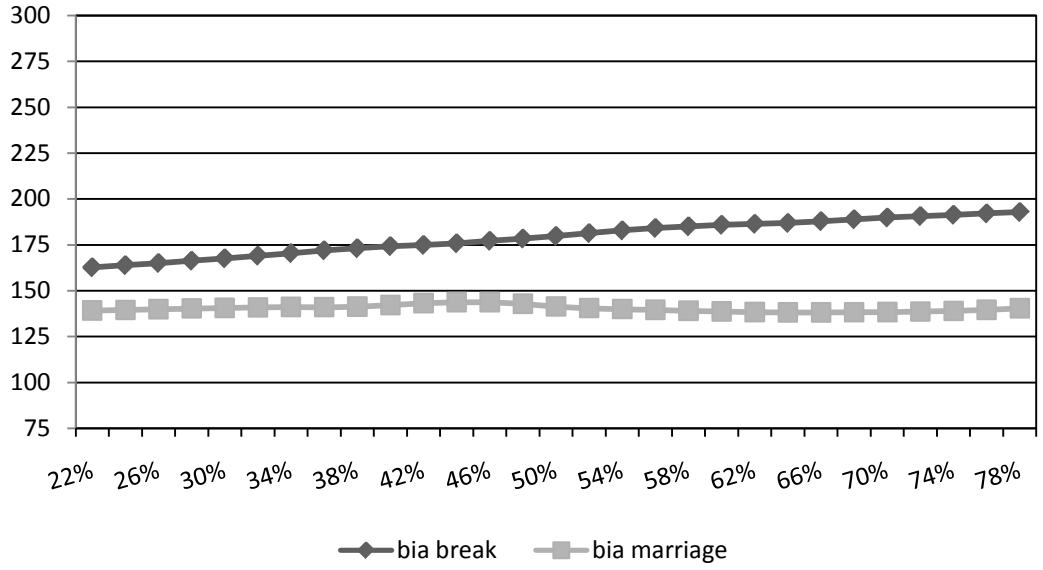


Figure 3-18. Pitch track for /bia/ for male speakers

The normalized and averaged pitch tracks for the /bia/ syllables (Figure 3-19) demonstrate that they are are assigned with two distinct tones one with mid-level pitch track and the other with a rising pitch contour. Hence, it confirms that apart from the falling and a level tone, Rabha also has a mid-level tone. The spectrographic evidence accumulated indicates that there are three tones in Rabha.

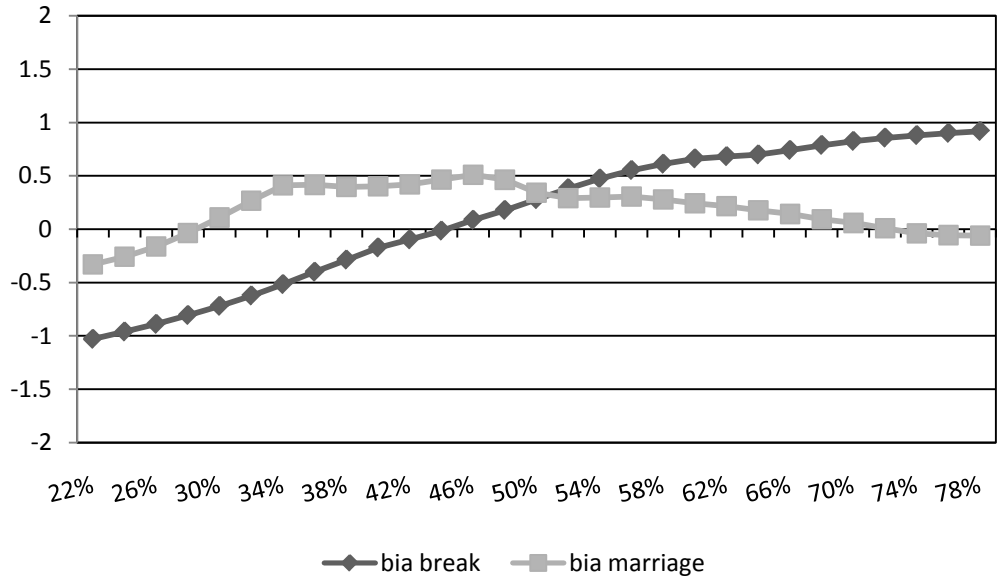


Figure 3-19. Normalized pitch track for /bia/ for all speakers

The pitch tracks of Rabha clearly show a three way pitch distinction in monosyllables (Figure 3-14 through Figure 3-19). From the shape of the pitch contours of the normalized pitch tracks it can be concluded that Rabha shows a three way pitch contrast. Whether the three-way pitch distinction can be translated into a three-way tonal distinction, will be discussed in the sections to follow.

As mentioned at the beginning of this section, the much claimed three-way distinction in Rabha words was also attempted to be captured. There were at least five sets of minimal triplets identified from previous works and presented to the speakers for elicitation. However, speakers' unfamiliarity with all three words in every set prevented us from testing that. Nevertheless, one set of the supposed three-way distinction could be successfully produced by all the speakers in this study. The /rai/ set of segmental homophones having three distinct meanings of 'banana leaf', 'to bring' and 'judgment' are analyzed in this section.

The syllable /rai/ is produced with two different tones by Rabha male and female speakers (Figures 3-20 and Figure 3-21). It is also noticed that the words for 'bring' and 'banana leaf' are

produced with a rising tone similar to that of /bia/ for ‘break’. However, the one for ‘judgment’ is produced with a level pitch that is similar to the pitch track of the /bia/ syllable for ‘marriage’.

Further investigation into this particular set revealed that like the /bia/ for marriage, the /rai/ for ‘judgment’ is borrowed from Assamese, an Indo-Aryan non-tonal language, and hence it is not unlikely that Rabha uses a mid-level contour tone for the loan words incorporated into the language. This argument is further substantiated by the fact that even the word /bia/ for marriage is also a borrowed lexical item from Assamese.

However, as the mid-level tone also occurs in Rabha indigenous words, it is safe to conclude that the mid-level tone, like the rising and the falling tone; is a lexical tone in Rabha. At the same time, it is also plausible that the mid-level tone is a default tone in Rabha. Like many other languages it is possible that Rabha also assigns the mid-level tone to the lexical items that are borrowed from other languages.

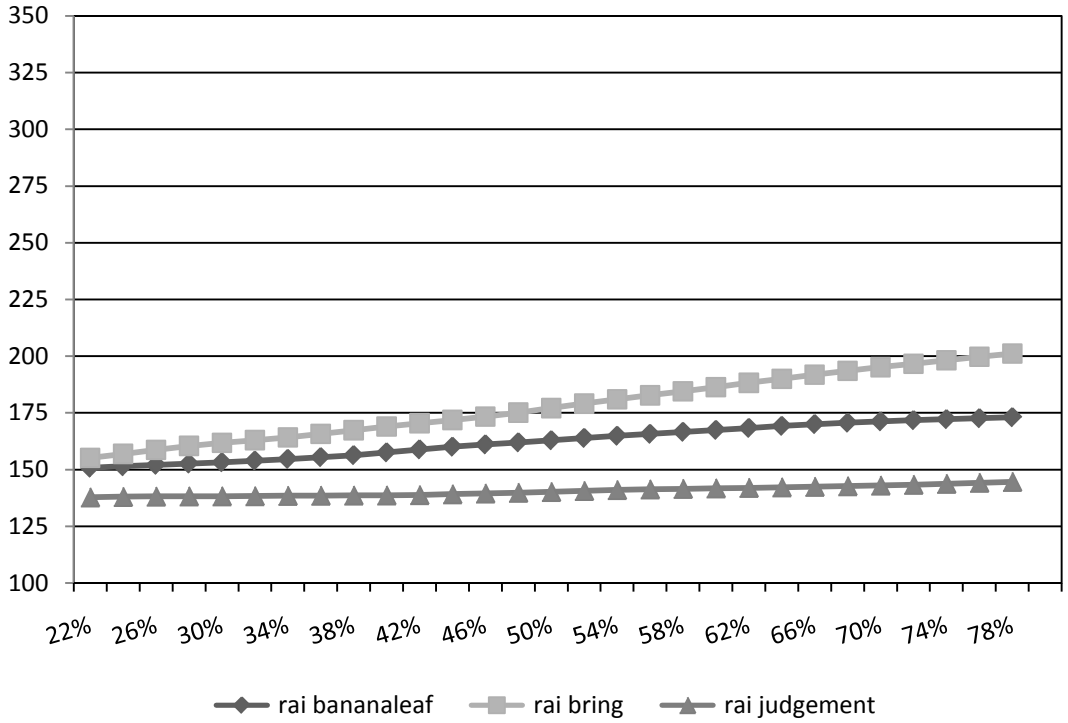


Figure 3-20. Pitch track for /rai/ for male speakers

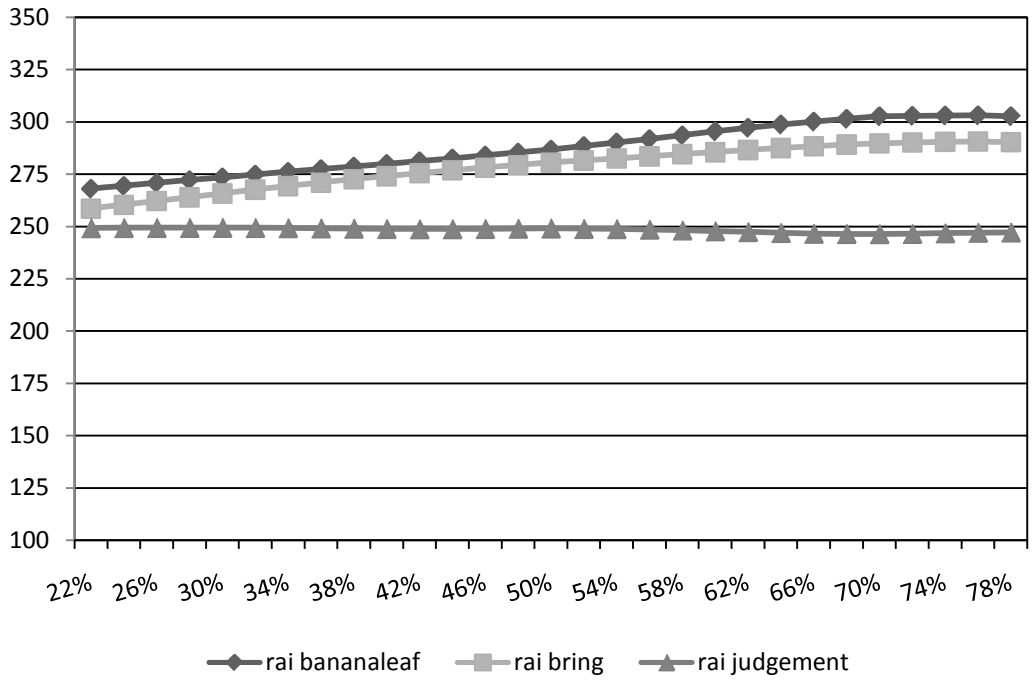


Figure 3-21. Pitch track for /rai/ for female speakers

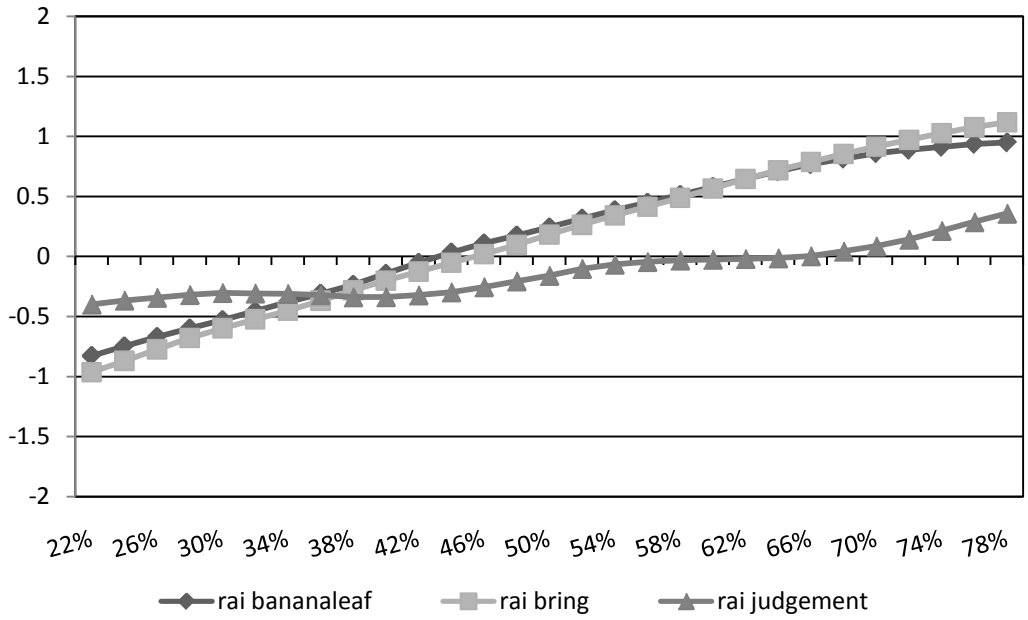


Figure 3-22. Normalized pitch track of /rai/ for all speakers

Statistical Analysis

The primary goal of the statistical analysis is to see if the three tones in Rabha differ from one another in a statistically significant way. As with Dimasa, at least two of the three tones in

Rabha are contour tones too. Hence, conducting a statistical test with average pitch values as dependent variable will be highly misleading. Hence, as in Dimasa after visually examining the pitch contours, F0d values of the Rabha monosyllables were categorized into three tonal categories namely rising, mid-level and falling (Figure 3-24). The F0d values of the three tonal categories were subjected to statistical tests and compared for statistical variation among them.

A one-way ANOVA was conducted on the Rabha data with F0d as dependent variable and tone types as independent variables (Table D-9, Appendix D). Subsequently a Bonferroni test was also conducted to further support the results of the ANOVA analysis (Table D-10, Appendix D).

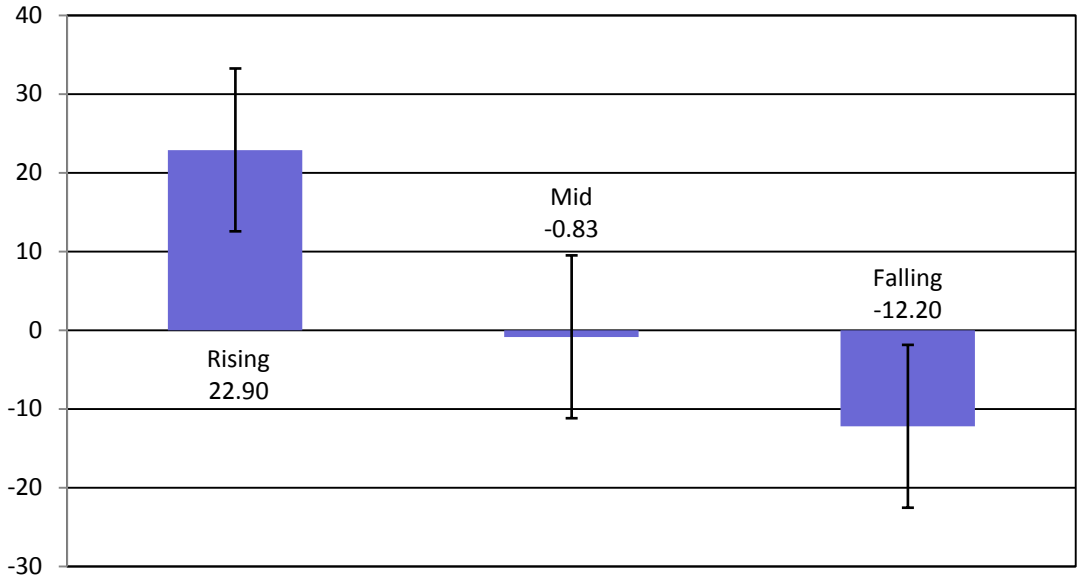


Figure 3-23. Mean F0d for non-normalized Rabha tones with standard error bars

The ANOVA test revealed that there is a significant difference among tonal categories where F0d is the dependent variable [F (2, 771) = 235.95, p<0.05]. In the Bonferroni *post-hoc* test the three tone types are individually compared with F0d as the dependent variable. The results of the Bonferroni *post-hoc* test shows that the three tone types are significantly different from each another (Bonferroni adjusted p < 0.017).

In Figure 3-24, pitch tracks normalized using z-score and averaged across all speakers for the three tones in Rabha are presented that demonstrate three different levels of tone assignment in monosyllables in Rabha.

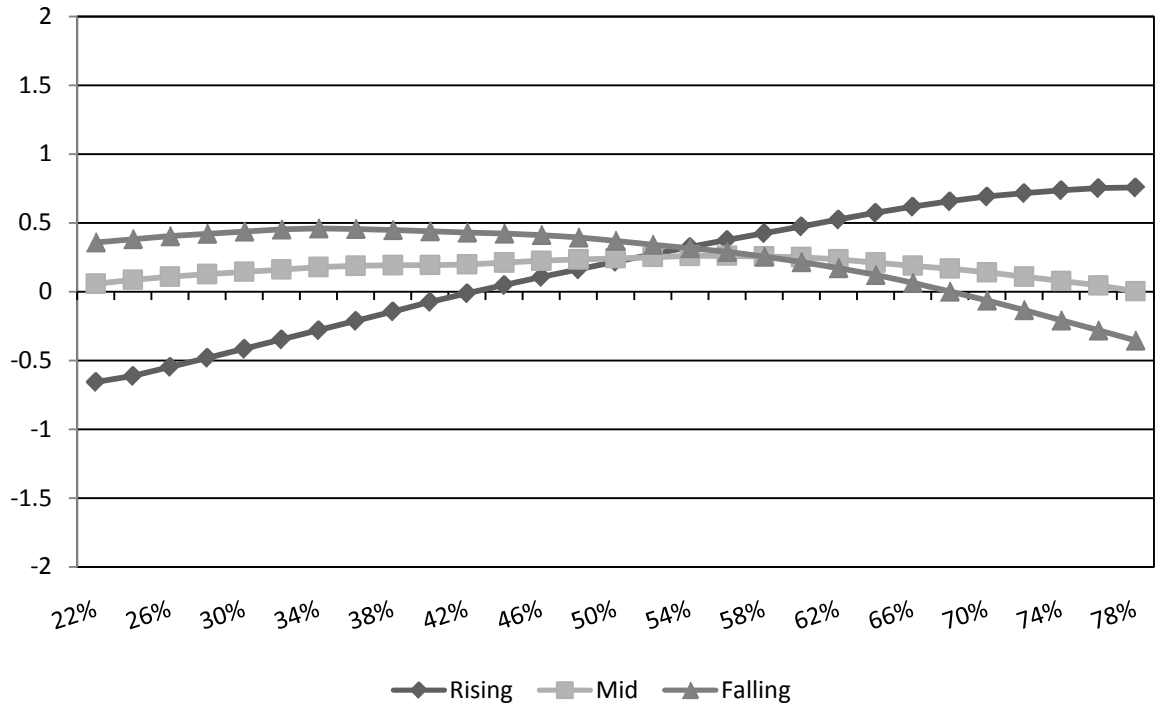


Figure 3-24. Normalized pitch contours of the three tones in Rabha

Discussion

In this chapter it was shown that both Rabha and Dimasa have three phonological tones namely, rising, falling and level-mid tone. It was also shown that any monosyllable in Rabha and Dimasa can be assigned any of the three phonological tones available in their lexical tone inventories. In Dimasa, apart from the three phonological tones, an allotone of the rising tone exists those surfaces as a high-level tone. This allotone is conditioned by the initial onset consonants /ʃ/ and /t^h/ that are highly sonorous. In both Dimasa and Rabha, some speakers showed extremely small difference in terms of average F0d of the contour tones. For instance, speaker CH of Dimasa has an average F0d of only 4.14 Hz in the production of rising tones and -

8.99 Hz in the production of falling tones (see Appendix C, Table C-1). Similarly, Rabha speaker KC has an average F0d of only 10.68 in the production of falling tones of Rabha. Even though the F0d values are very small, it is not uncommon to have such small differences of fundamental frequency in the production of contrastive tones in tone languages (e.g. Fok 1974, Peng 1997, and Barry and Blamey 2004).

On the other hand the highest F0d for rising and falling tones in Dimasa are 31.0 Hz and -31.18 Hz (produced by speaker MT). In case of Rabha the highest F0d for rising tones is 31.04 Hz as produced by speaker TR and the highest F0d for falling tones is -32.99 as produced by speaker KO. Average F0d for Dimasa rising tone is 16.7l Hz and for falling tone it is -20.64 Hz. In case of Rabha the average F0d for rising tone is 22.90 Hz and for the falling tone it is -12.20 Hz.

Contour tones in tone languages demonstrate a plethora of variations in terms of the difference between the offset and onset of the pitch contour. Languages like Mandarin Chinese and Thai show large differences between the onset and offset of contour tones. Abramson (1962) showed that Thai high falling tones show a fall of about 55 Hz (155Hz to 100 Hz) , while low (falling) tones show a fall of about 10 Hz (120 Hz to 110 Hz). On the other hand Thai high rising tones show a rise of about 45 Hz (110 Hz to 155 Hz) and low (rising) tones show a rise of about 15 Hz (130 Hz to 145 Hz). In a more recent study on Thai, Moré and Zsiga (2006) have shown that Thai falling tones may fall about 80 Hz (260 Hz to 160 Hz) and a low tone (phonetically falling) tone can fall about 50 Hz (210 Hz to 160 Hz). They have also shown that Thai rising tones may rise for 40 Hz (180 Hz to 220 Hz) from onset to offset, while a high tone (with a phonetically rising contour) in Thai may rise for about 25 Hz (225 Hz to 250 Hz).

In case of Mandarin Chinese tones, Chuang, Hiki, Sone and Nimura (1972) have shown that the rising tone in Mandarin Chinese can rise for 25 Hz (85 to 110 Hz) from the onset to the offset. Similarly, a falling tone in Mandarin Chinese may fall for 40 Hz (125 Hz to 85 Hz) from its onset to the offset. Moore and Jongman (1997) have shown that Mandarin Chinese rising tones rise for 60 Hz (210 Hz to 270 Hz) from their onset to the offset. They report that the average falling tone produced by the subjects in their study exhibit a fall of 90 Hz (270 Hz to 180 Hz) from onset to the offset.

Fok (1974) has shown that in Cantonese a high falling tone can fall for about 60 Hz (180 Hz to 120 Hz), while a low falling tone can fall for about 50 Hz (120 Hz to 70 Hz). Fok reports that in case of the high rising tones in Cantonese, the difference between the offset and the onset can be as large as 60 Hz (120 Hz to 180 Hz). On the other hand he observes that the difference between offset and offset of a low rising tone in Cantonese is almost half that of a high rising tone i.e. 30 Hz (120 Hz to 150 Hz). Khouw and Ciocca (2007) show that their subjects produced the low rising tone in Cantonese with a rise of about 50 Hz (180 Hz to 230 Hz). On the other hand their subjects obtained a fall of 55 Hz (225 Hz to 170 Hz) while producing the low falling tone in Cantonese. The same study reported that the rise in a high rising tone in Cantonese is of 85 Hz (180 Hz to 265 Hz).

However, the above mentioned differences between the offset and offset of contour tones are not always as large in all languages. Rather, they can be substantially small differences even in the languages that are discussed above. For example, Peng (1997) notes that in case of Taiwanese tones the difference of fundamental frequency between onset and offset of low rising tones can be as small as 10 Hz. Sum (2001) while comparing Cantonese contour tone production of normal and dysarthric speakers notes that normal Cantonese speakers may produce the low

rising tone of Cantonese with a rising slope of less than 10 Hertz. Barry and Blamey (2004) also presents data of two adult Cantonese speakers where the rising slope of the Cantonese low rising tone is 10 Hz or lower in some tokens. Moreover, it has been attested in case of Kammu that the fundamental frequency difference between the two tones in Kammu (high and low) can be quite small with the average ranging between 4 Hz to 25 Hz for male speakers (Svantesson and House, 2006). Considering the evidence from previous perception and production studies, it can be argued that the small F0d of some speakers of Rabha and Dimasa in producing the rising and the falling tones of the two languages falls well within the distinguishable range of the native speakers.

Dimasa Monosyllables

Acoustic analyses of the Dimasa monosyllables have shown that Dimasa has three lexical tones which can be assigned to any Dimasa monosyllables. The findings in this chapter concur with the findings of Singha (2001) as far as the number of tones in Dimasa is concerned. However, as far as the shape of the three tones is concerned, this work concludes that the three tones are actually rising, mid-level and falling tones. From the acoustic analyses of the Dimasa monosyllables, it appears that the shape of the pitch contour is more important in classifying the tones than the average fundamental frequency of the pitch contour. To further strengthen this argument, a statistical examination using Bonferroni test was conducted where average normalized pitch was the dependent variable and tone type was the factor. The results demonstrated that as far as average pitch of tones is concerned, the three tonal categories are not significantly different from one other in Dimasa (see Table D-1, Appendix D). As the rising and the falling tones are contour tones, it was expected that they show no significance in terms of their average pitch values. However, in terms of the difference between the normalized F0 of 78th and 22nd points of the averaged pitch contour (F0d), the three tones in Dimasa do show

significant difference among them. Hence, statistical analyses support the claim of this study that Dimasa tones are significantly different from each other in terms of the shape of the contours.

It is noticed that Dimasa speaker PJ's pitch contours in producing the three tones are very closely spaced (Figure 3-2 through Figure 3-4). However, in terms of the shape of the contour, the three tones are significantly different and spaced from each other. Hence, it is pertinent to say that the three lexical tones in Dimasa are namely rising, mid-level and falling tones.

Considering the spectral and statistical evidence, it can be concluded that Dimasa has three lexical tones that are assigned on monosyllables namely, rising, mid-level and falling. The results of the perception tests conducted on Dimasa speakers (Figure D-1, Appendix D) also reinforce this claim.

Rabha Monosyllables

As with Dimasa, acoustic analysis of Rabha monosyllables also demonstrates a three way tonal distinction. The evidence presented in this chapter demonstrates that Rabha has three lexical tones that are primarily distinguished by the shape of their contours. Similar to Dimasa, Rabha has a rising, a mid-level and a falling tone.

Even though, in the collected data not too many triplets showing three way tonal contrasts were found, it can be concluded that the three tones in Rabha can be assigned to any monosyllable in the language. However, observing the tone assignment pattern in loan words, it can be suggested that the mid-level tone is a default tone which can be assigned to words which are not underlyingly specified with a tone in Rabha.

Statistical analyses of the Rabha monosyllables show that as far as mean F0d is concerned, the three lexical tones are significantly different from each other. However, as far as the average pitch of the monosyllables is concerned, the three tones do not differ significantly (Appendix D, Table D-2). It is noticed that tone types do not have any effect on the average F0 of Rabha

monosyllables. On the contrary, it is seen that tone types do have a significant effect on the F0d of Rabha monosyllables.

Considering the statistical and acoustic evidence for Rabha monosyllables in this chapter, it can be concluded that Rabha, like Dimasa also has a three way tonal contrast and any of the three tones can be assigned to any lexical item in Rabha.

CHAPTER 4
TONES IN DISYLLABLES

This chapter describes the tone assignment pattern in disyllables in Dimasa and Rabha. Joseph and Burling (2001) and Sarmah (2004) claim that Bodo-Garo languages assign only one tone for each word, regardless of its syllable size. Both Joseph and Burling (2001) and Sarmah (2004) agree that Bodo assigns lexical tones to the rightmost syllable of a word whereas the preceding syllables are assigned a default mid tone. Joseph and Burling (2001) investigated the tone assignment pattern in Tiwa, another language of the Bodo-Garo group of languages. Joseph and Burling (2001) come to the conclusion that in Tiwa a lexical tone can be assigned to either of the syllables in a disyllabic word, whereas the remaining syllable is assigned a default tone. Not much is known about the tone assignment pattern in Rabha and Dimasa. Singha (2001) does not explicitly talk about tone assignment in disyllables in Dimasa. However, from the data provided in Singha (2001) it is apparent that the author is of the view that both the syllables in a disyllabic entry in Dimasa are capable of hosting a lexical tone each. Similarly Basumatary (2004) does not provide any insight into the tone assignment pattern in Rabha disyllables. Hence, in this chapter the goal is to investigate tone assignment pattern in two Bodo-Garo languages, Rabha and Dimasa, and to see whether their tone assignment patterns concur with the tone assignment pattern in Tiwa and Bodo as claimed by Joseph and Burling (2001) and Sarmah (2004), or each syllable hosts a single lexical tone.

This chapter demonstrates that like in the case of Bodo (Sarmah 2004), Dimasa and Rabha too underlyingly assign a single lexical tone to every disyllabic word. Moreover, it is also demonstrated that the lexical tone is aligned to the rightmost syllable of a disyllabic word. On the contrary the initial syllable of the disyllabic words is not underlyingly specified with any lexical tone. However, well formedness rule of tonal phonology requires that every syllable in the two

languages be assigned a tone. Hence, the initial syllable is assigned an unmarked mid tone of the two languages. In the following sections, the tone assignment patterns in Dimasa and Rabha are discussed.

Dimasa Disyllables

Acoustic Analysis

Dundas (1908) provides a few sets of segmentally homophonous disyllables. For this study, the sets found in Dundas (1908) were confirmed and enriched by a Dimasa language consultant (see Appendix A). Apart from that, Singha (2001) provides the following sets (Table 4-1) of disyllables with the tones minimally marked.[16]

Table 4-1. Set of disyllables

Meaning	Dimasa Word
‘year’	/ máitái /
‘crop’	/maitai/
‘source’	/maiṭai/

As with monosyllables, we measured pitch at 50 points along the tone-bearing unit of each syllable, and plotted pitch graphs for 9 sets of disyllabic words, including the ones in Example 4-1.

goron	‘company’	goron	‘confuse’	(4-1)
hat^{h}ai	‘bullet’	hat^{h}ai	‘hillock’	
hat^{h}ai	‘market’	hat^{h}ai	‘teeth’	

Dimasa speaker BT produces the the pitch track of the first syllable of the /goron/ syllables (Figure 4-1). As with monosyllables, the initial and final 20% of the pitch track is igniored assuming consonantal influence in that part. The pitch track of speaker BT producing the first syllable /goron/ resembles that of a mid tone in both pitch level and (lack of) contour (Figure

[16] The tone markings and transcriptions are as they are found in Singha (2004) where an accent mark on the top of the vowel signifies a high tone whereas vowels not assigned with any tone diacritics signifies that they are marked with a low tone which, according to Singha (2004) is a default tone in the Dimasa language.

4.1). Even if the two pitch tracks of the first syllable of the word /goron/ are different in terms of average pitch, both of them belong to the same toneme, i.e. a mid tone. However, the pitch tracks of the second syllable (Figure 4-2) show evidence of two distinct tones namely, rising and falling.

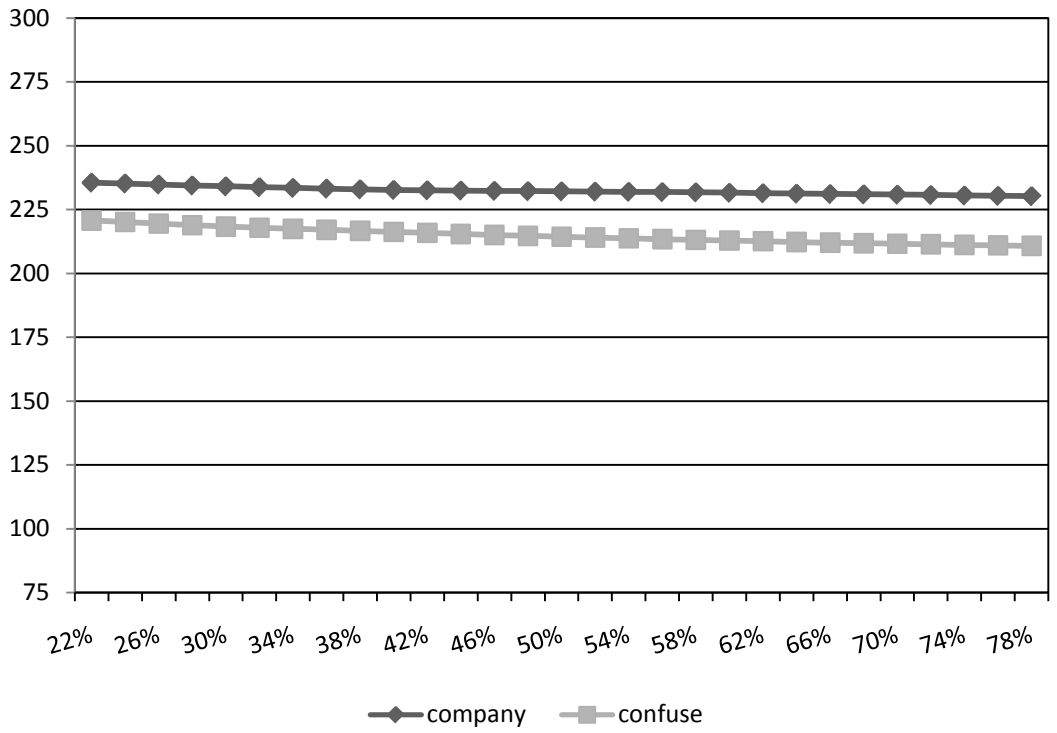


Figure 4-1. Pitch tracks of the first syllable /go/ for /goron/ as produced by subject BT

In case of /hat^{h}ai/, which has four different meanings associated with it, we see that the first syllable for all the four semantic representations is largely similar, in terms of direction of the pitch of the tone (Figure 4-3). This suggests that it is not possible for the Dimasa speakers to distinguish the word meanings from the initial syllable of the word /hat^{h}ai/. However, as far as the second syllable is concerned, acoustic evidences (Figure 4-4) confirm that there are two distinct tonal categories associated with them namely, the rising, mid-level and falling tones. Hence, thetone on the second syllables contributed to semantic identification of the /hat^{h}ai/ syllables.

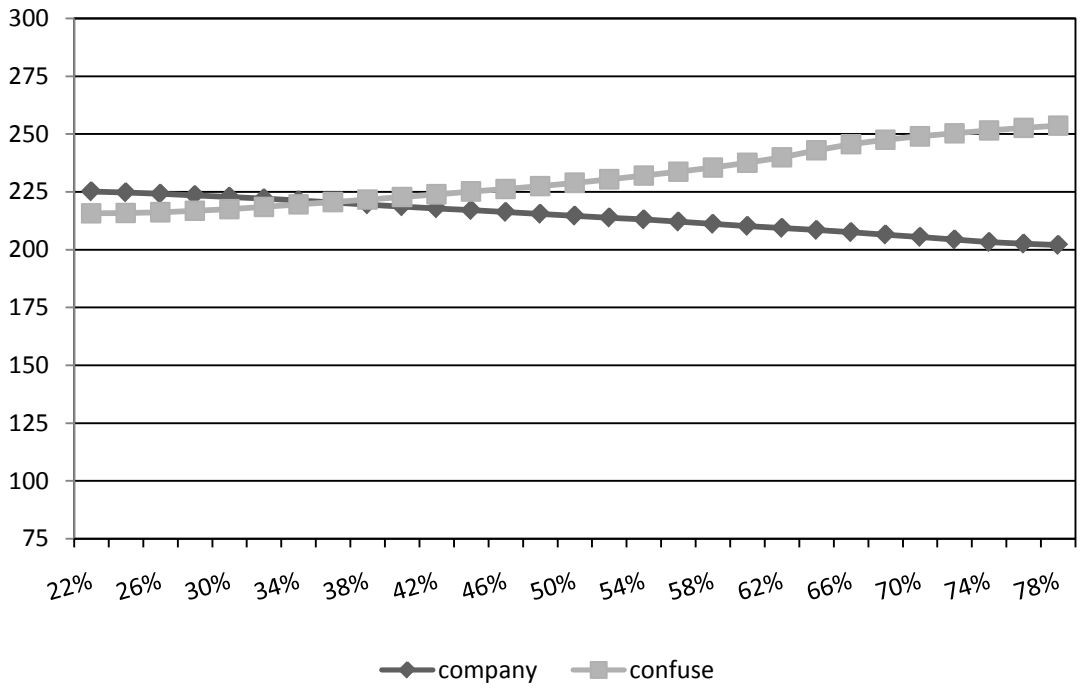


Figure 4-2. Pitch tracks for the second syllable /ron/ of /goron/ as produced by speaker BT

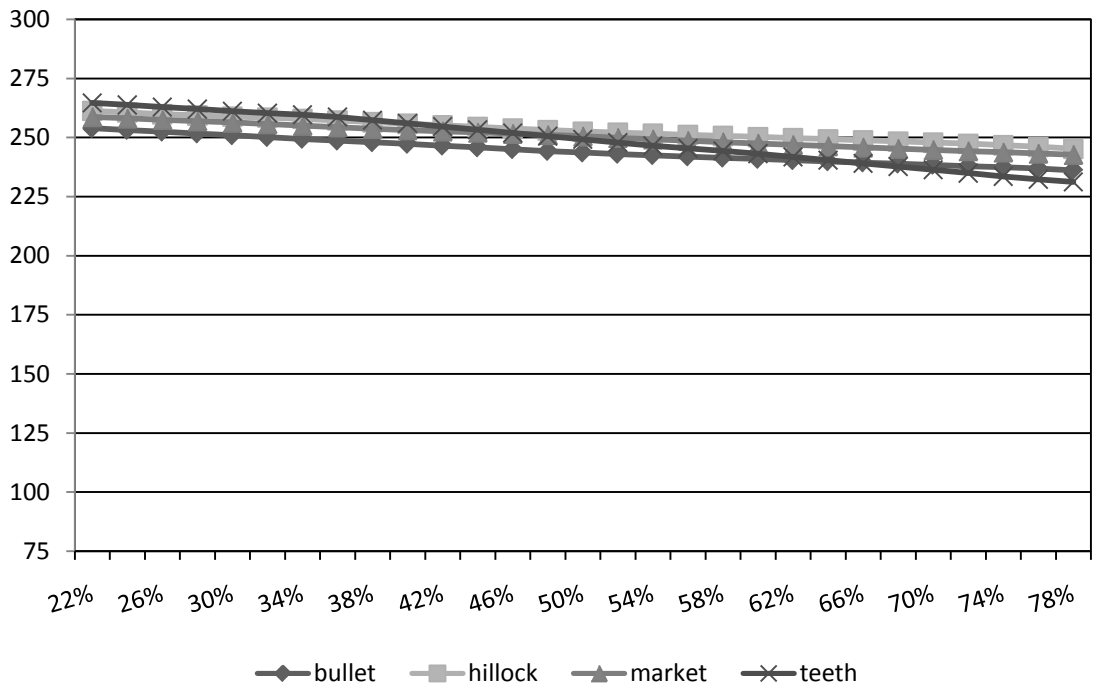


Figure 4-3. Pitch track on the first syllable /ha/of /hat^{h}ai/ as produced by speaker BT

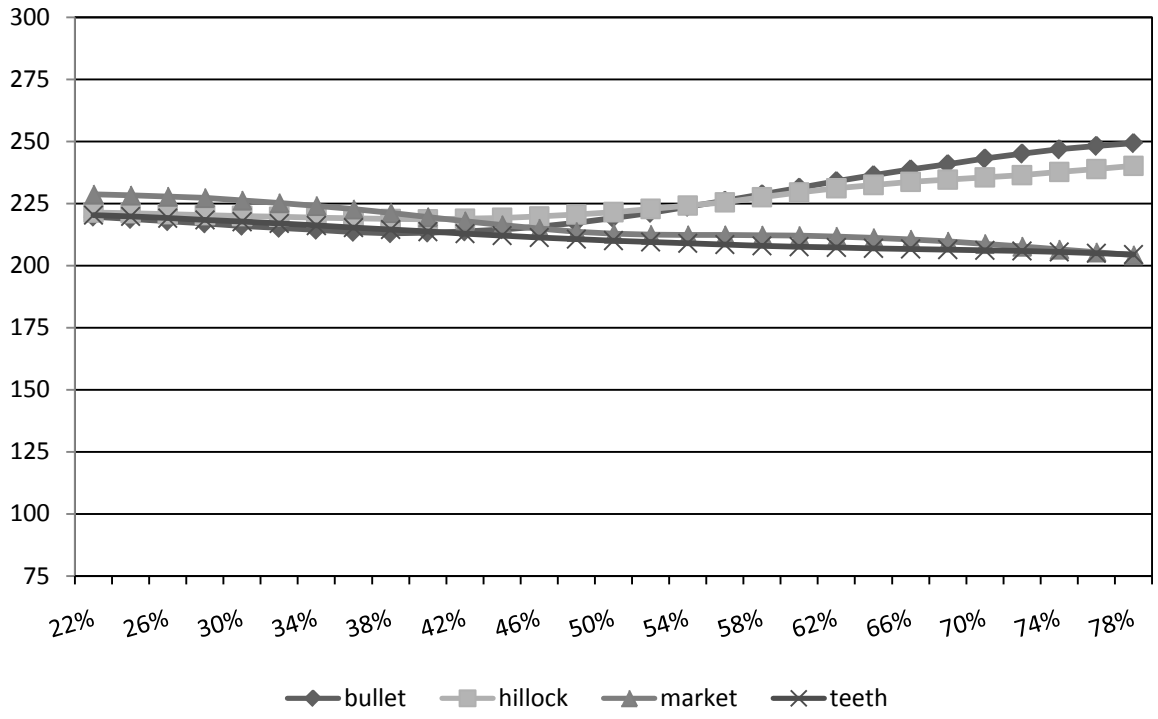


Figure 4-4. Pitch tracks of the second syllable /t^{h}ai/of /hat^{h}ai/ as produced by speaker BT

It is also noticed while analyzing the Dimasa data that the TBU duration in the first syllable of disyllables is significantly less than that of the second syllable. The average vowel length of Dimasa monosyllables and disyllables measured in Sarmah and Wiltshire (in press) indicate that the first syllables of Dimasa may be too short for a TBU to be recognized correctly.. Cross linguistic data also support the view that for contour tones to be realized, the vowel or rime duration has to be considerably long and not less than 100-130 ms (Xu 2004). Hence, due to the shorter length of the TBUs noticed in Dimasa (Table 4-2), it may not be possible to perceive or produce the contour tones (rising and falling) in Dimasa rendering the tone on the first syllable redundant for semantic identification.

Table 4-2. Average TBU length in Dimasa syllables

		CV	CVV/CVN
Monosyllables		137 ms	162 ms
Disyllables	First syllable	70 ms	114 ms
	Second Syllable	120ms	156 ms

Evidence presented here suggests that in Dimasa disyllables, the rising and the falling tones can occur only in the second syllable, while the first syllable can only have a mid-level tone. This conclusion is not surprising considering that similar phenomena have been noticed in other Bodo languages such as Bodo and Tiwa (Joseph and Burling 2001, Sarmah 2004)

Statistical Analysis

The data for the disyllables was subjected to statistical tests to confirm the claims of the previous sections. In the previous section it is claimed that there is no difference among the initial syllables of Dimasa disyllables as far as pitch is concerned. In that case it is expected that the initial syllables of a disyllable do not show any statistically significant difference among them. Hence, statistical tests are divided into two sections in this chapter. In the first section, ANOVA and Bonferroni tests will be conducted on the normalized F0d values of the individual words produced by all speakers to see the statistical differences in the initial and the final syllables. In the following section a statistical test will be conducted collectively on the initial syllables of all the Dimasa disyllables to see if they are statistically significant when grouped by words.

The /goron/ and /hat^{h}ai/ sets of disyllables

The normalized pitch tracks of the /goron/ set of syllables, as discussed in the previous section, do not demonstrate any significant F0d differences in the first syllable even if they are associated with two separate meanings. However, the F0d measures on the second syllable differ in correspondence to the meaning it represents.

The first syllables of /goron/ is assigned a mid-level tone; however the second syllables are assigned two distinct tones (Figure 4-5). The second syllable of the word /goron/ for ‘company’ is assigned with a falling tone whereas, the second syllable of the /goron/ for ‘confuse’ is assigned a rising tone.

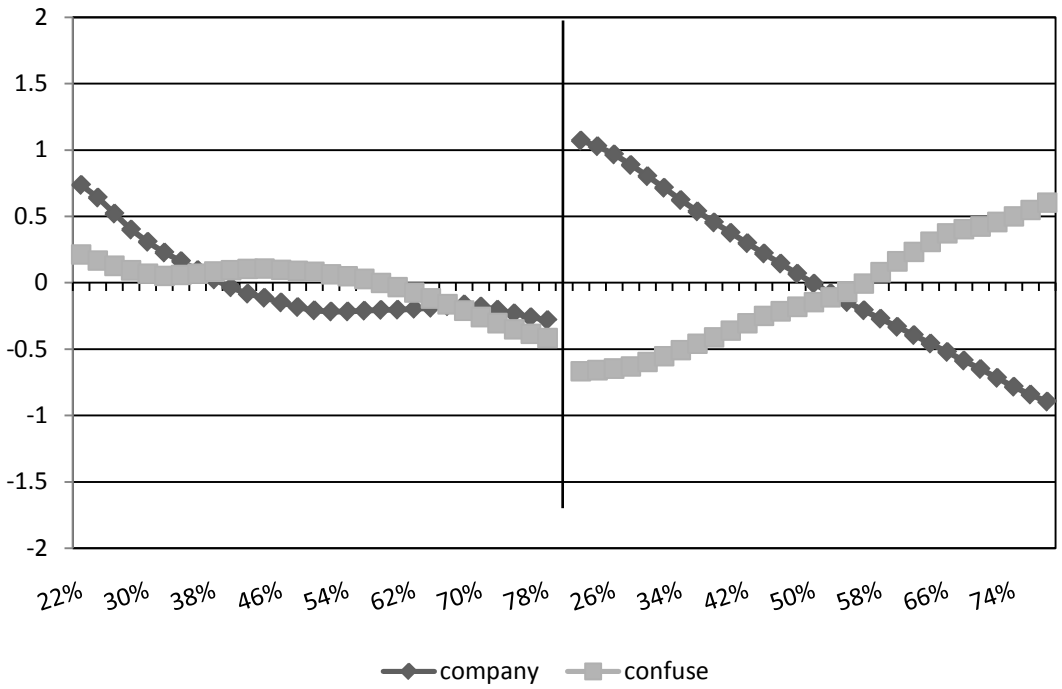


Figure 4-5. Normalized pitch tracks of the /goron/ disyllables

Similarly, the /hat^{h}ai/ set of syllables also do not show F0d difference on their first syllables. However, the pitch track of the second syllables does demonstrate categorical tonal differences (Figure 4-6).

The initial syllables of the /hat^{h}ai/ set of disyllables are assigned level tones. However, the second syllables of the /hat^{h}ai/ for ‘bullet’ and ‘hillock’ are assigned rising tones. The second syllable of the /hat^{h}ai/ for ‘market’ and ‘teeth’ are assigned a falling tone.

The F0d values of the first syllable of the syllables /goron/ and /hat^{h}ai/were subjected to one-way ANOVA and Bonferroni tests with syllable position (initial or final) as factors and F0d as dependant variable.

The results of the Bonferroni tests for /goron/ (Table D-11, Appendix D) indicate that the F0d values of the first syllables of the /goron/ syllables are not significantly different (Bonferroni adjusted $p > 0.001$). However, as far as the second syllables are concerned, the two words are significantly different from each other in terms of F0d (Bonferroni adjusted $p < 0.001$).

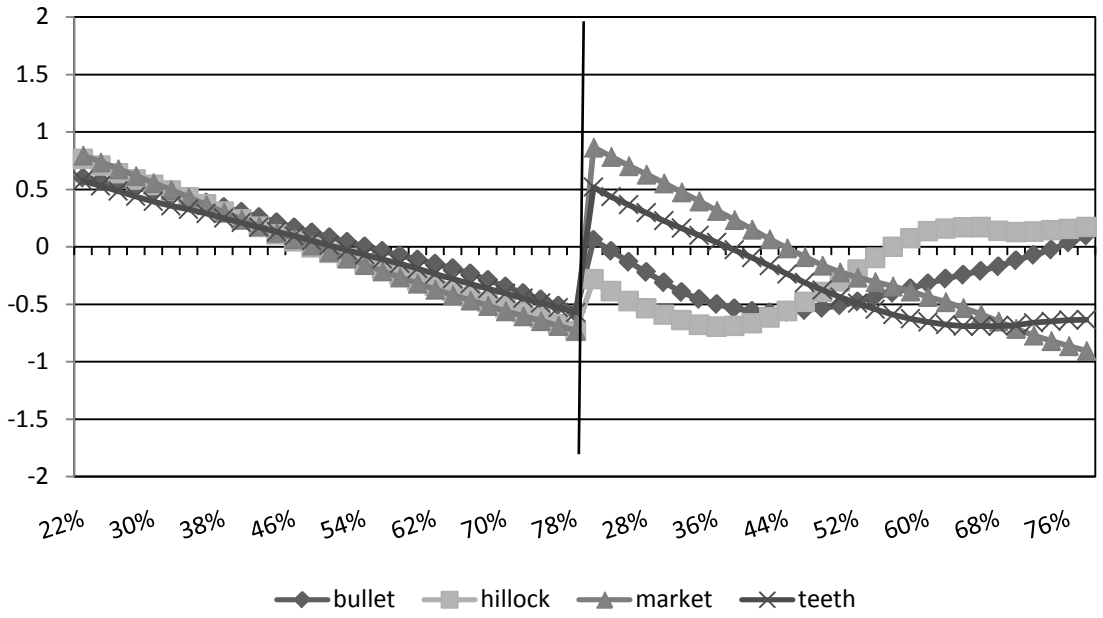


Figure 4-6. Normalized pitch tracks of the /hat^{h}ai/ disyllables

Similarly, the results of the statistical tests for the /hat^{h}ai/ syllables show that the difference between the initial syllables of different realizations of /hat^{h}ai/ is not significantly different from one another ($p > 0.002$). Even though the pitch track of the first syllables of /hat^{h}ai/ is phonetically falling, they are not falling significantly enough to be categorized as a falling tone in Dimasa. Hence, it can be concluded that the first syllables of /hat^{h}ai/ are assigned a mid-level tone and its falling nature is purely phonetic. It can also be assumed that the consistent fall on all the initial syllables is due to the anticipation of the rise in the following syllable conditioned by the onset consonant /t^{h}/.

However, the second syllables are significantly different from each other forming three separate groups among them (Table D-12, Appendix D). The second syllables of /hat^{h}ai/ for ‘bullet’ and ‘hillock’ are not significantly different from each other as they both are assigned a rising tone ($p > 0.002$). However, both ‘bullet’ and ‘hillock’ are significantly different from the /hat^{h}ai/ for ‘market’ and ‘teeth’ which are assigned a falling tone ($p < 0.002$).

The results from the statistical tests and spectrographic evidences (Figure 4-6) demonstrate that the /hat^{h}ai/ set of syllables are categorized into two distinct tonal categories namely rising and falling, based on the pitch contours of the final syllables. However, as far as the initial syllables are concerned the /hat^{h}ai/ set does not show any significant variation in the pitch contour. Considering the evidence from the /goron/ and /hat^{h}ai/ sets of syllables, we come to the conclusion that in Dimasa, only the second syllable of a disyllabic word is assigned a lexical tone (rising or falling in case of /goron/ and /hat^{h}ai/ syllables) and the initial syllables are assigned a default mid tone.

Rabha Disyllables

Acoustic Analyses

Rabha is primarily a monosyllabic language. However, Basumatary (2004) mentions a small set of disyllables in Rabha, not focusing much on the tone assignment pattern. In this study we tested five minimal sets of disyllables in order to investigate the tone assignment pattern in disyllables of Rabha.

The /kana/ and /rima/ set of disyllables mentioned in Basumatary (2004) have the following representations as in Example 4-2 in Rabha.

kana	‘abundance’	rima	‘cook’	(4-2)
kana	‘blind’	rima	‘catch’	
kana	‘dress’ (v.)			

The initial syllables of the /kana/ set of disyllables are demonstrated as spoken by speaker AR in Figure 4-7. It is shown that the speaker AR assigns a mid-level tone on all the three initial syllables of the three Rabha words. The three initial syllables are assigned a mid-level tone (Figure 4-7). Eventhough, the pitch track of ‘abundance’ is higher than the other two pitch tracks, the three pitch tracks fall within same same tonal category based on the direction of tone change.

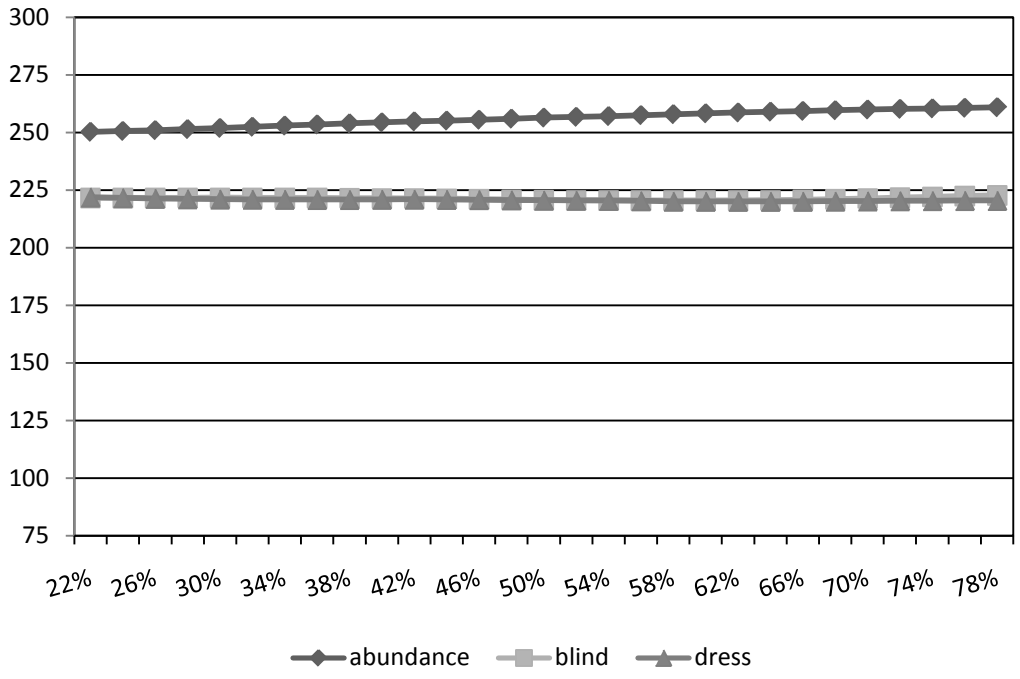


Figure 4-7. Pitch tracks of the first syllable /ka/ of /kana/ as produced by speaker AR

However, it is noticed that the second syllables of the words /kana/ are different from each other as far as the contour of the pitch track is concerned (Figure 4-8). While ‘dress’ and ‘blind’ are assigned a mid-level tone, ‘abundance’ is assigned the falling tone of Rabha.

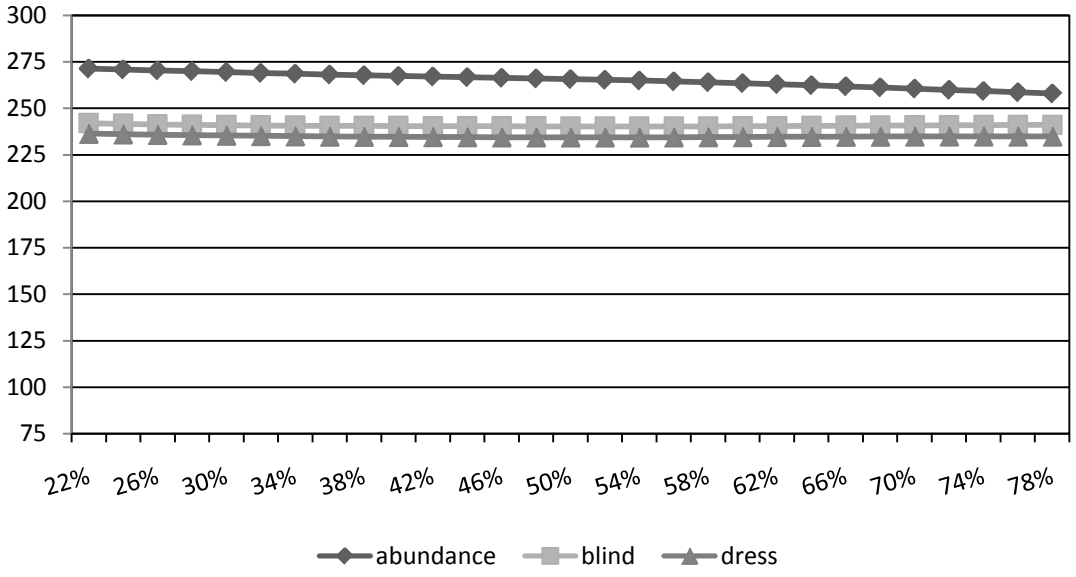


Figure 4-8. Pitch tracks of the second syllable /na/ of /kana/ as produced by speaker AR

Similarly, the pitch tracks of the /rima/ set of syllables as produced by speaker ARshow that the first syllables of the words for ‘catch’ and ‘cook’ are very similar (Figure 4-9). However, in case of the second syllables of the two words, it is noticed that the two words are behave differently in terms of the direction of their pitch track (Figure 4-10). The second syllable of the /rima/ for ‘cook’ is assigned a mid-level tone whereas; the /rima/ for ‘catch’ is assigned a falling tone.

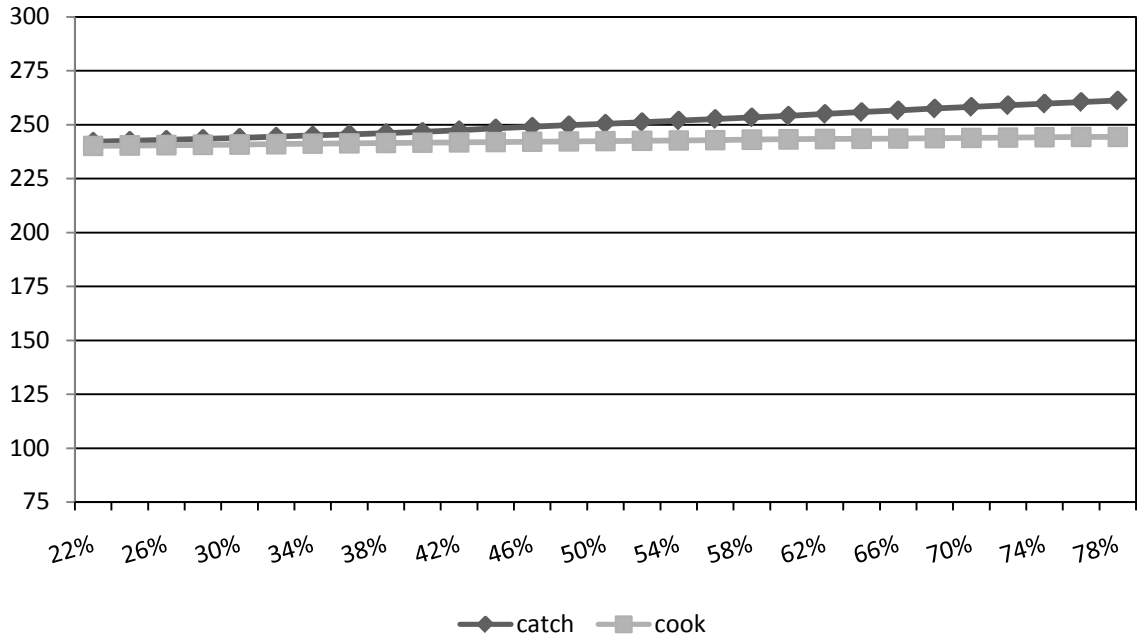


Figure 4-9. Initial syllable /ri/ of /rima/ as produced by speaker AR

From the above discussion, it can be hypothesized that as far as speaker AR is concerned, there is no tone difference between the first syllables in the Rabha disyllables. The first syllables are assigned a mid-level tone, which can be considered as the default one among the three tones in Rabha. However, the second syllables of the disyllabic words in Rabha are specified with distinct lexical tones that trigger distinct semantic representations. Tone assignement in Rabha disyllables are very similar to the tone assignement in other Bodo-Garo languages. For example, Sarmah (2004) reports similar mechanisms in Bodo.

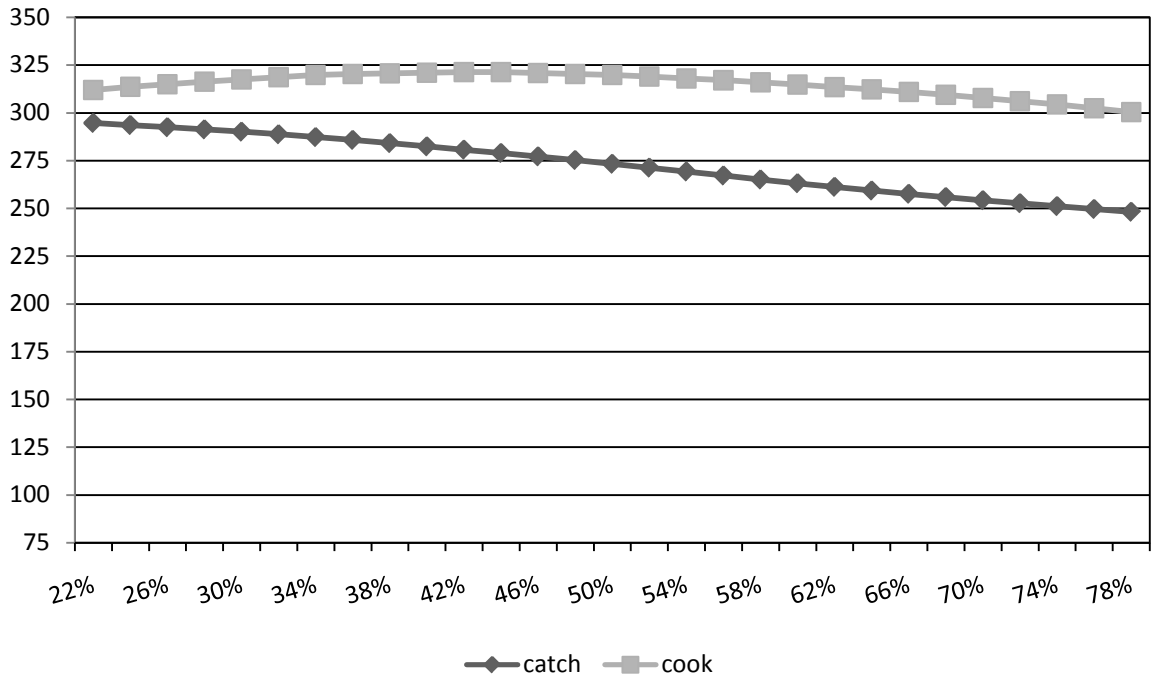


Figure 4-10. Final syllable /ma/ of /rima/ as produced by speaker AR

Statistical Analyses

In order to conduct statistical tests on the Rabha data for disyllables, the data was normalized using the z-score normalization method in order to avoid speaker variability in the production of the tones. The normalized pitch track for the /kana/ syllables is shown in Figure 4-11.

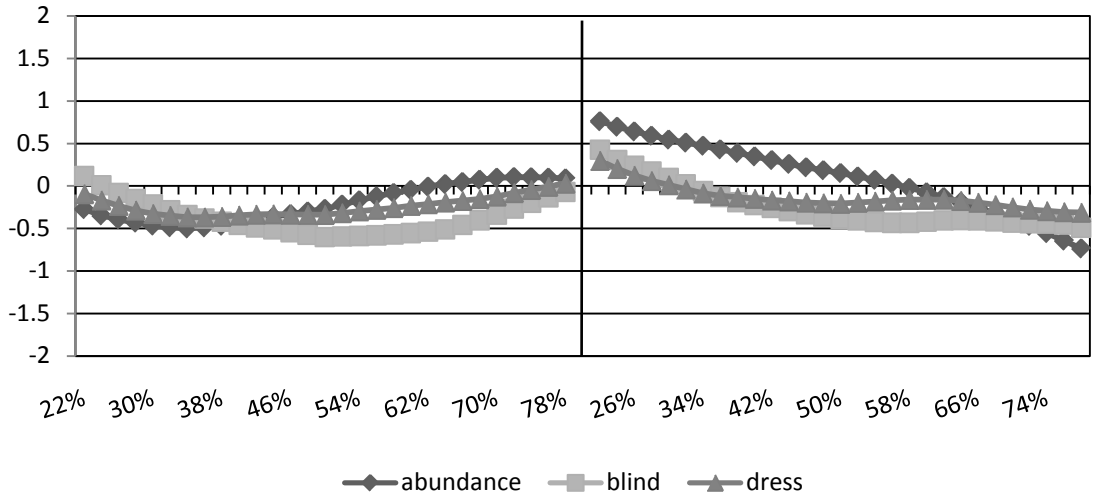


Figure 4-11. Normalized pitch tracks for /kana/

It is noticed in that all the initial syllables of the disyllabic entry /kana/ is assigned a mid-level tone (Figure 4-11). However, among the second syllables, ‘blind’ and ‘dress’ are assigned a mid-level tone, whereas, ‘abundance’ is assigned a falling tone.

Similarly it is seen that the pitch tracks on the first syllables of /rima/ are not entirely indicative of the meaning that the word represents (Figure 4-12). However, in the second syllables, the pitch track for catch is significantly falling assigning the final syllable a falling tones; whereas, the final syllable of the /rima/ for cook is assigned a mid-level tone.

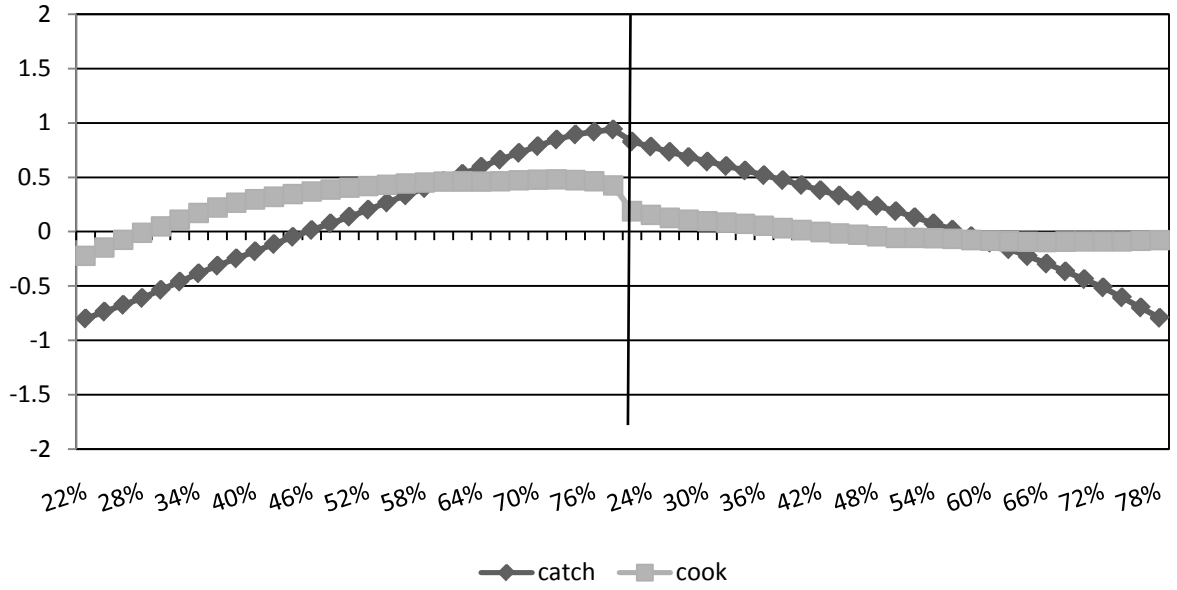


Figure 4-12. Normalized pitch tracks for /rima/

To further substantiate these observertions, an ANOVA test with a Bonferroni test for mean variance was conducted. In the Bonferroni test, F0d was considered as dependant variable and syllable position in the words were considered factors.

An ANOVA test conducted on the /rima/ sets of syllables confirmed that there is significant differences between syllable positions in terms of their average F0d [F (3, 128) = 23.32, $p < 0.05$]. A subsequent Bonferroni *post-hoc* test confirmed that the initial syllables of /rima/ are not different from each other in terms of average F0d (Bonferroni adjusted $p > 0.008$).

However, as far as the second syllables of /rima/ is concerned, they show a significant difference in terms of the average F0d (Bonferroni adjusted $p < 0.008$).

Similarly, the /kana/ sets of syllables also showed that there is a significant interaction between syllable position and their average F0d [F (5, 202) = 14.50, $p < 0.05$]. A follow up Bonferroni *post-hoc* test showed that initial syllables of the /kana/ sets of syllables are not significantly different from each other in terms of their average F0d (Bonferroni adjusted $p > 0.003$). However, in case of the final syllable, the average F0d of the second syllable of the /kana/ for 'abundance' differed significantly from the second syllable of the /kana/ for 'blind' and the /kana/ for 'dress' (Bonferroni adjusted $p < 0.003$). However, the second syllables of the /kana/ for 'dress' and 'blind' are not significantly different from each other (Bonferroni adjusted $p > 0.003$). These statistical results are analogous to the representations of the pitch tracks in Figures 4-11 and 4-12 where /kana/ and /rima/ pitch contours show a significant difference in the final syllable. Hence, the final syllable may be considered as the one which is assigned with a distinct tone that semantically distinguishes one disyllabic word from another.

Discussion

The acoustic and statistical evidence presented in the sections above demonstrate that in Dimasa and Rabha the tone of the initial syllable of a disyllabic entry is not active in distinguishing one lexical item from another. The initial syllables of the disyllabic entries are assigned a default mid tone. However, the final syllable of the disyllabic entries is assigned any one of the three lexical tones in the two languages. The tone assignment in the final syllable of a set of disyllabic entries is distinct so as to represent distinct semantic representations. In this chapter it has been seen that the mid-level tones in the two languages namely, Dimasa and Rabha, function as default tones which may also explain the assignment of the mid-level tones to loan words in Rabha

CHAPTER 5
MORPHOPHONOLOGY

Overview

This chapter investigates some of the morpho-phonological phenomena observed in Dimasa and Rabha. Among the Bodo-Garo languages, discussions on the interaction between tones and morphology are restricted mostly to Bodo.

Bhattacharya (1977), Weidert (1987), Joseph and Burling (2001) and Sarmah (2004) show that in Bodo morphology and tones interact with one another in an interesting way. According to Bhattacharya (1977), the high tone is lowered to the next lower tone (hence, tone 1 > tone 2)[17] and a low tone is raised to the immediate higher tone (tone 3>tone 2) in a condition where it is associated with a suffix. In other words, whenever a suffix is added, the tone of the root is assigned a mid tone. Weidert (1987) shows that the high tone in Bodo arises due to a glottal segment present in the lexical entry. Hence, according to Weidert the high tone in the second syllable of the word /dōikorʔ/ 'a well' is due to the glottal stop present in the word /dōiʔ/ 'water'. Therefore when the toneless plural suffix /por/ is attached to the stem /dōikorʔ/ we see that the suffix is assigned a high tone as the preceding syllable has a glottal stop at the end. Following Weidert this phenomenon can be represented as in Example 5-1.

[dōikórʔ]+ /por/→ [dōikórpór] (5-1)
'well' *pl.* → 'wells'

Weidert (1987)

Sarmah (2004) concludes that in Bodo derived words we observe a tonal pattern that is similar to the tone assignment pattern in disyllables. In derived words in Bodo as in the disyllabic words, the lexical tone assignment tends to be right aligned. It was observed that

[17] For tone marking, Bhattacharya (1977)'s transcription convention is followed here, where tone 1 is a high tone, tone 2 is a mid tone and tone 3 is a low tone. He also assumes an unmarked tone to be present in Bodo that he represents as tone 4.

prefixal causative and '*gōbang*' suffixal pluralization mimic non-derived words in permitting only a single tone specification on the rightmost syllable as demonstrated in Example 5-2.

^{M}man^{+H}si+^{M}gō$^{+H}$bang → ^{M}man^{M}si^{M}gō$^{+H}$bang (5-2)
'Man' + 'many' → 'many men'

Sarmah (2004)

Further, *-phōr, -sōr* pluralization results in transferring tonal specification on the stem to the suffixes, as shown in Example 5-3 and Example 5-4, neutralizing the tone on the stem, once again resulting in output form obeying the phonotactics of non-derived words:

$^{+H}$nōng +sōr → ^{M}nōng^{+H}sōr (5-3)
'you (hon, singular)'+ pl. → *you (hon, plural)"*

$^{+H}$no + phōr → ^{M}no^{+H}phōr (5-4)
'house' + *pl.* → 'houses'

Sarmah (2004)

However, Sarmah (2004) also demonstrated another kind of morphophonemic alteration in Bodo where the suffix is underlyingly specified for a distinct tonal identity. The *–ho* causative suffix in Bodo is underlyingly specified for a low tone and it retains it tonal specification in the derivation. At the same time the inherent tonal specification of the stem is also preserved. This type of affixation does not result in any tonal alteration of the stem as it is shown in Example 5-5.

^{M}pho^{+H}thai + *ho*^{L} → ^{M}pho^{+H}thai^{L}ho (5-5)
'to believe' *caus.* → 'to make believe'

Considering the interaction between tone and morphology in Bodo, it becomes pertinent to investigate if Dimasa and Rabha also demonstrate similar interactions between tone and morphology. Hence, in this chapter suffixation and reduplication in the two languages are investigated. It is concluded that Dimasa and Rabha derivations do not follow tone assignment pattern similar to each other. It is shown in this chapter that in Dimasa and Rabha the suffixes are underlying specified a lexical tone. In derivations in Dimasa, both the root and the suffix retain

their underlying tonal specifications. However, in Rabha the underlying tonal specification of the root is not retained but the underlying tonal specification of the suffix is preserved.

Dimasa

Dimasa primarily employs suffixation in derivation and inflection. In this section, the Dimasa causative suffix *–ri* and plural suffix *–rao* will be discussed. In the Bodo-Garo languages, reduplication is widely used to emphasize or to convey the adverbial sense of a lexical item. Hence, we also investigate the reduplication of nouns and adjectives in Dimasa in this section.

The *–ri* suffix

The *–ri* suffix in Dimasa is used to causativize verbs in the language as demonstrated in Example 5-6 from Singha (2001).

thì + *rì* → *thìrì* (5-6)
die + *.caus* 'to kill'

In this study, causativization with the *–ri* suffix was investigated both in monosyllables and disyllables. The aim of this investigation was to find out the tonal changes in derivational and inflectional processes. To construct a list of inflectional and derivational constructions, a few Dimasa verbs were chosen from the word list (Appendix A) and subsequently suffixed with the *–ri* suffix. The derived forms were presented to a native speaker of Dimasa who checked them for their grammaticality. Finally, fifty grammatically plausible derivations were selected for this study by the native speaker. The eight native speakers of Dimasa who participated in this study were asked to produce thederived forms in a sentence frame (Example 5-7). This sentence frame was also used for monosyllables of Dimasa. The speech data was recorded for acoustic analyses.

ang^{R} *X* $t^{h}i^{F}$-ba^{F} (5-7)
I target say-PST.1
'I said X'

The /ʃu/ set of syllables with a rising tone leads to the meaning of ‘to beat’ whereas, /ʃu/ with a falling tone would mean ‘measure’. The pitch track of the two underived /ʃu/ syllables produced in a sentence frame show this distinction clearly (Figure 5-1).

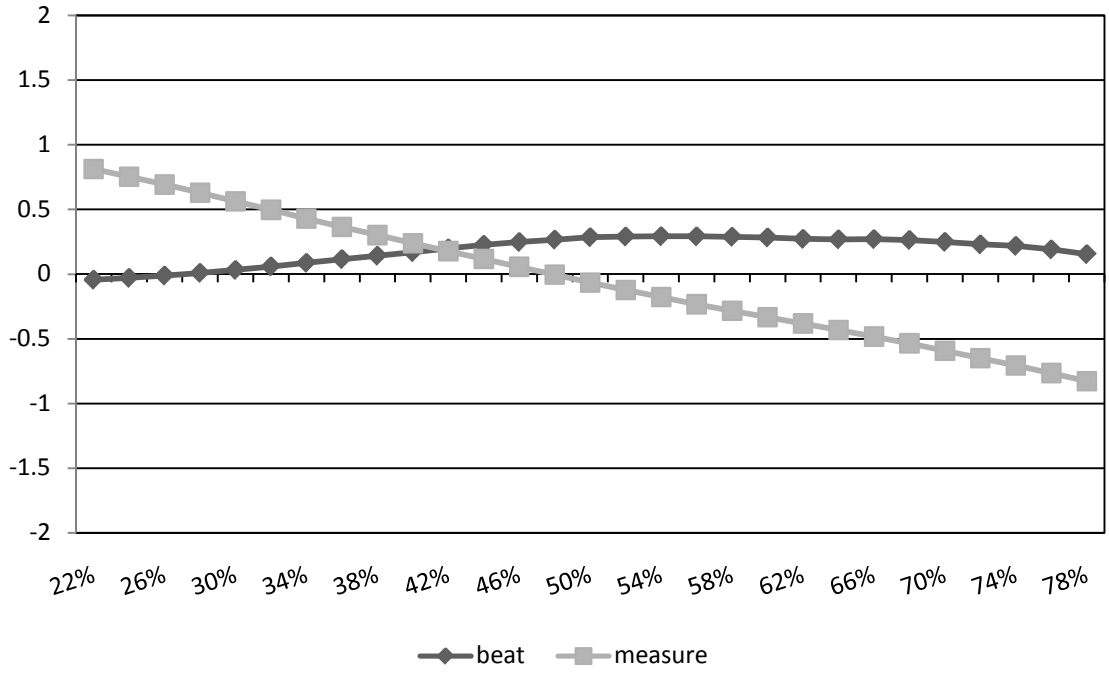


Figure 5-1. Average normalized pitch track of the pitch of /ʃu/ syllables produced in underived conditions by all speakers

The /ʃu/ set of syllables are produced with the suffix *–ri* deriving the causativized forms of the two verbs (Figure 5-2). In case of the causativization of the /ʃu/ set of syllables, it can be noticed that the root of the causativized words retain their tonal specification. The /ʃu/ for ‘beat’ is assigned a rising contour and the one for ‘measure’ is assigned a falling contour. On the other hand, suffixes are assigned with falling tones. In other words, the roots retain their inherent tonal specification but suffixes are assigned a falling pitch contour.

Pitch tracks of /k^{h}ai/ syllables produced in a sentence frame in an underived condition demonstrate that the /k^{h}ai/ for ‘run’ is assigned a rising tone and the /k^{h}ai/ for ‘rub’ is assigned a

falling tone (Figure 5-4). The /k^{h}ai/ set of syllables are also affixed with the causative suffix *–ri*. It is noticed that in spite of being affixed with the causative suffix *–ri*, the roots retain their tonal specifications and the suffix is associated with a falling tone (Figure 5-4).

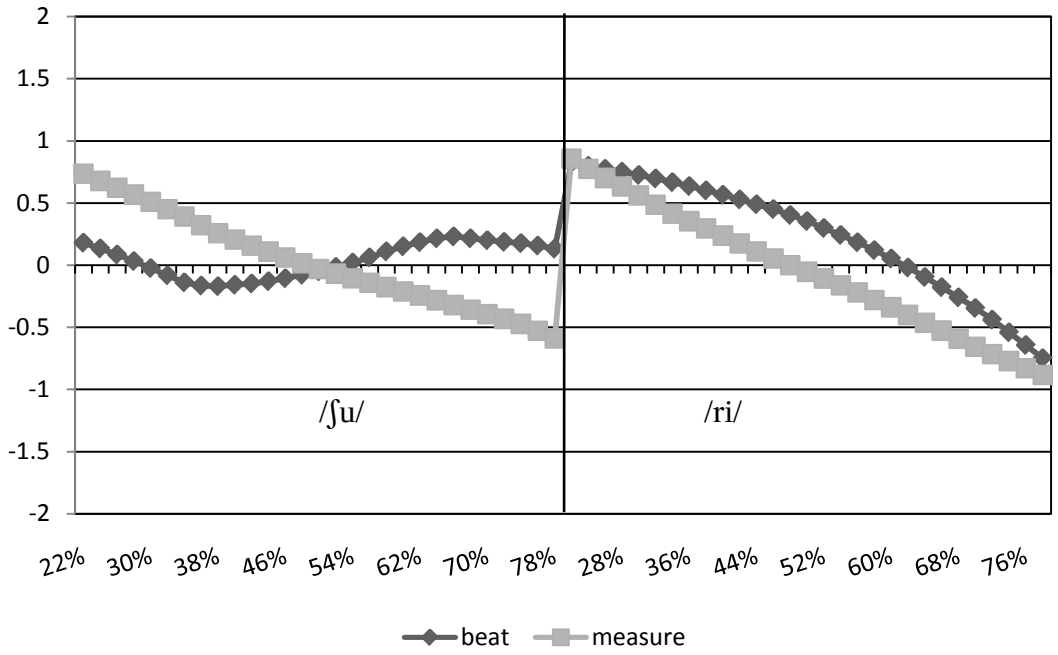


Figure 5-2. Average normalized pitch track of /ʃu/ syllables produced with the suffix *–ri* by all speakers

The pitch tracks of the disyllabic entry /goron/ meaning 'to confuse' and 'company' in an underived condition are also examined (Figure 5-5). The initial syllables of the disyllabic entries are assigned with a mid-level tone whereas, the second syllables are assigned two distinct tones namely, rising and falling.

As discussed in Chapter 4, the initial syllables of the two /goron/ disyllables are not statistically significantly different from each other. However, the second syllables do have statistical significance between them. In other words, in disyllabic /goron/ a speaker obtains the tonal cue for the identification of the word from the second syllable of the disyllabic entry. This set of syllables was also used to test tonal changes in disyllabic words in Dimasa. The /goron/ syllables were affixed with the suffix *–ri*.

It is observed from that the second syllables of the two derivations demonstrate two different pitch tracks (Figure 5-6). However, the first and the third syllables are assigned a level and a falling tone respectively.

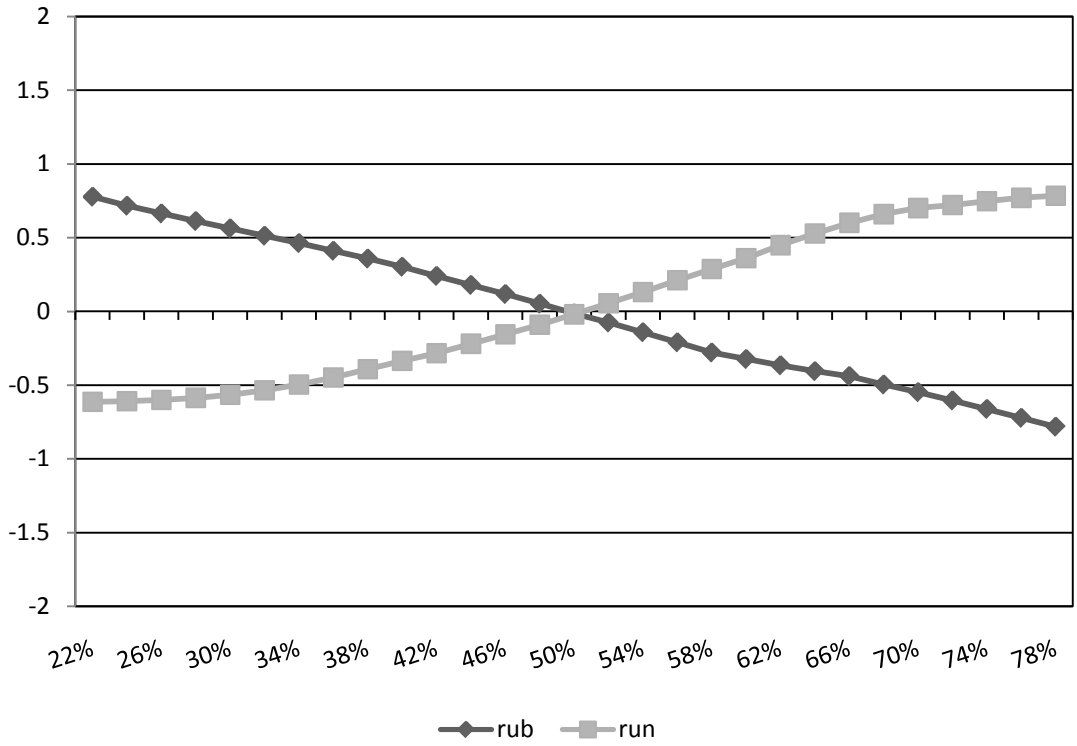


Figure 5-3. Pitch track of /k^{h}ai/ syllables in underived conditions

To confirm this observation a test of variance on the syllables of each of the derived words was conducted (Figure 5-6). A Bonferroni *post-hoc* test was conducted to compare the initial, medial and final syllables of the two separate instances of the /goron/ syllables.

The results of the Bonferroni test (Table 5-1) show that the average F0d of the /go/ syllables for ‘meet’ and ‘confuse’ are not significantly different from each other (Bonferroni adjusted $p > 0.003$). In other words, it is not possible for native speakers to distinguish between two meanings this set of syllables just by depending on the first syllable of the words. This result also reflects the tone assignment pattern in Dimasa disyllables.

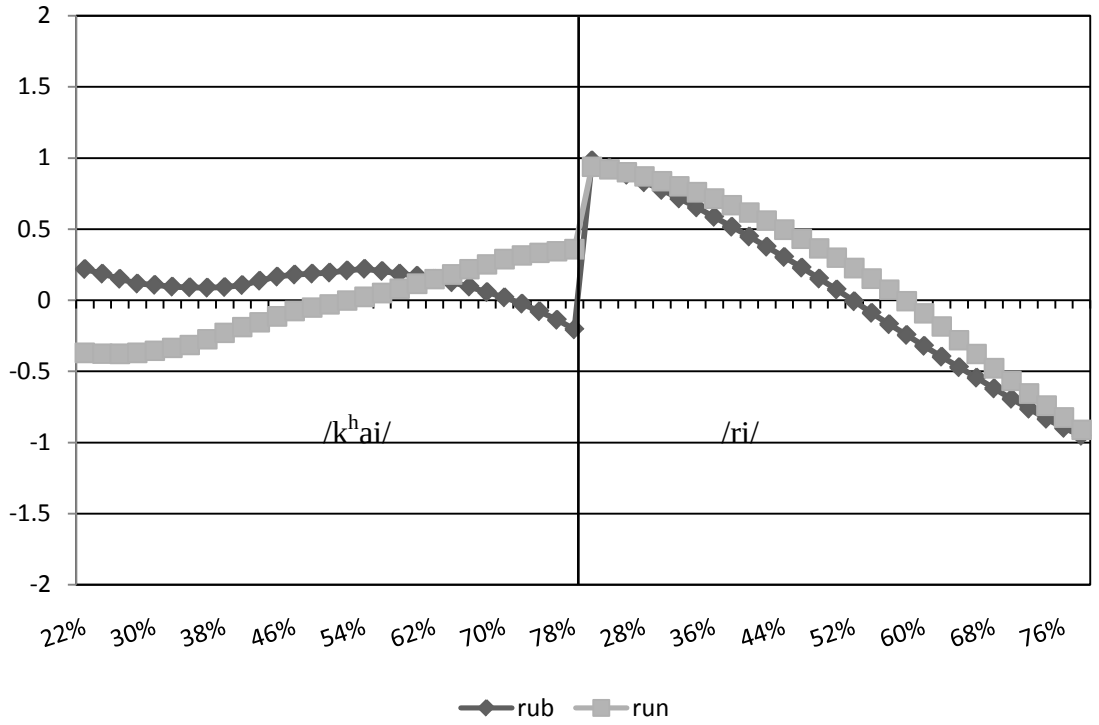


Figure 5-4. Pitch track of /kʰai/ syllables with causative –ri

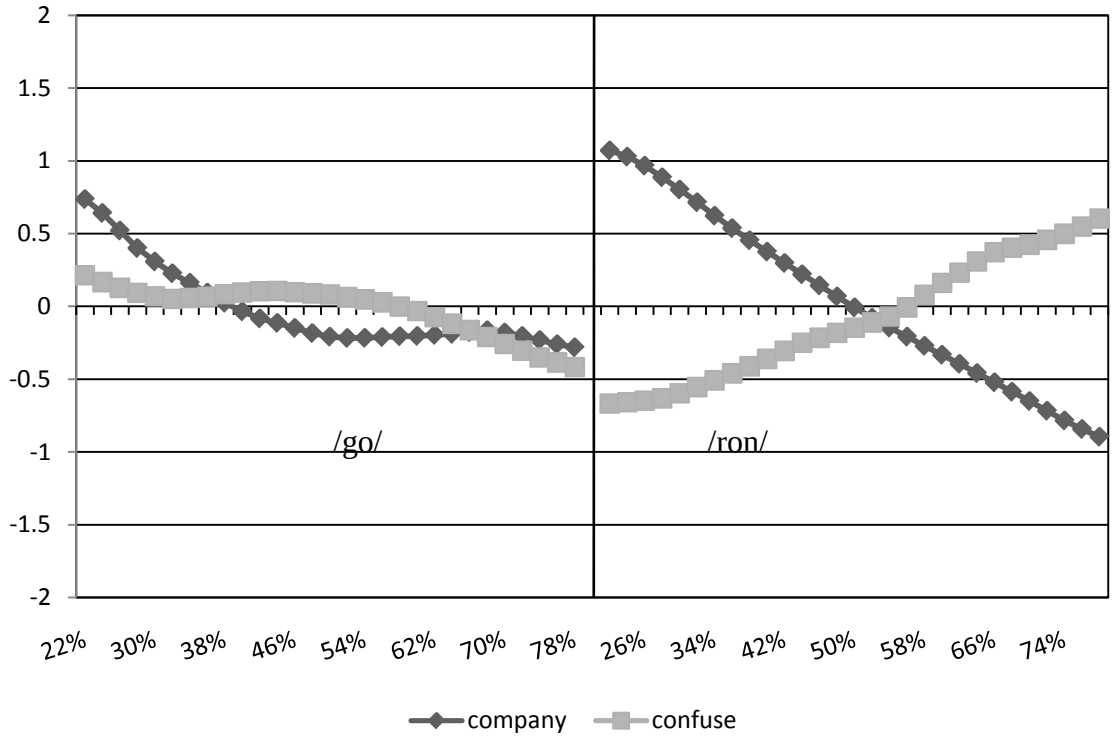


Figure 5-5. Averaged and normalized pitch track of /goron/ in underived condition produced by all speakers

In the case of the second syllable /ron/, the difference in mean F0d for the two words is statistically significant (Bonferroni adjusted p <0.003). As far as the suffix /ri/ is concerned it does not demonstrated any significant difference in terms of mean F0d for the two words (Bonferroni adjusted p > 0.003). These results demonstrate that for the two representations of the /goron/ syllables, despite being associated with a suffix, the underlying tonal specification of the two words are retained. Hence, it can be concluded from the above discussion that the *–ri* causative suffix in Dimasa is underlyingly assigned a falling tone. In cases where the *–ri* suffix is associated with a root, the underlying tonal representation of the root is retained. This phenomenon is quite similar to the *–ho* type of causative suffixes in Bodo as seen in Sarmah (2004) where *–ho* is underlyingly specified with a low (falling) tone.

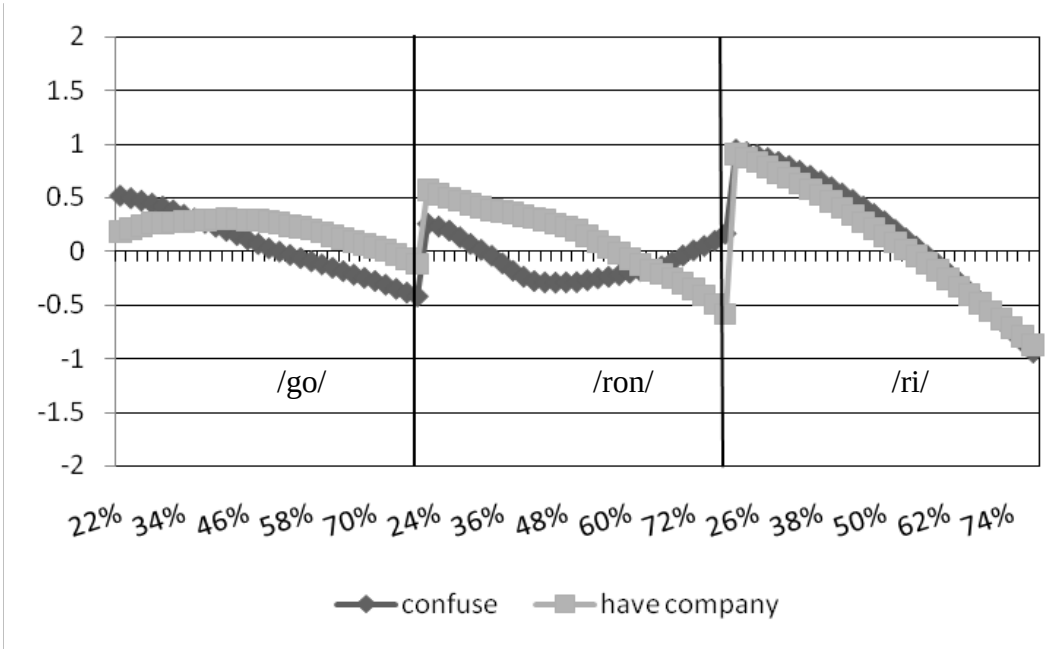


Figure 5-6. Averaged and normalized /goron/ set of syllables with the suffix *–ri* as produced by all speakers

Table 5-1. Bonferroni test for F0d of the three syllables

Groups	Difference	Statistic	Prob > Value
/go/	-3.813	2.161	0.037
/ron/	5.566	3.207	0.003
/ri/	-8.573	1.983	0.054

Sarmah (2004) argues that the *–ho* in Bodo is derived from a lexical entry and hence operates as a causative clitic in the language. Later, confirming this argument, a native speaker of Bodo confirmed that /ho/ is a lexical entry in Bodo meaning 'give'.[18]

In the case of Dimasa, further inspection into the collected data from the Dimasa speakers revealed that the causative suffix *–ri* is also a lexical word meaning *'give'*. The pitch track of /ri/ 'give'clearly indicates a low falling contour (Figure 5-7,). Hence, it can be argued that the suffix *–ri* is a derived from the lexical word /ri/ for *'give'*.

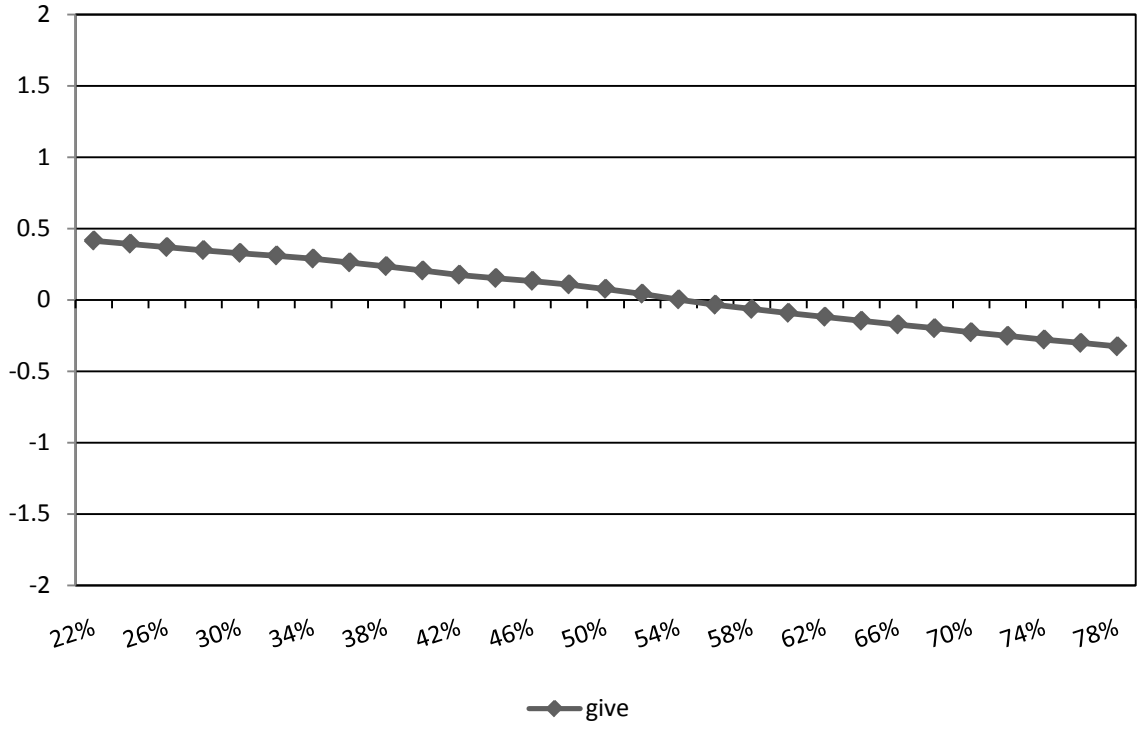


Figure 5-7. Pitch track of /ri/ 'give'

The *–rao* Suffix

The *–rao* suffix in Dimasa is a plural marking suffix. It can be assigned to a variety of nouns with a [+human] property to pluralize as in Example 5-8 and Example 5-9. In Example 5-8 the *–rao* suffix is assigned to the word for father and in Example 5-9 it is assigned to 'male'.

[18] This fact emerged from a native speaker of Bodo in a question-answer session after Prof. Robbins Burling's presentation at NEILS 2 held in Guwahati in February, 2007.

babà + raò → babàraò (5-8)
'father' +*pl.* → 'fathers'

miyā + raò → miyāraò (5-9)
'male'+ *pl.* → 'males'

As this suffix is associated with a noun with restrictive conditions, in this study only a few instances of words inflected with the –*rao* suffix were found. In the following discussion, the –*rao* suffix affixed with two disyllabic entries are specifically discussed.

The pitch tracks of the uninflected disyllabic entry /baba/ 'father' (Figure 5-8) shows that the initial syllable of the /baba/ disyllable is associated with a mid-level tone and the final syllable is associated with a falling tone. As discussed in Chapter 4, in Dimasa, the pitch on the second syllable of a disyllabic entry provides the cue for categorization of the disyllabic word into a tonal category. In other words, in Dimasa the tone on the initial syllable of a disyllabic entry is always a mid-level tone, however the second syllables are assigned contrastive tones for association of a disyllabic entry with a meaning.

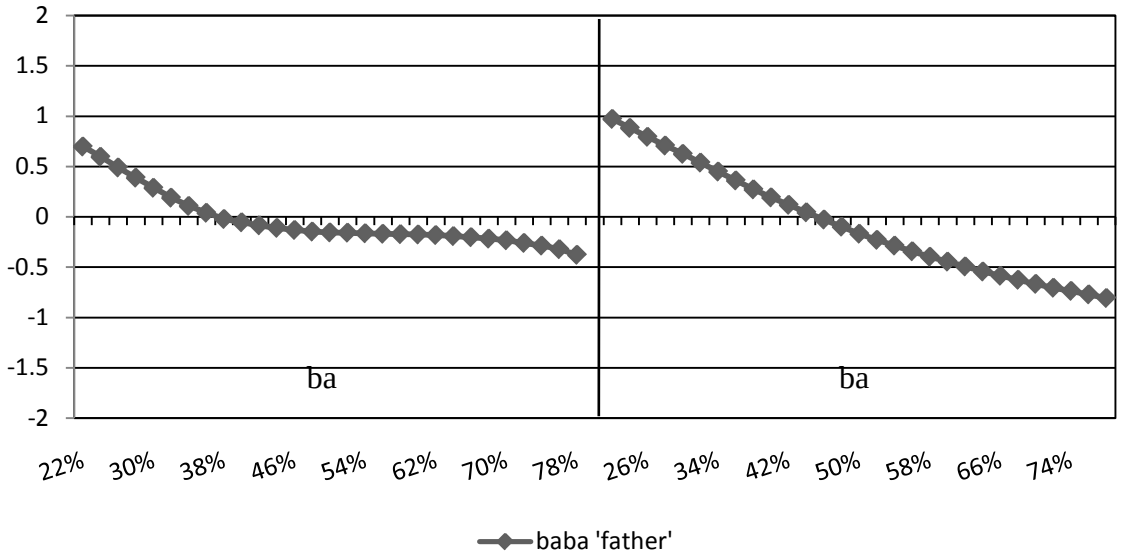


Figure 5-8. Normalized pitch track of /baba/ 'father' produced in uninflected condition

The –*rao* suffix is associated with the disyllabic entry /baba/ and tested for changes in the tones of the disyllabic entry. It is noticed that (Figure 5-9), the inherent tonal specification of the /baba/ syllables (meaning ‘father’) does not change with the addition of the plural suffix –*rao*.

Similarly in the pitch track of the uninflected disyllable /miya/ ‘male’ in the initial syllable is assigned a mid-level tone and the final syllable is assigned a rising tone (Figure 5-10). The initial mid-level tone is the default tone that is assigned to any initial syllable of Dimasa disyllables. However, the rising tone assigned on the second syllable is the phonemically assigned tone that conveys the semantics of the disyllable to a Dimasa speaker.

A comparison of the pitch tracks of the two different /miya/ syllables makes the claims further apparent. The pitch track of the initial syllables in both cases does not seem to be significantly different. These pitch tracks are indicators of mid-level tone. However, in case of the second syllables, the pitch track of ‘male’ indicates a rising tonal category (Figure 5-10) whereas, the pitch tracks for ‘yesterday’ clearly demonstrates a falling tone contour (Figure 5-11).

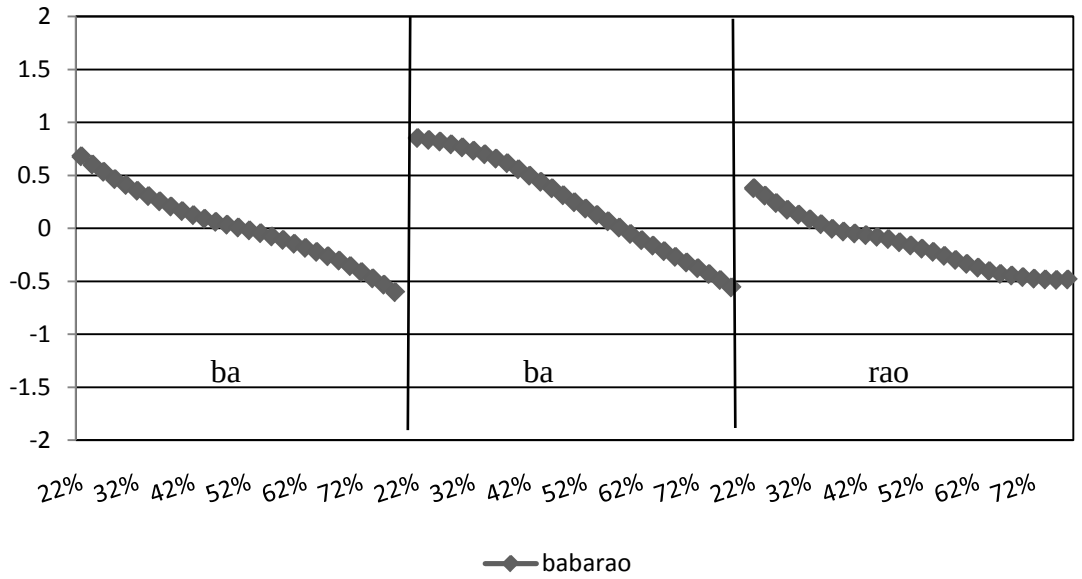


Figure 5-9. Normalized pith track of /baba/ affixed with plural marker –rao

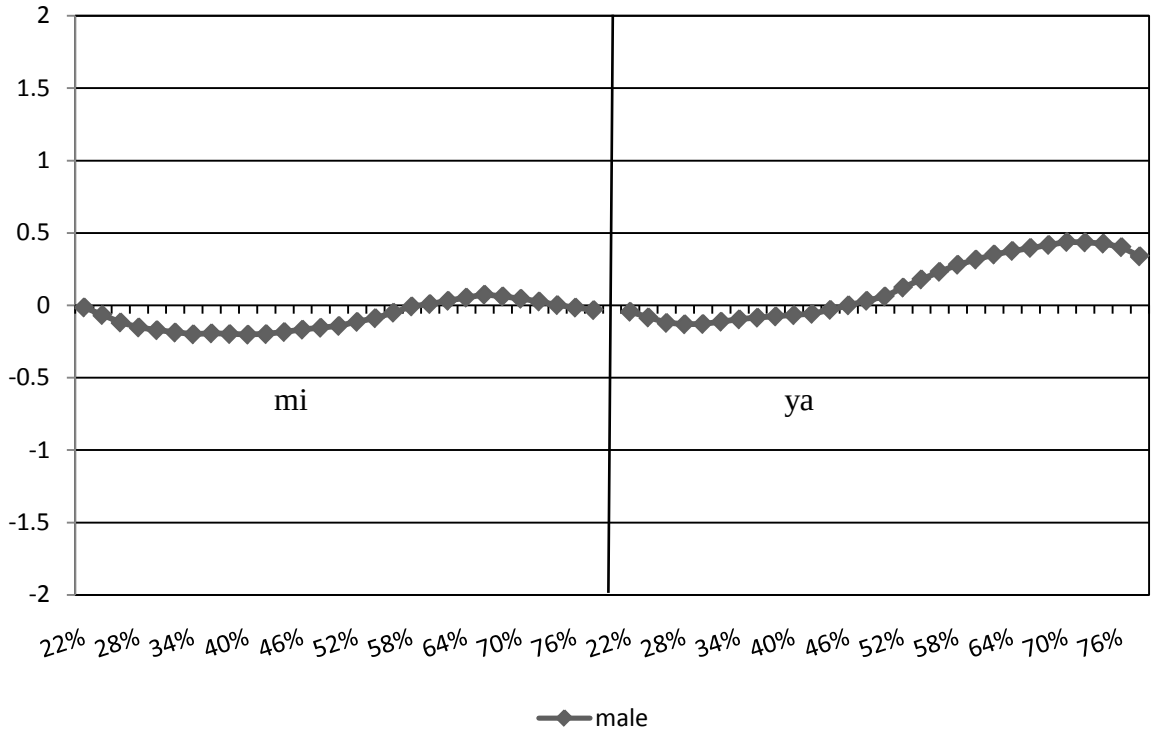


Figure 5-10. Normalized pitch track of /miya/ ‘male’ disyllable in uninflected environment

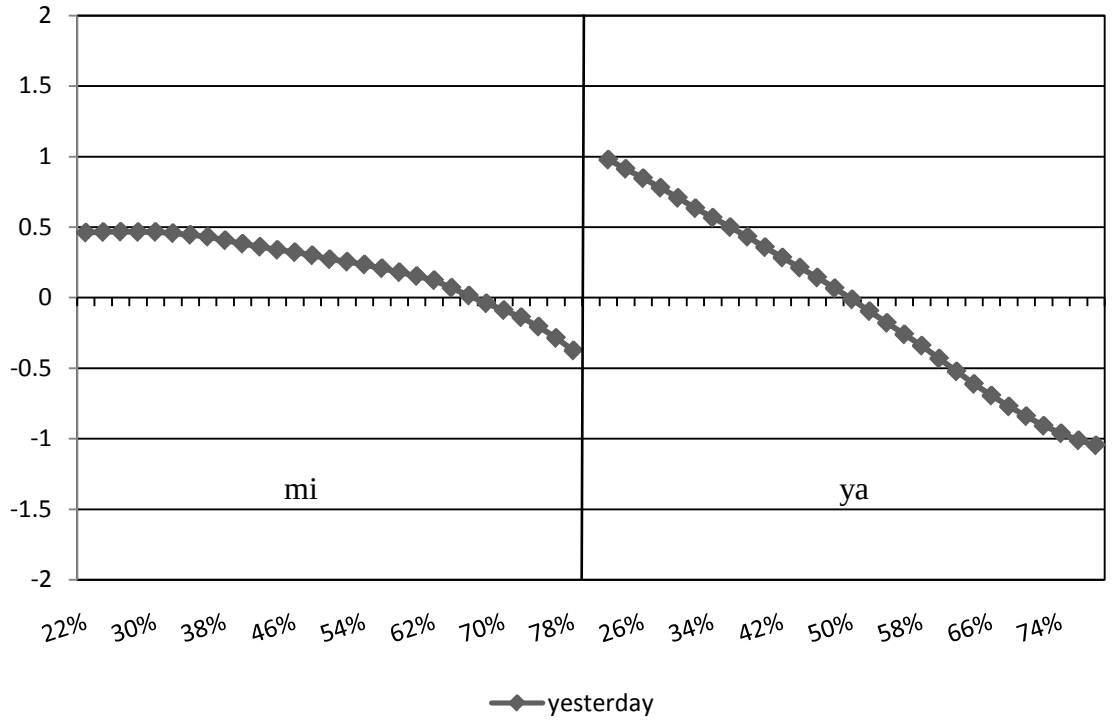


Figure 5-11. Normalized pitch track of /miya/ ‘yesterday’ in uninflected environment

In case of /miya/ ‘male’ is affixed with the plural marker –rao (Figure 5-12). The initial syllable of the inflected word /miyarao/ is assigned mid-level tone. The second syllable is assigned a rising tone, whereas the suffix –rao is assigned a falling tone.

From the discussion above, it is clear that the plural suffix *–rao* in Dimasa has its own underlying tonal specification and in cases where it is associated with a root, the tonal specification of the root is not altered. Hence, in case of Dimasa plural markers, it can be assumed that they operate as separate lexical items with underlying lexical tones associated with them.

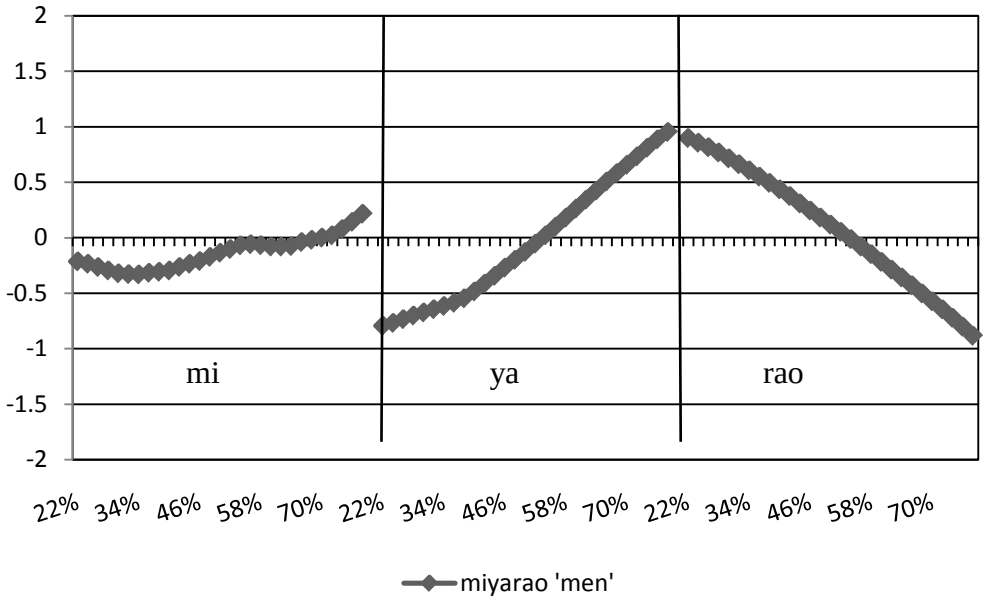


Figure 5-12. Normalized pitch track of /miya/ ‘male’ assigned plural suffix *-rao*

Reduplication

Dimasa uses reduplication for a variety of purposes. Dimasa reduplication may occur in order to emphasize, pluralize and adverbialize specific lexical items. For example in Example 5-10 and Example 5-11 reduplication is used to emphasize a lexical item in Dimasa.[19]

[19] In the examples of reduplications here, it is not clear whether it is a rightward reduplication or a leftward reduplication. However, considering the fact that Dimasa prefers suffixation, it is assumed that the syllables on the right are the reduplicated forms.

k^hase	+	k^hase →	k^hasek^hase	(5-10)
'small'		'small'	'small' (*emph.*)	

In the example below reduplication is used to pluralize a noun in Dimasa:

nolái	+	nolái →	nolái-nolái	(5-11)
village		*village*	*villages*	

Example 5-12 shows formation of adverbs from adjectives by means of reduplication in Dimasa:

rabá	+	rabá →	rabárabá	(5-12)
slight		*slight*	*slightly*	

In order to test the reduplications, in this study initially Dimasa words in their non-reduplicated forms are analyzed first. Later, the speakers were asked to produce the corresponding reduplicated forms in a sentence frame that was used with monosyllables and disyllables. In the sections below, we analyze the reduplication of the words /k^hase/.

The pitch track of /k^hase/ 'small' (Figure 5-13) produced by Dimasa speakers demonstrates that even though the initial syllable demonstrates a falling contour, it can be considered as a phonetic variation of the mid-level tone in Dimasa. In Chapter 3, it has been shown that in Dimasa the aspirated onsets tends to affect the following pitch contour resulting in a falling contour for level tones and high level contour for rising tones.

The second syllable is assigned the phonemic falling tone of the Dimasa language (Figure 5-13). Hence the tonal representation on the word /k^hase/ for 'small' is /kha^{M}se^F/ where the mid tone on the initial syllable is the default tone that is assigned to any initial syllable of a Dimasa disyllabic entry. The falling tone on the second syllable is lexical tone that was underlyingly specified with the word /k^hase/ for 'small'.

The pitch tracks of the /k^hasek^hase/ 'slowly' (Figure 5-14), the reduplicated form of /k^hase/ is shows that the initial three syllables of the reduplicated /k^hase/ is assigned the mid-level tone of Dimasa, whereas the final syllable is assigned a lexical falling tone. In other words, in the

reduplicated form, only the final syllable is allowed a lexical tone, whereas the initial three syllables are assigned the default mid tone. This is a tone assignment pattern noticed in Bodo where only the rightmost syllable is allowed a lexical tone.

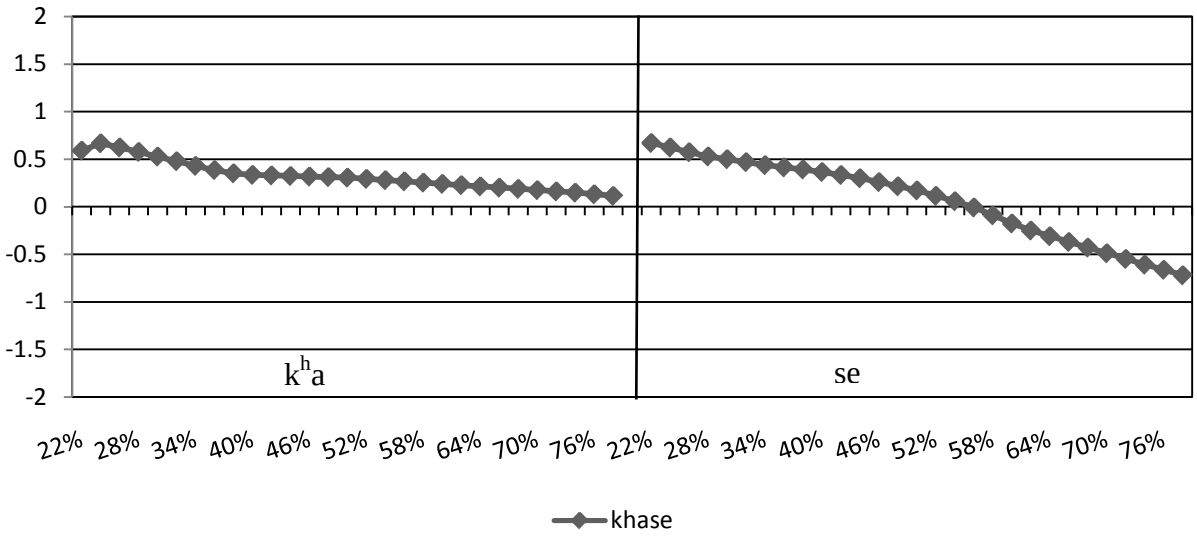


Figure 5-13. Pitch track of /kʰase/ ‘small’ produced individually in a sentence frame

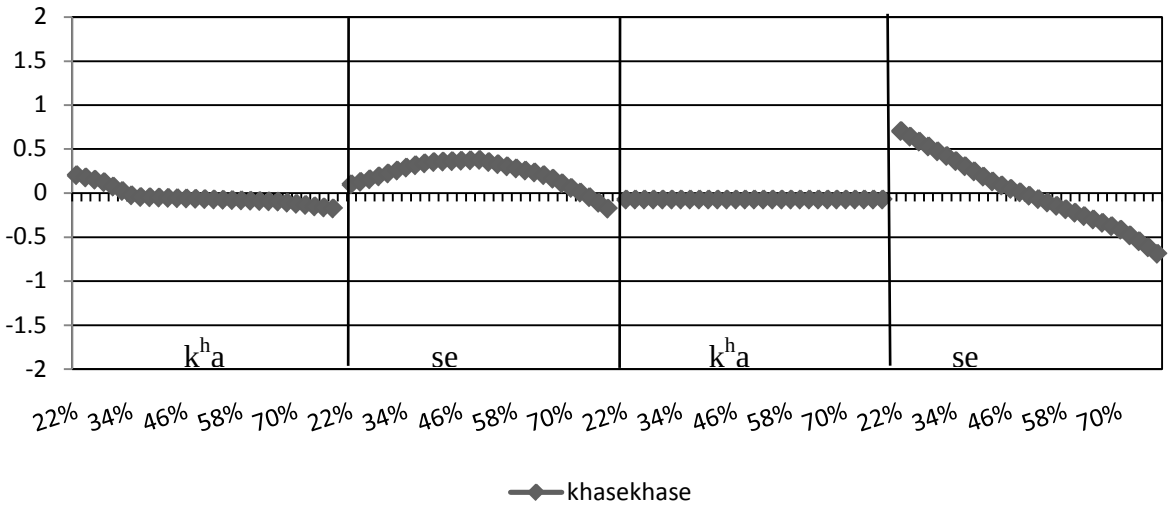


Figure 5-14. Pitch track of reduplicated /kʰase/

From the discussion above, it can be concluded that in Dimasa reduplication, the tonal specification of the constituent of the reduplicated form is retained only on the final or the rightmost syllable of the reduplicated form. The preceding syllables are specified with a default

mid-level tone. This implies that Dimasa, like many other Tibeto-Burman languages of North East India, is a word-tone language where only one lexical tone is assigned per word.

Rabha

The Bodo-Garo languages have shown interesting tonal transfer phenomena in derived polysyllables (Bhattacharya 1977, Sarmah 2004). Hence, in this study Rabha underived words were used with suffixes to see if there is any change in the stem of the derived word after a suffix has been added. As mentioned in Chapter 1 Rabha has a wide variety of suffixes but a limited number of prefixes.The Rabha suffixes discussed in this chapter are three nominalizers namely, -*kai*, -*brok* and –*dam.* They are used to nominalize Rabha verbs as shown in Example 5-13 to Example 5-15.[20]

rèng +	kaì	→	rengkaì		(5-13)
'to go'	*nom.*	→	'the act of going'		
prí +	brók	→	pribrók		(5-14)
'to buy'	*nom.*	→	'buyer'		
phár +	dám	→	phardám		(5-15)
'to sell'	*nom.*	→	'shop'		

The –*kai* Suffix

The –*kai* suffix is used in Rabha to nominalize verbs. In this study nominalization of the verbs /reng/ 'to go', /rung/ 'to drink', /si/ 'to die', /tan/ 'to cut' and /tong/ 'to stay' is investigated. A set of tonally distinct roots were selected for this test.The pitch track of the underived verb /reng/ is assigned a falling tone in Rabha (Figure 5-15). Similarly, the pitch track of the underived verb /rung/ shows a rising tone associated with the syllable in Rabha (Figure 5-16). These two verbs are nominalized and the tone assignment pattern in their nominalized forms is examines (Figure 5-17 and Figure 5-18).

[20] The accented tone markings here are following tone marking convention of Basumatary (2004)

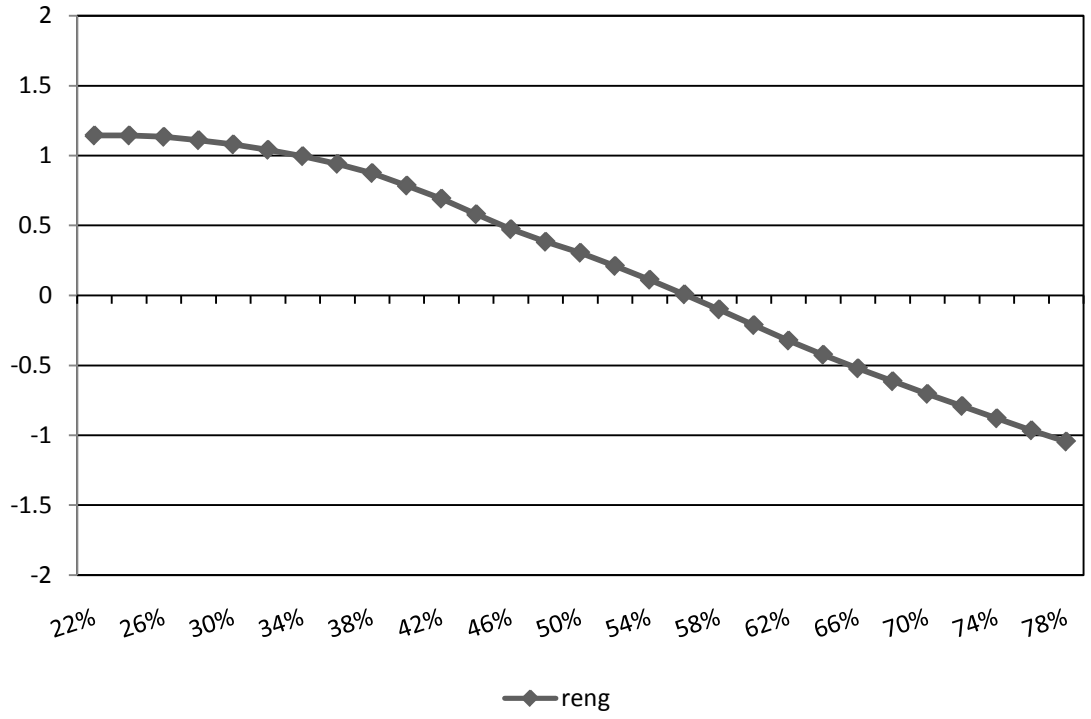


Figure 5-15. Pitch track of /reng/

The pitch track of the derived form of the verb /reng/ shows that the root /reng/ loses its tonal specification and becomes almost a level tone that is found in Rabha (Figure 5-17). However, the suffix *kai* is underlyingly assigned a falling tone that is retained in the derived form of the word /reng/.

Similarly, the pitch track of derivation of /rung/ is shows that as with /reng/, when attached to the nominalizing suffix *kai*, /rung/ loses its underlying tonal representation and is assigned a mid-level tone (Figure 5-18). However, the suffix *kai* retains its underlying falling tone as with the suffix *kai* in the nominal derivation of /reng/.

Similar to these two examples, it is noticed that /tongkai/ derived from /tong/ with a falling tone also follows a similar pattern (Figure 5-19). The root /tong/ in the derived form loses its tonal specification (falling) and is assigned a level tone and the suffix *kai* retains a falling tone. Even though the –*kai* suffix neutralizes the tone of the root and retains its tonal specification.

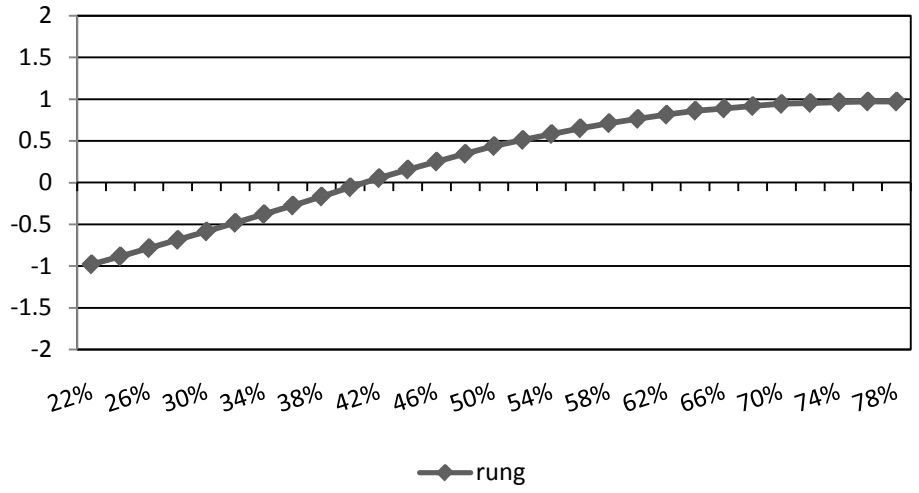


Figure 5-16. Pitch track of /rung/

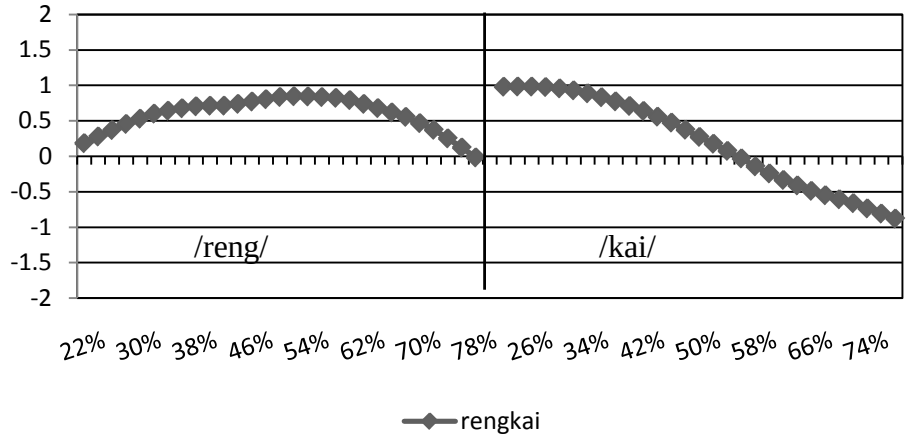


Figure 5-17. Pitch track of derived /rengkai/

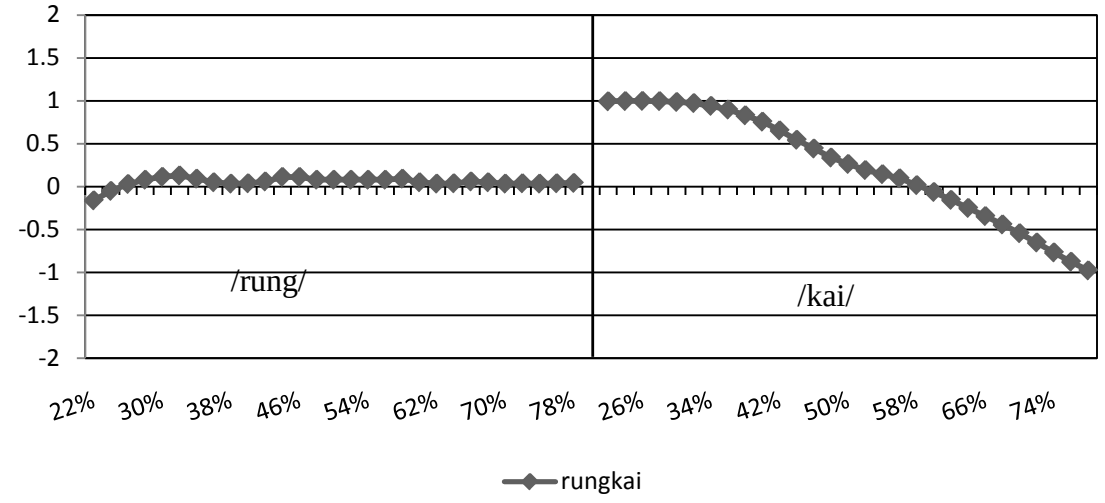


Figure 5-18. Pitch track of derived /rungkai/

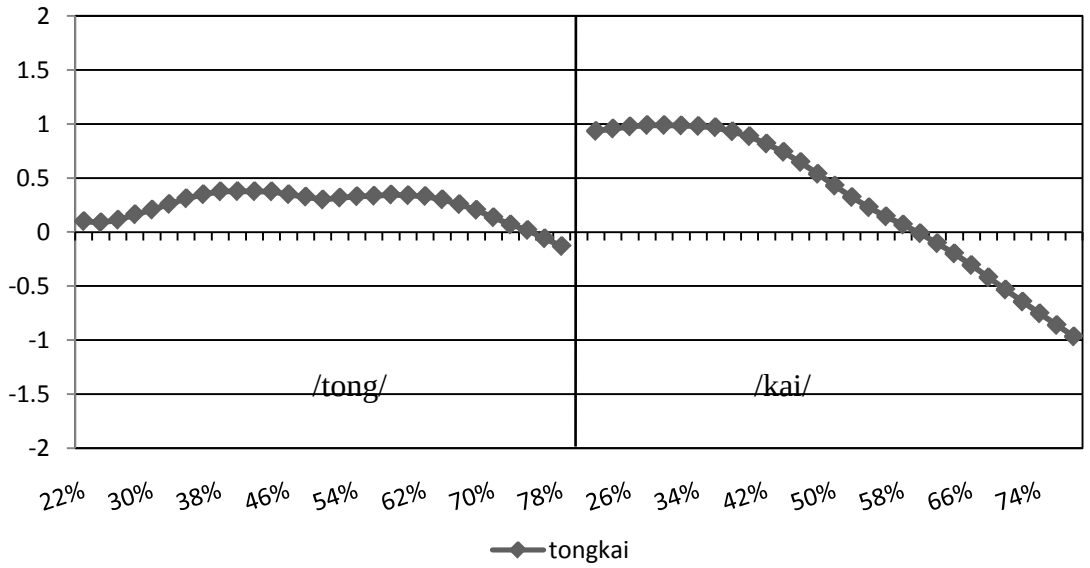


Figure 5-19. Pitch track of derived /tongkai/

Hence, from the examples above it can be concluded that suffixation with the nominal suffix –*kai* makes the roots lose their underlying tonal specifications and they are assigned a mid-level tone which is the default tone in Rabha. However, the suffix *kai* is inherently specified a falling tone and in nominal derivations the inherent tonal specification of the suffix is retained.

The –*dam* Suffix

Rabha uses the –*dam* suffix to nominalize both verbs and nouns. For example, *dam* is used as a suffix with the verb /p^{h}ar/ 'to sell' to make the verb a nominal /p^{h}ardam/ meaning shop. At the same time, *dam* can be used with the noun /par/ 'flower' to become /pardam/ meaning 'garden'. In this study the nominalization in /bar/ 'fire', /par/ 'flower', /k^{h}ar/ 'to work', /p^{h}ar/ 'to sell' and /trung/ 'to learn' are investigated.

The pitch track of underived /p^{h}ar/ is shows that the lexical item is assigned a rising tone (Figure 5-20). However, in the derived condition /p^{h}ardam/, the tonal specification of a rising tone in /p^{h}ar/ is lost (Figure 5-21) and it is assigned a mid-level tone; whereas, the suffix *dam* is assigned a rising tone.

Similarly, the verb /trung/ is assigned a falling tone (Figure 5-22). However, when attached to the suffix *dam* (Figure 5-23), the underlying tonal specification of /trung/ is lost and it is assigned a level tone. The suffix *dam* as with the case of /phardam/, is assigned a rising tone.

Hence, as with the *kai* type of nominal suffixes, the *dam* suffixes also neutralize the tone of the stem and assign the stem with a default mid tone. However, the *dam* suffixes are inherently specified with a rising tone and they retain the rising tone in the derivation but the tone in the root is lost and the root is assigned a default mid-level tone.

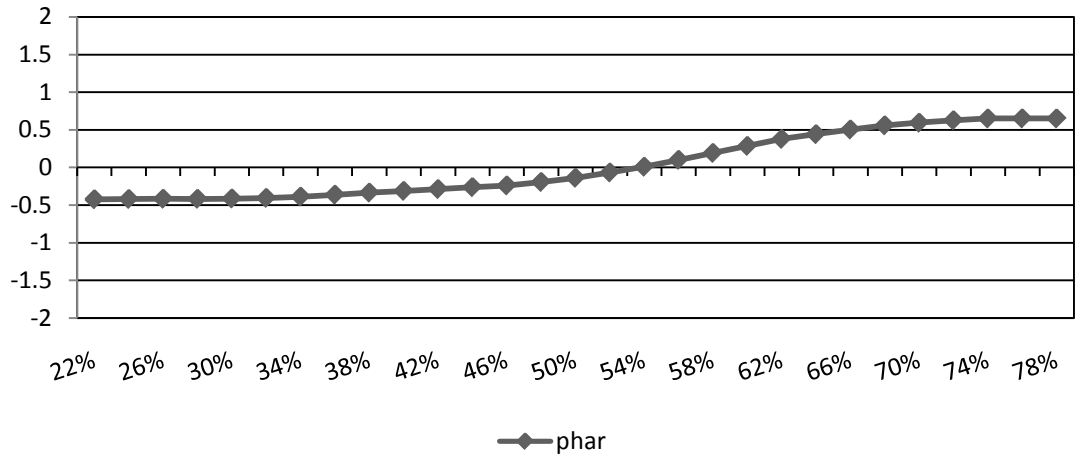


Figure 5-20. Pitch track of /phar/

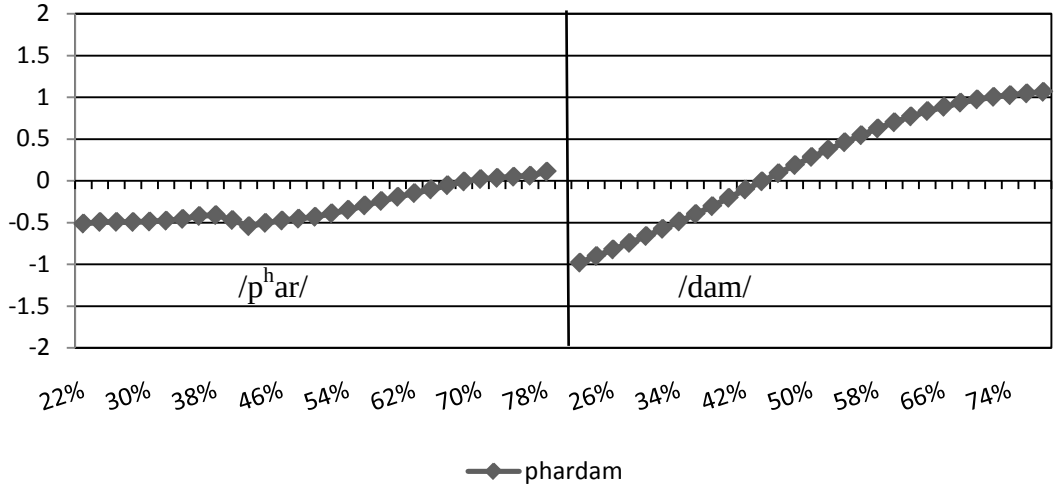


Figure 5-21. Pitch track of derived /phardam/

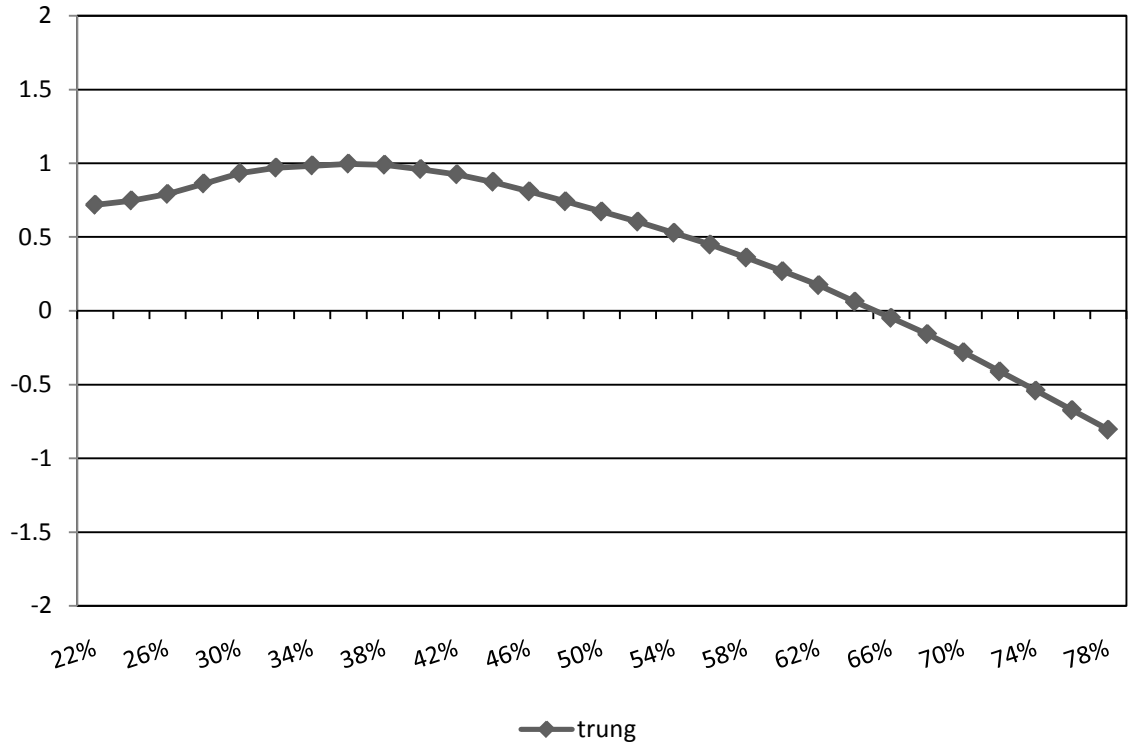


Figure 5-22. Pitch track of underived /trung/

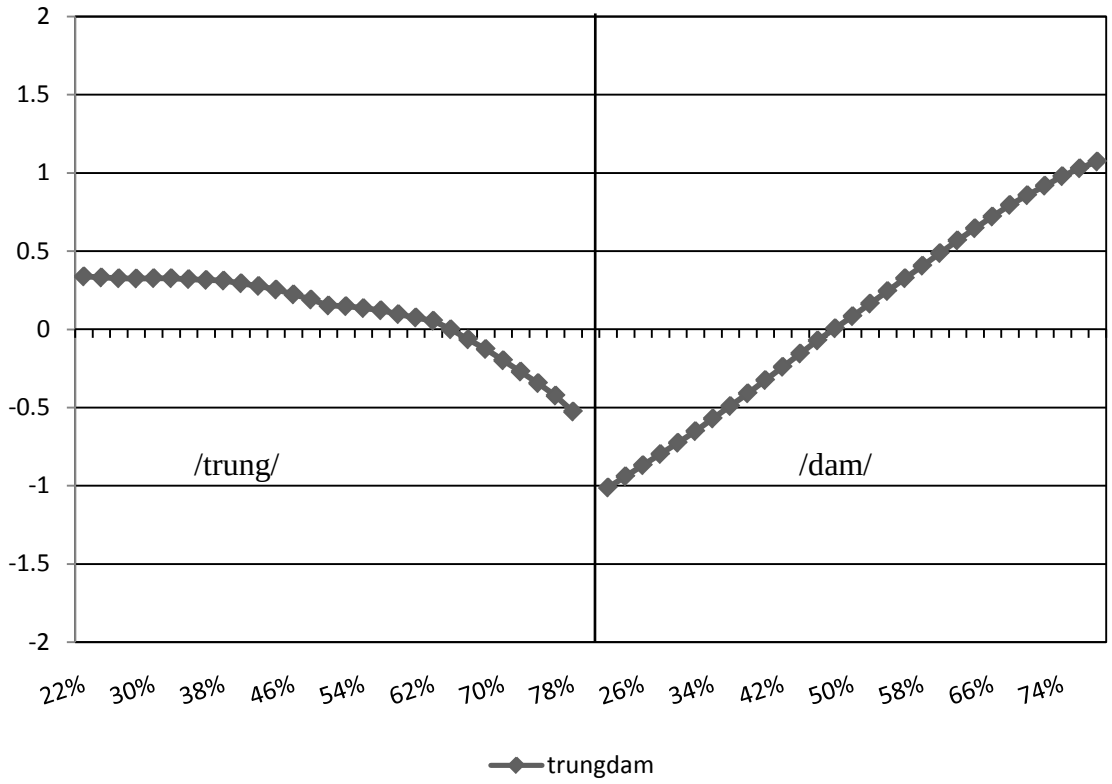


Figure 5-23. Pitch track of derived /trungdam/

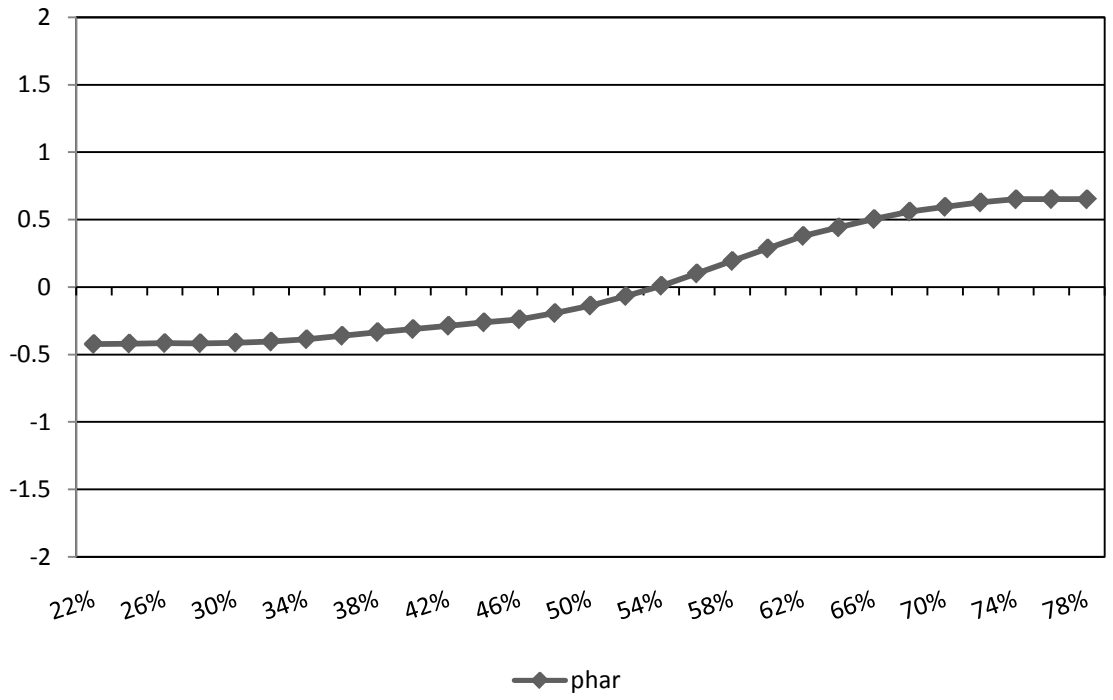


Figure 5-24. Pitch track of /phar/

The -brok Suffix

The –*brok* suffixes also nominalize a verb in Rabha. They can be used with a variety of Rabha verbs. In this study the -*brok* suffixes attached to the Rabha words /pri/ 'to buy', /sa/ 'to eat', /phar/ 'to sell' and /chi/ 'to see'.

The underived word /phar/ is associated with a rising tone in Rabha (Figure 5-24). However, when attached to the suffix –*brok*, the stem /phar/ is assigned a mid-level tone and the suffix *brok* is assigned a rising tone (Figure 5-25).

Simmilary in case of /chi/, in an underived position is assigned a falling tone (Figure 5-26). In other words, the underlyingly /chi/ is associated with a falling tone. However when suffixed by the suffix –*brok*,. /chi/ loses its underlying tonal specification. While –*brok* is assigned a rising tone, the root /chi/ is assigned a level tone (Figure 5-27). As in case of the –*dam* suffix, -*brok* also neutralizes the tone of the stem while retaining its own tonal specification.

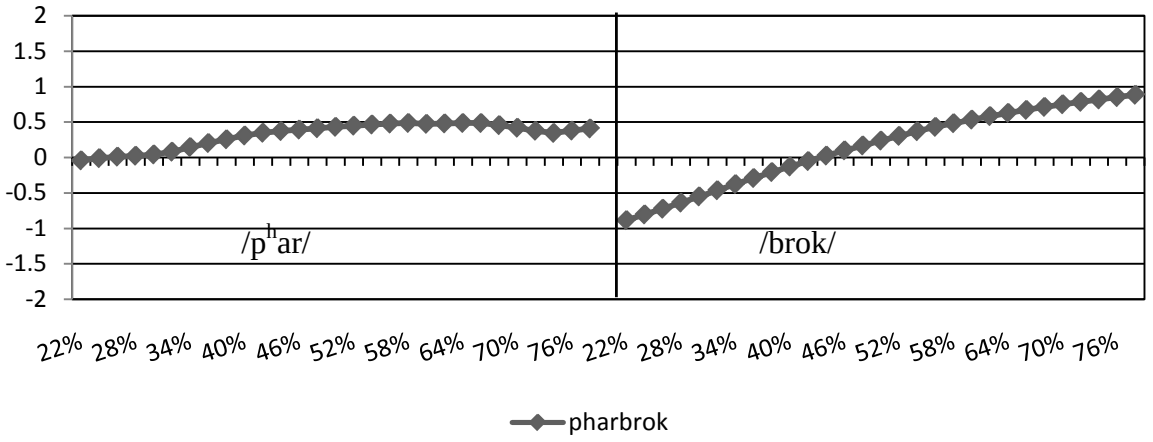


Figure 5-25. Pitch track of derived /pharbrok/

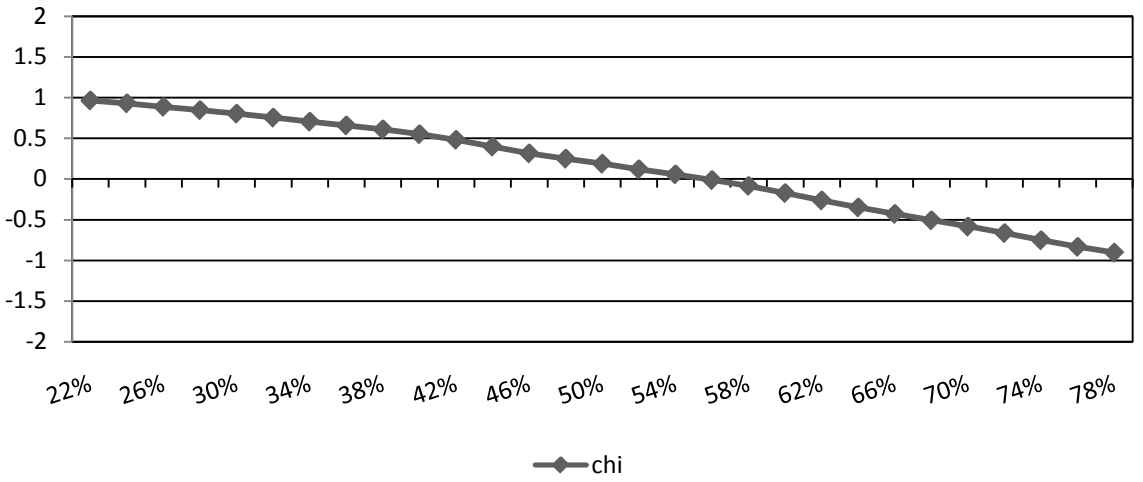


Figure 5-26. Pitch track of /chi/

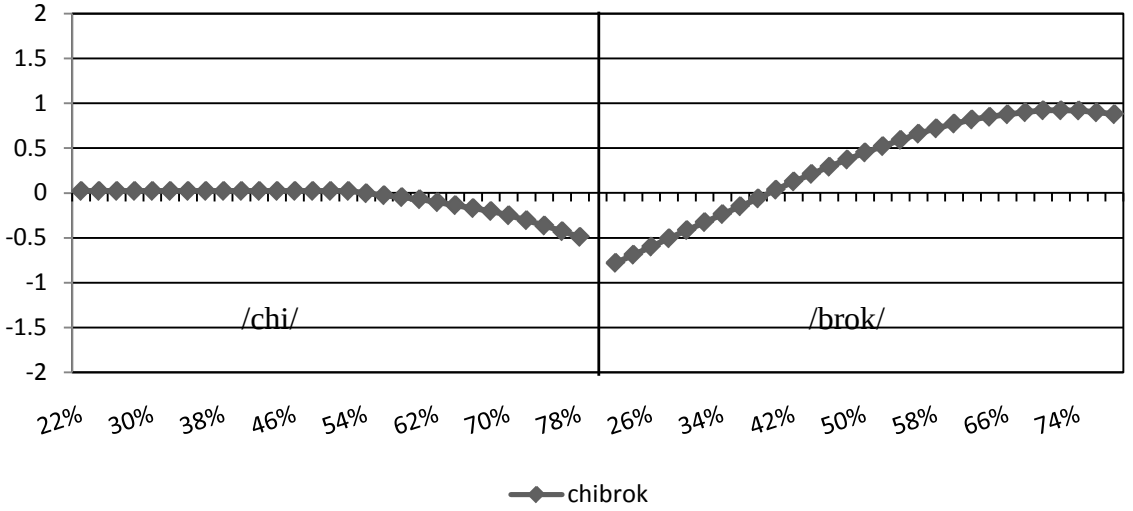


Figure 5-27. Pitch track of derived /chibrok/

Hence, from the above discussion it can be concluded that all nominal suffixes in Rabha are underlyingly specified with a lexical tone. When these suffixes are attached to a stem, the tonal specification of the stems is neutralized and the tonal specification of the suffix is retained. Among the suffixes that were examined in this study, none was underlyingly assigned a mid-level tone. However, that may be because of the small number of suffixes examined in this study. I accept this limitation as a gap in this study.

Discussion

This chapter demonstrates the tone assignment patterns in Dimasa and Rabha derived polysyllables. From the discussion above, it is evident that Dimasa suffixes in the discussion follow a tone assignment pattern as in the type III derivations in Bodo. In type III derivations of Bodo, the suffixes are underlyingly assigned a lexical tone. When the suffixes are affixed to a stem, the inherent tonal specification of the stem is still retained.

In Dimasa as in Bodo, every prosodic word is assigned one and only one lexical tone. Here the prosodic word is used in the sense of Selkirk (1980) and Peperkamp (1999) where prosodic words are defined as the domain of word stress, phonotactics and segmental word-level rules. Hence, in case of Dimasa suffixation it can be argued that both the stem and the suffix surface as two separate prosodic words thereby conforming to the phonological rule of Dimasa (and Bodo) that one prosodic word be assigned one lexical tone. The Dimasa tone assignment pattern can be explained with the template in Example 5-16.

```
   T          T
   |          |
[stem] . [suffix]
 prwd       prwd
```

(5-16)

However, in case of Dimasa reduplication, it is observed that reduplicated form follows the tone assignment pattern that is similar to the tone assignment pattern of Dimasa disyllables. The

reduplicated forms of words are assigned a lexical tone on the rightmost syllable. The preceding syllables are assigned a mid default tone. It can be concluded that Dimasa reduplicated polysyllables are considered a single prosodic word, which is the domain of tone assignment. Hence, only one lexical tone is assigned in this domain. This phenomenon can be demonstrated in the template in example 5-17.

$$\begin{array}{ccccc} T & & T & & T \\ | & & | & & | \\ [\sigma\ \sigma]_{prwd} & + & [\sigma\ \sigma]_{prwd} & \rightarrow & [\sigma\ \sigma\ \sigma\ \ \sigma]_{prwd} \end{array} \qquad (5\text{-}17)$$

On the other hand, the Rabha data discussed in the sections above demonstrate a distinct pattern of tone assignment. In case of Rabha, as in Dimasa the suffixes are underlyingly specified with a tone. However, unlike Dimasa the stems lose their underlying tonal specification in the derived form. In other words, in Rabha the derived polysyllables are treated as single prosodic words that conform to the phonological rule that each prosodic word is assigned only one lexical tone. At the same time, underlying lexical tones of Rabha suffixes are retained in the derived form. Hence, Rabha derived words show the morphological construction as shown in Example 5-18.

$$\begin{array}{cc} T^1 & T^2 \\ | & | \\ \text{stem} & \text{suffix} \end{array} \qquad \begin{array}{c} T^2 \\ | \\ [\text{stem + suffix}]_{prwd} \end{array} \qquad (5\text{-}18)$$

CHAPTER 6
OPTIMALITY THEORETICAL ACCOUNT OF DIMASA AND RABHA TONES

In this chapter, tone assignment in Rabha and Dimasa will be discussed from a theoretical perspective. Considering its functionality, an Optimality Theoretical (OT) analysis of the tonal phenomena in these languages is developed in this chapter. The optimality theoretical account proposed for the underived words in Dimasa and Rabha in this study are identical to each other. In case of derived polysyllables, similar constraints and their rankings are proposed for both Dimasa and Rabha. However, it was noticed that the two languages differ in their prosodic structures, where separate morphological accounts of prosodic structures act as a vital tool in making a unified optimality theoretical account functional. Even though OT allows assignment of prosodic structure from input to output distinctively for different languages, that approach is beyond the scope of the current study.

Optimality Theory

Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1993a, b) is a non-derivational model of Generative Grammar where the output results from the simultaneous application of constraints to the input. Two formal mechanisms in Optimality Theory, GEN and EVAL, mediate the relationship between inputs and outputs. GEN assigns possible structure to the input, and EVAL applies the constraint hierarchy to select the best candidate among those created by GEN. The grammar of a specific language ranks the constraints, which belong to universal grammar. The variation among different languages is addressed by re-ranking the universal constraints. Unlike earlier theories that assumed variations across languages to be the result of parametric selection of rules or constraints, Optimality Theory asserts that all constraints are present in all languages, the only difference being in the ranking of the constraints.

Optimality theory has a set of constraints called the Faithfulness Constraints, which preserve the input forms. To preserve different aspects of the input form, OT has different types of Faithfulness Constraints. However, the strength of the desire to preserve the input form varies from language to language. That variation can be taken care of by the ranking of the Faithfulness Constraints relative to other constraints in the language. On the other hand the existence of the Markedness Constraints depends on cross-linguistic evidence to avoid specific features or structures. These constraints account for segmental inventories, syllable structures and phonological alternations, in short, any aspect of linguistic phenomena, be it phonological, morphological or syntactic. The Faithfulness Constraints make sure that the specification of the input is preserved in the output, whereas Markedness Constraints try to select a candidate that decreases the markedness of the representation. Constraint ranking chooses the best candidate among many possible outputs. OT evaluates an infinite set of candidate output forms generated by GEN on an input. The winning candidate is the optimal one as it incurs least serious violations among a set of ranked constraints. The constraint hierarchy in this case is $C_1 >> C_2$: where C_1 is a higher-ranked constraint than C_2.

Table 6-1. Ranking of constraints in optimality theory

/INPUT/	C_1	C_2
a. ☞*candidate a*		*
b. *candidate b*	*!	

* = violation, ! = fatal violation, ☞= the most suitable candidate, shaded cells no longer matter because a higher ranked constraint has made the decision

The outputs can be listed vertically in any order while the constraints are listed horizontally. In Table 6-1, candidate a and candidate b are two possibilities (among the infinite set) generated by GEN. A solid line separates the constraints C1 and C2 indicating strict domination. Candidate a satisfies constraint C_1 but violates constraint C_2 (indicated by a '*').

However Candidate b violates constraint C_1 and it satisfies constraint C_2. Nevertheless, the violation or satisfaction of constraint C_2 does not matter anymore, as C_2 is a lower ranked constraint; moreover the higher ranked constraint C_1 has already made the choice clear. The constraint hierarchy assumes that the violation of C_1 is much more serious (indicated by '*!') than the violation of C_2. The violation of C_2 is irrelevant if C_1 is violated. Hence Candidate B cannot emerge as a suitable output (as it violates constraint C_1). Therefore Candidate A emerges as the optimal output as indicated by a '☞' (even though it may violate C_2).

Optimality Theoretical Account of Tones

Yip (2002) is an attempt at an OT analysis of tonal phonology. She proposes a few constraints pertaining to tone that are primarily based on the already existing constraints for segments. She lists a few modifications of the well-formedness conditions for tones proposed by Goldsmith (1976):

- Tones are usually associated with syllables, but not always
- Syllables are usually associated with tones, but not always
- Association is preferably one-to-one, but not always
- Tone (especially H tone) is attracted to prominent positions (beginnings of things, edges, accented or stressed syllables) but not always. All these can be true in some but not all languages. Each of these can be stated as a violable markedness constraint. They are expressed by Yip (2002) as follows:

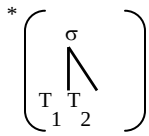
- ***Float**: A tone must be associated with a Tone Bearing Unit (TBU). This constraint makes sure that an output like the following is not selected where tone T^3 is not associated with a TBU:

$$^{*}\begin{pmatrix} \sigma & \sigma & \\ | & | & \\ T^1 & T^2 & T^3 \end{pmatrix}$$

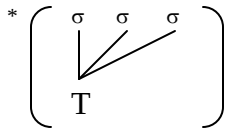
- **Specify T**: A TBU must be associated with a tone. This constraint rejects an output like the following, as the second syllable is not specified with a tone:

$$^{*}\begin{pmatrix} \sigma & \sigma & \sigma \\ | & & | \\ T^1 & & T^2 \end{pmatrix}$$

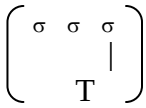
- **NoContour**: A TBU may be associated with at most one tone. This constraint rejects an output where a TBU is associated with more than one tone:



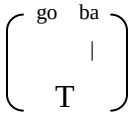
- NOLONG T: A tone may be associated with at most one TBU. Hence an output like the one shown below is to be avoided:



- **Align-Tone**: Align the specified edge (L/R) of a tone span with the head or edge (L/R) of a prosodic or morphological unit. For example, this constraint prefers the rightmost syllable of a word to be associated with a tone. It would prefer only the following structure:



- In non-derived lexical items Bodo prefers this structure as the tone is linked to the rightmost syllable:



Apart from these markedness constraints there are some general faithfulness constraints that preserve underlying contrasts of tone quality and placement as described in Yip (2002):

- **Dep-T**: No insertion of tones. This constraint restricts the insertion of a new tone in the output form. If a new tone is inserted then the output is considered to be violating this constraint.

- **Max-T**: No deletion of tones. This constraint prevents the deletion of a tone present in input.

- ***Associate**: No new association lines. This constraint restricts a tone from attaching to a new TBU in the output. It makes tones stay in their original position.

- ***Disassociation**: No removal of association lines. This constraint makes sure that a tone association stays in its original position. It prevents a tone from disassociating with the TBU it is associated with in input.

- **NoFusion**: Separate underlying tones must stay separate. Hence, two or more tones cannot come together and be attached to a single TBU.

- **Ident-T**: Correspondent tones are the same. The correspondence of tones in the output is as it is in the input. This constraint makes sure that the type of tone in the input cannot be changed in the output. For example, Ident-T makes sure that a L(ow) tone in the input does not change to a H(igh) tone in the output.

- **Linearity**: Preserve underlying linear order. The order in which tones occur in the output is the same as it is in the input. Yip attempts to capture Goldsmith's observations about the preference for contours and plateaux at the right edge of the word. Goldsmith calls it left-to-right association. In OT Yip captures Goldsmith's observation with the help of alignment constraints like the ones shown below:

- **Align-L**: Each T should align with the left edge of the domain (gradiently assessed). This constraint prevents a tone from occurring anywhere except the left edge of the word so that an output like

```
( σ  σ  σ )                                  *( σ  σ  σ )
( |       )   is preferred, not                ( |       )
( T       )                                    ( T       )
```

- ALIGN-R CONTOUR: Contour tones should align with the right edge of the domain. Therefore in Mende :

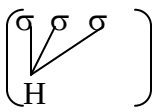
```
( nyà hâ )                    *( nyâ  hà )
( |   |\ )  is possible, but    ( /\    | )   is not possible.
( T   T T )                    ( T T   T )
```

According to Yip, tone is also subject to more general phonological conditions such as the Obligatory Contour Principle (OCP), locality, and markedness constraints:

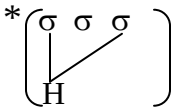
- **OCP**: Adjacent identical elements are prohibited. Leben (1973) proposed the Obligatory Contour Principle (OCP), which says that words with sequences of high toned syllables must be represented as in (a), not as in (b):

```
a.( σ  σ  σ )          NOT          * b.( σ  σ  σ )
  ( |/      )                            ( |  |  | )
  ( H       )                            ( H  H  H )
```

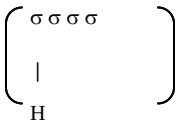
- **NoGap**: Multiply linked tones cannot skip TBUs. A set of TBUs, which are linked by only one tone cannot leave a TBU in the middle unspecified with a tone. Hence,



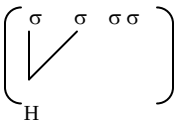
is possible, but not



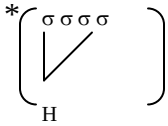
- **LOCAL**: Spread only to the adjacent items. When an association changes the new association line is formed associating the adjacent item. Hence, for the input



the output can be



and not



- **General markedness**: *R, *F>>*M. This constraint shows there is a preference for mid tones over rising and falling tones in the languages in the current analysis. The rising and the falling tones are more marked than the mid tone.

It is worth mentioning again that in OT all the constraints are universal and present in the grammars of all languages. If a constraint is very low ranked it is assumed that its effects are not visible and hence will not be discussed. Nevertheless it is to be assumed that the constraints exist in all languages even if their effects are not seen in some languages.

Tones in Dimasa and Rabha

In this section an Optimality Theoretical account of Dimasa and Rabha tones is proposed assuming the facts from Chapter 3 through 5 on tone assignment in the two languages in monosyllables, disyllables and morphological derivations.

Lexical Tone Inventory in Dimasa and Rabha

In Chapter 3 and Chapter 4 it has been argued that every non-derived lexical entry in Rabha and Dimasa must be specified with one of the three lexical tones namely, rising (R), mid-level (M) and falling (F), in the two languages. Goldsmith (1976), Yip (1991) and many subsequent studies have proposed that contour tones in languages are necessarily combinations of level tones, viz. high and low tones. One of the primary reasons behind this claim is the observation that in tone shifts or tone spreading only the level part of a contour tone is spread. This may be well founded in some languages; however, in the Bodo group of languages, for

example in Bodo, it has been noticed that the contour tone can shift in its entirety to local tonal domain (Sarmah, 2004). For example, in Bodo when the underived word nōng^{M}thang^{+H} is assigned a high rising contour on the rightmost syllable, the initial syllable is assigned a mid-default tone (Figure 6-1).[21] However, when the word nōng^{M}thang^{+R} is associated with a plural suffix *–mon*, the rising tone is shifts to the plural suffix in its entirety and preceding syllables are assigned mid-default tones (Figure 6-2). According to Bodo morphophonemics, the plural suffix is not underlyingly associated with any tone, and in the surface form it is associated with the lexical tone of the stem. Note that in this case the entire tone contour is shifted to the plural suffix and hence, an analysis where contour tones are considered combinations of level high and low tones will be inappropriate for the Bodo group of languages.

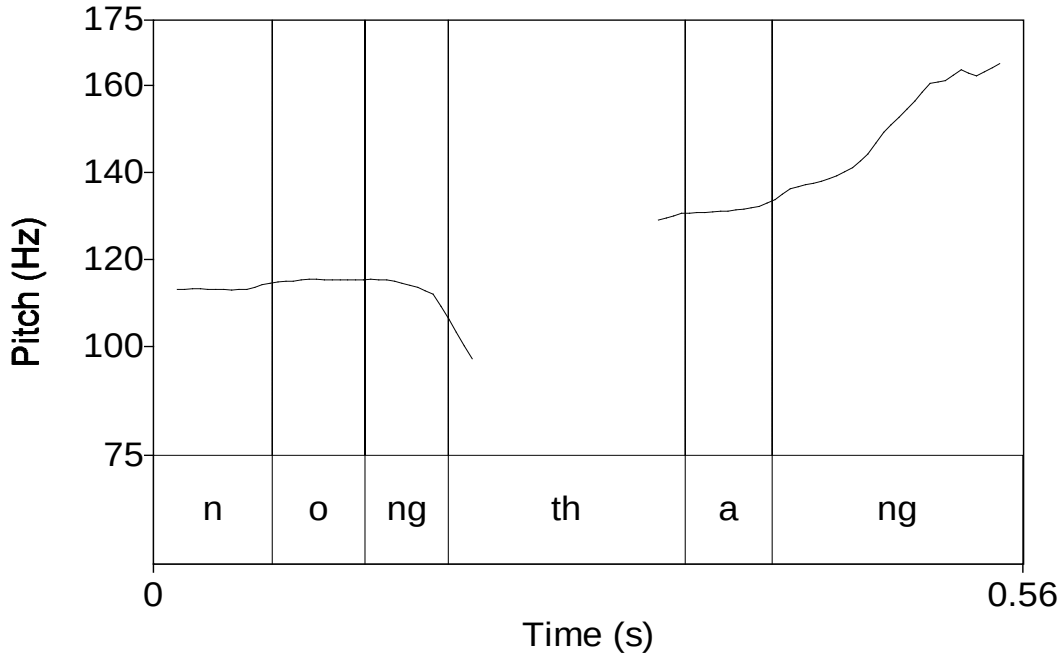


Figure 6-1. Pitch track of nōngthang ‘you (hon., singular)’

[21] In these examples the tone marking conventions from Sarmah (2004) is followed where +H indicates a high rising tone and M indicates a mid-default tone.

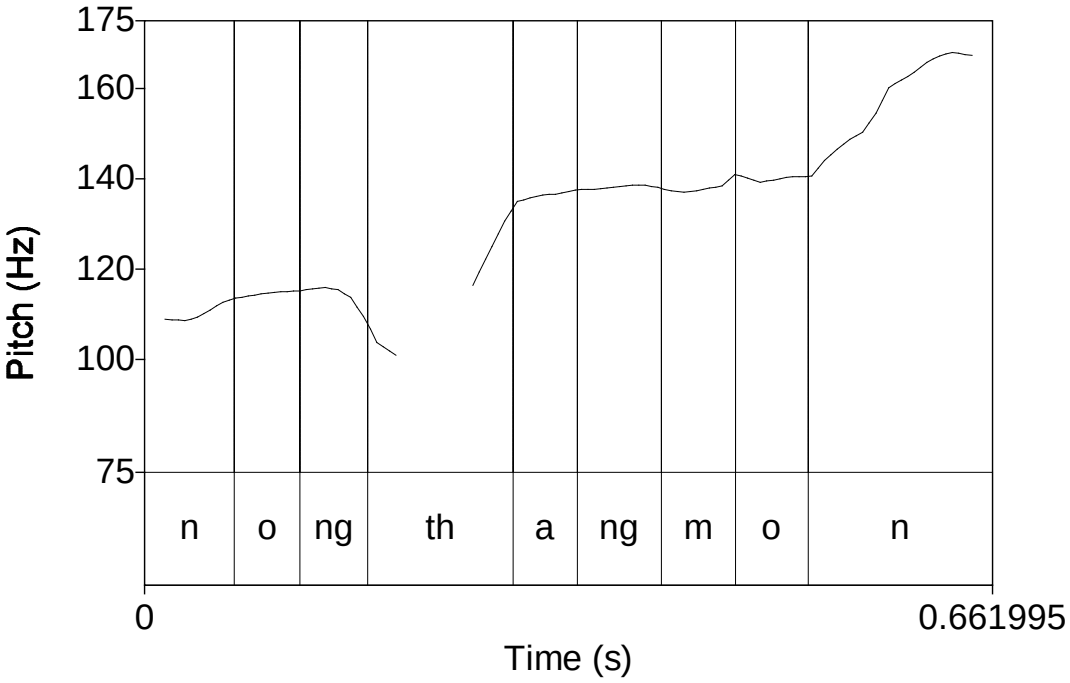
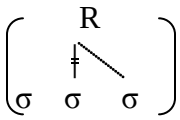
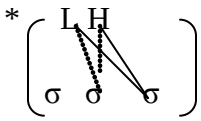


Figure 6-2. Pitch track of nōngthangmōn *'you (hon., plural)'*

In other words, the tone shift in Bodo can be described as in Example 6-1, where the entire high-rising tone shifts to the following syllable. However, a representation as in Example 6-2 is unmotivated and complicated for a case like the one with Bodo tone shifting.



(6-1)



(6-2)

Hence, it is pertinent that one considers contour tones as a single tonemic unit in Bodo-Garo languages, rather than considering them to be combinations of register tones.

Following conclusions about the tone assignment pattern in Dimasa and Rabha have been arrived at:

(a) In both Dimasa and Rabha, a non-derived lexical item must be specified with one of the lexical tones present in the grammar of the language.

(b) A tone bearing unit (TBU) without a lexical tone is produced with a default mid-level tone.

(c) The rightmost syllable of an underived disyllable is produced with a lexical tone whereas the initial syllable is produced with a mid default tone.

(d) Suffixes are underlyingly specified with a lexical tone and in derivations the tonal specification of the suffix is retained.

(e) While the suffixes retain their underlying tonal specification, in the case of Dimasa, the stem also retains its underlying tonal specification. However, in the case of Rabha, the stem loses its underlying tonal specification and is produced with a mid-default tone.

Considering the facts above, the following constraints are used for an OT analysis of tone assignment in Dimasa and Rabha:

- **Tonal faithfulness constraints**
- **DEP-T**: No insertion of tones.
- **MAX-T**: No deletion of tones.
- ***ASSOCIATE**: No new association lines.
- ***DISASSOCIATION**: No removal of association lines.
- **NOFUSION**: Separate underlying tones must stay separate.
- **IDENT-T**: Correspondent tones are the same.
- **LINEARITY**: Preserve underlying linear order.

Tones also take into account more general phonological conditions like the Obligatory Contour Principle (OCP), locality, and markedness constraints. The following are the constraints that we consider significant in the OT analysis of tones in Dimasa and Rabha.

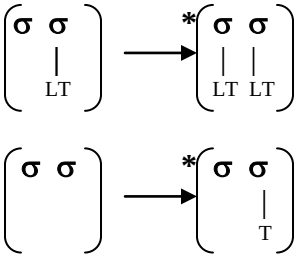
Tonal markedness constraints

- **OCP**: Adjacent identical elements are prohibited.

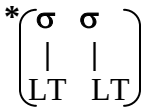
- **NoGap**: Multiply linked tones cannot skip TBUs.
- **Local**: Spread only to the adjacent items.
- ***Float**: A tone must be associated with a TBU.
- **Specify T**: A TBU must be associated with a tone.
- **NoLong T**: A tone may be associated with at most one TBU.
- **Crisp-Align-Tone R**: Each T should align with the right edge of the domain.

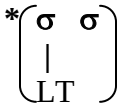
A Lexical Item Must be Specified with a Tone

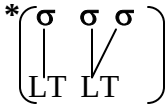
As described in Chapters 3 and Chapter4, both Dimasa and Rabha non-derived lexical items are underlyingly specified with a lexical tone. They are specified with the rising (R), mid-level (M) or a falling (F) tone on a single syllable. It is observed that non-derived lexical items must retain the underlying tonal specification in the output. It is also not possible to have non-derived lexical entry without being specified with a lexical tone. Hence the markedness constraint **Specify T (LT, Prwd)** is ranked high in the two languages that makes sure that every prosodic word (PRWD) is specified with a lexical tone (LT).Every non-derived Dimasa and Rabha lexical entry is associated with a lexical tone and there is no possibility that a rising (R) or a falling tone (F) is inserted into the output form. However, a mid (M) tone may be inserted in the output form in case a syllable is not underlyingly specified with a lexical tone. Hence, the constraint ranking ***R, *F >> *M** is used in this analysis. **DEP-T** is ranked low in the in the two languages as there is a possibility of a mid tone insertion in case a syllable is not underlyingly specified with a lexical tone. This constraint rules out the following possibilities:



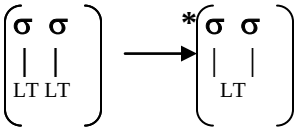
In the previous chapters we also observed that the underlying lexical tones of Dimasa and Rabha are specified on the rightmost syllable. Again, in morphological derivations it was observed that the right edge of a derived polysyllabic lexical entry is specified with a lexical tone. Hence the constraint CRISP-ALIGN-R (PRWD, LT) is proposed to be active that makes sure that the right edge of the domain in a prosodic word is aligned with a lexical tone. It prohibits the following situations:







The grammar of Dimasa and Rabha rules out any possibility of a lexical item being specified with a lexical tone, anywhere except the right edge of the domain. Hence an input, which, for example, has its left edge specified with an underlying tone, loses its left edged tonal specification in the output. This results in the violation of the tonal faithfulness constraint MAX-T, which restricts the deletion of tones. As Dimasa and Rabha allow this violation in derived polysyllables, MAX-T is considered to be a low ranked constraint compared to some other constraints. Following is the violation of this constraint:



As every prosodic domain in Dimasa and Rabha has to be associated with a lexical tone, the constraint SPECIFY T is highly ranked in the constraint hierarchy. Similarly, it is not possible

for rising and falling tones to be inserted in the output form. However, it is possible that a mid-level tone is inserted in the output form in a TBU that is not specified with a lexical tone. Hence, the constraint *R, *F >> *M is also highly ranked in the two languages that restricts the insertion of rising or falling tones, but allows the insertion of default mid-level tones. As discussed in the previous chapters, the mid-level tone in the two languages behaves as a default tone in the two languages. As CRISP-ALIGN-R (PRWD, LT) may lead to the deletion of tones, MAX-T is ranked lower than the former. However, MAX-T is ranked above *R, *F >> *M, so that the latter does not replace even the lexically specified rising and falling tones with mid tones. Hence, the final constraint ranking of these constraints can be represented as:

SPECIFY T, CRISP-ALIGN-R (PRWD, LT), IDENT-T >> MAX-T>> *R, *F >> DEP-T, *M

Table 6-2. General constraint ranking for Dimasa

INPUT ho ba F	SPECIFY-T	CRISP-ALIGN-R (PRWD, LT)	IDENT T	MAX-T	*R,*F	*M	DEP-T
a. ho ba | F	*!				*		
b. ho ba | | R F			*!		**!		*
c. ho ba | | F F				*!	**!		*
d. ho ba | | M M			*!	*!		**	**
d. σ σ ☞| | M F					*	*	*

The disyllabic input /hoba/ is specified with one lexical tone on the second syllable (Table 6-2). However, the initial syllable is not specified with any tone in input. Hence, candidate a) violates the higher ranked constraint **SPECIFY T** ruling out it out of being the winning output in the presence of a better candidate. In case of candidate b) a rising tone is assigned to the initial

syllable. Hence, candidate b) violates this high ranked constraint **IDENT-T**. As an R tone is inserted, it violates the lower ranked *R, *F constraint. It also violates the lower ranked DEP constraint which functionally does not have any effect on the outcome of the optimal candidate here. Similarly, in case of candidate c), a F(alling) tone is inserted to the initial syllable of the input. It violates the ***R, *F** constraint and in absence of other higher ranked violations the ***R, *F** violation is fatal for candidate c). It also violates the lower ranked DEP constraint. Candidate d) is specified with an M tone on both the syllables. Hence, the F tone of the input does not have any identical element in the output making candidate d) violate the higher ranked **IDENT-T** constraint. As the tone in the input is deleted this candidate also fatally violates **MAX-T.**

Here, candidate e) emerges as the winner as the lexical tone is on the rightmost syllable of the lexical entry satisfying the higher ranked **CRISP-ALIGN-R (PRWD, LT)**. To satisfy the **SPECIFY T** constraint, the default mid-level tone is inserted in the initial syllable of the entry.[22] This insertion violates the lower ranked constraints ***M** and **DEP-T.** As it violates ***R, *F** only once (by allowing the insertion of a M tone), it is not a fatal violation. Hence, the ***R, *F** constraint makes sure that only one lexical tone is allowed in the output. However, as both of them are lower ranked constraints**,** their violation does not affect the outcome in this case.

Optimality Theoretical Treatment of Dimasa Tones

In this section the constraint ranking proposed in the previous section is used on Dimasa examples. In the following example, the disyllabic input of Dimasa is specified with a rising tone. Considering the constraint hierarchy proposed above the Table 6-3 demonstrates the choice of the optimal output in Dimasa:

[22] Here we assume that the mid tone (M) operates in two ways. As observed in the previous chapters, the mid-level tone can be assigned in the underlying form where it is regarded as an underlying lexical tone. However, in cases where a TBU is underlyingly unspecified, the mid-level tone operates as a default tone assigning itself to the unspecified TBU and hence, satisfying the **SPECIFY T** constraint. In other words, even though phonetically similar, the mid-level tone can be functionally very distinct.

Table 6-3. Optimality theory tableaux for Dimasa

INPUT [mai thai] R	SPECIFY-T	CRISP-ALIGN-R (PRWD, LT)	IDENT T	MAX-T	*R,*F	*M	DEP-T
a. [mai thai] | R	*!	*!			*		
b. [mai thai] | | R R					**!		*
c. [mai thai] ╲╱ R		*!			*		
d. [mai thai] ☞ | | M R					*	*	*

In Table 6-3, the input /mait^{h}ai/ is underlyingly specified with a rising (R) tone. In the output candidate a), the underlying tone R is associated with the initial syllable of the lexical entry /mait^{h}ai/. However, this candidate violates the constraint **SPECIFY T** as the second syllable of the lexical input is not specified with any tone. Moreover, candidate a) also violates **CRISP-ALIGN-R (PRWD, LT)** as the lexical tone R is not assigned to the rightmost edge of the prosodic word.

Similarly candidate b) is also implausible as it violates ***R, *F** twice two R(ising) tones are inserted in the output. The R insertion here also violates the lower ranked DEP-T constraint.

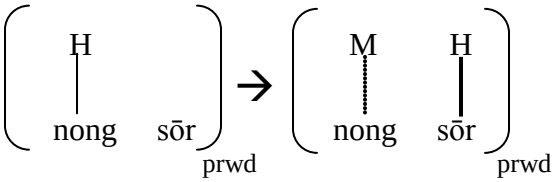
In case of candidate c), the R tone is associated with both the syllables of the lexical entry. Hence it violates the **CRISP-ALIGN-R (PRWD, LT)** constraint. It is also assumed here that the markedness constraint **NOLONG T** is also ranked high in Dimasa making candidate c) implausible.

In candidate d), the underlying R tone is assigned to the rightmost syllable of the word and the leftmost syllable is assigned a mid-level tone. As the underlying lexical tone R is associated with the rightmost syllable, **CRISP-ALIGN-R (PRWD, LT)** is satisfied. At the same time, in

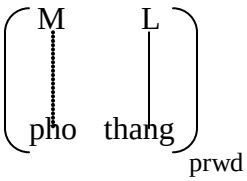
the output form the leftmost syllable is assigned a default mid-level tone satisfying the **SPECIFY T** constraint. However, it violates ***R, *F** once, but considering other candidates, candidate d) has the least fatal violations. Similarly, candidate d) violates *M and DEP-T constraints, as both of these constraints are lower ranked, they do not influence the outcome of candidate d) as the winning candidate. Hence, candidate d) emerges as the winning candidate in the OT analysis.

However, in Dimasa suffixation, suffixes that are examined in Chapter 5 are underlyingly associated with a lexical tone. This phenomena is quite opposite than that of the noted morphophonological phenomena in Bodo (Sarmah, 2004) where, most of the suffixes and prefixes are not underlyingly specified with any tones. In Bodo, the inflected or derived polysyllables in a majority of cases operate as a single prosodic unit where according to the Bodo rules of tone assignment, a lexical tone is assigned on the rightmost syllable of the polysyllabic entry. In the following examples in Bodo this point is demonstrated clearly:

$^{+H}$nōng+sōr→^{M}nōng^{+H}sōr (6-3)
'you'+ *pl.* → 'you' (pl)



pho+^{L}thang→ ^{M}pho^{L}thang (6-4)
pho(caus.)+sow seeds → to make sow seeds



In the input /nong/ is associated with a high tone and the suffix /sor/ is not associated with any lexical tone. However, in the derived form, the high tone of the stem is spread to the tonologically underspecified suffix /sor/ and the stem loses its lexical tone specification resulting in the assignment of the default mid tone on the stem. In Dimasa, both the stem and the suffix

behave as two separate prosodic units in the derived form. Hence, both the prosodic units retain their tonal specification in the output form. The association of suffixes to Dimasa words is demonstrated in the examples below:

shu^{F}	**+**	**ri^{F}**	→	**shu^{F}ri^{F}**	(6-5)
'measure'	+	*caus.*	→	to make to measure	
miya^{M} +	**+**	**rao^{F}**	→	**miya^{M}rao^{F}**	(6-6)
'man'	+	*pl.*	→	'men'[23]	

In case of Dimasa suffixation, the suffixes are considered as separate prosodic units separated from the stem of the derived word. This is phenomenon is quite similar to the Type III suffixation of Bodo demonstrated in Sarmah (2004) where the causative suffix *–ho* is underlyingly specified with a lexical low tone (L) and in derivations the tonal specification of the suffix in preserved along with the underlying tonal specification of the stem. Sarmah (2004) assumes that in the *–ho* type of suffixation in Bodo both the suffix and the stem behave as two distinct prosodic words that can be morphologically represented as in Example 6-7.

$$\underset{\text{prwd}}{[\quad]} \,.\, \underset{\text{prwd}}{[\underset{\text{L}}{\text{ho}}]} \qquad (6\text{-}7)$$

Hence, in this analysis the Dimasa suffixes are also considered as distinct prosodic words. As mentioned in Chapter 5, at least for the *–ri* type of suffixes it has been shown that the suffix is actually derived from a lexical word /ri/ which means 'to give' which explains why *–ri* has its own tonal specification and why they can be considered as distinct prosodic words. Hence, the proposed constraint ranking also works for the derived words in Dimasa (Table 6-4). In Table 6-4, the input [baba][rao] is underlyingly specified with two lexical tones for each of the prosodic

[23] There is no tone marking in the first syllable of /miya/ as the first syllable is not underlyingly specified with any tone. However, in the output the first syllable is assigned a mid-level tone fulfilling the requirement for specifying a tone on every syllable of Dimasa.

words. The prosodic unit [baba] is assigned the lexical falling (F) tone and the suffix [rao] is also underlyingly specified with a falling (F) tone. In case of candidate a), the prosodic unit [baba] is only specified on the right edge with a lexical tone; whereas the initial syllable is not specified with any lexical tones. Hence, it violates the high ranked **SPECIFY T** constraint making the candidate a) unfavorable as a plausible output. In case of candidate b) the lexical tonal specification of the prosodic word [baba] is entirely deleted. While it violates the lower ranked **MAX** constraint, it also violates the **SPECIFY T** constraint twice making b) implausible. In case of candidate c) the underlying tonal specifications of the stem and the suffix are preserved and the lexical mid-level tone of the stem is associated with the right edge of the prosodic word [baba]. In the initial syllable of the prosodic word [baba] a mid-level tone is associated as a default tone satisfying **SPECIFY T** and **CRISP-ALIGN-R (PRWD, LT)** and ***R, *F**. Candidate c) violates DEP-T and *M constraint. However, as both of them are low ranked constraint it does not affect the outcome of the analysis. Hence, candidate c) emerges as the optimal output in the computation.

Table 6-4. Optimality theory tableaux demonstrating tone assignment in Dimasa

INPUT **[baba] [rao]** F F	SPECIFY-T	CRISP-ALIGN-R (PRWD, LT)	MAX-T	*R,*F	*M	DEP-T
a. [miya] [rao] F F	*!			**		
b. [miya] [rao] F	** !	*!	*!	*		*
c. [miya] [rao] ☞ M F F				*	*	*

Optimality Theoretical Treatment of Rabha Tones

Rabha non-derived words follow a tone assignment pattern similar to the Dimasa one. Hence, the proposed schema of constraints is also applicable to Rabha (Table 6-5). In Table 6-5,

in the input form the R(ising) tone is not associated with any of the syllables of the word /rima/. In case of candidate a), the R tone is associated with the initial syllable of the word. Hence it violates the higher ranked constraint **CRISP-ALIGN-R(PRWD,LT).** Moreover, the second syllable of the input is not assigned any tone. Hence, it violates another high ranked constraint **SPECIFY-T.** In case of candidate b) a rising tone is inserted and specified with one of

Table 6-5. Optimality theory tableaux of Rabha tone assignment

INPUT [ri ma] R	SPECIFY-T	CRISP-ALIGN-R (PRWD, LT)	MAX-T	*R,*F	*M	DEP-T
a. [ri ma] | R	*!	*!		*		
b. [ri ma] | | R R		*!		**		*
c. [ri ma] ╲╱ R		*!		*		
d. ☞ [ri ma] | | M R				*	*	*

the syllables in the word. The insertion of the rising tone violates the higher ranked constraint *R. It also violates the **CRISP-ALIGN-R(PRWD,LT)** constraint. Candidate c) also violates **CRISP-ALIGN-R(PRWD,LT)** as the underlying R tone is spread to two syllables. However, in case of candidate d) the initial syllable is assigned a mid tone and the underlying tone is assigned to the second syllable. Even though this candidate violates the constraints *M and DEP-T, the constraints' lower rank does not prevent d) from being the winning candidate.

However, in case of morphological derivations in Rabha, even if the stem of a derivation is underlyingly associated with a lexical tone, it loses its tonal specification fulfilling the requirement for tone assignment on the rightmost syllable, resulting in the assignment of a

default mid tone on the stem. Tone assignment in Rabha derivations is demonstrated in Example 6-8, Example 6-9 and Example 6-10.

rung^{R} +	kai^{F}	→	rung^{M}kai^{F}	(6-8)
to drink	*nom.*		'the act of drinking'	
trung^{F} +	dam^{R}	→	trung^{M}dam^{R}	(6-9)
to learn	*nom.*		'learner'	
phar^{R} +	brok^{R}	→	phar^{M}brok^{R}	(6-10)
to sell	*nom.*	→	'seller'	

In the examples from Rabha, it is seen that the suffixes are underlyingly specified with lexical tones. When attached to a toned stem, the suffixes retain their tonal specification but the stems lose their tonal specification to accommodate the strict align right constraint in Rabha. The stem is then assigned a default mid tone satisfying the constraint **SPECIFY-T**. The fundamental difference between derivations in Dimasa and Rabha is that in Dimasa even after derivation the morphological boundaries are preserved resulting in two separate prosodic units. However, in Rabha the derived word is considered to be a single prosodic word. In other words, the derivation in Rabha can be demonstrated as in Example 6-11.

$$[\sigma\sigma]_{PRWD} + [\sigma\sigma]_{PRWD} \rightarrow [\sigma\sigma\sigma\sigma]_{PRWD} \qquad (6\text{-}11)$$

Table 6-6. Optimality theory tableaux for Rabha derivations

INPUT **[rung]** **[kai]** R F	SPECIFY-T	CRISP-ALIGN-R (PRWD, LT)	MAX-T	*R,*F	*M	DEP-T
a. **[rung kai]** R F		*!		**		
b. **[rung kai]** F	*!		*	*		
c. **[rung kai]** ☞ M F			*	*	*	*

Hence, the derivations in Rabha can be explained with an example as in Table 6-6. In Table 6-6, candidate a) is not plausible as the initial syllable of the derived word still retains the lexical tone that was specified underlyingly violating the high ranked constraint **CRISP-ALIGN-R (PRWD, LT)**. Candidate b) is also ruled out as the initial syllable is not specified with any tone after the lexical tone was deleted. This candidate violates the low ranked **MAX-T** constraint but more importantly it violates the high ranked **SPECIFY T** that makes candidate b) implausible. In case of candidate c) the insertion of the mid tone on the initial syllable violates the low ranked constraints ***M**, **DEP-T** and **MAX-T** but it satisfies the high ranked constraints. The initial syllable then is specified with a default mid-level tone which satisfies the **SPECIFY T** constraint resulting in the emergence of candidate c) as the optimal output.

Discussion

The optimality theoretical analyses of Dimasa and Rabha tones can be demonstrated with the same set of constraints. The individual morphophonotactics of the two languages make it possible for the two languages to be analyzed with the same set and ranking of constraints. In case of tone assignment in underived disyllables both Dimasa and Rabha operate in exactly the same way. However, in case of derived disyllables the two languages operate differently. In case of Dimasa, the suffixes and stems form two separate prosodic units. This makes lexical tone assignment both on the stem and suffix possible.

In case of Dimasa derived polysyllables the prosodic structure demonstrated in Example 6-12 is followed.

$$[\text{stem}]_{\text{PRWD}} \; . \; [\text{suffix}]_{\text{PRWD}} \qquad (6\text{-}12)$$

However, in case of Rabha, the whole morphological unit consisting of the stem and the suffix, functions as a single prosodic unit. Hence, for Rabha derived polysyllables, the prosodic structure demonstrated in Example 6-13 is followed.

$[\text{stem . suffix}]_{\text{PRWD}}$ (6-13)

From the discussion above and from the facts mentioned earlier in the chapter from Sarmah (2004), it can be concluded that among Tibeto-Burman languages, the Bodo-Garo group of languages are considerably richer in derivational and inflectional morphology. Van Driem (2001) mentions that even though there was a complex morphology in the proto forms of the Sino-Tibetan languages, it was simplified in many Tibeto-Burman languages leading to paucity of derivational morphology in them. Considering that, it is interesting to note that the Bodo-Garo group of languages still has a much richer morphology than many of the other Tibeto-Burman languages. However, the morphotonological interactions in these languages are not uniform and rather conflicting, as demonstrated in the case of Rabha and Dimasa. Hence, a further direction that this work could take is to investigate the cognates of the derivational and inflectional affixes in the sister languages of the Tibeto-Burman language subfamily.

CHAPTER 7
CONCLUSION

This dissertation reports on a study conducted on the tonal phonology of Dimasa and Rabha languages. The primary aim of this study was to figure out the tonal inventories of two Tibeto-Burman languages, namely, Dimasa and Rabha using acoustic and statistical means. Apart from that, this work also attempted to determine the operation of tones in morphological changes in Dimasa and Rabha derivations. In the following sections the major findings of this study are summarized. Towards the end of this chapter suggestions for further study are discussed.

Tone Inventories

This study determined the number of tones in Dimasa and Rabha with the help of acoustic and statistical analysis. As far as the number of tones is concerned, this study concludes that in both Dimasa and Rabha, there are three phonological tones or tonemes. It has been shown that in both languages the type of the three phonological tones is also very similar. Depending on the shape of the pitch contour, it is assessed that Dimasa and Rabha have a rising (R), falling (F) and a mid-level (M) tone.

The three phonological tones of Dimasa are obtained by normalizing the pitch contours of the three Dimasa tones with the carrier phrases of the target toned word (Figure 7-1). It has also been observed that words with /t^h/ and /ʃ/ as onsets affect the entire pitch contour of the rising tone. The inherent quality of these two phonemese render a high level pitch contour whenever a rising tone occues on the following tone bearing unit. However, this pitch contour is only a phonetic variation of the phonological rising tone and hence considered to be in the same category as of the rising tones. Hence, it is concluded that Dimasa has two allotones for the rising tone in the language.

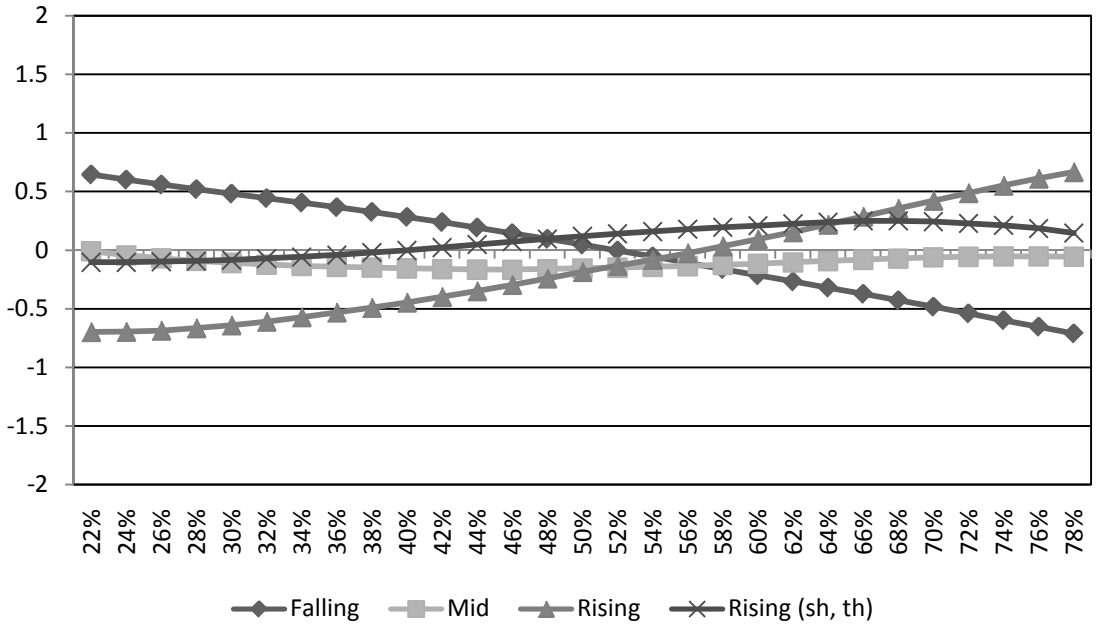


Figure 7-1. Three phonological tones of Dimasa

The normalized pitch contours for the three phonological tones show certain differences. Unlike Dimasa, Rabha rising tones rise very sharply but the falling tones fall less sharply (Figure 7-2). Mean F0d or the difference between the offset and the onset values vary largely between Dimasa and Rabha. The value of F0d in Rabha is observed to be much bigger in case of the contour tones, than in Dimasa (Figure 7-3).

Tones in Monosyllables

In both Dimasa and Rabha, any one of the three lexical tones can be assigned to any monosyllable. In both languages, the speakers seem to depend more on the shape of the contour than the average pitch values. The evidence for this claim comes from the fact that in both languages, there are two contrastive contour tones and only one register tone. Let this argument be illustrated with an example. It is also noticed that the averaged normalized Rabha pitch contours overlap with each other to a large extent (Figure 7-2). In other words the onsets vary not only among tones but also within a single tone. However, that does not give rise to any functional difficulty in perceiving Rabha tones as Rabha speakers pay more attention to the

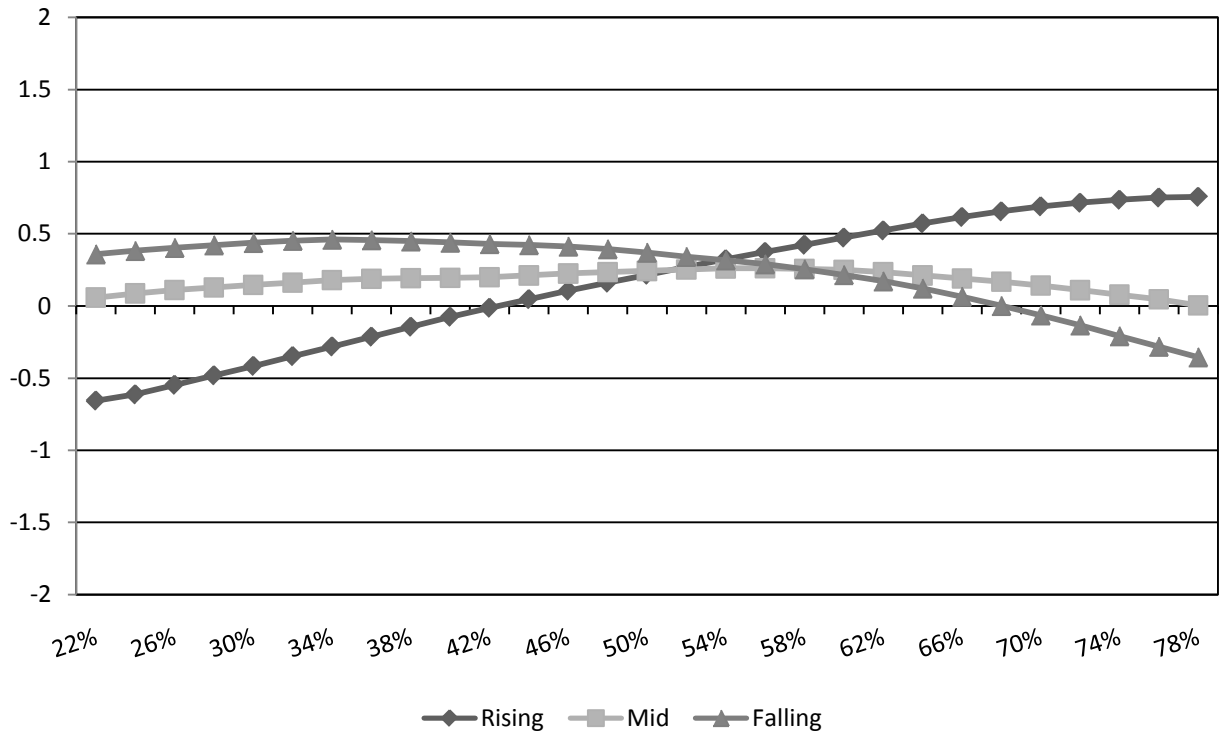


Figure 7-2. Three phonological tones of Rabha

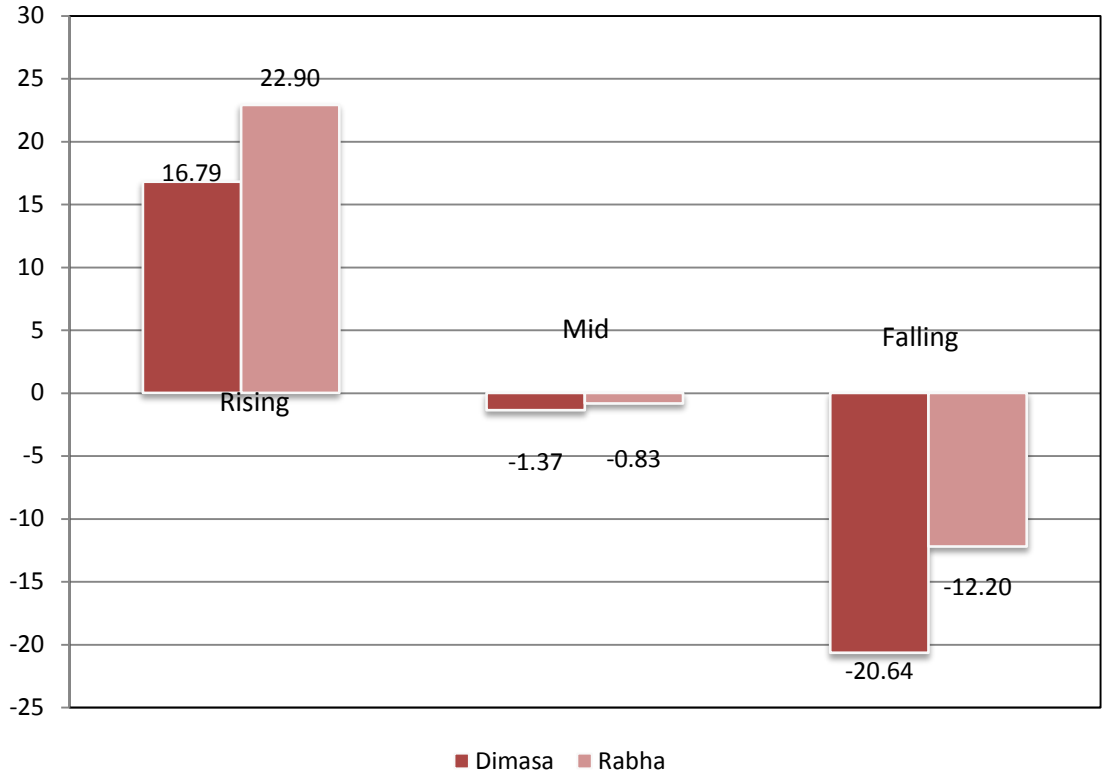


Figure 7-3. Comparison between Dimasa and Rabha F0d

overall change of pitch values than the average values of pitch across a pitch continuum.

The case of Dimasa (Figure 7-1), it shows a significant effect of the onset consonants, resulting in an allotone of the rising tone in Dimasa. The rising tone in Dimasa, when following a /t^h/ or a /ʃ/ in the onset position, changes its rising contour into a high-level contour.

In both Dimasa and Rabha, some speakers showed extremely small difference in terms of F0d of the contour tones. For instance, speaker CH of Dimasa has an average F0d of only 4.14 in the production of rising tones and -8.99 in the production of falling tones (Appendix C, Table C-1). Similarly, Rabha speaker KC has an average F0d of only 10.68 in the production of falling tones of Rabha. Even though the F0d values are very small, it is not uncommon to have such small differences of fundamental frequency in the production of contrastive tones in tone languages, as seen in Chapter 3. Considering the minimum F0d noticed in the contour tones of other languages, the small F0d of some speakers of Rabha and Dimasa in producing the rising and the falling tones of the two languages may be well within the distinguishable range of the native speakers.

Tones in Disyllables

Sarmah (2004), Joseph and Burling (2001, 2007) note that in Bodo and Tiwa disyllables only one syllable is specified with a lexical tone. The remaining syllable is usually toneless according to Joseph and Burling (2001, 2007) and assigned with a default mid tone according to Sarmah (2004).

In this study, it has been demonstrated that in Dimasa and Rabha only one lexical tone is underlyingly specified, and that it emerges as right aligned in the output. In other words Dimasa and Rabha lexical tones are assigned only on the rightmost syllable in a disyllabic word. The initial or the leftmost syllable is assigned a mid-level tone. Hence, it can be claimed that the mid-

level tone is the most unmarked tone in the grammar of Dimasa and Rabha and it can be assigned to any syllable that has not been underlyingly specified for a lexical tone.

General Tone Assignment Pattern

Owing to the facts reported in the previous sections, it can be concluded that in both Dimasa and Rabha underived words, only one lexical tone is underlyingly specified and that lexical tone is associated with the rightmost syllable of word. Any syllable that is devoid of an underlying lexical tone is assigned an unmarked mid-level tone that is a part of the tonal inventory of both the languages.

Tones in Derived Polysyllables

Unlike tone assignment patterns in monosyllables and disyllables, tone assignment patterns in derived polysyllables are distinct in Dimasa and Rabha. In Dimasa derivations, both the suffixes and stems retain their underlying tonal specifications. In other words, in Dimasa both the suffixes and stems are phonologically considered as two separate lexical items, even after they have been added together. However, in case of reduplications in Dimasa, the reduplicated form is considered a single prosodic word where only one lexical tone is attached.

However, in the case of Rabha, only the underlying tonal representation of the suffix is retained and the tonal specification of the stem is lost. In other words, the derived words in Rabha are considered one lexical item and fulfilling the criterion of only one lexical tone for each lexical item, only the tone on the rightmost syllable is retained. However, the left edge or the stem subsequently receives a mid-level tone satisfying the phonetic requirements of the derived word.

Implications from the Current Study

This study is an attempt to understand the tones of Tibeto-Burman languages, specifically, of languages of the Bodo-Garo subfamily. The findings of this study are expected to enrich the

knowledge about the tonal typology of the Tibeto-Burman languages. This study provides the first acoustic analyses of tones of Dimasa and Rabha tones.

The methodology adopted for acoustic analyses provided crucial information about the nature of tones in Dimasa and Rabha. Apart from that it also confirmed the maximum extent of consonantal interference in Rabha and Dimasa. This study found that the initial 20% and the final 20% of a pitch track are most likely to be affected by the consonant quality in the onset or coda. Hence, this study proposed that to obtain a genuine and reliable pitch track of a tone, unaffected by coda or onset consonants, the initial 20% and the final 20% of the pitch track should not to be taken into account.

The methodology of this study also took care of speaker variability by normalizing the pitch contour of the target word with the average pitch of the carrier phrase. This method not only took care of speaker variability but also of listing artifacts.

Future Directions

The results of this study support the idea that the Bodo-Garo group of languages is two or at most a three tone language system. It also indicates that all Bodo-Garo languages may have only one lexical tone assigned in each polysyllabic entry. Along these lines, it is imperative that other languages of the Bodo-Garo family be subjected to acoustical analyses. This kind of investigation is also very important as far as linguistic typology is concerned as not much is known about the tonal characteristics of the languages of the Bodo-Garo subfamily.

Findings of any production experiment can be further strengthened if they are supported by perception experiments. Hence, it is probative that a more complete perception study on Dimasa and Rabha tones be conducted to validate the findings of this acoustic study.

APPENDIX A
DIMASA WORD LIST

Table A-1. Dimasa words with English meanings

Dimasa	English	Dimasa	English
bai	to spin	bai-ri	to cause to dance
bajang	where	bai-ri	to cause to filter
bajang	younger brother	bai-ri	to cause to order
balai	nearly, almost	bai	to cause to ship
odei bani	because	bai	to cause to spin
bani	made by hand	balai-ri	to cause to accomplish
bao	to arrange	balai-buthu	leaves
bao	to think	bao-ri	to cause to spread
dao	bird	bao-ri	to cause to think
dao	to make	dao-buthu	birds
dao	to make/weave	dao-ri	to cause to make
du	to make eat	dao-ri	to cause to weave
du	to make soil ready	du-ri	to cause to feed
gisi	call of rooster	du-ri	to make soil ready
gisi	depend	gishi-ri	cause to depend
gisi	wet	gishi-ri	cause to wet
goron	company	goron-ri	to cause to meet
goron	confuse	goron-ri	to cause to confuse
hadi	field	hadi-buthu	fields
hadi	rain	hathai-buthu	markets
hathai	hillock, white ant	hathai-buthu	teeth
hathai	market	hathai-buthu	bullets
hathai	teeth	hoba-ri	to cause to scream
hathai	bullet	hoba-ri	to cause to knit
hoba	scream	kha-buthu	livers, hearts
hoba	to weave	kha-ri	to cause to tie
kha	liver, heart	khai-ri	to cause to rub
kha	to tie	khai-ri	to cause to run
khai	to rub	khao-ri	to cause to pluck
khai	to run	khao-ri	to cause to steal
khaoba	to pluck	khu-buthu	mouths
khao	pluck	khu-ri	to cause to dig
khaoba	to steal	khu-ri	to cause to serve
khao	steal	miya-buthu	bamboo shoots
khu	face	miya-raw	male persons
khu	to dig	sa-raw	sons
khu	to serve	sa-buthu	teas
miya	bamboo shoot	sao-ri	to cause to rot
miya	male person	sao-buthu	bodies
miya	yesterday	shain-buthu	suns

Table A-1. Continued

Dimasa	English
basa	son
sa	tea
sao	to rot
sao	body
shain	sun
shain	to ask, beg
shu	to beat
shu	to measure
shu	to stitch
shu	to wash
sing	bark
sing	to ask
sing	to cut, shave
thao	tasty, oil
thao	to sow
thu	deep
thu	sleep
thu	spit
wai	eat/to chew
wai	fire
zao	to puncture
zao	to row
zao	to winnow
zik	female
zik	to kick
thi	speak
thi	to die
thi	blood
maithai	year
maithai	source
lai	page
lai	easy
lai	wish
tang	go
tang	survive
ri	give
ri	cloth
asari-buthu	rainy seasons
baba-raw	fathers
ba-ri	Make shallow
ba-ri	carry a child
badai-buthu	grandmothers
bagarang-buthu	feathers

Dimasa	English
shain-ri	to cause to ask, beg
shu-ri	to cause to beat
shu-ri	to cause to measure
shu-ri	to cause to stitch
shu-ri	to cause to wash
sing-ri	to cause to bark
sing-ri	to cause to ask
sing-ri	to cause to cut, shave
thao-ri	to cause to sow
thu-ri	to cause to sleep
thu-ri	to cause to spit
wai-ri	to cause to chew
zao-ri	to cause to puncture
zao-ri	to cause to row
zao-ri	to winnow
zik-ri	to cause to kick
thi-ri	to cause to speak
thi-ri	to cause to die
káse	'small'
káse-káse	'small small'
gedé	'big'
gedé-gedé	'big big'
nolái	'village'
nolái-nolái	'villages'
láma	'road' (n)
láma-láma	'roads'
rizaŋ	'thousand'
rizin-rizin	'thousands'
nobro	'ward'
nobro-nobro	'wards'
lailó	'easily'
lailó-lailó	'very easily'
hasrú	'smiling'
hasrú-hasrú	'very smiling'
kére	'slow'
kére-kére	'slowly'
prik	'silent'
prik-prik	'silently'
gibin	'different'
gibin-gibin	'differently'
gibi	'true'
gibi-gibi	'truely'
rabá	'slight'

Table A-1. Continued

Dimasa	English
bai-ri	to break
bai-ri	to cross
lugú-lugú	'friendly'
máitái	'year'

Dimasa	English
rabá-rabá	'slightly'
rezéŋ	'light'
rezéŋ -rezéŋ	'lightly'
lugú	'friend'

'

APPENDIX B
RABHA WORD LIST

Table B-1. Rabha words with English meanings

Rabha	English
rima	to cook
rai	banana leaf
rai	judgement
rai	go to bring smt
ro	length
ro	endless
sa	eat
ram	a proper name
bakok	bamboo tube
aphe	star
dokhom	low stool
rampar	wind
masi	deer
maru	wild cat
khusung	tortoise
rethe	banana
nakor	ear
nukhang	face
si	die
si	blood
kha	tie
kha	bitter
so	rot
so	burn
na	hear
na	fish
su	peck
su	pierce, pound
kho	weave a basket
kho	draw water
song	village
song	to set on the stove
nang	need, useful
nang	you
graw	abundant
graw	intensely
sakay	act of eating
mini	to laugh
minikay	act of laughing
reng	to go

Rabha	English
dhawa	war
dhawadam	warfare
besor	mustard seed
besordam	mustard field
may	paddy
maygrim	paddy field
pan	tree
pangrim	forest
sam	grass
samgrim	field of grass
kay	human being
kaygiri	master
chay	song
chaygiri	song writer
krourang	literature
krouranggiri	litterateur
chayphang	singer
bay	deity
bayphang	assistant of a priest
nuken	eye
chika	water
nukenchi	tears
zi	stool
nukzi	eye excreta
khusem	mouth
men	hair
khusemmen	moustache
masu	cow
masubizan	cows
bak	pig
bakbizan	pigs
na	fish
nabizan	fishes
minku	cat
minkubizan	cats
nen	cloth
nenbizan	clothes
the	fruit
thebizan	fruits
pan	tree

Table B-1. Continued

Rabha	English
rengkai	act of going
si	to die
sikai	death
tan	to cut
tankay	act of cutting
tong	to stay
tongkai	act of staying
rung	to drink
rungkai	act of drinking
natham	to listener
nathamgir	listener
tring	to learn
tringgir	learner
kitring	to teach
kitringgir	teacher
pri	to buy
pribrok	buyer
phar	to sell
pharbrok	seller
chi	to see, look
chibrok	seer, onlooker
sa	to eat
sabrok	eater
ron	to distribute
ronbra	distributor
poray	to read
poraybra	reader
tringdam	school
khar	to work
khardam	workplace
phardam	shop
tunuk	to show
tunukdam	auditorium
bar	fire
bardam	fireplace
par	flower
pardam	garden

Rabha	English
panbizan	trees
sandri	sieve
sandribizan	sieves
nok	house
nokbizan	houses
dada	elder brother
dadatang	elder brother and others
bibi	elder sister
bibitang	elder sister and others
zuzu	grandmother
zuzutang	grandmother and others
aya	mother
ayatang	mother and others
gabur	youth
gaburtang	youths
mecha	woman
mechatan	women
baba	father
babarong	father and others
buzi	sister in law
buzi	sister in law and others
nang	you
nangrong	you (pl)
o	he
orong	they
noknok	from house to house
song song	from village to village
changchang	who
ata	what
ataata	what
bhairas	virus
sam	uraal
sam	wait!
sam	grass
tatheng	foot
tatheng	don’t go
ram	road

APPENDIX C
STATISTICS CONDUCTED ON INDIVIUAL SPEAKERS

Table C-1. Comparison of F0d values for each speaker in Dimasa

Speaker	Gender	N	ANOVA (p value)	Mean F0d for each tone			Bonferroni Post hoc test (differences in means)		
				R	M	F	R x M	M x F	F x R
BB	F	213	0.00	18.45	-0.97	-25.74	0.000	0.000	0.000
BT	F	241	0.00	25.43	0.21	-23.28	0.000	0.000	0.000
ST	F	162	0.00	15.72	-0.11	-15.83	0.000	0.000	0.000
SD	F	134	0.00	21.72	-1.12	-16.11	0.000	0.000	0.000
MT	F	245	0.00	31.00	-1.55	-31.18	0.000	0.000	0.000
JH	M	108	0.00	19.69	0.96	-14.24	0.000	0.000	0.000
CH	M	108	0.00	4.14	-0.74	-8.99	0.000	0.000	0.000
PJ	M	162	0.00	13.44	-1.90	-12.60	0.000	0.000	0.000

Table C-2. Comparison of F0d values for each speaker in Rabha

Speaker	Gender	N	ANOVA (p value)	Mean F0d for each tone			Bonferroni Post hoc test (differences in means)		
				R	M	F	R x M	M x F	F x R
AN	F	136	0.00	27.59	-1.42	-31.73	0.000	0.000	0.000
LK	F	156	0.00	24.60	0.50	-12.15	0.000	0.000	0.000
AR	F	134	0.00	23.22	-1.67	-15.27	0.000	0.001	0.000
SB	F	125	0.00	25.12	1.59	-20.06	0.000	0.000	0.000
OK	M	113	0.00	22.01	2.19	-12.58	0.000	0.000	0.000
KC	M	128	0.00	28.05	1.15	-10.68	0.000	0.000	0.000
KO	M	130	0.00	26.15	-1.00	-32.99	0.000	0.000	0.001
TR	M	118	0.00	31.04	2.28	-15.22	0.000	0.000	0.000

APPENDIX D
ADDITIONAL FIGURES AND TABLES

Table D-1. Bonferroni tests for average normalized tones with Dimasa tone types as factors

Groups	Difference	Statistic	p value
Rising-mid	-0.025	1.721	0.858
Rising-falling	-0.148	9.431	0.746
Mid –falling	-0.123	8.806	0.746

Table D-2. Bonferroni tests for average normalized tones with Rabha tone types as factors

Groups	Difference	Statistic	p value
Rising-mid	0.000	0.000	1.000
Rising –falling	-0.070	1.128	0.268
Mid-falling	-0.070	0.892	0.383

Table D-3. Results of an ANOVA test conducted on different groups of the F0 contour

Source	D.F.	SS	MS	F	Prob>F	OMEGA SQR.
Between	4	18204.96	4551.24	4.16	0.00	0.01
Within	2200	2405768.07	1093.53			
Total	2204	2423973.03				

Table D-4. Results of a Bonferroni test comparing different groups on the F0 contour of Dimasa

Groups	Difference	Statistic	Prob > Value	Significant?
0-20% vs. 22-40%	6.060	2.949	0.003	YES
22-40% vs. 42-60%	0.215	0.095	0.925	NO
42-60% vs. 62-80%	-0.330	0.144	0.886	NO
62-80% vs. 82-100%	2.489	1.045	0.296	NO

Table D-5. Results of one-way ANOVA test on Dimasa tone types

Source	D.F.	SS	MS	F (2, 1070)	p value
Between	2	271953.86	135976.93	701.98	0.00
Within	1070	207264.02	193.70		
Total	1072	479217.88			

Table D-6. Results of Bonferroni post-hoc test on Dimasa tone types

Groups	Difference	p value
Rising-mid	18.071	0.000
Rising-falling	37.440	0.000
Mid-falling	19.369	0.000

Table D-7. ANOVA test conducted on Dimasa normalized data

Source	D.F.	SS	MS	F (2, 1070)	p value
Between	2	1139.11	569.55	328.74	0.00
Within	1070	1853.81	1.73		
Total	1072	2992.91			

Table D-8. Bonferroni test conducted on Dimasa normalized data

Groups	Difference	Statistic	p value
Rising-falling	2.730	31.006	0.000
Rising-mid	1.411	12.723	0.000
Mid-falling	1.319	13.757	0.000

Table D-9. One-way ANOVA results for Rabha tones

Source	D.F.	SS	MS	F (2, 771)	p value
Between	2	138454.42	69227.21	235.95	0.00
Within	771	226206.72	293.39		
Total	773	364661.14			

Table D-10. Bonferroni test for three tone types in Rabha

Groups	Difference	Statistic	p value
Rising-mid	23.695	15.431	0.000
Rising-falling	35.060	18.923	0.000
Mid-falling	11.366	8.902	0.000

Table D-11. Bonferroni test on F0d of each syllable of /goron/

Groups	Difference	Statistic	Prob>Value
Initial syllables	-0.388	0.758	0.458
Final syllables	-3.238	7.007	0.000

Table D-12. Bonferroni test on mean F0d of each syllable of /hat^{h}ai/

Initial syllable			
Groups	Difference	Statistic	p value
bullet-hillock	0.323	0.985	0.343
bullet-market	0.352	1.403	0.180
bullet-teeth	-0.027	0.069	0.946
hillock-market	0.029	0.246	0.809
hillock-teeth	-0.350	0.895	0.387
market-teeth	0.894	2.098	0.049
Final syllable			
Groups	Difference	Statistic	p value
bullet-hillock	-0.417	0.448	0.662
bullet-market	1.808	2.902	0.000
bullet-teeth	-0.318	0.328	0.000
hillock-market	2.225	4.156	0.000
hillock-teeth	2.539	3.627	0.000
market-teeth	-0.712	4.475	0.002

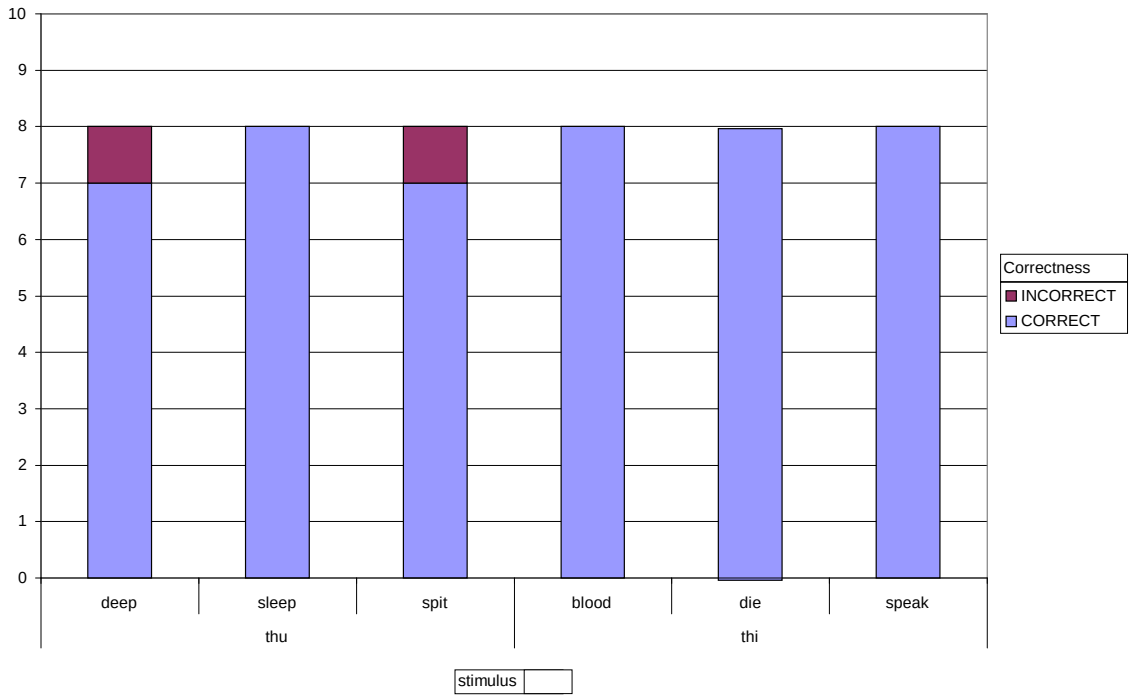


Figure D-1. Results of the Dimasa perception test categorized by correctness

LIST OF REFERENCES

Abramson, A. (1962). The vowels and tones of Standard Thai: Acoustical measurements and experiments. *International Journal of American Linguistics*, 28; 2, part II.

Barry, J. G., & Blamey, P. J. (2004). The acoustic analysis of tone differentiation as a means for assessing tone production in speakers of Cantonese. *Journal of the Acoustical Society of America*, 116(3), 1739-1748.

Basumatary, Phukan Chandra. (2004). *A Study in Cultural and Linguistic Affinities of the Boros and Rabhas of Assam*. Ph.D. Dissertation. University of Gauhati, Guwahati, Assam.

Basumatary, Phukan Chandra. (2005). *An Introduction to the Boro Language*. New Delhi: Mittal Publications.

Benedict, P. K. (1972). *Sino-Tibetan: A Conspectus*. Cambridge: Cambridge University Press.

Bhattacharya, Pramod Chandra. (1977). *A Descriptive Analysis of the Boro Language*. Department of Publication: Guwahati University.

Boersma, Paul & Weenink, David (2008). Praat: doing phonetics by computer (Version 5.0.30) [Computer program]. Retrieved July 22, 2008, from http://www.praat.org/Bradley 1982,

Bradley, David. (1982). Register in Burmese. In *Papers in South-East Asian Linguistics, No. 8. Tonation*,117-132. Canberra: Research School of Pacific Studies, the Australian National University.

Burling, Robbins. (1959). Proto-Bodo. *Language* 35, 433-453.

Chelliah, Shobhana L. (1997). *A Grammar of Meithei*. Berlin: Mouton de Gruyter.

Chhangte, Lalnunthangi. (1986). *A Preliminary Grammar of the Mizo Language*. Master's thesis, University of Texas, Arlington.

Chhangte, Lalnunthangi. (1993). *A Grammar of Mizo*. PhD Dissertation. University of Oregon.

Chuang, C.K., Hiki, S., Sone, T. and Nimura, T. (1972). The acoustic features and perceptual cues of the four tones of standard colloquial Chinese. Proceedings of the 7th International Congress of Acoustics (Vol. 3): 297-300. Budapest: Akademial Kiado.

Coupe, A.R. (2003). *A phonetic and phonological description of Ao: a Tibeto-Burman language of Nagaland*. Canberra: Pacific Linguistics.

Disner, S. (1980). Evaluation of vowel normalisation procedures. *Journal of the Acoustical Society of America 67*, 253-261.

Dundas, W. C. M. (1908). *An outline grammar and dictionary of the Kachari (Dimasa) language*. Shillong: Eastern Bengal and Assam Secretariat Press.

Fok, C.Y.Y. (1974). A perceptual study of tones in Cantonese. Hong Kong: University of Hong Kong Press.

Goldsmith, John. (1976). An overview of autosegmental phonology. *Linguistic Analysis* 2(1): 23-68.

Goldsmith, John. (1976). *Autosegmental Phonology*. Doctoral Dissertation, MIT.

Gowda, K.S. G. (1975). *Ao Naga Phonetic Reader*. CIIL : Mysore.

Green, A.D. (1994). *Syllable Structure in Burmese: a constraint based approach*. MS. Cornell University.

Grierson, George. A. (1903). *The Linguistic Survey of India.* Vol. V. Indo-Aryan Family. Eastern Group. Part I. Specimens of the Bengali and Assamese languages. Calcutta: Office of the Superintendent of Government Printing, India.

Gruber, Jeffrey. (1964). *The distinctive features of tone*. MS. Massachusetts Institute of Technology.

Halvorsrud, H. (1959). *Boro Grammar*. Rev. H.Halvorsrud for The Boro Literature Board.

Haudricourt, André-Georges. (1954). De l'origine des tons en Viêtnamien. JA 242:69-82.

Henderson, E.J.A. (1979). Bwe Karen as a two-tone language? Pacific Linguistics: Australian National University.

Hombert, J.-M., J. J. Ohala, et al. (1979). Phonetic Explanations for the Development of Tones. *Language* 55 (1), 37-58.

Hyman, Larry M. (2001). Tone systems. In Martin Haspelmath, Ekkehard König, Wulf Oesterreicher, & Wolfgang Raible (eds), *Language typology and language universals: An international Handbook*. 2, 1367-1380. Berlin & New York: Walter de Gruyter.

Ishihara, Shunichi. (1999). An acoustic-phonetic descriptive analysis of pitch realisations in Kagoshima Japanese. *Proceedings of the 1999 Conference of the Australian Linguistic Society.*

Joseph, U. V. and Robbins Burling. (2001). Tone Correspondences among the Bodo Languages. *Linguistics of the Tibeto-Burman Area*. 24(2), 41-55.

Joseph, U. V. and Robbins Burling. (2007). *The Comparative Phonology of the Boro-Garo Languages*. Mysore: Central Institute of Indian Languages.

Khouw, Edward and Ciocca, Valter. (2007). Perceptual correlates of Cantonese tones. *Journal of Phonetics*, Volume 35, Issue 1, January 2007, Pages 104-117.

Klatt, Dennis H. (1973). Discrimination of Fundamental Frequency Contours in Synthetic Speech: Implications for Models of Pitch Perception. *Journal Acoustic Society of America*, 53.1:8-16.

Lalrindikii.(1989). *Some Aspects of Autosegmental Phonology of English and Mizo*. M Litt dissertation. Hyderabad: Central Institute of English and Foreign Languages.

Leben, William. (1973). *Suprasegmental Phonology*. Ph.D. dissertation, MIT.

Leben, William. (1978). The representation of tone. *Tone: A linguistic survey*, edited by Victoria Fromkin, 177–219. New York: Academic Press.

Matisoff, J.A. (1991). Sino-Tibetan linguistics: present state and future prospects. *Annual Review of Anthropology.* 20, 469-504.

Matisoff, J.A. (2000). On 'Sino-Bodic' and other symptoms of neosubgroupitis. *Bulletin of the School of Oriental and African Studies (London).* 63.3, 356-69.

Matisoff, J.A. (1999). In defense of Kamarupan. *Linguistics of the Tibeto-Burman Area*. 22.2, 173-82.

Mazaudon, Mertin. (1985). Proto-Tibeto-Burman as a two-tone lanaguge? Some evidence from Proto-Tamang and Proto-Karen. J. A. M. G. Thurgood, D. Bradley (eds.), *Linguistics of the Sino-Tibetan Area: The State of the Art.* Canberra: Australian National University.

McCarthy, John and Alan Prince. (1993 a). *Prosodic Morphology I: constraint interaction and satisfaction.* MS., University of Massachusetts, Amherst, and Rutgers University, New Brunswick, N.J.

McCarthy, John and Alan Prince. (1993 b). Generalized alignment. *Yearbook of Morphology.* 1993, 79–154.

McCarthy, John and Alan Prince. (1994).Prosodic Morphology, in John Goldsmith, ed., *A Handbook of Phonological Theory*, Basil Blackwell, Oxford. Pp. 318–366.

Moore, C.B., and Jongman, A. (1997). Speaker normalization in the perception of Mandarin Chinese tones. Journal of the Acoustical Society of America, 102, 1864-1877.

Morén, B. & E. Zsiga.(2006). The lexical and post-lexical phonology of Thai tones. NLLT 24: 113—178.

Peng, S-H. (1997). Production and perception of Taiwanese tones in different tonal and prosodic contexts. *Journal of Phonetics*,25: 3, 371-400.

Peperkamp, Sharon. (1999). Prosodic words. Glot International 4, 15-16.

Pike, K. L. (1948). *Tone Languages*. Ann Arbor, Michigan: University of Michigan Press.

Prince, Alan and Paul Smolensky. (1993). *Optimality Theory: constraint interaction in generative grammar*. MS., Rutgers University, New Brunswick, N.J., and University of Colorado, Boulder.

Ravindran, N. (1974). *Angami Phonetic Reader.* Central Institute of Indian Languages, Mysore.

Rose, P. J. (1987). Considerations on the normalisation of the fundamental frequency of linguistic tone. *Speech Communication* 6. 343-351.

Rose, P. J. (1991). How effective are long term mean and standard deviation as normalisation parameters for tonal fundamental frequency? *Speech Communicati*on 10. 229-247.

Sapir, Edward. (1925). Sound patterns in language. Language (1): 37–51.

Sarmah, Priyankoo and Caroline Wiltshire. (in press). An Acoustic Study of Dimasa Tones. *Selected papers from NEILS 2*.RCLT La Trobe University, Australia.

Sarmah, Priyankoo and Caroline Wiltshire. (2006). An Acoustic Study of Mizo tones and Morphotonology. Paper presented at ICSTLL-39, University of Washington (Seattle), September.14-17, 2006.

Sarmah, Priyankoo. (2004). *Some Aspects of the Tonal Phonology of Bodo*. M Phil dissertation, Hyderabad: Central Institute of English and Foreign Languages.

Schacter, P & Victoria Fromkin.(1968). A phonology of Akan: Akuapem, Asante & Fante. Working papers in phonetics 9, University of California, Los Angeles.

Selkirk, E. (1980). Prosodic domains in phonology: Sanskrit revisited. Aronoff, M. & Kean, M-L. (eds). *Juncture*, Saratoga, Ca.: Anma Libri, 107-29.

Singha, Kh. Dhiren. (2001). *The Phonology & Morphology of Dimasa*. M.Phil. Dissertation. Silchar: Assam University.

Sreedhar, M. V. (1976). *Sema Phonetic Reader*, CIIL, Mysore.

Thirumalai, M.S. (1972). *Thaadou Phonetic Reader.* CIIL, Mysore.

Temsunungsang, T. and Paroma Sanyal. (2005). Truncation in Ao Verbal Morphology. Paper presented at ICOSAL-6, Hyderabad, India.

Trubetzkoy, N. (1939). Grundzüge der Phonologie. Travaux du cercle linguistique de Prague 7.

van Driem, George. (2001).*Languages of the Himalayas: An Ethnolinguistic Handbook of the Greater Himalayan Region*. BRILL.

Wang, William S-Y. (1967). Phonological Features of Tone. *International Journal of American Linguistics*. 33.2, 93-105.

Watkins, J. (2000). Phonation type phenomena in Burmese Tone. Tone Symposium. Tromsø, Norway.

Weidert, A. (1987). *Tibeto Burman Tonology*. John Benjamins.

Welmers, W. (1959). Tonemics, morphotonemics and tonal morphemes. General Linguistics 4, 1-9.

Woo, Nancy H. (1969). *Prosody and Phonology*. Doctoral dissertation. MIT.

Xu, C. X. and Xu, Y. (2003). Effects of Consonant Aspiration on Mandarin Tones. *Journal of the International Phonetic Association.* 33, 165-181.

Xu, Y. (2001). Sources of tonal variations in connected speech. *Journal of Chinese Linguistics.* 17, 1-31.

Xu, Y. and X. Sun. (2002). Maximum speed of pitch change and how it may relate to speech. *Journal of Acoustical Society of America.* 111(3),

Xu, Yi. (2004). Understanding from the Perspective of Production and Perception. *Language and Linguistics*. 5, 757-797.

Yip, M. (1991). *The Tonal Phonology of Chinese*. New York: Garland Publishing.

Yip, M. (2002). *Tone*. Cambridge: Cambridge University Press.

BIOGRAPHICAL SKETCH

Priyankoo Sarmah was born in Tinsukia, Assam (India). He received his B.A. in English from Gauhati University in 2000. He earned his M.A. in English (linguistics) and M.Phil. in linguistics from the Central Institute of English and Foreign Languages (now the English and Foreign Languages University) in 2002 and 2004 respectively. He joined the University of Florida as a Ph.D. student in fall 2004.