A DESCRIPTIVE STUDY OF SEGMENTAL AND SELECTED SUPRASEGMENTAL FEATURES OF HINDKO DIALECT SPOKEN IN TANAWAL, HAZARA

Researcher:

Muhammad Nawaz

Supervisor:

Dr. Ayaz Afsar

Reg. No. 09-FLL/PHDENG/S-08

Department of English
Faculty of Languages and Literature

INTERNATIONAL ISLAMIC UNIVERSITY,

ISLAMABAD

2014

phd
400
MVD

Language

A Descriptive Study of Segmental and Selected Suprasegmental Features of Hindko Dialect Spoken in Tanawal, Hazara

Thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy, at the Department of English, Faculty of Languages and Literature, International Islamic University, Islamabad

Muhammad Nawaz
Reg.No.09-FLL/PHDENG/S-08

Department of English Language and Literature

International Islamic University, Islamabad

2014

Acceptance by the *Viva Voce* Committee

itle of the thesis: **A Descriptive Study of Segmental and Selected Suprasegmentl Features of Hindko Dialect Spoken in Tanawal, Hazara.**

Name of Student: Muhammad Nawaz

Registration No: 09-FLL/ PhDENG/S08

ccepted by the department of English, Faculty of Languages & Literature, International lamic University, Islamabad, in partial fulfillment of the requirement for the Doctor of hilosophy degree in English.

***iva Voce* Committee**

External Examiner
Dr. Nasim Akhtar Raja
Professor, Department of English,
AJ&K University,
Muzaffarabad

Dr. Munawar Iqbal Ahmad
Dean
Faculty of Languages & Literature

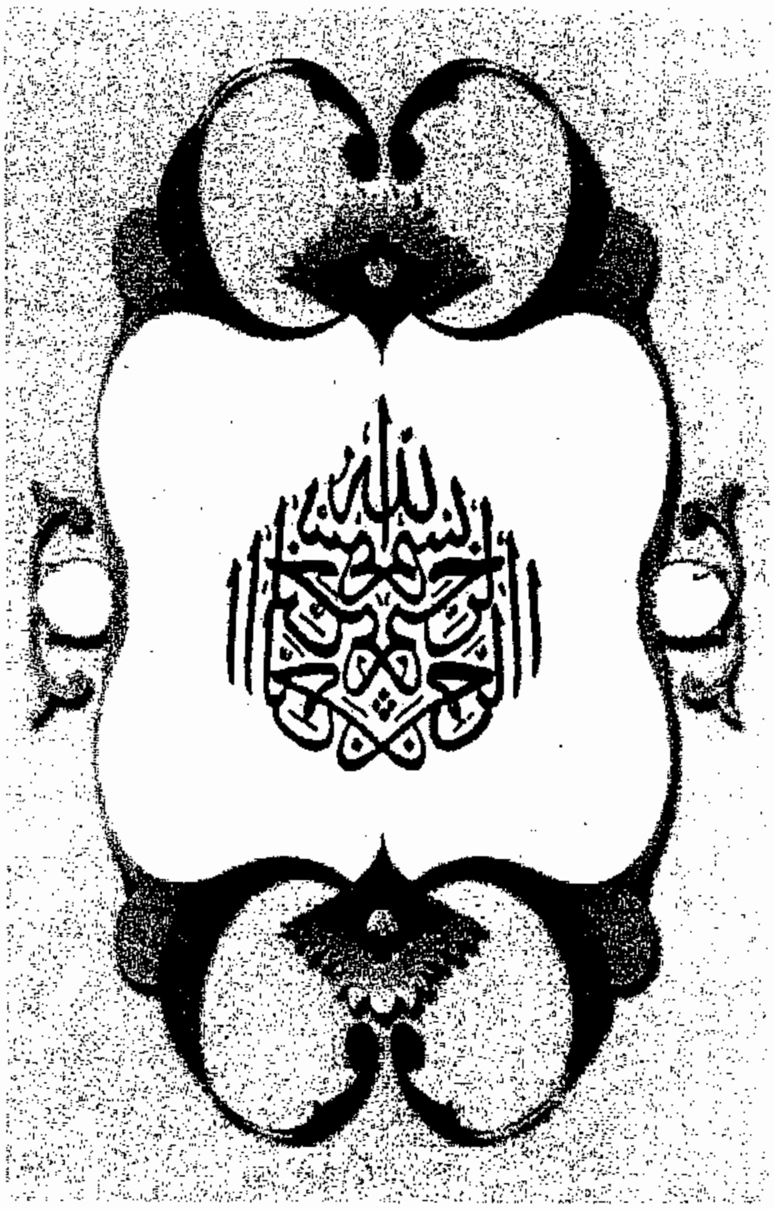
External Examiner
Dr. Saiqa Imtiaz Asif
Professor, Department of English,
Bahauddin Zakariya University,
Multan

Dr. Munawar Iqbal Ahmad
Chairman
Department of English

Internal Examiner
Dr. Fauzia Janjua,
Assistant Professor,
Department of English, IIUI

Supervisor
Dr.Ayaz Afsar
Associate Professor
Department of English, IIUI

August 18, 2014


بسم الله الرحمن الرحيم

Dedicated to my parents

DECLARATION

I, Muhammad Nawaz, Registration No. 09-FLL/PHDENG/S-08, student of PhD in English Linguistics at International Islamic University Islamabad, do hereby declare that during the period of this study, I was not registered in any other course. The material used in the thesis entitled "A Descriptive Study of Segmental and Selected Suprasegmental Features of Hindko Dialect Spoken in Tanawal, Hazara" has not been submitted by me wholly or in part for any other academic award or qualification and shall not be submitted by me in future for obtaining any degree from this or any other university. I confirm that this thesis is the original work of the researcher except where otherwise acknowledged in the dissertation.

I also understand that if evidence of plagiarism is found in my thesis/dissertation at any stage, even after the award of a degree, the work may be cancelled and the degree revoked.

(Muhammad Nawaz)

ACKNOWLEDGEMENTS

I am thankful to Almighty Allah who enabled me to get done this lengthy project. Darood o Salam upon the last prophet Muhammad (peace be upon him) whose life has been a continuous source of inspiration for me in seeking knowledge.

Research is never a hard job when one gets good teachers, friends and supporters. I am truly grateful to all of them who guided, supported, motivated and helped me, one way or the other, during the period of my study. In particular, I owe many thanks to my supervisor Dr Ayaz Afsar for being so delightfully sane. My formal and informal meetings with him remained invaluable experience during this project. He proposed me the research area during the course work and helped me find out what I want to do in this PhD thesis. His precious ideas, suggestions and criticism were fresh in my mind at every step of the study. This made my thesis what it is now.

I am thankful to my teachers, Dr Munawar Iqbal Gondal, Dr Raja Nasim Akhater, Dr Ahsan ur Rehman, Dr Safeer Awan and Dr Nadeem Haider Bukhari who taught the course work, guided in doing the research and helped in academic matters. My profound gratitude goes to my school teachers Alamzeb, Roshan Khan, Muhammad Irshad, Muhammad Iqbal and Muhammad Yousaf Shah for their sincere efforts and motivation to study. I would also like to thank my college teachers, Muhammad Iqbal, Khalid Butt, Muhammad Fayyaz and Muhammad Afzal for their guidance.

I would also like to thank Higher Education Commission of Pakistan (HEC) for giving me scholarship for PhD and providing me an opportunity to visit School of Oriental and African Studies (SOAS), University of London (UK) for six months research programme under IRSIP.

During my stay at SOAS, many people helped me, but especially, I am grateful to Dr Monik Charette (my research supervisor at SOAS) who guided me in phonological analysis of my data, Dr Sophie Salffner who helped me in using the Praat software, Dr Candide Simard for her guidance in acoustic phonetics, (HOD) Dr Lutz Marten for his unfaltering support in academic matters, and Bernard J Howard for his technical support in the lab. I am also indebted to my cousin Muhammad Akram who really helped me during six months stay at London and provided unflagging support to my life outside academia.

My indebtedness also goes to Muhammad Zia-ud-Din, General Secretary, Gandhara Hindko Borad (GHB), Dr Zahoor Ahmad Awan (Late) Ex. Chairman GHB, Dr Elahi Buksh Akthar Awan (Late) and Ejaz Ahmad Qureshi, Chairman GHB, who sincerely helped me during this project and wanted me to do PhD in the area of phonetics and phonology.

My sincere gratitude goes to my family members including Abdul Rashid, Wazir Muhammad, Ali Asghar, Zaheen Khan, Rashid Shamim, Amjad Shamim and my father Fazal ur Rehaman who always prayed for my success. I am highly thankful to my late mother (May Allah rest her soul in peace) for her love, sacrifices, encouragement and special prayers; I miss her every time. I owe many thanks to my friend Muhammad Riaz Ashraf and his family for their financial and moral support. Thanks to my friend Muhammad Rashid Hafeez who guided me at the initial stages of my research.

I am most grateful to the people of Tanawal (Area of Banna) who left their domestic and farming works and gave me time for recording the data. Thanks to my nephew Usama Asghar for his patience and assistance during the data recording. I am also thankful to those Tanoli respondents who ran away for not recording the data in order to save their precious time.

Thanks to Umar Zaman Tanoli for his life-long motivation for my higher education. I would also like to thank my close friends and class-fellows who were there for me when I needed them; thank you Dr Muhammad Kamal Khan, Dr Abdul Qadir Khan, Shaukat Hussain, Muhammad Ashfaq, Muslim Khan (Late), Akhtar Aziz, Dr Malik Naseer Hussain, Tasaddaq Hussain, Khalid Mahmood, Abid Qureshi, Ajeeb-ul-Amin, Aleem Shakir, Muhammad Tanveer Zia and Muhammad Shahzad.

Last but not the least, my sincere gratitude goes to my daughters, the little kid Muhammad Zohaib Nawaz, and my wife who were the actual sufferers of this lengthy project. They always prayed for my success and patiently put up with my problems, took care and consistently supported me at all the stages of this work. We weathered the storm together!

Table of Contents

A DESCRIPTIVE STUDY OF SEGMENTAL AND SELECTED SUPRASEGMENTAL FEATURES OF HINDKO DIALECT SPOKEN IN TANAWAL, HAZARA

Abstract

This study is a descriptive analysis of the segments and syllabification system of Hindko spoken in Tanawal region of Hazara Division, Pakistan. The dialect of Tanawal, in particular, has not attracted the attention of previous researchers and not become a topic of rigorous research. This study is limited to the inventory of phonemes by examining the data collected from native speakers and by analyzing it qualitatively and quantitatively through machine analysis. The segments were established by making minimal pairs. It was found that Hindko has three ways of voicing: voiced, unaspirated and aspirated sounds. In addition to consonants and oral vowels, Hindko also allows nasal vowels. The recorded data was analyzed with the help of Praat software and the results were presented through spectrographic and statistical analyses. The study also describes the syllabification systems of Hindko in light of Onset Rhyme Theory, Maximal Onset Principle (MOP) and Sonority Sequencing Principle (SSP). The findings show that Hindko allows three syllabic consonants, 13 templates for syllables and two consonant clusters. Hindko generally follows the principles of maximal onset and sonority sequencing. Tanawal dialect of Hindko also allows gemination word medially and finally. It is suggested that remaining suprasegmental features of Hindko such as stress and tones should be investigated on the same pattern so that the complete picture of the dialect may be formed.

Abbreviations and Symbols

The following list shows abbreviations and symbols used in the thesis:

ANOVA	Analysis of Variation
C	Consonant
CV	Consonant and Vowels
Co.Var.	Coefficient Variation
dB	Dynamic range (a property of spectrogram setting)
English	British Standard English unless otherwise stated
F1	First Formant
F2	Second Formant
F3	Third Formant
^{h}	Aspiration
Hz	Hertz
Hindko	Hindko spoken in Tanawal unless otherwise stated
IPA	International Phonetic Alphabets
KP	Khyber Pakhtunkhwa
LOF	Law of finals
LOI	Law of initials
LSD	Least Significant Difference
MOP	Maximal Onset Principle
ms	Milliseconds
MSD	Minimal Sonority Distance
N	Nucleus
n.d.	No date
NA	Not applicable
O	ONSET
OR	Onset Rhyme
R	Rhyme
RP	Received Pronunciation
Std. Dev.	Standard Deviation
Sec.	Seconds

SSP	Sonority Sequencing Principle
TBB	Text Book Board
V	Vowel/Short vowel
VOT	Voicing onset time
VV	Long vowel
X	Skeleton
μ	Mora
σ	syllable
*	Ungrammatical form of consonant clusters
//	Transcription
‘’	Meaning of the word
:	Used after geminate consonants and long vowels

List of Tables

List of Figures

CHAPTER 1

INTRODUCTION

This study is a descriptive analysis of the segments and syllabification system of Hindko spoken in Tanawal region of Hazara Division, in Khyber Pakhtunkhwa (KP), a Province of Islamic Republic of Pakistan. This language is widely spoken in the Districts of Mansehra, Abbottabad and Haripur including the cities of Peshawar and Kohat. Similarly, some people of Attock, Mardan, and Azad Jammu and Kashmir (AJK) also speak Hindko as their native language. Nevertheless, this thesis is about a dialect of Hindko spoken in Tanawal, Hazara, called as Tanoli Hindko. This chapter gives background information on the language and the speakers including objectives, research questions, significance, and organization of the study.

1.1 Geographical setting of Hindko speaking areas and Tanawal region

The speakers of Hindko are mostly found in the plains and the foot-hills of the Himalayas. They live both on the east and on the west of the River Indus. According to Rensch (1992), the territory of the Hindko speakers extends from the point where the Indus emerges, i.e. from Kohistan, downstream to the south and west for more than two hundred kilometres. Generally, this statement refers to the territory of Hazara, a division of KPK, and Tanawal is located within this division.

The exact linguistic boundaries of Hindko are difficult to mention here due to its use in the various cities of the province. The sister languages such as Punjabi and Pahari are another barrier to mark the actual borderline for Hindko speaking community. Nevertheless, a general effort, including informal interviews with Hindko speakers of Hazara, has been made to mark the boundaries that start from Kohistan, Babusertop near Challas, Azad Jammu and Kashmir, Murree, Hassanabdal, Attock, Swabi and the Indus River from Tarbaila to Besham. This description does not include other cities of KP where Hindko is spoken such as Peshawar, Kohat and Mardan etc. The map[1] shows the location of Tanawal and Hazara division including KP (formerly NWFP) province in the Figure 1.1.

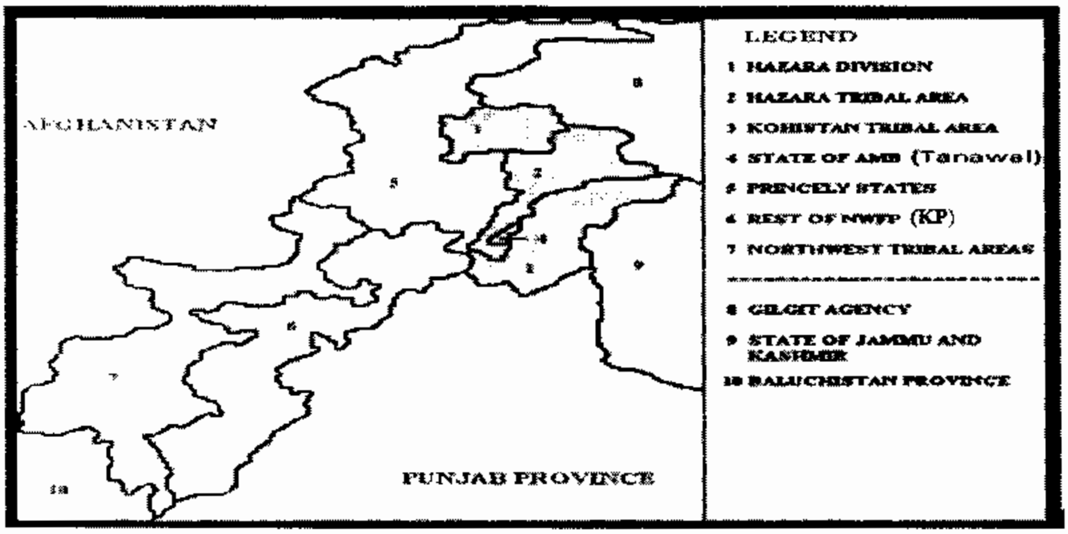


Figure 1. 1 Location of Tanawal in the map of KP

The map indicates the territory of Tanawal at no 4 in the legend. It is located in the northwest of Mansehra, west of Abbottabad, north of Haripur, south of Oghi and east of the Indus River. Some speakers also live along the western bank of the river. An estimated distance of the regions of Tanawal from various district Headquarters is about 17 km from Mansehra, 25 km from Abbottabad and 35 km from Haripur. Overall, Tanawal region spreads across 1600 square kilometres of these three districts.

[1] https://www.google.com.pk/search?q=map+of+district+mansehra....

During observation and informal interviews, the elderly people of Tanawal informed the researcher that before the partition of sub-continent, Tanawal had two parts: Upper Tanawal and Lower Tanawal. Upper Tanawal was an independent state known as the state of Amb. Its capital was Amb city located on the right bank of the river Indus. This city drowned in Indus River due to the construction of Tarbela dam in 1974. Nawabs (heads of the tribe) ruled over Upper Tanawal for more than one and a half century (1810-1952). The Nawabs' regime on Amb state officially ended in 1952 and Upper Tanawal became a part of Pakistan. On the other hand, Lower Tanawal consists of almost half of the land of Tanawal region, located to the south east of the Indus River. This area had been directly ruled by the British Empire till 1947.

The original inhabitants of the area are called Tanoli but they have many sub-castes. In Upper Tanawal, all Tanoli families have lateral /l/ sound at the end of their caste names, e.g. Khankhail, Pejjhal, Mettial, Seryal etc. Moreover, adjacent to Hindko community are speakers such as Gujjars speaking 'Gojri', Pashtuns speaking Pashto and Punjabis speaking Punjabi.

1.2 Population of Hindko speakers

It is hard to determine the exact number of Hindko speakers because in the last census 1998, there was no specific column in the form for regional languages, and Hindko was counted as 'other' language. Just after the census; however, Peshawar high court issued orders to keep a specific column for Hindko language in the form.

According to Rahman (2002), an estimated population of Hindko speakers is 2.4 percent of the total population of Pakistan. According to local inhabitants of the region, an estimated population of Tanawal, where this research has been carried out, is around 0.8

million. A predominant majority of the people of Tanawal use the Tanoli dialect and a small minority of these people are influenced by the neighbouring Hindko dialects. Generally speaking, there is no considerable variation within the Tanoli dialect.

1.3 Dialects of Hindko

There is significant dialect variation among Hindko speaking regions. Regarding the dialect of a language, Fromkin, et al. (2005) state, " When there are systematic differences in the way different groups speak a language...each group speaks a dialect of that language...a dialect is not degraded form of language, and logically could not be so since a language is a collection of dialects" (p. 401). The language, Hindko has many dialects with different names like Peshawari Hindko, Kohati Hindko, Hindko of Haripur, Abbottabad, Mansehra, Tanoli Hindko, and others. Lothers and Lothers (2010, p.6) call the Tanoli dialect as Tinauli (see Appendix- E). Rensch, et al. (1992) draw Hindko dialects difference in the following words:

> The Hindko language is spoken over a rather large geographic area, especially in its north-south dimension. Some enclaves of Hindko speakers are not geographically contiguous to others. Therefore, it is not surprising to find that there is significant dialect differentiation among the varieties of speech called Hindko (p.53).

In general, dialects can be different in terms of grammar, vocabulary, phonetics and phonology of a language. According to Petyt (1980), "Dialects are the various different forms of the same language. Using a language, thus, necessarily involves using one of its dialects" (p.11). The speakers of the same language can understand various dialects of the same language while the speakers of various languages cannot, if languages are not in contact.

The speakers of Tanawal dialect easily comprehend other dialects of Hindko while the speakers of other dialects face difficulty in understanding Tanoli Hindko. Conversely, it is hard for inhabitants of Tanawal to speak other dialects unless they spend a sufficient time among speakers of other Hindko dialects. The speakers of all Hindko dialects are generally known as Hindkuwan or Hindki. Regarding the standard Hindko dialects, Shackle (1980) states, "Peshawar Hindko has been cultivated as a vehicle for literature to a greater degree than the other northern dialects so far considered, and it is beginning to be promoted as a North West Frontier Province (NWFP) Standard Hindko" (p. 486). Similarly, Hindko speakers also considered Peshawari dialect of Hindko as the standard.

Many organizations have been working for the promotion of Hindko in Peshawar. They have published a reasonable amount of books. Specifically, Gandhara Hindko Board Peshawar has published around 50 books based on literature, folk tales, theology, and History of Hindko. A few studies have also been conducted in some other dialects. However, the dialect of Tanoli Hindko does not have much written on it.

Most of the Hindkuwan are unaware of the script of Hindko. However, the provincial government of KP (2008-2013) made an effort to teach the local languages to the native speakers during their early education. The well-established Pashto language was already being taught in the KP province and the government motivated the speakers of scriptless languages to standardize their scripts. In this regard, the KP Text Book Board (TBB) took the responsibility and arranged various meetings. Eventually, a meeting of Hindkuwan was held in July 2011 at the office of TBB Peshawar and approved the basic script of Hindko (see Appendix, A). In April 2013, a basic book of Hindko for the nursery class was introduced in Government schools of KP to teach the children of Hindkuwan.

1.4 History of Hindko

Many interpretations have been given for the name Hindko. Native speakers pronounce it Henko or Hendko language. For Grierson (1968), Hindko is the member of Indo-Aryan language family (see Appendix, F). Shackle (1980) has referred to the term Hindki, the speakers of Hindko language, which is "an Indian language" (p.482). Moreover, Rensch, et al. (1992) claim, "Some associate the term Hindko with India, others with Hindu people and still others with the Indus River, which is, of course, the etymological source of all these terms" (p.3). Awan (2008) has done much work on the history of this language. He wrote a book with the title of Sarzamin-e-Hindko. A brief overview of the book is given in the following section.

Awan claims that the history of the Hindko land, its people, its culture, and its language is more than 5000 years old. Hindko existed much before the advent of the Sanskrit language. The indigenous Hindko people were much cultured, educated, social, and linguistically rich before the attacks of Aryan people from central Asia in around 1500BC. The word "Hindko" was derived from the word "hind" by adding suffix "ko" to it[2]. So Hindko people were the aboriginal people of this area who existed in Hindko land even before the arrival of Aryans in this land (pp. 100-105). Since their arrival to this land in around 1500BC, the Aryans remained detached from the indigenous people for about 1000 years, so the languages of both the people did not mix up for that period. After these 1000 years, owing

[2] 'Hind' is the root word of Hindustan (sub-continent) or Hindu religion; and 'ko' refers to mountain. According to Qureshi (1984), Aryans of Rigvedic period called the region of Hind as Sapta-Sundhava, the land of seven Rivers of which Indus (Sindhu) was the main river. With the passage of time, it became Sindhu/Sindh. The word 'Hind' is a phonetic variation of Sindh. Muslim were the first to give name to Hindu to the tradition of Aryan culture (p.10; Volume.1)

to the contact of the languages of two nations, a new language Sanskrit was originated. Aryan people termed their language as Sanskrit, while the language of the local people was termed as Prakrit. (pp. 116-118). In short, Hindko is the generic name for the indigenous people, the indigenous culture, and the indigenous language of the area referred to as "Hind/Hindu/ Hindku."The words Hindu and Hindko are derived from the word Sindhu[3] as the sound "s" of Sindhu was altered with the sound "h" of Hindu/Hindko. Many sounds, grammatical rules, and the vocabulary of the Sanskrit language were derived from the Hindko language. Aryan people were strong in warfare so they dominated the people of this area whereas Hindu/Hindko people were socially, culturally, educationally and linguistically superior to the Aryan people, so, they influenced their language and culture. No matter what the history of the language is, not much literature is available on this language.

1.5 Present status of Hindko

The researcher observed the present status of Hindkuwan (2009-2013) which may be divided into four groups. First group of Hindko speakers has been working day and night for the promotion of Hindko. The people of this group are not much in number but they are the learned people of the community. In this group, the speakers of Peshawari dialect have the key role. They arrange conferences and gatherings and publish books which motivate other Hindkuwans to participate, to write and to speak for the cause of Hindko.

Second group of Hindkuwan comprises of those who speak the language in their daily life but have no concern for its promotion. Majority of Hindkuwan is the part of this group. This group contains literate and illiterate people who think that they know about the use of

---

[3] Sindh is now a province of Pakistan.

their language. The language of this group is not as pure as that of group one and they mix words of Urdu, Punjabi and English in daily use.

However, third group of Hindkuwan is of the elderly people who speak Hindko without mixing it with the other languages. Due to the purity of their language, data for the present study is collected from this group. Most of the people of this group are above fifty years of age and they get rare chance to interact with people of other languages. Majority of these speakers can be seen in villages.

A fourth group refers to the speakers who have migrated to the cities from the villages. The young generation of these Hindkuwan is discouraged by their parents to speak Hindko. Rather they are encouraged to become fluent in Urdu and English. In fact, parents of this group do not speak Hindko with their children claiming that Hindko has limited use in the society. The children of these people can understand Hindko but cannot speak. The claim made about second, third and a fourth group is pretty true picture of Tanoli Hindko.

Briefly speaking, Hindko spoken in Tanawal is an undocumented and undescribed language and there has been no research till date on this dialect. The present research is, thus, exploratory in nature and fills this gap by offering a study of sounds and syllable structure of Tanoli Hindko. It is descriptive and data-driven in nature rather than idea-driven.

According to Lehmann (1999), "Description of a language is an activity (and derivatively, its result), that formulates, in the most general way possible, the patterns underlying the linguistic data. Its purpose is to make the user of the description understand the way the language works"(p.10). Data for this descriptive study is collected through the developed lists of possible words; observation and interaction with the native speakers in such a way that a pretty true picture of the dialect may be taken into account (see Sections, 3.2.2, 3.3.2 & 3.4.1). These methods of data collection were easy for the researcher as a native speaker of Tanoli Hindko.

1.6 Objectives of the study

The objective of this study is to identify and describe the phonemes of Hindko spoken in the region of Tanawal. It will also examine the syllabification rules of the dialect including syllabic templates, consonant clusters, syllable boundaries and sonority sequencing principle (SSP).

1.7 Research questions

This research provides answers to the following research questions. These include two main questions and six sub-questions.

1) What are the segmental features of Tanoli Hindko?
   i. What is the consonantal system of Tanoli Hindko?
   ii. What is the vowel system of Tanoli Hindko?
2) What is the syllabification system of Tanoli Hindko?
   i. How many syllabic templates exist in Tanoli Hindko?
   ii. How many consonant clusters exist in Tanoli Hindko?
   iii. How do syllable boundaries and SSP work in Tanoli Hindko?
   iv. How does gemination system work in Tanoli Hindko?

1.8 Significance of the study

This research provides a basic description of the segmental features of the Tanoli Hindko. This language is spoken in KP, a highly multilingual province of Pakistan, where 29 languages are spoken and most of them are undescribed. The study may yield new information as no research has thus far been carried out on this dialect. This research will be the first study of the dialect based on experimental phonetics and phonology that provides a comprehensive description of Tanoli dialect of Hindko.

The study may, therefore, not only highlight the features that distinguish it as a different dialect of Hindko but it may reflect upon the working articulatory phonetics, acoustic phonetics and syllabification systems of some other languages, particularly, undocumented and undescribed languages. This study may be of interest for linguists, who have already been working in the area of phonetics and phonology. It may be of particular help for the researchers of regional languages within the country. Since the description of languages on experimental basis began in forties, most of the languages of the world have gone through such experiments in the last century. Therefore, the description of Tanoli Hindko on experimental basis may enable the language to become part of well-described languages.

1.9 Fieldwork

The researcher personally visited Tanawal region in July 2011. Being a native speaker of the dialect, it was not hard to approach the informants. A list of the participants (see Appendix, C) was prepared and appointments were fixed according to their convenience. They were from the villages of New Darband circle, i.e. Kangrorian, Bandi, Nawan Sher, Barra Balla, Barra Pain and Doodkot.

1.10 Organization of the study

This section shows a brief view of the following Chapters of the study.

Chapter 2 shows the previous research on two dialects of Hindko spoken in Peshawar and AJK. The chapter also shows the relevant literature, in general terms, to review the relevant concepts. First, it gives a review of specific features of articulatory phonetics such as consonants, i.e. stops, nasals, fricatives, affricates and approximants, and vowels including oral, nasals and diphthongs. Secondly, it shows related literature on acoustic phonetic features of each consonantal group and vowels. The described features are applied in the data analysis Chapters four, five, six and seven. Finally, it elaborates phonological approaches of syllable structure and syllabification. Then, it finds out Onset Rhyme model for syllable structure, principles of maximal onset (MOP) and sonority sequencing (SSP) for the analysis of data of Tanoli Hindko.

Chapter 3 deals with methodology of the study. It shows the description of the sample, material used for data collection, methods of data collection and data analysis procedure of all the variables of the study such as consonants, vowels and syllables.

Chapter 4 exhibits minimal pairs for the entire Hindko consonants. This chapter shows the analysis of stop and nasal consonants in terms of articulatory and acoustic phonetics. Firstly, it shows articulatory analysis of stops followed by discussion and then acoustic analysis of these sounds is carried out including discussion. Secondly, it depicts the similar methods of the data analysis for nasal sounds of the dialect.

Chapter 5 describes Tanoli Hindko fricatives, affricates and approximants. Each group shows the analysis of data in light of articulatory phonetics and acoustic phonetics respectively followed by discussion. Finally, it shows the distinctive features of Tanoli Hindko Consonants.

Chapter 6 shows articulatory and acoustic analysis of Tanoli Hindko oral vowels and diphthongs. It also depicts the articulatory analysis of Tanoli Hindko nasal vowels. A comprehensive discussion is given against each section of the Chapter.

Chapter 7 describes syllabic templates and consonant clusters word initially, medially and finally of Tanoli Hindko. Theory of Onset Rhyme is employed for the analysis of Tanoli Hindko syllable structure. It also presents analysis of data in light of MOP and SSP principles. Finally, the chapter depicts Tanoli Hindko gemination system.

Chapter 8 sums up the whole thesis and present the findings.

1.11 Chapter summary

This chapter has introduced Hindko, the language that is being investigated in the present study. It provides the background information about the location of Hindko speaking belt, population, dialects, and history of Hindko. It also shows objectives, research significance, and research questions of the study. Finally, it gives an overview of the organization of the study.

The following Chapter gives a review of previous research on Hindko. It also gives a review of related literature on consonants, vowels, and syllables respectively. The purpose of giving detail of each feature is to clear the terminology.

CHAPTER 2

LITERATURE REVIEW

This chapter overviews the previous research on other dialects of Hindko to give a background to the present study of Tanoli Hindko. It also reviews the relevant literature on the segmental features, consonants and vowels of language in terms of articulatory and acoustic phonetics. It also gives an account of the literature on syllable structure and syllabification.

2.1 Previous research on Hindko

Although a few studies have been carried out on Hindko, yet in the field of linguistics not much work has been done. A PhD thesis has been produced by Awan (1974) entitled, "The Phonology of Verbal Phrases in Hindko." In the thesis, he focused on the language spoken in Peshawar city. He gave a detailed description of junction features within the verb-root and the root and the inflexion. Primarily, the study applies a prosodic analysis on Hindko material. In the data analysis, he relied on his knowledge and own experience.

In later work, Awan (2004) identified 35 consonants on an articulatory basis. The following chart, in the Table 2.1, is adapted from (p. 55) (see Appendix, A). Regarding the developed chart of Hindko, Awan states, "This chart is developed according to my own language. As every speaker has its own way of articulation, it is possible that the findings of some other Hindko speakers remain different from these results."

Table 2.1 Consonantal chart of Hindko spoken in Peshawar

	Bilabial	Dental	Alveolar	Retroflex	Palatal	Velar	Glottal
Stops	p p̆[4] pʰ b	t̪ t̪̆ t̪ʰ d̪	t t̆ tʰ d	-	k k̆ kʰ g	-	-
Affricates	-	-	ʧ ʧ̆ ʧʰ ʤ	-	-	-	-
Nasals	m	n	-	ɳ	-	-	-
Fricatives	f v	s z			ʃ	x ɣ	h
Lateral		l					
Trill/Flap		r		ɽ			
Glide					j		

The above chart shows that Hindko has 16 stops, 4 affricates, 3 nasals, 8 fricatives and 4 approximants. Stops have four places of articulation, bilabial, dental, alveolar and palatal. Affricates show the alveolar place of articulation, and nasals include three places of articulation, bilabial, dental and retroflex. Fricatives are articulated at bilabial, dental, palatal, velar and glottal position. Approximants include three places of articulation, lateral, retroflex and palatal. It also shows that each place of articulation of stops and affricates has two unaspirated, one aspirated and one voiced segment.

In case of Hindko vowels, Awan (2004) describes nine oral vowels and each vowel has its nasal counterpart. Six are long vowels, /a:/, /E[5]/, /e/, /i:/, /o:/, /u:/ and three are short

[4] In addition to the stop voiced, unaspirated, and aspirated sounds, the chart by Awan also shows another group, i.e. unaspirated sounds with a diacritic (p̆, t̪̆, t̆, k̆ and ʧ̆); however, many other studies depict that this phenomenon occurs in some other languages of sub-contienent due to the tone such as Punjabi and Pahari (see Baart, n.d; Khan, 2012). In the researcher's opinion, in case of Hindko, the vowels following the consonant carry a low tone which makes it a different word, e.g. the word /ta:l ٹال / means heap of woods etc, and if the same word is spoken with the low tone on the vowel following the first consonant, i.e. /ta:l/ ٹہل it means 'descent'.

vowels /a/, /i/, /u/ (see Appendix, A). Like consonants, these vowels are also identified in articulatory phonetics. However, he admits that proper identification of vowels is not possible without the use of machine (p.71). Awan's study also shows six long and three short nasal vowels; however, it does not repeat any diphthongs.

In a more recent study, Rashid (2011) acoustically measured the formants of vowels of Hindko spoken in AJK. It reveals that there are nine oral vowels, i.e. six long and three short vowels. He also describes syllabic templates of Hindko, consonant clusters and gemination system as well. In case of consonant clusters, Rashid states, "Consonant cluster is a rarity in Hindko. Hindko does not seem to allow consonant clustering at pre-vowel position. However, it does so at the coda position" (p.64). In case of gemination, Rashid refers to only word medial gemination whereas the studies carried out by Awan (2004, 2008) show gemination in Hindko word finally and word medially; however, both studies lack detailed rules of Hindko gemination system.

Regarding the alphabets of Hindko, Text Book Board (TBB) of Khyber Pakhtunkhwa arranged a meeting of Hindko speakers in July (2011) and finalized the Hindko alphabets (see Appendix, A). These alphabets lack of /ɳ/ sound, which is commonly used in Hindko, because most of the members of committee were of the view that this sound can be written as the combination of /n/ and /ɽ/ not as /ɳ/, (The researcher was also present in the meeting). However, sound /ɳ/ is commonly used in some other languages of Pakistan such as Punjabi

---

[5] This symbol is unclear whether author means Cardinal Vowel No. 3, i.e. /ɛ/ 'epsilon' or /E/ 'small capital E' for a front unrounded vowel at exactly the midpoint, i.e. between Cardinal 2 and Cardinal 3 (see symbols detail, Pullum, G. K. & Ladusaw, W. A., 1996: 50-52).

and Sindhi. Furthermore, committee added /ʒ/ sound while it does not exist in Hindko (see Section, 5. 1. 6).

Moreover, two dictionaries of Hindko have appeared. First was written by Sakoon in (2002) containing seven thousand words. This dictionary mostly reflects the vocabulary of Abbottabad, Mansehra and Haripur dialects of Hindko. Other dictionary was compiled by Awan in (2008) with thirty thousand words. It mostly reflects the vocabulary of Peshawar dialect. Other published material is beyond the purpose and scope of the present study.

In summary, both studies were carried out in other two dialects of Hindko, i.e. Peshawari Hindko and Kashmiri Hindko. Awan carried out the phonemic inventory of Peshawari Hindko in terms of articulatory phonetics, and Rashid conducted the vowels inventory of Kashmiri Hindko in light of acoustic phonetics. The present thesis deals with the phonetic and phonology of Hindko dialect spoken in Tanawal region. It develops the phonemic inventory of the dialect in both articulatory and acoustic phonetics. The phonological part of the study shows the syllable structure and the syllabification system of Tanoli Hindko.

The following section of this chapter shows a detailed account of segmental features which deals with the phonetics of language. Then the relevant literature is given on articulatory and acoustic phonetics in terms of consonants and vowels. Finally, it also shows theories of syllables and syllabification of language. Overall, the purpose of given literature is to clarify terminology used in the analysis.

2.2 Phonetics of language

Referring to the phonetics of a language, Ball and Railley (1999) state that phonetics is a broad term but can be referred to a simple definition, 'anything to do with speech' that includes physiology of speech production along with the articulatory differences between vowels and consonants.

The phonetics can be classified in three major areas: auditory phonetics, articulatory phonetics and acoustic phonetics. The auditory phonetics deals with listening, recognizing and distinguishing of the sounds; articulatory phonetics categorizes the sounds of a language according to their articulatory categories and both areas are subjective and impressionistic. On the other hand, acoustic phonetics refers to the method of speech measurement in terms of its physical properties of intensity, duration and frequency. It gives a quantitative evidence for the presence or absence of certain acoustic cues in sounds. Therefore, these three areas provide a full variety of a phonetic study of a language.

Ball and Railley (1999) refer to further division of phonetic features that phonetic approach analyzes the sounds speech in a precise articulatory feature whereas phonemic approach classifies the speech in terms of a number of general sound types. For example, during the analysis of phonetic approach, fricatives versus plosives are carried out while in case of phonemic approach, all the phonemes on consonantal grid and vowel trapezium of the International Phonetic Alphabet (IPA) are taken into account.

The phonemes and allophones of a language can be distinguished through proper study of its sound system. For the findings of the phonemes and allophones, Davenport and Hannahs (2010) state, "We need first to be able to determine the phonemes then relate them to their allophones. Phonemes are most often established by finding a contrast between speech sounds. These contrasts can be most easily seen in minimal pairs" (p.118). It means that developing the minimal pairs is a helpful tool for the phonemic inventory of a language.

In articulatory terms, for the classification of segments through minimal pairs, Cruttenden (2001) indicates that these are the pairs of words which differ in respect of only one sound, e.g. /pin/, /bin/, /tin/ supply us three words. These words are distinguished simply by a change of the first consonantal element of the sound sequence, which are said to be in contrast, or opposition. For Clark, et al. (2007), minimal pairs give solid evidence of phonemic contrast.

In addition to the minimal pairs, the contrastive distribution of the segments is a helpful tool for the verification of the phonemes. Segmental distribution at different positions gives further verification about identified sounds through minimal pairs. The occurrence of a segment at different places of words is one of the indications of the presence of phoneme in the language in question, which avoid the obscurity of sounds identification. Ball and Rahilly (1999) describe, "It is important to note that when we are attempting to identify phonemes we must do so on the basis of sounds which occur in similar positions in otherwise identical items (i.e. in parallel distribution)" (p.146). Furthermore, a brief view of related literature on consonants including their articulatory features such as voicing, places and manners is given in the following section:

2.3 Consonants

All the articulated sounds which obstruct to the flow of air as it comes up from lungs and passes through larynx to the lips are called consonants. This obstruction makes the air passage narrow or complete closure. In this regard, Cruttenden (2001) denotes that to describe the consonants of a language, it must be made sure whether language has pulmonic or non-pulmonic system, egressive or ingressive organism, voiced or voiceless sounds, oral, nasal or nasalized consonants, places of articulation and manners of articulation of sounds. The answers to these issues give a brief phonetic label for the sounds of a language.

Voicing is an important feature in the description of consonants. A consonant can be either voiced or voiceless. Fromkin, et al. (2011) signify that consonants can be voiced or voiceless; in voiced sounds, vocal cords come close and vibrate while in the production of voiceless sounds, vocal cords are open and the air flows freely between the vocal cords without vibration. Clark, et al. (2007) state that there are languages in the world like French, Greek, Russian, Hungarian, Turkish, Vietnams and Zulu which allow contrasting sounds with their counterparts such as voiceless /f/ and /s/ and voiced /v/ and /z/.

The active articulators make the obstruction by moving towards passive articulators. The mobile and immobile parts of the speech organs allow for the articulation of sounds. The functions of these articulators may be referred to as the places and manners of articulation.

2.3.1 Oral stop sounds

Stop consonants are produced with the complete closure of air in the oral cavity. During production of stop sounds, the articulators come close to each other with the complete closure of air which comes up from lungs. Initially, in this process, no air escapes from the vocal tract. Soft palate is raised in order to stop the air from escaping through nose. Defining the stop sounds, Giegerich (1992) states, "A stop is a sound that involves complete closure of the oral cavity" (p.19).

Many phonetic studies show three stages during the articulation of stops. Such as the works of Cruttenden (2001) and Davenport and Hannahs (2005) show the closing stage, the compression stage and the release stage. They further describe that during the closing stage; the active articulators come in contact with the passive articulators and form the closure. The second phase is the compression stage which is also known as a hold or closure stage. Hall (2003) highlights that during the hold phase, the articulators are got closed and air is compressed which comes from the lungs. The air is stopped, and not allowed to go out. Bloomer, et al. (2005) state that during release stage, the closure is opened, allows the closed air abruptly to be released with some force and this process makes the puff sounds. This process of sound production refers to the term 'plosive' for oral stops which means stopping the airstream and then suddenly releasing it (see Section, 4.2.1 for stops analysis).

2.3.2 Nasal stop sounds

Like stops, nasal consonants are also articulated with the closure in the vocal tract. The airflow is completely obstructed in the oral tract and escaped through the nasal cavity. In this regard, Hall (1997), Ladefoged (2001), Cruttenden (2001) and many other linguists state that nasals are articulated through a lowered velum while non-nasal segments are produced with a raised velum. Thus, unlike stop, nasals are sonorous consonants. In addition, IPA chart shows that nasals are voiced sounds in all of the world's languages. However, Davenport and Hannahs (2010) point out that a few languages like Buremes make contrast between voiceless and voiced nasals (see Section, 4.3.1 for nasal sounds analysis).

2.3.3 Fricative sounds

Fricatives are the only segments in the International Phonetic Alphabet chart that include all the possibility of places of articulation of speech sounds (see appendix-D). Roach (1983) states that fricative sounds are found in all of the languages of the world. Fricatives are articulated while air goes out through a narrow passage with hissing sounds in vocal tract. According to Olive, et al. (1993), phonemes of fricatives are produced at the place of constriction in the vocal tract instead of glottis, and "this sound source is a randomly varying signal (noise)... the vocal tract behind the point of constriction (the back cavity), has less influence on the acoustics of the sound than the part of the tract in front of the constriction" (p.154). Ashby and Maidment (2005) state that during the production of fricatives, the flow of air makes turbulence that generates the acoustic energy for fricative. Thus, air comes up from lungs and gets a small passage for escape in the vocal tract with a turbulent noise (see Section, 5.1.1 for fricatives analysis).

2.3.4 Affricate sounds

Affricates are found in many languages of the world. Ladefoged and Maddieson (1996) state that affricate /ʧ/ is used in 45 of the languages in their sample. The combination of the stops /t,d/ and fricatives /ʃ,ʒ/ make affricate sounds as /ʧ/, /ʤ/. Dorman, et al. (1980) refer to the difference of the two group of sounds that short durations in the articulation of fricatives and rapid rise times leads to the perception of affricates while longer fricative noise durations and slow rise time lead to the perception of fricatives. Furthermore, the term affricate is defined by Cruttenden (2001), "Any plosive whose release stage is performed in such a way that considerable frication occurs approximately at the point where the plosive stop is made...sounds may be considered either as single phonemic entities or as sequences of two phonemes" (p.171). It implies that phonetically, affricates are similar to plosives and fricatives due to their behaviour of sequential utterance (see Section, 5.2.1 for affricates analysis).

2.3.5 Approximant sounds

In articulatory term, unlike stops but like fricatives, approximant sounds are directly articulated without closure of the vocal tract. In contrast to fricatives, approximants are sonorous segments. Cruttenden (2001) describes that approximant segments are produced in

2.4 Vowels

Unlike consonants, vowels are articulated without hindrance to the airflow in the vocal tract. It is well known fact that vowels cover less area of vocal tract from palatal to velar part. Ladefoged and Maddieson (1996) refer to distinctive features of vowels that they can be pronounced alone while consonants are articulated with vowels. Roach (2000) denotes that during the production of vowels, airflow is not obstructed in the cavity, as it comes from the lungs and goes out directly towards the lips. Ladefoged (2001) refers to any segment that is found in the centre of a syllable is unconditionally articulated without closing lips and obstruction of outgoing airflow. For the articulation of vowels, he also signifies that vibration of air in the vocal tract is twofold due to the position of tongue, i.e. rear part and front of the mouth, and the role of tongue cannot be minimized in the vowels production due to its position. Therefore, vibration of air for each vowel changes at different hertz. He further states that knowing the position of the tongue refers to occurrence of vowels, and the formant values of vowels make them different from language to language.

Brinton and Brinton (2010) highlight that for vowel classification, places of articulation are taken into account whereas manner of articulation are not considered because all vowels are articulated with open approximation. The works of linguists (e. g. Lyons, 1968; Ball & Rahilly, 1999; Roach, 2000; Cruttenden, 2001; Ladefoged, 2001 & 2003; Johnson, 2003; Davenport & Hannahs, 2010; among others) show that vowels are characterized in terms of height of the tongue (acoustically saying Formant1 of the vowels), which refers to high, mid and low vowels or close, half close, half open and open vowels.

Formant 2, on the other hand, refers to the position of tongue, which identifies how far the uplifted body of the tongue from the backside of the mouth. It refers to the description of vowels as, front, central and back. The lips position classifies whether the vowels are open, closed, rounded or unrounded. In this regard, Brinton and Brinton (2010) state that rounding lips have double effect of changing the shape of opening the resonating chamber. A vowel with a long resonance chamber (rounded lips) that are temporally short or temporally long, i.e. short /u/ and long /u:/. Long vowels include longer time duration than short vowels. Thus, vowels can be classified in terms of vowels height, vowels backness and vowels rounding.

Cruttenden (2001) states that in articulatory terms, some points can easily be marked for the classification of vowels as front, back, or close vowels, yet it is not possible to identify the exact position of the tongue for the vowels. Thus, this flaw, i.e. description of vowels in terms of auditory and articulatory phonetics, made linguists to look for a better and standard method. According to Ladefoged (2001), in certain dialects, phoneticians should rely on their auditory abilities for identification of vowels. He further states that plotting vowels on the chart can give complete picture of the vowels of a language. This chart may provide satisfactory result for the identification of vowels that are near the corners of the possible vowel area. However, he also adds that this chart lacks fixed points which are far from the corners of the chart. In this regard, the points proposed by the famous phonetician Daniel Jones are helpful to identify the exact position of vowels. He devised a series of eight vowels in 1920s which provide fixed reference point for phoneticians. This chart is called cardinal vowels.

2.4.1 Cardinal vowels

Ashby and Maidment (2005) state that cardinal vowels, "can be thought of as landmarks in the auditory space provided by the vowels quadrilateral" (p. 77). Vance (2008) describes that the main purpose of cardinal vowels was to provide a precise platform to the researchers who want to describe a language. They can compare any possible vowels with the cardinal vowels which assist them to identify the vowels of a language. Thus, cardinal vowels became famous among phoneticians and largely used as a set of reference for the description of vowels of language in term of both categories either, articulatory or auditory. Roach (2009) states that quadrilateral in terms of cardinal vowels has become a common practice for the linguists. Likewise, the International Phonetic Association also uses the four sided diagram of cardinal vowels in their works.

First, Daniel Jones proposed the eight primary cardinal vowels (see figure 4.4a) from vowel no 1 to 8 but later he added ten more vowels to meet the requirements of other world languages termed as secondary cardinal vowels. The below diagram (see Figure, 2.1b) shows vowel no 9 to 16. Another pair of cardinal vowels is vowel no 17 /ɨ/ the high central unrounded and no 18 /ʉ/ the high central rounded vowel (Davenport and Hannahs, 2010). They describe, "The high central unrounded 17 /ɨ/ and the high central rounded18 /ʉ/ give a total of eighteen cardinal vowels. Secondary cardinals 9-16 and 18 vowels have same place of articulation as 1- 8 and 17 respectively with the opposite lip rounding" (p.41). In this regard, Rogers (2000) designates that in the primary cardinal vowels, the position of tongue and lips are common in most of the languages of world but there are European languages like French, German and some other languages have uncommon lips and tongue combinations. Similarly, world's languages have front rounded, back unrounded vowels and central vowels. However, the aim of cardinal vowels was to provide a platform to classify all types of vowels in the world's languages. Hence, the primary cardinal vowels lack to fulfil these entire requirements. Many works show cardinal diagrams for the classification of vowels, the following diagrams adapted from (Knight, 2011, p.77, 78):

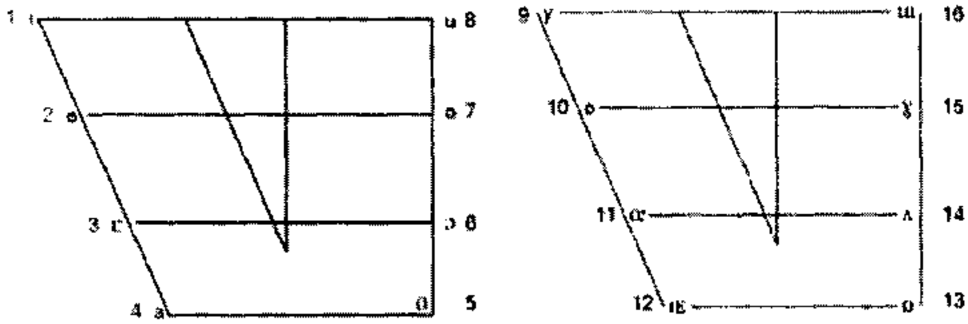


Figure 2. 1 (a) The primary cardinal vowels (b) The secondary cardinal vowels

It would be worthwhile to mention here that identified places of vowels in the cardinal vowels quadrilateral are not fix for any language rather sounds location fluctuate depending on the articulatory system of that language. Such as Yavas (2011) describes that languages have similar vowels but un-identical location even in two languages. For example, a vowel /æ/ is identical in Cantonese, French and Dutch but finds different location in the quadrilateral as can be seen in the following diagram adapted from Yavas (2011, p. 20):

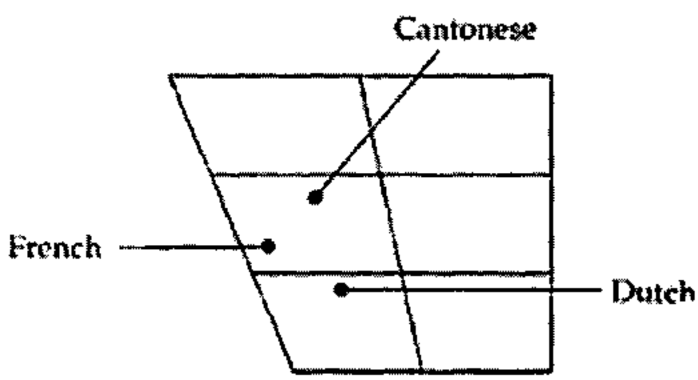


Figure 2. 2 Realization of /æ/ in Cantonese, Dutch and French

Figure 2.2 reveals place of a front vowel in three different languages that /æ/ in Cantonese has highest tongue position; it gets middle position in French while the lowest position in Dutch language. Similarly, the work of Ladefoged and Disner (2012) shows the position of /e/ and /ɪ/ in Californian English vowels quadrilateral which have also different location from common languages.

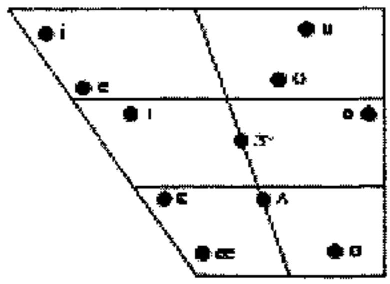


Figure 2. 3 Formant chart of Californian English

Knight (2011) states that cardinal vowels do not occur in any language rather it devise as a set of reference vowels to which vowels of other languages can be compared. However, languages have some vowels which are quite identical to the places of cardinal vowels. According to Ladefoged (2001) vowels were traditionally described according to the tongue height. Yet in recent times, phoneticians also classify the vowels in terms of formant frequencies but the use of auditory judgment in terms of a set of reference cannot be minimized as well.

According to Rogers (2000), in addition to the vowels height, rounding and backness, i.e. to the spectral characteristics, there may be other qualities for identification of vowels of a language, i.e. temporal characteristics. This phenomenon refers to the sounds utterance duration, i.e. short (lax) and long (tense) vowels. Similar to vowels qualities, time duration play a key role in distinguishing the vowels.

Davenport and Hannahs (2010) state that vowels can also be classified not only in terms of quality, i.e. high, back and rounded but also in terms of quantity that refers to length of vowel, either long vowels or short vowels, e.g. long vowels mostly remain 50-100 percent longer than the short vowels (see Section, 6.1.1 for analysis).

All languages of the world have vowels which are called monophthongs. But some languages also have combination of two vowels, termed as diphthongs. Thus, the concepts regarding diphthongs are elaborated in the following section:

2.4.2 Diphthongs

Vowels are the single entity while a diphthong shares the qualities of double vowels. Unlike the consistency of the speech organs in single vowels, the articulators during the articulation of diphthong shifts from preceding vowel to following vowel in the vocal tract. According to Ladefoged and Maddieson (1996), diphthong is like a vowel for which more than one target vowel quality is specified. Ladefoged (2001) designates that out of two parts; first part of diphthong remains more prominent than the second part. The first part refers to the falling diphthong while the last part lingers longer than the first and termed as rising diphthong.

Likewise, Davenport and Hannahs (2010) compare another aspect between the duration of the vowels and diphthongs. For example, the words 'see' /si:/ and 'sigh' /sai/ contain vowel /i/ and diphthong /ai/ respectively. For preceding sound, tongue position remains steady while for the following sound, tongue highest point shifts from low to high position. Steady vowel /i:/ in /see/, /si:/ is called monophthong while the other vowel in 'sigh', /sai/ refers to diphthong. Thus, diphthong can be transcribed as /ai/ in two symbols. Its utterance duration is similar to long vowels. Sometime such diphthong can also be transcribed as vowel + glides as /aj/ rather than /ai/ but it's a phonologically issue not phonetic (p.43).

According to Lindau, et al. (1985), diphthongs are found in the phonemic inventories of one third of the languages of the world. A study carried out by Maddieson (1984) (cited in Watkins, 1999) shows some results and suggestions about diphthongs in the following way:

> Cross-linguistic survey recognized diphthongs only if they could not, according to the distributional patterns observed in other segments in the language, be analysed as a VC, CV or VV sequence. Under this rather strict criterion, diphthongs were recorded in only 23 out of 196 languages (p.133).

Moreover, Clark and Yellop (1995) add that if a language exhibits more than about ten vowels, it may have diphthongs as well (see Section, 6.2.1 for diphthong analysis).

In conjunction with the earlier mentioned entities of sounds, i.e. monophthongs and diphthongs, another feature linked with vowels that affect their acoustic properties, called as nasalization.

2.4.3 Nasalization

Nasalization occurs in nasal tract. Nasal segments are articulated through lowering the soft palate and allowing air through the nasal cavity. Ball and Rahilly (1999) state that nasalized vowels are found in many languages of the world. Some languages have nasalized vowels as a contrastive sound, e.g. French and Portuguese whereas in case of English, a vowel can be nasalized if followed or preceded by a nasal stop. However, English has no nasal vowel as a contrastive sound. Thus, nasalization in English makes no difference to the meaning of a word whether a vowel is nasalized or non-nasalized (Ladefoged, 2003). Nasalized vowels are written with a diacritic /˜/ known as tilde, on a vowel that forms it a nasal vowel.

Johnson (2003) describes that in the articulation of nasal vowels, two operating systems of speech work together, i.e., pharynx cavity with mouth cavity, and pharynx cavity with nasal cavity. Earlier is the oral tract which has resonance at about 500, 1500 and 2500 Hertz (Hz) while latter, the nasal tract "has resonances at about 400, 1200 and 2000Hz and all these formants are present in the spectrum of nasalized vowels" (p.163).

Nasalization has two types of vowels: nasalized vowels and nasal vowels. According to Davenport and Hannahs (2010), nasalized vowels occur while nasal consonants are found on either side of the vowel as in English word 'man', but some languages like French, Polish and Navajo include nasal vowels without the effect of the adjacent nasal stops. Nasal vowels in these languages have their own distinctive position. They state, "Nasal vowels look essentially like other oral counterparts, but also exhibits a typical 'nasal formant' at around 250Hz, and two linguistically significant formants above that" (p.65). Thus, if a language includes nasals or nasalized vowels, its phonemic inventory cannot be validated without studying its nasalization system (see Section, 6.3.1 for nasalization analysis).

The above mentioned section shows related literature on articulatory phonetics whereas the following section gives an epigrammatic view of related literature on acoustic phonetics in light of vocalic and non-vocalic sounds.

2.5 Acoustic Phonetics

Articulatory phonetics plays an important role for the identification of sound system of language. However, acoustic phonetics provides more reliable results. Ball and Rahilly (1999) state that ear-based approaches have an important place in the field of phonetics; however, in some situation, they are inadequate and "only the acoustic measurement have any real validity" (p.154). Crystal (2003) defines that in acoustic phonetics, latest instruments are used to identify sounds that provide clear results of data to the phonetician.

According to Davenport and Hannahs (2005), acoustic phonetics investigates not all but linguistically relevant properties of sounds such as aperiodic and periodic waves, frequency, amplitude and formants. Therefore, a sound is needed to be investigated through specific properties which are relevant to place them in their right position.

About the importance of acoustic phonetics, Di Paolo and Yaeger (2011) state that in recent times, acoustical analysis for identification of the sounds of a language has become more reliable source than ever before, and it provides finer detail on the object of scrutiny. Simply speaking, acoustic means the study of transmission of the sound waves. The acoustic study of a language refers to the analysis of waves of the speech sound system of a language with the help of instruments.

In the acoustic analysis of human speech, use of a spectrogram for the investigation of a sound has become a common practice among phoneticians (e.g. Ball & Rahilly, 1999; Roach, 2000; Cruttenden, 2001; Ladefoged, 2003; Johnson, 2003; Yavas, 2006; Reetz & Jongman, 2009; Davenport & Hannahs, 2010 among others). Spectrogram is a visual representation of the speech sound that shows the frequency into Hz on the left side of the visual in the vertical axis whereas horizontal axis of spectrograph shows the time in Millisecond (ms). The dark part in the spectrogram indicates formants which refer to regular vibration of the vocal fold. The much dark picture of a spectrogram shows greater the amplitude of sound (Olive, et al. 1993). With the help of Pratt, spectrograms of sounds are drawn to find out acoustic cues. Before the acoustic analysis of Hindko consonants, related literature on acoustic features of each class of consonantal sounds is given one by one in the following section:

2.5.1 Acoustic features of oral stops

Regarding the acoustic cues, various acoustic features help to differentiate voiced sounds from voiceless such as during stops closure duration, the presence of voicing is one of the key features (Ladefoged, 1993; Ladefoged & Maddieson, 1996; & Johson, 2003). In addition to this acoustic cue, Yavas (2011) proposes some other indicators including presence of a voice bar, i.e. duration of the stop gap, release burst, duration of the previous vowel and aspiration. He states that these indicators help to identify stop sounds according to manners of articulation.

Duration of stops gap

This cue refers to the hold phase of stop consonants. According to Raphael, et al. (2007), the element of silent gap is an important acoustic cue to stop consonants which play its role during the closure of the air. In the articulation of voiced sounds, they state, "/b/, /d/, and /g/, a low-intensity harmonic, the fundamental frequency (f) may run through all or part of articulation of the stops closure. Nonetheless, the term, silent gap, is often used to describe the closure for all of the stop consonants"(p.148).

The silent period helps in identifying the stops of a language. The acoustic cue of silence remains throughout the spectrum part of stops. Voiced sounds are produced with a narrowed glottis whereas voiceless sounds are articulated with an open glottis and preceding sounds contain less closure duration than following sounds.

Presence of a voice bar

It is another acoustic cue of voicing. Voiced sounds contain less energy than voiceless. According to Mees and Collins (2003), voiceless plosives have energetic articulation, also known as fortis stops while voiced stops have weaker articulation and potential voice which are called lenis. Yavas (2011) states that presence of voice bar refers to the dark area found at low frequency around below 250 Hz in a spectrogram and its presence can only be seen in voiced sounds not in voiceless sounds. Kingston and Diehl (1994) state that voiced obstruents remain shorter than voiceless. The voice bar is, therefore, an indicator originated in horizontal axis in the very beginning of the spectrogram.

Release burst

The third acoustic feature related to stops production is the release burst that assists in categorizing stop consonants. Johnson (2003) explains it in the following way:

> The stop burst is produced when increased air pressure in the vocal tract is released. Air rushes out of the mouth at high speed, producing a pressure impulse that lasts only 2 or 3 milliseconds. Thus, the burst noise marks the moment of stop consonants release. Like the shutting stage, release can also be voiced (with modal, creaky, or breathy voicing) or aspirated (p.174).

The burst can be seen on a spectrogram in a shape of a vertical spike in the section of silent gap. However, the voiceless stops spectrums show more prominent spikes than the voiced stop consonants (Yavas, 2011). Raphael, et al. (2007) describe, "Release bursts include (10-35 ms) but it covers a broad range of frequencies with varying intensity. The frequencies at which the bursts are most intense are relevant to place of articulation" (p.148).

Duration of the previous vowel

Yavas (2011) states that the idea of the previous vowel duration[6] refers to the sonority hierarchy that vowels are sonorous sounds than consonants. Obviously, stops are the least

---

[6] For example, the following words, /ɪt/, /eg/, /esk/, /ɪŋk/ show combination of vowels and consonants, and the previous vowels before the consonants in the words have longer duration and more sonority than consonants.

sonorous sounds among other consonants. Moreover, Goksel and Kerslake (2000) denote that duration of vowels before voiced stops remains longer than that of voiceless sounds.

Aspiration in plosive sounds

In some languages, aspirated sounds are phonemic while in others this phenomenon is allophonic. According to Reetz (2009) like unaspirated sounds, aspirated sounds also lack voicing with longer closure duration and significant delay between the aspirated sounds release and onset of following vowel. Similarly, Davenport and Hannahs (2010) state that aspiration is the result of audible frication of the air which takes place while the closure of stop is released before the beginning of voicing.

In a nutshell, the above mentioned acoustic features of stops provide detailed account for the classification of sounds. Nevertheless, they are limited to the manner of articulation, i.e. the way of production, and give one side of the picture. For Silverman (2006), the component of manner of articulation has mainly concern with voicing. In other words, studying sound system through manner is helpful to separate voiced sounds from voiceless. The following section shows the acoustic features of place of articulation:

Place features

Hayward (2000) states that the acoustic cues for manner of articulation, i.e. gap, release burst or voice bar do not give account for places of sounds because their features are similar from one place to another place. Yet, the cues for place of articulation indicate how a bilabial sound is different from dental etc. He specifies that two potential acoustic cues, spectrum of burst and transition to following vowels facilitate in identifying the places of articulation of sounds.

The role of acoustic phonetics in indentifying the places of articulation is viewed by Ladefoged (2003) that acoustic phonetics does not provide satisfactory account. Nevertheless, formant transitions can be a helpful acoustic feature. He explains the phenomenon in the following way:

> Acoustic phonetics analysis is not the best way to find out about different places of articulation. You can do much better with the simple palatography techniques, or even by just looking at the speaker's mouth. I have described many languages but have never been found acoustic analysis useful for determining the places of articulation....What acoustic information there is about the place of articulation of consonants is mainly available from the movements of the formants in the neighbouring segments (p.160).

It implies that articulatory phonetics is a better way to identify the places of utterance. In addition to the above mentioned acoustic features of places, i.e. spectrum of burst, transition, the cues of VOT and locus have also been employed in the works of Fry (1976), Cruttenden (2001), Roach (2000), Davenport and Hannahs (2010), Hewlett and Beck (2006), Reetz (2009), Yavas (2011) among others to see the place of articulated sounds. The detail of the places cues are given in the following section:

Stop burst

Stop burst is the acoustic feature to place of articulation which shows the frequency of noise burst at the onset of the release stage referring to the characteristic bends of F2 and F3. (Cruttenden, 2001). Bilabial contains shorter burst duration than other stops (van Santen, 1997). Similarly, Greenberg (2004) states that at the release stage of stops a short burst of energy occurs and this energy is found in diffuse form in bilabial and alveolar sounds on spectrograms. Bilabial /b/ shows more energy at lower frequency while alveolar /d/ displays at higher frequencies. The release burst, on the other hand, for velar /g/ is found in a "more compact form centred in the middle frequencies" (p.111).

Hayward (2000) explains that stop burst for bilabial is weaker than those of alveolar and velar stops. It can be summarized that stop burst is found in the region of F2 and F3. It is mainly found in the lower region for bilabial with less duration, in the upper area for alveolar spectra and in the middle part of velar stops.

Formant transitions

Formant transitions are another important part of acoustic phonetics which indicates credible indications to place of articulation. Styles (2005) defines the term formant: "horizontal bands of energy in a spectrogram...and the formant transition is the shift in frequency leading into each formant" (p.148).

Yavas (2006) describes that formant transitions identify the transitions of 'stop-to-vowel' (CV) and 'vowel-to stop' (VC). If stop segments exist at initial position of a syllable (CV), frequency of first formant (F1) of the vowel will rise whereas if stop segments occur at final position of a syllable (VC), frequency of F1 of vowel will decrease. However, he specifies if transitions of F1 cannot give detail regarding place of stops, transitions of second and third formants (F2 & F3) will be of great helpful formants.

Hayward (2000) and Yavas (2006) state that in case of English, CV position of bilabial, the transitions of F2 and F3 show rising movements whereas in VC sequence, F2 and F3 show the 'mirror image'. In case of velar stops, they state that transitions of F2 and F3 come close to each other and F2 falls in CV context while F3 rises. Thus, function of both formants in the production of velar stop makes a wedge-like form. On the contrary, in situation of VC, the role of F2 and F3 are much narrowing. Hayward (2000) also states that formant transition of F2 for /d/ and /g/ may be same before low vowels; however, transitions of F3 are different which play role to differentiate the places.

Potter, et al. (1947) (cited in Hayward, 2000) state that general pattern shows for articulation of alveolar segments, a small line of F2 indicates level or rising for front vowels but falling for the production of back vowels while transition of F3 is almost found in level or rising position in CV sequence on a spectrum. On the other hand, Yavas (2006) describes that during VC sequence of alveolar stops, there is least movement of formants; F2 shows a small downward line while F3 indicates a small upward line of the movement. In addition, Cruttenden (2001) adds that in case of voiced stop sound, it is possible to be a marked rising bend of F1 of the adjacent vowel in /b, d, g/ but not in /p, t, k/.

Locus

Locus is another acoustic feature which provides cues to place of articulation. Yavas (2006) argues that locus is the frequency which is the beginning point and the transitions of second formant emerges to be pointing. Pointing means the very starting of the transitions; and in the production of stops, tongue starts to move towards the following vowels, however; this point cannot be seen in a spectrogram (Hayward, 2000). Hardcastle (2010) refers to the works of Liberman, et al. (1954) and Delattre, et al. (1955) that indicate, "place of articulation could be differentiated by using F2 points to a "locus" on a frequency axis close to the time of stop release" (p. 95). Thus, on frequency axis, a point emerges, and from that point, transitions of second formants (F2) begins, the movement of tongue to following vowels, and this whole process of the cues assists in identifying the places of stops.

Voicing Onset Time (VOT)

The acoustic signal of voice onset time (VOT) classifies voicing and places of stop sounds of a language. The term VOT became famous with the work of Lisker and Abramson (1964) (cited in van der Weijer & van der Torre, 2007). They carried out research on eleven languages and measured their VOTs and pointed out that VOT is a crucial tri-modal which includes plosives with a negative VOT (related to voiced sound), plosives with a little positive VOT, (refers to no aspiration) and plosives with a positive VOT, (sound production with aspiration). They state that most of the languages of the world use two-way voicing feature like voiced and voiceless while some of other world languages apply three-way voicing feature such as voiced, unaspirated and aspiration.

Hewlett and Beck (2006) denote that VOT differentiates between voiceless and voiced sounds. Kong (2009) carried out a research on VOTs of four languages, Korean, Japanese, Thai and English and found out that it was a successful parameter for Thai and English voicing while Japanese and Korean needed some other acoustic parameters, like fundamental frequency: f0 for distinguishing stop voicing type. Cho and Ladefoged (1999) measured VOTs of 18 languages and made four categories for velar stops: unaspirated stops contain 30ms, slightly aspirated stops 50ms, aspirated stops 90ms and highest values for highly aspirated stops in Navajo and Tlingit languages. Ladefoged (2003) further comments on it, "When making a description of a language, the VOT of the stop consonants should always be given as it varies across languages" (p.98). Like, voiceless aspirated velar stops of Navajo have VOT of over 150ms, on the other hand, in Scottish Gaelic, similar sounds have a mean VOT of 75ms. According to Gussenhoven and Jackob (1998), "Typical values for aspirated plosives are between VOT + 50ms and VOT + 80ms" (p.4).

VOT measurement in terms of place of articulation varies among languages. The general concept is that VOT of stops is increased as it goes further in the back part of the oral cavity, i.e. from bilabial to velar (e.g. Peterson & Lehiste 1960; Lisker & Abramson 1964; Klatt, 1975; Zue , 1976; Cho & Ladefoged, 1999; Ladefoged 2003; & Morris, et al. 2008). Furthermore, Lisker and Abramson (1964) also state that velar stops get maximum VOT; bilabial includes minimum VOT while alveolar stops contain intermediate VOT. However, Chao, et al. (2008) describe that Mandarin language does not follow this general finding for oral stops. Cho and Ladefoged (1999) believe that for each place of articulation there are language specific differences. It implies, therefore, that acoustic cue of VOT is employed for voicing and place of articulation of stop consonants and variations in VOT are found cross-linguistically (see Section, 4.2.3 for analysis).

2.5.2 Acoustic features of nasal stop consonants

Ladefoged (2003) describes that nasals consonants have lower amplitude than vowels. However, unlike vowels, nasal formants are not fully observable on a spectrogram. According to Davenport and Hannahs (2010), "Nasals have additional formants at about 250 Hz, 1200 Hz and 2400 Hz" (p.66). They also denote that front nasals have lower frequency than back nasal consonants and the frequency rises as the air decreases from front /m/ sounds to back /ŋ/ segment.

Ladefoged (2003) further states that measurements of formants frequency that refers to the movement of the formants in the adjacent sounds are useful to differentiate places of articulation of nasal consonants. Yavas (2006) describes that nasal acoustic cues show discontinuity between formants and the adjacent sounds. He also denotes that nasals include a very low frequency of F1, visible frequency of F3 whereas invisible frequency of F2. Overall, unlike vowels and approximants, nasal formants remain light at the spectrograms. For Ladefoged (2001), this characteristic is typical pattern of nasal consonants.

Like plosive sounds, therefore, the consonantal formant transitions help to know the difference in the places of articulation while other acoustic features provide an account for the manner of articulation of nasals. Consequently, various acoustic features are helpful tools to indicate nasal sounds (see Section, 4.3.3 for analysis).

2.5.3 Acoustic features of fricative consonants

Yavas (2006) states that fricatives spectrograms display energy in a scribby pattern which lack regular vertical or horizontal spikes, e. g. English sibilant fricatives, /s, z, ʃ, ʒ/ have higher amplitude and the greater interval of frication noise than non-sibilant segments, i.e. /f,v, ð, θ, h/ include a weak noise whose energies are found in a spread form with higher frequency on a spectrogram. Raphael, et al. (2007) describe the sibilant as posterior and non-sibilant as anterior fricatives. Yavas (2006) placed /h/ in non- sibilant fricatives. It can be concluded that sibilant fricatives contain more intense energy with lower frequency than non-sibilants.

Gorden, et al. (2002) carried out an acoustic study on voiceless fricatives in seven languages and measured cues of duration, centre for gravity, overall spectral shape and formant transitions of fricatives from adjacent vowels. They found out that fricatives can be well measured with the overall spectral shape than other acoustic cues. Gorden's study also supports the idea of Hayward (2000) that spectral shape intensity and formant transitions are the important acoustic cues of fricatives. It reflects that fricatives should be examined in light of duration, noise frication, formants transitions and overall spectral shape. Overall, both intrinsic and extrinsic properties should be taken into account.

Raphael, et al. (2007) identify that in the manner of fricative segments, the main acoustic cue is the extended period of noise that is created by the turbulent of airflow as it escapes through the vocal tract. They further signify that formants movements of F2 and F3 are important acoustic features to fricatives places of articulation. Gut (2009) points out that voiced fricatives appear on spectrum with faint formant structure having little energy. Sibilant fricatives contain steep, high-frequency spectral peaks while non-sibilant fricatives include flat spectra (Raphael, et al. (2007). Hence, in light of acoustic cues discussed so far help to identify fricatives in manners and places of articulation.

For the sampling frequency of fricatives, Hayward (2000) identifies that the spectra of fricative may display prominent peaks above 5000 Hz. Hence, there is intense need to use a higher sampling rate than 10,000 Hz. Similarly, Ladefoged (2003) also recommends sampling rate for fricatives above 10,000 Hz. The works of many phoneticians including Hayward (2000), Ladefoged (2003), Davenport and Hannahs (2010) show spectrographic frequency for fricative sounds above 8000 Hz. It implies that for the recording of fricatives, the sampling frequency should be selected above 8000 Hz.

In the spectrographic analysis, Davenport and Hannahs (2010) state that English fricative sounds show aperiodic vibrations in the upper part of the spectrograms in form of irregular striation. According to them, "The main resonant frequencies of fricatives rise at the size of oral cavity decreases… thus, [h]'s strongest resonances are around 1000 Hz, those of [ʃ] about 3000 Hz, 4000 Hz for [s]…and between 4500 and 7000 Hz for [f]" (p.68). In addition to acoustic theories of fricative sounds, some relevant studies, on the acoustic analysis of fricatives in the world's languages, are also discussed in the following section:

Unlike other languages, English fricatives remained the focus of majority of researchers. Like, Behrens and Blumstein (1988) carried out a research on English fricatives and measured the duration and found that sibilant sounds were longer than non-sibilants. However, he also identified that there was not much difference between the segments of the same class. Jongman (1989) states that frication noise duration is an important cue for distinguishing fricative sounds that a receiver can perceive fricative sounds even on a fraction of friction noise duration. Furthermore, frication noise duration is also a helpful cue for voicing cue that voiceless fricatives have longer duration than voiced.

Cole and Cooper (1975) also applied frication noise duration cue for distinguishing the voiced and voiceless sounds and found significant results. Another acoustic cue is the spectral peak location which is applied by Hughes and Halle (1956) for the identification of fricative places of articulation. Similarly, Al-Khairy (2005) carried out a research on Arabic fricatives and investigated four acoustic cues, i.e. amplitude measurements (noise amplitude), temporal measurements (noise duration), spectral measurements (spectral peak location and spectral moments) and formants transition (see Section, 5.1.3 for analysis).

2.5.4 Acoustic features of affricate consonants

Although affricates in languages are phonemic, yet they are the combination of stops and fricatives. In this regard, Ball, et al. (2008) state that acoustic features of affricates are much similar to stops and fricatives. They describe that affricates include silent gap of stop closure, i.e. obstruction of vocal tract and the burst of noise which refers to the release of stop. On the other hand, affricate sounds consist of duration of frication which are the cues of the fricatives. It shows that affricates are somehow amalgamation of stops and fricatives. However, being phonemic entity, affricate sounds have their own acoustic characteristics.

Many studies refer to the acoustic properties of the affricate sounds. Such as Hayward (2000) describes that the noise portion of affricates is lengthened and the period of silence is shortened than that of stops, (stop part occurs at initial position of affricate), whereas in the production of fricatives, (fricative part in affricates occur at final position of phoneme), noise part of affricates includes the constrictions intervals without silence. He further explains that duration of affricate stop and affricate portions are less than that of stops and fricatives respectively.

Ladefoged (2001) states that in the spectrographic analysis, striations of individual segment of /ʃ/ and /ʒ/ in case of fricative is more prominent than collective segments of affricates, /ʧ/, /ʤ/. In addition, Johson (2003) refers to the acoustic cues of affricates, "The amplitude of frication noise rises quickly to full amplitude in affricates and more slowly in fricative" (p.144). Thus, these acoustic features, like normal striation, silent gap, abrupt release, friction and quick rising of frication to full amplitude are important cues of affricates (see Section, 5.2.3 for analysis).

2.5.5 Acoustic features of approximants

Approximants are the most sonorous consonantal sounds. Regarding acoustic phonetics, Pisoni (2008) states that approximants and vowels have similarity in some of the acoustic cues in manner of articulation. Like vowels, the glides and liquids have un-constricted articulation and the formant structure. Specifically, glide /j/ sounds like vowel /i:/ by the extension of transition period. He further states that approximants have also resemblance with diphthongs; both segments contain articulatory movements and the changes in formant frequencies which are internal to the segments.

In spite of the similarities, some contrastive cues indicate the difference between approximants and diphthongs. Liberman, et al. (1956, cited in Pisoni, 2008) state that approximants have faster rate of formant frequency change than those of the diphthongs. However, this rate is not as faster as the formant transition of vowels in preceding and following of stops. Such elements, therefore, separate the approximants from vowels and make them consonantal sounds.

Hayes, et al. (2004) identify that potential sources for approximants are place cues, "Unlike other consonants, approximants (liquids and glides) have formants structure that serves as an internal cue. They also benefit from transition cues on the neighbouring vowels; typically, formants change fairly gradually in the transition between vowels and approximants" (p.60).

Nolan (1983) and Lehiste (1964, cited in Kim & Lotto, 2004) state that lateral is measured in terms of F1, F2 and F3 at the point of maximal vocal-tract narrowing of the production of the sound. Similarly, glides are well measured by the first three formants. In addition, acoustic energy for the /l/ is seen below 500 Hertz (Hz) and spectrogram lacks energy above 500 Hz. The flap contains short duration with short closure and release. They further state that glide /j/ includes lower F1 and higher F2 frequency than /i:/ and /l/ sounds. There is much resemblance among vowels, diphthongs and approximants; however, each group of the sounds has its own characteristics which should be kept in mind during the analysis of the approximants (see Section, 5.3.3).

2.5.6 Acoustic part of oral vowels

A problematic feature involves in the articulation of vowels that sound articulators do not touch with one another and air goes out directly out ward without obstruction. Thus, it is difficult to know the actual position of the articulation of vowel segments. However, this problem is solved by the acoustic phonetics that accurate information about vowels can be pinpointed by the acoustic properties. In this regard, Ladefoged (2001) designates that the most authentic way to identify the vowels system of a language is through their acoustic properties. He states that vibration of air in the front part of the vocal tract produces the vowel sound which is heard, whereas in the rear part of the body of air, vibration of the air changes the pitch of a sound. Being a lower in pitch this peak is called first formant (F1). Next peak in the frequency is the second formants (F2). Formants of vowels vary from language to language and the vowel system of a specific community is relatively similar. He further states that knowing the vowel formants is a minute investigation to identify the vowels of a language.

Ladefoged (2003) describes that the key acoustic properties of vowels are formants which are the highest resonating frequencies in a sound utterance. Formants are found more prominently on a spectrogram in dark form. Generally, three major formants, first (F1), second (F2) and third formant (F3) are the important features to describe the vowels of a language. However, in the present study, only two formats, (F1) and (F2) are considered because these two formants are adequate to identify vowels of language and to draw its quadrilateral. F1 shows height of the tongue while F2 shows the position of the tongue during vowels articulation. Thus, vowels can be well identified by using the frequencies of formants (F1& F2). The following figure of 'F', adapted from Lodge (2009, p.194). It shows the diagram of vocal tract marked with F1 and F2.

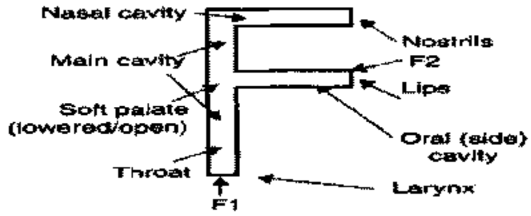


Figure 2. 4 Formants positions in the vocal tract

The figure 2.4 reveals functions of oral and nasal cavities in the production of vowels which include formants. During the articulation of vowel sounds, F1 occurs at the rear part whereas F2 get position at the front part of vocal tract. It also indicates oral and nasal cavities including soft palate that remains lowered for nasal and open for oral sounds.

During the acoustical measurement, a formant is found in form of dark part on a spectrogram which is the by-product of regular vibration of the vocal folds. These formants frequencies occur vertically on a spectrogram in form of F1, F2, F3 and F4 respectively. In addition, duration of vowel utterances is measured horizontally in millisecond. It helps to identify the length of vowels of a language whether short or long.

Moreover, the little difference in formant frequencies is also very important for the classification of vowels. Diane Kewley Port a psychologist (n.d.) (cited in Ladefoged, 2001) state that a native speaker of a language can even distinguish only 12 Hz discrepancy of the formant frequencies in the vowel space.

Therefore, during the acoustic analysis of present study, formants frequencies of Hindko vowels are measured to know the place of each segment in the vowel space. Thus, in light of F1 and F2 frequencies measurement, Hindko oral vowels are placed on quadrilateral. Moreover, oral vowel utterances are also measured to see sound duration. Overall, Hindko oral vowels are analyzed keeping in view two kinds of acoustic cues, i.e. vowel quality and vowel duration. Vowel qualities refer to the spectral characteristics of vowels as low, high, back, front etc while vowel duration represent the temporal differences of vowels as short or long (see Section, 6.1.2 for analysis).

2.5.7 Acoustic part of diphthongs

Brinton and Brinton (2010) state that diphthong are articulated through tongue gliding from one place to another within a syllable and articulated as continuous segment, rather it contains a change in the position of tongue and change in the shape of the lips. Unlike other sounds, formants of diphthongs are measured at two positions because these sounds have the combination of two vowel segments. Ladefoged (2003) identifies, "Diphthongs should be measured near the beginning and end of the vowel, at point that are not affected by consonants transitions" (p.132). He further states that mark first at the beginning of diphthongs but not so close to the consonant and second, at the end but to be kept far from the consonantal effects (see Section, 6.2.2 for analysis).

2.6 Representation of syllables

In general term, combination of vowel and consonant, or vowels alone, refers to the syllables of a language. According to Giegerich (1992), syllables are the larger phonological units than the individual phonemes. These units play a vital role in the phonological analysis of a language. On the basis of syllables, therefore, phonological systems of a language are structured.

Jurafsky and Martin (2009) state that there is no exact definition of syllable which can be agreed upon. Nevertheless, they describe that syllable is a vowel like sound, which is more sonorous than its neighbouring consonants. Languages have words containing one, two, three and more syllables. According to Gupta (2008), "A syllable is a unit of spoken language consisting of a single uninterrupted sound formed by a vowel, diphthong, or syllabic consonants alone, or by any of these sounds preceded, followed or surrounded by one or more consonants" (p.88).

It shows that a syllable is the most sonorous sound of a word and a word can consist of one syllable or more than one syllable in a language (see Table, 7.1). It also exhibits that vowels are not only the sounds which make syllables but syllabic consonants also form syllables.

2.6.1 Syllabic consonants

According to Katamba (1989), all languages have the rhyme in its syllables structure. Rhyme is an obligatory part of a syllable. However, the rhyme elements differ from language to language. The nucleus slot of the rhyme can be occupied by either vowels or consonants. Gussmann (2002) states vowels are the essential elements of the syllables while consonants are the optional. However, in many languages, liquids and nasals form syllable without vowels. He signifies that in English, the liquid /l/ at the end of the word brittle */britl̩/* and nasal /n/ at the end of button */bʌt* n̩/ become syllabic. In addition to the first syllables, in the above given words, in form of phonetic vowels /i/ and /ʌ/, consonantal melody */ l̩/* and */n̩/* also take nuclear position. A syllabicity mark ‹ ̩› is used for syllabic consonants (as per IPA conventions) indicating that the symbol it is written represents a syllabic sound (Pullum & Ladusas 1996, p.238).

Ewen and van der Hulst (2001) state that if a syllable lacks vowel, the next most sonorous sound within that syllable takes the position of nucleus (becomes syllabic). In such a case, sonority is an important part to make the syllables. It is a complex phenomenon that some languages subsume consonantal syllable. This category, therefore, opens a new way in form of a syllable having skeleton and melody such as the word /little/ includes initial and final /l/. The first one refers to onset and final one is termed as nucleus. Like many other languages, Tanoli Hindko dialect also allows consonants forming syllables (see Table, 7.2).

After the identification of syllables of a language, various issues come across such as ill-formedness and well-formedness of consonants in syllables. These forms refer to various permissible and impermissible positions of consonants word initially, medially and finally. Such issues, in languages, are dealt under the umbrella of syllable structure. A thorough analysis of syllable structure of a language, therefore, leads to the syllabification rules termed as phonotactic constraints. Selkirk (1982) states in favour of syllable structure that it is necessary part for "the most general and explanatory statement of phonotactic constraints" (p.337). A brief glimpse of phonotactic constraints is given in the following section:

2.6.2 Phonotactic constraints

Basically, phonotactic constraints are rules related issues of a language. These issues deal with phonological constraints on sequence of segments in syllables structure. These constraints are identified either by a native speaker or by syllabification system of a language. Ewen and van der Hulst (2001) signify that a native speaker of English can easily judge the ill-formed and well-formed strings of a syllable word initially, medially and finally. Such as */lmɒk/ is ill-formed string because English does not allow /lm/ at initial of a word. Therefore, */lm/ violates the phonotactic constraint for a language.

Similarly, *mr-, *-pkm- and *-pk in English are ill- formed syllables word initially, medially and finally respectively. Kahn (1976) refers to clusters that in English /tl/ is not possible word initially as in a word 'tlas' whereas possible word medially, i.e. 'cutlass'. The given examples reflect that syllable structure analysis is crucial to know the phonotactic constraints of a language. Likewise, Davenport and Hannahs (2010) refer to the role of syllable structure in terms of phonotactics that provides interesting insights about the permissible sequence of segments in a specific language (see Section, 7.3 for data analysis). The above mentioned reviews give unflinching support for the analysis of syllable structure and on the basis of such analysis, therefore, phonotactic constraints, i.e. rules of a particular language are described to generalize phonological phenomenon.

Thus, some theoretical approaches for syllable structure analysis are given in the following section and then find out the suitable approach which best serve for the analysis of Hindko syllable structure.

2.7 Approaches to syllable structure

Segments, consonants and vowels, form syllables; syllables form feet; feet form words and words form sentences. Each language has its own syllable structure. Describing the possible syllable structure implies describing the sound system of a language. Generally, in the syllable structure, some languages have simple CV and others have complex phenomenon, i.e. complex onset, complex coda, closed syllables and intervocalic clusters. Hindko is one of those languages which permits consonant clusters word initially, medially and finally in its syllable structure.

Syllable structure allows nucleus, onset and coda. In a syllable, nucleus is an obligatory part which is preceded (onset) and followed (coda) by optional consonants. It is obligatory to have a nucleus in a syllable, very common to have onset and less common to have coda (Hayes, 2009). According to Ewen and van der Hulst (2001), syllables are the units which need to be employed in the phonological theory. Segments are the constituents of syllables structure. A common example of a syllable in form of tree structure is given in the following diagram (Adapted from, p.128).

Diagram: 2. 1 (a)

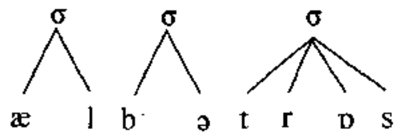


Diagram 2.1 shows three syllables indicated by /σ/ sigma. Peak segment /æ/and coda /l/ are the constituents of first empty onset syllable (VC); onset /b/ is followed by peak /ə/, these two segments are the constituents of no coda syllable (VC) and third peak /ɒ/ is preceded by onset /tr/ and followed by coda /s/ in form of (CCVC). From the first to third syllables, segments become the part of the larger unit of syllable node /σ/. The lines among the syllable nodes and segments signify the constituency.

In the diagram 2.1, syllable /bə/ contains onset and peak (CV). It is universal phenomenon that all languages allow CV. Some phonologists are of the view that onset and peak (CV) are integral part of a syllable while coda is not a necessary part. In this regard, Burquest (2006) signifies that the reason behind the notion that onset is stronger syllable position than the coda because CV syllable pattern is said to be universal and every language contains CV type of templates in its syllable structure, and more specifically, some languages have only this type of syllables.

On the other hand, some languages allow no onset but peak and coda (VC) as in the first syllable of diagram, i.e. /æl/. In such cases, Gussmann (2002) indicates that onset can be empty while there is no skeletal and melodic position or when there is skeletal position but no melody. In addition, Burquest (2006) identifies that some languages of the world do not follow the pattern of CVC syllables, and the coda gets subsidiary syllable position. Such factors introduced a new theory for the syllable structure named onset rhyme theory. It refers to syllable rhyme as an intermediate node in the structure. This theory is termed as branching hierarchical syllable structure expounded by Pike (1967), Pulgram (1970), Kiparsky (1979), Harris (1983) among others. They presented it in the multi tiered phonological theory (Katamba, 1989). Some other prominent figures of this theory are Kaye and Lowenstem (1982), Levin (1985), and Kaye, Lowenstem and Vergnaud (1987).

Moreover, Ewen and van der Hulst (2001) refer to the structure of the word /ælbətrɒs/ that the representation of the syllables is a flat constituent. It has no internal structure like the third syllable of the word, i.e. /trɒs/. It shows that each segment is immediately connected constituents with the syllable nodes without intermediate projection of syllable structure. Nevertheless, they propose three different representations of the internal structure for English monosyllabic word */tramp/* and add the 'x' symbol to label nodes at intermediate stage of the diagram which is between segments and the syllables in the following way (p.128):

Diagram: 2. 2 (a) (b) (c)

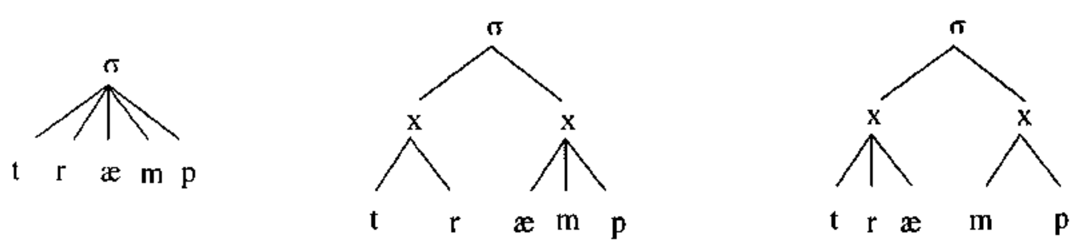


Diagram 2.2 (a) shows flat structure of a monosyllable and diagram (b) has major split before the vowel segment of the syllable that refers to onset-rhyme theory of the syllable structure. Onset part shows cluster of CC while rhyme part displays the branching of V and CC cluster at coda position.

On the contrary, diagram (c) presents CC cluster with nucleus at onset position while in coda part CC cluster stand alone without nucleus. This division which is marked after vowel of the syllable represents mora theory. In addition to these basic concepts, van der Hulst and Ritter (1999) state that for the internal syllable structure of a language, these two theories are taken into account. They cited Vennemann (1984) who termed mora theory as the body-tail structure and the onset rhyme theory as the head body structure. He further argues against the preference of approaches that, "The proper choice is dependent on the process that one studies" (p.22).

In summary, it can be said that both theories are suitable for the analysis of syllable structure. It would be worthwhile to mention here that such theories have a common goal to describe syllable structure. The surface difference is to just mark the peculiar ways of the description of syllables. Thus, the approaches applied to the syllable structure are briefly discussed in the following section to know which theory can represent the data of Hindko in a better way. Firstly, the body-tail structure is described in the following part, commonly termed as mora theory.

2.7.1 Moraic theory of syllable structure

The pioneer of mora theory is Trubetzkoy (1939) and the expounded are McCawley (1968), Hyman (1985), McCarthy and Prince (1986) and Hayes (1989). This approach is defined by McCawley (1968) in the words that, "A mora can be described imprecisely as 'something of which a long syllable (vowel) consists of two and a short syllable (vowel) consist of one" (p.58). Similarly, Clements and Keyser (1983) identify, "We understand the mora as a unit involved in the determination of, such that light syllables count as one mora and heavy syllables count as two….and this distinction between heavy and light syllables play an important role in many languages" (p.79). They further add that heavy syllables refer to the complex (branching) nucleus while light syllables represent (non-branching) nucleus.

Hayes (1989) designates that the key impact of mora approach has been on the treatment of compensatory lengthening. Hayes (1989) and Piggot (1995) (cited in Watson, 1999, p.507) state that mora theory can be summed up under sources of syllable weight as:

a. Short vowels contribute one mora and long vowels two moras (universal)

b. Weight-by-position: a 'coda' consonant is assigned a mora in the course of syllabification (parametrics)

They also add that in terms of moraic theory, the short vowel is termed as mono-moraic while long vowel is called bi-moraic. It means that a short vowel is one mora and a long vowel is two moras.

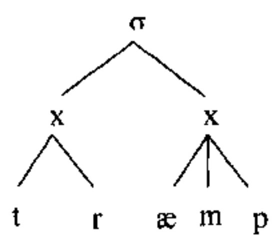
There are various views and a number of studies have been done in light of moraic theory. The works of many phonologists like Bird (1999), Hyman and Katamba (1999) show that mora model represents the constituent onset as it does not exist. Moreover, van der Hulst and Ritter (1999) describe, "Mora theory, not recognizing an onset constituent, cannot express the notion of onset well-formedness in a straightforward manner. There is no notion of unified rhyme either since the constituent status of post-vocalic consonants depends on their weight" (p.36). Davenport and Hannahs (2010) designate that onset is irrelevant part in the syllable weight. In a nutshell, mora is an element which refers to weight. It implies that structure of the syllables can be heavy or light.

It can be concluded, therefore, that mora model has purely connection with syllable weight and other constituents like onset does not fit under the umbrella of moraic model. Unlike it, onset rhyme theory is described according to the sonority peak in the syllables which include specific place for onset and rhyme part in the structure of syllable. Similarly, in addition to basic concept of the moraic theory, Hayes (1987) connects the moraic theory in some extent with the rhyme theory in the following way: "Segments dominated by 'μ' is equivalent to the domain of rhyme-internal segments" (p.10). Therefore, this statement shows a close relationship between the mora and the onset- rhyme theories. The following section describes onset rhyme approach which is abbreviated as OR model (van der Hulst & Ritter, 1999).

2.7.2 Onset-rhyme model of syllable structure

In onset-rhyme theory, structure of the syllable is represented as the syllable node 'σ'. This node has two immediate constituents. The left hand line before the vowel indicates the onset of the syllable while the right hand side shows the rhyme part. In rhyme part, a vowel is followed by consonants (coda). The earlier mentioned example of a word /træmp/ (see Diagram, 2. 2b) is reproduced in the following for further analysis:

Diagram: 2. 3 (a)



This theory shows the structure of the syllable containing two constituents, the onset and the rhyme. The above diagram makes the branching of the segments at the onset and the rhyme positions. In this regard, Ewen and van der Hulst (2001) state:

> A syllable can be seen as a sequence of onset and rhyme, it has been claimed that the constraints on the co-occurrence of segments holding between onset and rhyme are much less severe than those holding within each of the two constituents. That is, given a list of well formed onsets and well formed rhyme; these can combine quite freely to well-formed

syllables. Thus, onsets and rhymes are seen as autonomous units, each with their own constraints on their internal structure (p.130).

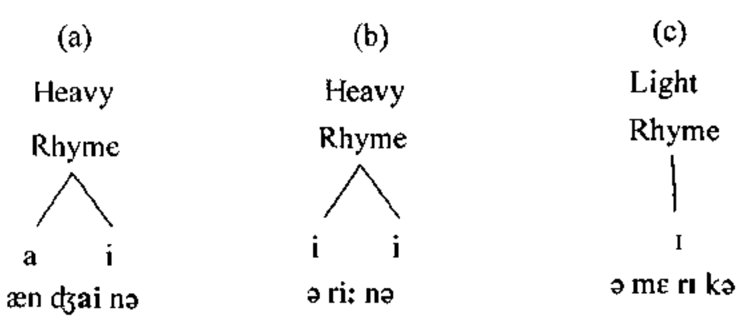
It implies that the combination of onset and rhyme cannot occur freely rather there are many restrictions on the well-formedness of English syllables. In this regard, Clements and Keyser (1983, p.20) point out that /f,v,s,z/ are excluded before /u:r/; voiced fricatives and /cl/ clusters are not possible before /u/ and /cr/ clusters are excluded before /er,or,ar/. The cluster of spop, skick, and stit are ruled out even though the same sequences without the initial /s/ are well formed in English.

However, the above constraints in the syllable structure open a new way for Clements and Keyser and they challenge the onset-rhyme model in support of the flat syllable structure. They identify that in onset rhyme approach, the association of vowel and the following consonants, i.e. rhyme part seems stronger than that of vowel and the preceding consonants. According to Ewen and van der Hulst (2001), the constraints within the onset or within the rhyme are more common than the two constituents, i.e. vowel and the following or the preceding consonants. For example, in case of English, the occurrence of stop followed by a nasal, /kn, pn, gm/ at onset position is not possible combination. Similarly, the combination of tense vowel /i:/ and /au/ followed by /ŋ/ in form of /i:ŋ, auŋ/ is not allowed too. Likewise, it is also not possible to have clusters of /mg/ and /ŋb/ word finally. It entails that a nasal consonant and a stop which are not homorganic are not possible to have combination within a morpheme.

In addition to the constituent structure, the onset–rhyme theory also includes the internal structure of the rhyme. The preceding section corresponds that rhyme is a flat constituent in a syllable. Nevertheless, it can be seen in diagram 2.3 that rhyme has two constituents, the nucleus followed by the coda. The stress assignment in the syllable structure supports the rhyme as a constituent. The reason behind the notion is that some languages contain stress attracting syllables whereas others are not "and that this appears to be a function of the content of the rhyme- the onset is not relevant to such processes" (Ewen & van der Hulst , 2001, p.132). For example, the penultimate syllable in two English words, /arena/ and /agenda/ contain the form of stressed syllables, both have same features, whereas the word /America/ rejects stress. This shows that number and consonants in the onset position are entirely different. It implies that rhyme must be a unit which can be referred to the phonological rules.

Similar to diphthongs, long vowels get the position of two moras in the rhyme. Long vowels are called heavy while short vowels termed as light. In case of English, as examples shown in the following section, the stressed syllable in the word /arena- ariina / become heavy and get the positions of two syllables (see Diagram, 2.4b). Heavy are those syllables which attract stress while light syllables lack stress because heavy syllables contain two segments such as in the word 'angina', 'angaina' the diphthong /ai/ apply the same rule of stress pattern. On the other hand, the /i/ in the word 'America' is the light syllable (p.132).

Diagram: 2. 4

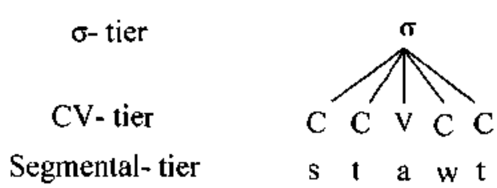


The above diagrams show that rhyme node has more than one daughter in some cases. However, the two segments in the diagrams are not necessary to be the heavy syllables in some languages. Halle and Clements (1983, p. 129) refer to Selkup, language spoken in West Siberian, that if two-segment rhyme has long vowel, it termed as heavy vowel whereas if two-segment rhyme has short vowel followed by a consonant, it becomes light vowel. Hence, in Selkup, VV is heavy while VC is light. Furthermore, the distinction between heavy and light syllable in such languages lies in the number of segments at nucleus position not in the rhyme as a whole. This distinction between two types of languages refers to syllable weight. Overall, these two types of the syllables are commonly found in the languages. Contrary to onset rhyme model, Clements and Keyser (1983) propose another approach for the syllable structure which is termed as CV model of phonology. This approach is found in between segments and syllable nodes.

2.7.3 CV model of syllable structure

According to Katamba (1989), CV theory was introduced by Hocket (1947) and latter supported by Abercombine (1967) and McCarthy (1982). Clements and Keyser (1983, p.25) state that CV is the universal theory which includes three tasks: Firstly, it includes well-formed expression of the theory, i.e. state universal principles governing syllable structure. Secondly, it describes the typology of the syllable structure, i.e. defines the range within which syllable structure may vary from language to language. Finally, it must define language specific rules which modify underlying syllable structure. They recommend that syllables can be represented through three-tiered. In the following diagram, three- tier representation is given at the left hand while the flat model is structured at right of the page (p.18).

Diagram: 2. 5



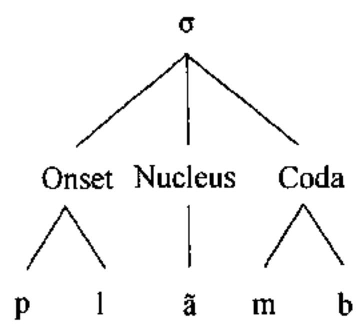
This model shows immediate constituent structure. Syllable tier 'σ' dominates the whole tree, and CV tier immediate dominate the segmental tier. So this theory makes a link with one another (Katamba, 1989). It can be said that CV model further simplified the syllable structure and it eliminates the constituents of onset and coda of OR theory and placed C for consonants and V for nucleus.

However, van der Hulst and Ritter (1999) criticise the CV model of phonology in the following words: " Our main objection to this model, however, is the absence of an onset constituents and thus the impossibility of making direct statements regarding the complexity of material that intervenes between successive nuclei" (p.37). It implies that onset constituents need to be treated explicitly having indirect connection of elements with the syllable nodes which gives more insight about the syllable structure of a language. Contrary to CV approach, another model is given by Davis (1985) with the name of hybrid model.

2.7.4 Hybrid model of syllable structure

Hybrid model for the syllable structure was introduced by Pike and Pike (1947) and developed by Davis (1985). According to this model, a Hindko word /plãmb/ 'climb' can be represented in the following way:

Diagram: 2. 6



Unlike CV approach, this model allows the branching for each column. In the given structure, a single vowel is shown at nucleus position; however, this model also allows branching at nucleus position as well, if the nucleus vowel is bimoraic or a diphthong. Thus, each column freely makes branching for onset, nucleus and coda. However, van der Hulst and Ritter (1999) raise objection against this approach, "the drawback of this model is that there is no recognition of rhymal unit" (p.38). Therefore, this model has also similar representation to the CV approach in the sense of direct connection with the syllable nodes but allows branching like OR model.

In summary, each model has its own characteristics and can be applied on the syllable structure of a language, if the nature of the data allows. However, in the current study, Onset-Rhyme model is applied to describe the syllable structure of Hindko. This model seems comparatively the most suitable approach due to its parameterization and descriptive nature of the study.

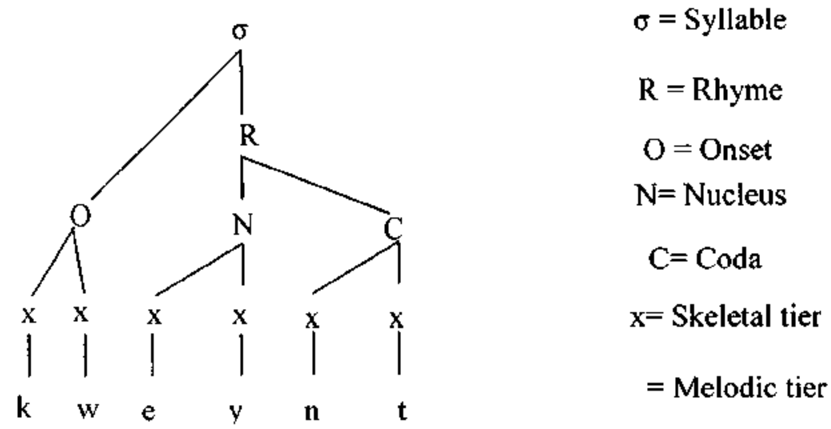
In the selection of models, mora approach is also a suitable and quite similar to onset rhyme model; however, it lacks the structure of well-formedness, i.e. pertaining to onset, at initial position of the syllable. For the preference of these two models, Paradis (1988) state, "Concerning the other differences between the two models, i.e. the timing tier and onset constituent, if evidence can be found to support the necessity of their existence that would argue in favour of the onset/rime model as the more superior" (p.18). In addition, OR describes the key aim of mora theory, i.e. distinction of the weight as well.

Another important aspect of a syllable structure is the branching of the segments at onset and rhyme positions. Regarding the branching, Clements and Keyser (1983) state that the binary branching is a highly enriched theory of syllables. They write, "There is no upper limit on the number of such levels, rather the depth of branching is determined by the number of terminals elements in the syllable" (p.5). Halle and Vergnaud (1987) and Selkirk

(1982) strongly favour OR model that constituent Rhyme is universal. In addition to the constituent structure, the onset–rhyme theory also includes the internal structure of the rhyme. Therefore, OR theory allows the binary branching and unlike CV and Hybrid models, it has indirect connection with syllable nodes and gives more detailed view about the phonotactic constraints. In the present study, considering one approach, i.e. onset rhyme is adequate to describe the syllables of Hindko. Similarly, this approach has been applied for the syllable structure of various languages of the world. This model can also be seen in the phonological works of McCarthy (1979) on 'The Arabic Phonology', Fudge (1969 &1987) on 'The syllable structure of English', Kim (1986) and Sohn (1987) on "The syllable structure of Korean", and Duanmu (1990) on 'The syllable in Chinese' among others.

A comprehensive diagram of English word /kweynt/ 'quaint' for the hierarchical onset-rhyme model is given in the following which is adapted from van der Hulst and Ritter (1999, p.22).

Diagram: 2. 7



The above structure displays syllable node 'σ' at upper top of the diagram which makes branching at onset 'O' and rhyme 'R' positions. In rhymal part, 'R' makes further branching constituents, i.e. nucleus 'N' and the coda 'C'. At third layer, terminal part of the structure is represented by the 'x' which refers to the skeletal tier[7]. Regarding the skeletal tier, Ewen and van der Hulst (2001) state, "That there is a body of evidence to suggest that syllable structure must incorporate a skeletal tier, both in onset-rhyme theory and mora theory" (p.159). The alphabetic symbols, given at the end of the diagram, abbreviated a hierarchal structure of tiers with features and termed as melodic tier.

This hierarchical onset-rhyme model is more descriptive in nature. Hindko data is analyzed in light of this structure. However, between melodic and skeletal tier, root node is added like Diagram 2.8 to differentiate between geminate and non-geminate segments (see Section, 2.11).

There are some other phonological issues related to syllable structure including syllabic templates, syllable boundaries, sonority sequencing principle and gemination. These are briefly explained in the following sections to clear the concepts related to the analysis. Then the data is analyzed in the light of these syllabification theories.

2.8 Syllabic templates

Syllabic templates vary from language to language containing V, CV, and CVC etc. Fijian (Fiji) and Senufo (West Africa) languages permit CV template, Thargari language (Western Australia) allows CVC (Davenport and Hannahs, 2010). They state that English and polish permit up to three consonants on onset position of a word; nucleus part includes short vowels, long vowels and diphthongs as well. English shows up to four consonants at coda

---

[7] The fundamental function of the skeletal tier is to capture the purely quantitative or temporal properties of linguistic forms, while their qualitative properties are located on the melodic level (Gussmann, 2002).

position, e. g. /siksθs/ 'sixths' whereas polish allows more than four consonants at coda position, such as /nastmpstf/ means 'consequence'.

McCarthy and Prince (1986); Roca (1994) among others are of the view that the most fundamental syllabic template is CV and this structure is found in all languages. Clements and Keyser (1983) describe that if a language allows VC, it must have CV and CVC. They further state that languages may have any one of the following canonical syllable types (p. 23): Type 1: CV (represented by Senufo); Type 2: CV, V (Maori); Type 3: CV, CVC (Klamath); Type 4: CV, V, CVC, VC (English). In addition to the above mentioned syllable types, they also state that some languages have well formed core syllable, which may contain combination of consonants and vowels, such as CCCVCC or CCVVC or V elements, for example, English word /strænd/ 'to be halted' has CCCVCC elements.

According to Gut (2009), English has 20 different types of syllable templates. Like, CV, VC, CVC and the most basic structure is the monosyllabic form of syllables, i.e. CV which refers to the syllables that end with vowels and termed as open syllables. He also identifies that English has 43% of all syllables in open form. However, there are some constraints in syllable structure that a single vowel cannot stand alone as a syllable while a long vowel or a diphthong can occur as a syllable, e.g. even an article /a/ is also pronounced as /ei/ or Artificial Intelligence (AI) is written as /ei ai/. Barber, et al. (2009) states that open syllables ends with vowels, and when single vowels like /o/ and /e/ are lengthened, they become long open vowels in Standard English (see Section, 7.2 for data analysis).

In the phonological description of a language, various issues are encountered such as if a language allows templates above CV, e.g. CVCCV or CVCV etc, question arises for the syllable boundaries whether medial C or CC are the part of the preceding syllable or following. This debatable issue about the exact boundaries of syllables can be seen in the works of Haugen (1956), Hoard (1971), Vennemann (1972), Hooper (1972) and Kahn (1976) among others. The following section shows a brief description about marking the boundary of syllables.

2.9 Syllables boundaries

A word containing more than one syllable such as CVCCVC, generally, seems easy to demark each type or cluster of consonants. A native speaker feels comfortable in using the right syllable boundaries in his language. Nevertheless, during marking the exact boundaries, it becomes difficult whether a C medially is the part of preceding syllable or following. In this regard, Clements and Keyser (1983) propose that the boundary of VCV is to be marked as V.CV. In contrast, Duanmu (2008) argues, "If a language allows CVC, CV, and VC syllables, as English does, how would CVCVC be syllabified? Both CV.CVC and CVC.VC seem to be possible" (p.52). Therefore, such issues of a language need to be analyzed for clarity.

Phonologists have different views on this issue of syllabification and recommend some principles to mark CV boundaries among syllables. Like, Haughen (1956) and Halle (1962) state that a native speaker can easily pin down the words into syllables and know the ill-formed and well-formed strings of a syllable. However, Hammond (1999) claims that it is hard to mark the accurate boundary of a syllable. Similarly, Zhang (2007) cited in Duanmu (2008) that the result of native speakers' demarcation of the syllables boundaries cannot be consistent. In addition, many studies have been carried out to know whether a native speaker can judge the clear cut boundaries of syllables. In this regard, Duanmu (2008) tests some speakers and finds that their judgment varies. He proposes that only native intuitive knowledge is not final for syllables boundaries.

Generally, many models have been introduced by the linguists to mark the syllable boundaries. However, the model of Maximal Onset Principle (MOP), introduced by Pulgram (1970) and Kahn (1976), is famous among many phonologists due to its well-established nature. According to this principle, first consonants (C) should be maximized to the left of vowel (V) till syllable structure conditions of the language in question, subsequently; syllable final consonants (C) should be maximized to the extent with the syllable structure. In the present study, the boundaries of Hindko syllables are marked in light of MOP. On the basis of this principle, phonotactic constraints of the language are proposed (see Section, 7.4 for data analysis).

There is another principle which describes the phonotactic constraints such as the well-formed syllables are determined by sequences of segments by their relative sonority. On the basis of this principle, syllabification rules of a language can also be taken into account. A brief description of sonority principle is given in the following section:

2.10 Sonority sequencing principle (SSP)

The term, sonority hierarchy was first introduced by Hooper in (1972). It is a common fact that vowels are more sonorous than consonants but languages have restrictions on the sequences of phonemes in their syllable structure. Various definitions and hierarchies are found in the works of linguists for the sonority system of a language. However, the present study includes a 10-point scale hierarchy given by Hogg and McCully (1987) cited in Yavas (2006, p.131).

Sounds	Sonority Values
Low vowels	10
Mid vowels	9
High vowels (and glides)	8
Flaps	7
Laterals	6
Nasals	5
Voiced fricatives	4
Voiceless fricatives	3
Voiced stops	2
Voiceless stops	1

The above scale of sonority hierarchy shows that voiceless stops are least sonorous sounds while the low vowels have maximum sonority among sound segments. The sonority scale is also a helpful method to identify the number of the syllable in a word. In any utterance, peaks, i.e., sonority of sounds, always remain more outstanding than any other segment. Since vowels are more sonorous sounds, they always keep the peak position in a syllable. Regarding the peak, Clements (1990) indicates that all vowels have same sonority whereas Kenstowicz (1994) and Crosswhite (1999) are of the view that vowels are different in terms of sonority. (The present study deals with overall sonority of a syllable).

According to Hussain (2009), "Syllables are formed by high-sonority nuclei with falling sonority going outwards towards the edges of the syllable from this nucleus (onset and coda), as generalized as sonority sequencing principle" (p.5). Miller (2010) states that sonority 'involves the ability of segments to bear tone and occur as syllable nuclei' and within vowels, low vowels are the most sonorous sounds because of their high formant frequency while the high vowels have low frequency and that are the least sonorous sounds. Therefore, SSP means that a sound in a syllable rises from the least sonority by crossing the more sonority and reaches to the most sonority, and then a sound gets reverse in a similar way to the margin.

In the earlies of the previous century, Jesperson (1904) proposes sonority ranking for onset and coda in the following way: that at the onset position t > s > d > z > n > l > r > w > whereas at the coda position w > r > l > n > z > d > s > t (cited in Khan, 2012). It shows that voiceless stops have least sonority and glides are the most sonorous sounds. According to Clements (1990), Jesperson's sonority scale is basic in its nature; however, it has influenced most of the later theories. In addition to sonority sequencing, some languages such as Spanish allow Minimal Sonority Distance (MSD) (Harris, 1983). This term maintain sonority between two phonemes strictly, e.g., within obstruents.

Many phonologists (e.g., Hooper, 1976; Kiparsky, 1979; Harris, 1994 among others) are of the view that SSP is a universal principle. However, researchers like Butskhrikidze (2002) in Georgian, and Rowicka (1999) in Polish describe that these languages have the surface violations against Sonority Sequencing Principle. In addition, Butskhrikidze states that SSP is one of the universal phonotactic principles.

Davenport and Hannahs (2010) state, "It is clear that sonority hierarchy is not always conformed to within a syllable; it is possible in many languages to find the acceptable syllables, in which the segments in the onset or the coda are in the 'wrong' order. So, for example, English has words like 'stoat' and 'skunk'...similarly, German allows words such as Sprache 'language' with initial /ʃp/ or Strauss 'ostrich' with initial /ʃt/ " (p.76).

Rubach and Booij (1990, p.122-3); and Rowick (1999: ch.5) (cited in Ewen & van der Hulst, 2001) state that Polish is a commonly cited language which violates SSP because it allows maximum consonant clusters word initially. It shows that in languages, it is not difficult to find out the words, which violate the SSP. In addition, if appendages of the syllables are taken into account, violation of SSP can be seen more easily. In the present study, prependices and appendices are not considered and only core syllables are analyzed in light of SSP (see Section, 7.5 for data analysis).

In addition to the other features of syllable structure, Hindko also allows gemination. Thus, the relevant concepts are described in the following section:

2.11 Gemination

Generally, gemination refers to the tone of a consonant in the articulation of a word that becomes double in its duration and length. According to Leslau (2000), the easiest way to describe gemination is doubling of consonants. Ladefoged (1975) states that geminate consonants are a class of long consonants which occur in English across word boundaries.

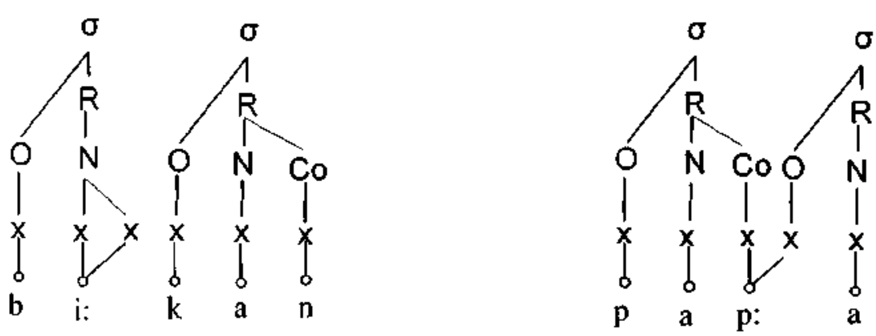
Some phonologists consider geminated segment as a single phoneme while others claim that gemination lengthens the duration of a consonant as two times. According to Abercrombie (1967), gemination can be termed as double consonants that duration of geminate consonants extends over two syllables while a long consonant remains limited to a single syllable. On the contrary, Delattre (1971) states that gemination is not a single sound, rather a quite different phenomenon of languages which includes two types of consonantal features in the syllable structure, i.e. feature of preceding consonants and feature of following consonants.

Other phonologists, such as Ohala (1983) and Hayes (1989) are of the view, that gemination is produced in an articulatory movement while Selkrik (1991) argues that geminate consonant is a bi-segment not mono-segment. Hayes (1986), Clements (1985) and McCarthy (1986) consider gemination as long consonants. They state that the geminated segment is a single sound but has two skeleton slots. According to Burquest (2006), "When long vowels or consonants are given a VV or CC interpretation they are called geminates" (p.183).

Ewen and van der Hulst (2001, p.154) state that recent approaches to phonological structure represents the length of sounds incorporating the skeleton. They state that C and V function as abbreviation of segmental matrices, and the segmental root node is connected directly with terminal node of the syllabic structure. In the onset rhyme theory, these terminal elements are termed as skeleton or skeletal tier. Specifically, this approach represents the length of the segments.

In the following diagrams, they structured two words of English and Italian respectively in light of OR theory to show long and geminate segments where the skeletal points are symbolized by 'x'.

Diagram: 2. 8 (a) (b)



In diagram (a), a long vowel /i:/ get the position of single root node but two skeletal tiers whereas short vowel /ə/ denotes single root node and single skeleton position. Similarly, in (b), geminated consonant /p/ at intervocalic position is also represented in form of two skeletal tiers. Clements and Keyser (1983) termed the skeleton position as timing units that long vowels require more time for articulation than the short vowels, e.g. long vowels includes the duration of two segments, two timing slots but one segmental tree.

According to OR theory, long vowels, geminated consonants and short sounds can be characterized in the following way (Ewen and van der Hulst , 200, p.154).

Diagram: 2. 9

Long vowel or geminated consonants Short vowel or non-geminated consonant

In summary, it can be said that linguists agree that gemination closes one syllable and opens another syllable. Literature shows that gemination is possible word initially, medially and finally in languages, and word medial gemination is more common that word initially and finally. Taylor (1985) states that she carried out research on 29 languages (cited in Callender, 2006). According to Taylor, obstruents geminate in all languages, and if a language geminates a sonorous sound, it must have at least one obstruent sound as well. She also reports that 15 languages have voiced and voiceless geminated sounds and claims that if a language has voiced gemination, it must have voiceless gemination but if a language has voiceless gemination, it is not imperative to have a voiced gemination. She also refers to the universal phenomenon of gemination that if a language has fricative gemination, it must include stops gemination as well.

Taylor also finds out that out of 29 languages, 26 languages have medial gemination, and out of them 14 also allow word finally gemination. In addition, she refers to the universal tendency that if a language includes gemination word finally, it must have gemination word medially. Furthermore, she highlights that out of 29 languages, six languages also allow gemination at word initial position.

It is well a known fact that Indo-Aryan languages allow the gemination and Hindko is one of them. However, Hindko allows gemination of consonants at two positions, i.e. at intervocalic and final positions of words. Therefore, collected data is also analyzed in light of above mentioned phonological feature of gemination (see Section, 7.6).

2.12 Chapter summary

This chapter shows the previous research carried out in other dialects of Hindko. It also gives review of related literature on segmental features, in general, in terms of articulatory phonetics including consonants, oral vowels, diphthongs and nasals vowels. Then, it offers a review of literature on acoustic features of consonants, oral vowels and diphthongs respectively. Finally, it shows literature on the approaches of syllable structure. In addition, an overview is also given on the principles of syllabification system.

The following Chapter deals with the methodology employed for the study.

CHAPTER 3

RESEARCH METHODOLGY

This chapter describes the research design followed in this study. It includes the description of data collection. It also elaborates the methods adapted for data analysis. As the study has concerned itself with the segmental and the selected suprasegmental features of the Tanoli dialect, the chapter has been divided according to three categories of analysis including consonants, vowels and syllabification respectively.

3.1 Sampling of the study

A descriptive analysis of any language is a daunting task and requires extensive field work. It is not possible to describe a language completely in a single research project and it was, therefore, necessary to limit the focus of this study to a few aspects of Tanoli dialect. The research has, therefore, limited itself to a description of consonants, vowels and syllabification system of the dialect. As this description pertains to phonetics and phonology, live or recorded data is required for such an analysis. In order to obtain such data, non-probability and purposive sampling technique was adopted for the selection of 12 informants including six males and six females. The reason for choosing this sample size is in accordance with Roach's argument (2000), "If we study only one or two speakers, it is likely that our results will not be typical of other speakers" (p.207). Regarding the sample of such studies, Ladefoged (2003) states that many linguists used to record one speaker for the description of phonetics of a language but it is not sufficient to meet the requirement of the modern standards of phonetic description. A single speaker may have individual way of speaking, or he may be more literate and have his own view about the language. For the description of a language, ideal data can be collected from six males and six females. Similarly, Gordon (2003) recommends that six male and six female speakers are an ideal pool to collect data from for quantitative study. Increasing the sample to more than 12 speakers was to spread the volume of data and as a result, the minute observation of speech sample from the selected people would have been difficult. Reason for including both sexes for the data is that there may be systematic difference between their speeches.

All the twelve subjects were the speakers of Tanoli dialect of Hindko and knew only Tanoli Hindko. The subjects were above 50 years of age (see Appendix-C). They were illiterate and had not any schooling. The reason for selecting such a sample is that the participants will have minimum possible contact with other languages and uninfluenced data may be gathered for identification of sounds. Thus, pure phonemic inventory of the dialect may be the result of this effort.

The speakers who were found with speaking and hearing problems were not considered. This criterion was employed after testing their recording on Pratt software. Thus, all informants had normal speaking and hearing ability. The recording was made at a peaceful corner at the residence of the speakers. The informants were asked to keep a constant speech rate and were made to articulate each word three times to ensure minimum error.

Before recording the data, Tanoli Hindko consonants and vowels were established by using minimal pairs (see Tables, 4.1 & 6.1). According to Davenport and Hannahs (2010):

> Minimal pairs rest on contrastive distribution …consonants in /fat/, /bat/ and /mat/ contrast with each other. We saw this contrast by means of a commutation test, i.e. a substitution of one sound for another yielding a different lexical item. Contrastive distribution can show a contrast anywhere in the word, however, not just initially (p.118).

After identification of the phonemes through minimal pairs, consonants and vowels were further verified by word distribution in the relevant section of articulatory phonetic, and then the data recording lists were developed for acoustic analysis of Hindko phonemes. First, the description of consonantal data collection is given in the following section:

3.2 Methods of consonants data collection and analysis procedure

The detail of methods used for Hindko consonants is given in the following section:

3.2.1 Stimuli for consonants

A word list, comprising three tokens for each consonant of Hindko, was developed and recorded in intervocalic pattern (VCV) for the acoustic analysis of the consonants. All token words were monosyllabic and the consonants were preceded and followed by vowel /a/. The list is prepared in light of most commonly used method by phoneticians for the acoustic analysis of sounds (e.g. Ball & Rahilly, 1999; Ashby & Maidment, 2006, Davenport & Hannahs, 2010; and others). As mentioned above that first, Hindko phonemes were established through minimal pairs (see Table, 4.1) and then the following list was developed for recoding the consonantal data.

Table 3. 1 List for the recording of consonants

Sounds	Recording	Sounds	Recording	Sounds	Recording	Sounds	Recording
/b/	aba	/tʰ/	atʰa	/dʒ/	adʒa	/ɣ/	aɣa
/p/	apa	/k/	aka	/tʃ/	atʃa	/x/	axa
/pʰ/	apʰa	/g/	aga	/tʃʰ/	atʃʰa	/ɦ/	aɦa
/t̪/	at̪a	/kʰ/	akʰa	/f/	afa	/r/	ara
/d̪/	ad̪a	/m/	ama	/v/	ava	/l/	ala
/t̪ʰ/	at̪ʰa	/n/	ana	/s/	asa	/ɽ/	aɽa
/ʈ/	ata	/ɳ/	aɳa	/z/	aza	/j/	aja
/d/	ada	/ŋ/	aŋa	/ʃ/	aʃa		

The above table 3.1 reflects Hindko data containing real and nonsense words to elicit a complete consonantal picture of Tanoli dialect of Hindko. In VCV sequence, the C is the target consonant whereas an identical V is used at both positions of each word to keep consistency among sounds. It presents a more controlled elicitation data than natural speech for the descriptive purpose of any language.

3.2.2 Collection of consonant phonemes

As mentioned earlier that all speakers were illiterate, so it was not possible to record them by providing a list for reading. Thus, in the beginning of the data collection, the researcher asked a primary passed native speaker 'who was not part of this study' to read the list which was recorded on the sound recorder. He was trained to keep speech rate. His recorded sound was provided to all of the twelve subjects for recording their sounds. Therefore, they held the hands free (headphone) in the ears, listened and uttered the words; which were directly recorded in 'Pratt' software, version 5.1.17 by Boersma and Weenink (2009).

The sampling frequency for consonants, except fricatives, was adjusted at 8000 Hz with 4000 Hz low-pass filter on 16 bit precision at Pratt. Unlike other consonants and vowels, fricative sounds of Hindko were recorded on Pratt at the sampling frequency of 16000 Hz with 8000 Hz low-pass filter on 16 bit precision. As fricatives have strong frication, and noise energies are assumed to be higher than 4000 Hz. This idea was adapted from Hayward (2000) and Ladefoged (2003) (see Section, 2.5.3). Each recording was saved in a separate file and recordings were processed to find out the acoustic cues of each vocalic and non-vocalic sound. However, for articulatory phonetics, the speakers' utterances were analyzed keeping in view the place of articulation and voicing feature. The feature of voicing was also observed by the researcher but entirely based on auditory aspect of the uttered words. These observations were recorded on a piece of paper. Thus, in addition to the researcher's insightful knowledge about the dialect as a native speaker, it remained a useful experiment. The analysis procedure is given in the following section:

3.2.3 Analysis procedure of consonants

Consonantal data for articulatory phonetics was set out qualitatively before acoustic analysis of sounds. For spectrographic (qualitative) and statistical (quantitative) analysis of the data, consonants were recorded in terms of VCV sequence (see Table, 3.1). During the analysis, gridlines were made for each of the spectrogram on Pratt such as the text of utterances including vowel-consonant-vowel, closure duration of stop, VOT of stop, frication of fricatives etc. Each segment was marked with the boundaries of VCV and other target features. Then, the target features of sounds were measured statistically in terms of time in seconds (sec.). Frequency means values were measured in Hertz (Hz) for first and second formants (F1 & F2) of the adjacent vowels. After the individual measurement of each segment, the average mean values were calculated so that through average values, the overall trend in Tanoli Hindko sounds could be found. Thus, on the basis of average calculation of sounds, their standard deviation (Std. Dev.) and coefficient of variation (Co.Var.) were taken into account. In addition, the measured values were further tested by ANOVA to verify differences within segments. The level of significance was set as 0.01 and 0.05. Moreover, Least Significant Difference (LSD) test was also applied for further analysis (where required) to detect which pair is actually different. Statistical analysis is carried out in excel. This procedure remained consistent in all Hindko consonants and vowels as well.

In addition to this general description for analysis of consonants, specific detail for the analysis of each group of sound, i.e. stops, nasals, fricatives, affricates and approximants is given in the following section:

Stops

A total of 432 tokens (12 stops x 3 repetitions x 12 informants) for stops were recorded and analyzed qualitatively and quantitatively. First, stop spectrograms were visually analyzed to know their characteristics. For the ease of spectrographic analysis, stops were categorized into three groups according to their three ways of articulation, i.e. spectrograms of voiced, unaspirated and aspirated respectively. Stops were mainly analyzed in light of voice bar, release burst, formant transitions and locus which cover both parts of articulation, i.e. manners and places. These acoustic features are widely used by phoneticians for the acoustic analysis of stops (see Section, 2.5.1). Each utterance of stops was examined for the accuracy of the results.

Secondly, stops were measured statistically in terms of closure duration and VOT, the measurement time is given in seconds (sec.). First gridline and boundaries were made to show vowel-stop-vowel, second gridline was added to measure closure duration of stops and third gridline was included to find out the measurement of VOTs. However, for voiced stops, two cues, VOT and closure duration occur simultaneously and that's why the measurement of one cue was considered for the second.

Nasals

A total of 144 tokens (4 nasal stops x 3 repetitions x 12 informants) were recorded for acoustic analysis of nasals. During the nasals analysis, the intensity of spectrograms was increased. This idea was in line with the views of Ladefoged (2003) that during the spectrographic analysis of nasal consonants, the intensity should be increased to make the invisible nasal formants more visible because nasals have lower amplitude.

First, Hindko nasals were investigated qualitatively through spectrographic analysis. Secondly, the quantitative analysis was carried through statistical measurements of the first three formants of nasal sounds and neighbouring segments as well. The formants frequency value of F1 was taken manually because in most of the cases, automatic shown formants were either disappeared or merged with upper formants. Thus, measurement of F1 was taken into account by clicking in the medial of the consonantal formant. However, average mean values for other two formants, F2 and F3 were measured from the automatic formant list, having side boundaries of the sounds, values are shown after clicking in the medial of required segments, except some of the values of velar F2 due to the dispersed formant contours. Therefore, their frequency values were measured by visual analysis. In addition, during the formants transitions analysis, in case of invisible formants, Pratt spectrum option 'extract visible spectrogram' was employed to see the formants slope.

Fricatives

A total of 288 tokens (8 fricatives x 3 repetitions x 12 informants) were analyzed to identify Hindko fricatives in light of acoustic cues. Fricative features were investigated by visually examining the spectrograms on speech analyzer Pratt software. Nevertheless, unlike other consonants, fricative spectrograms were displayed between 0 to 8000 Hz in the spectrographic range. During the statistical part of fricative sounds, frequency mean values of spectral shape, frication duration and neighbouring vowels duration of utterances were measured. Spectral peaks were measured by placing frequency time marker in the beginning of spikes at the spectrogram of the fricatives.

Affricates

A total of 108 tokens (3 affricates x 3 repetitions x 12 informants) were recorded on Pratt software to find the characteristics of Hindko affricates. First, the visual analysis of affricate spectrograms was carried out to know both intrinsic and extrinsic properties. For this purpose, spectrogram of each utterance was studied and the most common trends in sounds were described. Secondly, sounds were statistically measured in terms of silent gap duration; frication duration and overall duration of consonants.

Approximants

A total of 144 tokens (4 approximants x 3 repetitions x 12 informants) were recorded on Pratt for acoustical analysis of approximants. Recorded sounds were examined visually on spectrograms. Then, recorded data of approximants was statistically measured in terms of duration and their formants as well. First three formants, F1, F2 and F3 were measured to find out approximant formants structure. Formants frequency values were measured at the temporal midpoints of consonants that contained steady state formants and then mean values were taken directly from the automatic formants list. This method of measurement was almost similar to the acoustic analysis of vowels because both phenomena are interrelated in many aspects. However, in case of dispersed formants; values were taken into account by visual analysis.

3.3 Methods of vowels data collection and analysis procedure

Like consonantal section of the study, for the identification of Hindko vowels, a similar method for data collection and selection of informants was employed (see Sections, 3.1 & 3.2.2). Computer software 'Pratt' was used for recording and analysis of the vowels. The vowels, however, had different stimuli and analysis procedure.

3.3.1 Stimuli for vowels

The material for the data collection of oral vowels was selected in CVC sequence and CV context for diphthong. Regarding data selection for the phonemic inventory of vowels, Di Paolo and Yaeger-Dror (2011) state that:

> Collect vowels data in a "neutral" consonantal phonetic context...phenomena such as co-articulation influence the spectral features and duration...a neutral context means all the moving articulators are at rest as they are for /h/, which does not require any particular tongue body shape, lip protrusion...this is why many studies use a paradigm such as heed, hid, hayed, head, had, HUD, hawed, haught, hood, who'd, Hoyt, hide (combining real and nonsense words to complete the set) for eliciting a complete American English vowel system (p.88).

They also state that data should be recorded in neutral phonetic environment in the form of monosyllabic or disyllabic words, which is likely to induce variation and change. They point out that there is need to make a list of each vowel in the phonetic environment, and each word will be needed to be repeated three times for recording purposes which is the common phonetic practice. Basically, this method was used by Peterson and Barney (1952, cited in De Paolo and Yaeger-Dror, 2011) for the measurements of vowel formants. On the other hand, for diphthongs, Maddieson and Disner (1984) identifies that if diphthongs cannot be found in distributional pattern, they can be analyzed as VC, CV, or VV contexts.

Thus, the list for data recording of Hindko vowels was developed in CVC context while for diphthongs; it was recorded in CV sequence. For both monosyllabic and disyllabic cases, all selected words were real having different lexical meanings. I selected contrasting sets of words preceded and followed by stops /t/ and /p/ since stops are the least sonorous sounds and have minimum effect on the most sonorous sounds.

3.3.2 Collection of vowel phonemes

Method of vowels data collection was almost similar to Hindko consonants (see Section, 3.2.2). However, in articulatory terms, it was not possible to identify the position of vowels owing to free air passage from the oral and nasal cavities. Therefore, height of tongue and position of tongue for vocalic part of study is purely based on acoustic phonetics. The list for the vowel section was developed in CVC context, in light of minimal pairs (see Table, 6.1), and three repetitions for each word were recorded from the speakers. This list is given in Table 3.2.

List of oral vowels

The list below was developed taking into consideration the neutral phonetic environment in the form of disyllabic words such as CVC sequence.

Table 3.2 List for the recording of oral vowels

Sounds	Recording	Gloss	Sounds	Recording	Gloss
/i:/	ti:p	Fashionable	/o:/	to:p	Swelled land
/ɪ/	tɪpp	Drip	/ʊ/	tʊpp	Cap
/æ:/	tæ:p	Tape	/u:/	tu:p	Tube
/a/	tapp	Tub	/e:/	pe:	Father
/a:/	ta:p	Top			

The above table shows the data for oral vowels in CVC context; however, one long vowel /e:/ cannot occur word medially and initially in Tanoli Hindko and is, thus, recorded word finally in CV context (see Section, 6.1).

List of diphthongs

The list of diphthongal sounds is given in the following table:

Table 3.3 List for the recording of diphthongs

Sounds	Recording	Gloss	Sounds	Recording	Gloss
/ei/	kei	A tool of digging	/ai/	bai	An Arm of a cot

Table 3.3 reflects words for acoustic analysis of diphthongs and both words were recorded in CV sequence (see Table, 6.10).

3.3.3 Analysis procedure of vowel phonemes

The analysis of vowels follows almost the same procedure like the consonantal analysis. The speech data was digitized at sampling frequency of 8,000 Hz that produced the frequency of 4000 Hz for each vowel spectrogram. In order to get reliable formant values and duration of each vowel, wide-band spectrograms were made. Each speaker's file was converted into text grid files and then the interval tiers were added. The purpose of these tiers was to mark text of each segment under the spectrogram and to measure the frequencies of formants values and utterance durational time from the same files. Then the boundaries for the sounds were made which were quite helpful in finding out the accurate results. This reproducible technique is also helpful for any future verification as measurement without boundaries may be different next time.

Most of the recording was made in CVC context to avoid the transition influence of the preceding and following consonants (onset and coda). The least sonorous sounds, i.e. stops /t/ and /p/, were selected in the neighboring of vowels in order to have least influence on the formant structure. The vowels boundaries were, therefore, made 15 milliseconds between vowel and each consonant. The frequencies of F1 and F2 were measured in order to draw the quadrilateral of Hindko vowels. Frequency value of each formant was taken by clicking in the mid of marked boundaries. The mean values were directly copied from the automatic formants bar of the software. However, for the duration of sounds, the measurement was taken horizontally between initial and final boundaries which referred to the time marker. Furthermore, if any problem (rarely happened) was encountered during the measurements of formant frequencies, they were determined by eye check after changing the spectrogram bandwidth. A total of 324 tokens (9 vowels x 3 repetitions x 12 informants) were investigated statistically to find out formant values and duration of utterances.

During the analysis of diphthongs, visual checking of formants remained the top priority to see the continuity or discontinuity of glides between the combinations of two vowels. It seems necessary to describe here that around ten diphthongs[8] were recorded and each one was acoustically analyzed. Finally, only two were confirmed as diphthongs in Hindko which had continuity in glides.

Furthermore, the procedure for measuring diphthongs was different from other sounds due to unification of two sonorous sounds. Hence, the starting and ending measurement points were taken about twenty percent of the total duration of diphthong where no more consonantal effect remains and the formants became steadier. This procedure remained consistent in the measurement of each speaker's diphthongal sound. A total of 72 tokens (2 diphthongs x 3 repetitions x 12 informants) were investigated statistically and spectrographically and their acoustic cues were found.

---

[8] At the time of data collection, all the possibilities of diphthongs were recorded, whether phonetically or phonemically, when the data was analyzed, it was found that Hindko has only two diphthongs.

3.4 Methods of syllables data collection and analysis procedure

Data for the suprasegmental features of Hindko was collected from dictionary database, observation and informal interviews carried out with native speakers.

3.4.1 Collection of syllables

Data for the syllables of Hindko was collected from two sources; first, from two dictionaries, Awan's (2008) dictionary containing around 30,000 words in Peshawar dialect and Sakoon's (2002) dictionary comprising around 7,000 words in Abbottabad dialect, and secondly, by recording the daily conversations of the native speakers of Tanawal. Relevant words used by native speakers were recorded in a notebook (always ready in the pocket) for the syllables and syllabification analyses of the study. This activity of the observation was spread over a period of around one year and four months, starting from September, 2010 to January, 2012. Obviously, the role of the researcher was that of as an observer and the researcher's personal experience as a native speaker was very helpful. Overall, data consisting of 5000 root words was taken into account. The developed corpus was analyzed for syllabic templates, consonant clusters, syllable boundaries, SSP and gemination system of Hindko.

3.4.2 Analysis procedure of syllables

The corpus of Hindko was first transcribed into IPA and then each sound was marked as C and V and translated into English. As mentioned above, this corpus was built up for analyzing syllabic templates, consonant clusters word initially, medially and finally, syllable boundaries, SSP and gemination system of Hindko spoken in Tanawal. The theory of Onset Rhyme was employed for this analysis. Syllabic templates and consonantal clusters were analyzed both quantitatively and qualitatively. The experiments for quantitative analyses helped to find out the number of possible syllabic patterns and permissible consonantal cluster strings in the dialect. Syllable boundaries, SSP and gemination system of Tanoli Hindko were, however, analyzed qualitatively to find out syllabification rules.

Apart from relying on dictionaries and observed data, in some cases, where boundaries of the syllables, gemination word finally, syllabic consonants, templates, SSP and consonantal clusters etc seemed ambiguous, native speaker's help was also taken into consideration to find out the phontactic constraints and syllabification of some of the words. They were asked to utter the words four to five times. During this experiment, the researchers marked the target phonological aspects of the data and jotted them down on a piece of paper. These experiments were also set out in line with the phonological theories. In line with the views of the linguists mentioned above (e.g. Haugen, 1956; Chomsky, 1957; Halle, 1962), it was found that a native speaker of Hindko has the ability to judge the well and ill-formed syllable structure of his language. Thus, the findings were presented and syllabification rules for Hindko spoken in Tanawal were described.

As theories suggest (see Section, 2.7), long vowels and geminate consonants carry two skeletons. That is why in the diagrams of the syllable, long vowels and geminate segments were marked with colon (:). However, in the diagrams, colon (:) is placed after geminate consonants[9] at word final position, whereas this method of marking colon after a consonant is not applied word medially for the reason to show clearer picture of syllable boundaries. Moreover, symbol of long vowels were described as VV and short vowel as V. Similarly, in the description of consonants, symbol of singleton were marked as C whereas geminate consonants were presented as CC.

---

[9]Ewen and van der Hulst (2001) recommend colon (:) after geminate consonants like long vowels (p.155, see Diagrams, 87b & 92 c. p.157).

3.5 Chapter summary

In this chapter, the methodology and methods have been discussed. It elaborates methods of data collection and procedure for data analysis of segmental features. It also gives the detail of the methods used for data collection of syllables and then the analysis procedure.

The following chapter deals with the analysis of data. It analyzes oral stops and nasal stops of Hindko in terms of articulatory and acoustic phonetics. Data will be analyzed both qualitatively and quantitatively so that authentic results of Hindko consonants may be achieved.

CHAPTER 4

DATA ANALYSIS OF HINDKO ORAL AND NASAL STOPS

In this chapter, Hindko stops and nasals are described on the basis of articulatory phonetics in terms of contrastive position of segments, distributional occurrence, voicing features, places and manners of articulation. It also analyzes stops and nasals in terms of acoustic phonetics and each section is followed by discussion. The chapter begins with a phonemic inventory of all Hindko consonants in light of minimal pairs in the following table:

4.1 Minimal pairs of Hindko consonants

Minimal pairs of all Hindko consonants are tabulated in the following and all contrastive sounds are italicized in the Table:

Table 4.1 Minimal pairs of Hindko consonants

Serial No	Symbol of Sounds	Words in Hindko	Gloss	Words in Hindko	Gloss
1	/p/	*p*atta:	Belt	*b*atta:	Stone
2	/b/	*b*a:l	Hair	*p*a:l	Looking after/ avoiding
3	/pʰ/	*pʰ*adda:	Fight	*kʰ*adda:	Trench
4	/t̪/	*t̪*æ:r	Getting ready	*d̪*æ:r	Late
5	/d̪/	*d̪*æ:x	See/observe	*m*æ:x	Nail
6	/t̪ʰ/	*t̪ʰ*app	Slap	*tʰ*app	Fold/beat
7	/t/	*t*a:l	Big heap	*d*a:l	A branch of Tree
8	/d/	*d*akk	Stop	*t*akk	Clean out
9	/tʰ/	*tʰ*app	Fold/Beat	*kʰ*app	Fuss
10	/k/	*k*ull	All	*g*ull	Flower/star

11	/g/	*g*add	Mix up	*k*add	Take out
12	/kʰ/	*kʰ*all	Skin/Halt	*pʰ*all	Fruit
13	/m/	*m*ãnd̪	Shocking	*k*ãnd̪	Wall
14	/n/	*n*æ:ɽa:	Near	*b*æ:ɽa:	Big boat
15	/ɳ/	mã:*ɳ*	Pride	mã:*ŋ*	Demand
16	/ŋ/	bã:*ŋ*	Prayer call	bã:*ɳ*	A kind of a net of a cot
17	/ʧ/	*ʧ*aʤʤ	Manner	*ʤ*aʤʤ	Judge
18	/ʤ/	*ʤ*ott	Combat	*k*ott	Beat
19	/ʧʰ/	*ʧʰ*at̪t̪	Roof	*kʰ*at̪t̪	Letter
20	/f/	*f*æ:ra:	Round	*k*æ:ra:	Paddy field
21	/v/	*v*ass	Control	*n*ass	Flee
22	/s/	*s*æ:r	A weight unit	*d̪*æ:r	Brother-in-law
23	/z/	*z*a:r	Curse	*n*a:r	Canal
24	/ʃ/	*ʃ*aʤʤra:	Pedigree	*s*aʤʤra:	Fresh
25	/x/	*x*ra:b	Spoilt	*ʤ*ra:b	Socks
26	/ɣ/	*ɣ*o:l	Round/Circle	*x*o:l	Open/untie
27	/ɦ/	*ɦ*arraff	Alphabet/letter	*b*arraff	Snow/ice
28	/r/	*r*a:t̪	Night	*s*a:t̪	Moment/
29	/ɽ/	*t̪*a:ɽ	See/stare	*t̪*a:r	Sunday
30	/j/	*j*a:ʃ	Profligate	*t̪*a:ʃ	Playcards
31	/l/	*l*aʧʰʧʰa:	Bunch	*b*aʧʰʧʰa:	Cow calf

Table 4.1 shows Hindko consonantal phonemes by minimal pairs. All phonemic pairs show the difference in respect of only one feature. Results reflect that Hindko has total 31 consonantal phonemes including 26 unaspirated and 5 aspirated sounds. In addition to minimal pairs, each segment is investigated in word distribution as initially, medially and finally, place of articulation and voicing features in the relevant sections such as stops (see Section, 4.2.1), nasals (see Section, 4.3.1), fricatives (see Section, 5.1.1), affricates (see Section, 5.2.1) and approximants (see Section, 5.3.1). In light of the above table, Hindko phonemes are placed on a chart recommended by International Phonetic Association, commonly termed as IPA, for the language symbols.

The abbreviation IPA simultaneously used for dual purposes: International Phonetic Association and International Phonetic Alphabet. The association recommends the alphabets as symbols for the sounds of world's languages. Hayward (2000) believes that International Phonetic Alphabet are mostly used for the first time for an unexplored language. He has also identified that through IPA, phonological system of a language is analyzed. In simple words, IPA is one of the flexible systems of describing a language which facilitate the readers all over the world without having knowledge of sounds of that language. The identified phonemes are tabulated in the following chart. This chart is developed according to the revised version of (2005) of the International Phonetic Alphabet Chart (see Appendix, D).

Table 4.2 Chart of Hindko Consonants

Manners of articulation	Places of articulation								
	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Glottal
Plosives	p b		t̪ d̪	t d				k g	
	p^h		t̪^{h}	t^h				k^h	
Nasals	m			n		ɳ		ŋ	
Trill				r					
Flap						ɽ			
Fricatives		f v		s z			ʃ	x ɣ	ɦ
Affricates				ʧ ʤ					
				ʧ^h					
Approximant							j		
Lateral Approximant				l					

Table 4.2 reflects consonantal segments of Hindko language. Horizontal rows in the Table display places of articulation from left to right. Hindko bilabial are the most front sounds of the vocal tract and go back towards the velar and glottal sounds by showing maximum five places of articulation, i.e. 'in horizontal form of vocal tract'. The vertical column in the Table reflects the manners of articulation from top to bottom, containing eight series of Hindko consonants that plosives get maximal constriction (placed at the top of the table) and move down in a sequence towards the less constriction approximant segments. It is striking that all of unaspirated stops and affricates have aspirated counterparts in Hindko.

Thus, like most of the world's languages, Hindko is a multidimensional language which allows various linguistic features for its phonemes. In the following section, the phonetic analysis of Tanoli Hindko is carried out to distinguish segments in respect of voicing, contrast, distribution, places and manners of articulation.

4.2 Hindko oral stops

On the basis of minimal pairs through contrastive sounds (see Table, 4.1), it was found that Hindko has 12 stops including /p/, /b/, /pʰ/, /t̪/, /d̪/, /t̪ʰ/, /t/, /d/, /tʰ/, /k/, /g/, /kʰ/ with four different places of articulation as bilabial, dental, alveolar and velar. Analysis of these sounds in terms of articulatory and acoustic phonetics is carried out in the following sections.

4.2.1 Articulatory phonetic analysis of Hindko stops

Data of stop sounds for places of articulation is given in the following table:

Table 4.3 Data based on contrast for places of Hindko stops

Bilabial Words	Gloss	Dental Words	Gloss	Alveolar Words	Gloss	Velar Words	**Gloss**
pall	Fat	t̪all	Fry	tall	Move	kall	Tomorrow
bo:ra:	Big bag	d̪o:ra:	Visit	do:ra:	Deaf	go:ra:	White man
pʰall	Fruit	t̪ʰall	Filed	tʰall	Beat	kʰall	Stay

Table 4.3 reflects the broad transcription of the oral stops of Hindko. Three stop sounds /b/, /p/ and /pʰ/ are produced with the closure of lips at bilabial position and phonemes /d̪/, /t̪/ and /t̪ʰ/ are articulated at dental position. Three segments, /d/, /t/ and /tʰ/ are produced at alveolar position and /g/, /k/ and /kʰ/ are uttered at the velar position of utterance. Data shows that /b/, /d̪/, /d/ and /g/ are in the contrastive position, /p/, /t̪/, /t/ and /k/ make contrast with one another, and the aspirated sounds, /pʰ/, /t̪ʰ/, /tʰ/ and /kʰ/ also make contrast at four places of articulation.

Moreover, Hindko allows the use of the phonetic distinction of voicing. Some of the oral stops are voiced while others are voiceless. Voiced and voiceless consonants can distinguish one word from another. For identifying the feature of voicing in Hindko, data is analyzed on articulatory basis in the following table:

Table 4.4 Data based on contrast in voicing of Hindko bilabial stops (/p/, /b/, /p^h/)

Position of sounds	Bilabial unaspirated	Gloss	Bilabial voiced	Gloss	Bilabial aspirated	Gloss
Initial	patta:	Belt	batta:	Stone	p^{h}atta:	Plank
Medial	rappaɽɽ	Ground	rabbaɽɽ	Rubber	rap^{h}p^{h}aɽɽ	Dispute
Final	d̪app	Loudly	d̪abb	Press	d̪ap^{h}p^h	Drum (a one sided hand instrument)

The above table 4.4 shows the voicing contrast of bilabial stops. The observation of given examples reveals that vocal folds vibrate continuously through /b/ sounds whereas in the production of /p/ sound, an uninterrupted air goes out through vocal tract. Phoneme /p^h/ is articulated with wide opened vocal cords after the release of /p/ segment having a puff of air. That's why this sound has superscription /^{h}/ followed by unaspirated /p/ symbol. All three stops show contrast of voicing in pairs word initially, medially and finally. Thus, bilabial /p/ is an unaspirated, /b/ is the voiced and /p^h/ is an aspirated sound.

Table 4.5 Data based on contrast in voicing of Hindko dental stops (/t̪/, /d̪/, /t̪^{h}/)

Position of sounds	Dental unaspirated	Gloss	Dental voiced	Gloss	Dental aspirated	Gloss
Initial	t̪all	Fry	d̪all	Grind/Chew	t̪^{h}all	Level land
Medial	kot̪t̪arr	Cut	kod̪d̪arr	Where	kot̪^{h}t̪^{h}arr	Iota
Final	sa:t̪	Time	sa:d̪	Taste	sa:t̪^{h}	Help/company

Table 4.5 displays voicing of three dental plosives. Plosive /t̪/ is uttered without vibration in the vocal tract. It is articulated right after the release of the /t̪/ without getting delayed which refers to the unaspirated sound. On the other hand, /d̪/ is produced with a narrowed glottis and a voiced sound is heard. The phoneme /t̪^{h}/ is produced with the open glottis and an audible puff of the air follows the release. The vocal cords remain wide open after the utterance of /t̪^{h}/ which refers to its aspiration. Each segment freely makes the contrast of voicing in the pairs. As a result, dental /t̪/ is an unaspirated, dental /d̪/ is a voiced and /t̪^{h}/ is an aspirated oral stops in Hindko.

Table 4.6 Data based on contrast in voicing of Hindko alveolar stops (/t/, /d/, /t^h/)

Position of sounds	Alveolar unaspirated	Gloss	Alveolar voiced	Gloss	Alveolar aspirated	Gloss
Initial	takk	Clean	dakk	Stop	t^{h}akk	Knock
Medial	katti:	Calf	kaddi:	Take out	kat^{h}t^{h}i:	Drain
Final	gatt	Get	gadd	Mix	gat^{h}t^h	Heavy bundle

Table 4.6 presents three plosive alveolar phonemes. Segment /t/ is uttered without vocal folds vibration. Similarly, aspirated /t^h/ sound is articulated with the open glottis but with an audible puff of the air. Contrary to it, the vocal folds for the production of /d/ are held gently together and make vibration as well. These segments also make freely contrast of voicing with each other word initially, medially and finally. Consequently, in Hindko, alveolar /t/ is an unaspirated, /d/ is a voiced and alveolar /t^h/ is an aspirated oral stop.

Table 4.7 Data based on contrast in voicing of Hindko velar stops (/k/, /g/, /kʰ/)

Position of sounds	Velar unaspirated	Gloss	Velar voiced	Gloss	Velar aspirated	Gloss
Initial	kapp	Cut	gapp	Gossip	kʰapp	Noise
Medial	akkaɽɽ	Pride	aggaɽɽ	Respect	ʊkʰkʰaɽɽ	Get remove
Final	ʧakk	Bite	ʧagg	Mimic	ʧakʰkʰ	Taste

Data in the table 4.7 indicates that Hindko has three velar plosives. Like the other plosives in the previous tables, these phonemes make contrastive pairs of voicing as well. For the articulation of /k/, the airflow is switched into the sound energy not at larynx but somewhere else in the vocal tract and produced as unaspirated sound. Likewise, aspirated /kʰ/ is also uttered without vibration of vocal folds. On the other hand, velar phoneme /g/ is articulated with the vibration of narrowed vocal folds. The pairs of all velar phonemes /k/, /kʰ/ and /g/ make contrast in voicing with different lexical items. Data shows that these sounds occur at three different positions. Therefore, velar /k/ is an unaspirated, velar /g/ is a voiced and aspirated /tʰ/ is a velar oral stop. In addition to the places and voicing features of stops, the data is given in the following word initially, medially and finally.

Table 4.8 Distribution of Hindko stops

Sounds	Initial	Gloss	Medial	Gloss	Final	Gloss
/b/	bæ:t̪	Stick/bat	kʰabba:	Left	xra:b	Spoil
/p/	patta:	Belt	rappaɽ	Ground	sapp	Snake
/pʰ/	pʰadda:	Fight	rapʰpʰaɽɽ	Dispute	lɪpʰpʰ	Flexible
/t̪/	t̪aɽɽ	Courage	kut̪t̪arr	Cut	lat̪t̪	Leg
/d̪/	d̪æ:x	See	ad̪d̪a:	Half	d̪ud̪d̪	Milk
/t̪ʰ/	t̪ʰapp	Slap	ku:t̪ʰt̪ʰarr	Iota	nat̪ʰt̪ʰ	Bridle

/t/	tokk	Cut	batta:	Stone	satt	Fire/throw
/d/	dakk	Stop	k^hadda:	Cavity	dadd	Frog
/t^h/	t^happ	Fold/beat	pa$t^h$$t^h$a:	Young	na$t^h$$t^h$	Run away
/k/	koʃt̪i:	Wrestling	mukka:	Fist	lo:k	People
/k^h/	k^hall	Skin	ma$k^h$$k^h$i:	Fly	ʤu$k^h$$k^h$	Measure
/g/	gaddi:	Vehicle	ko:gi:	Dove	sa:g	Green vegetable

The above table 4.8 displays the distribution of Hindko plosives. Data shows that all stops of Hindko are found word initially, medially and finally. Each example consists of different lexical items.

4.2.2 Discussion on articulatory analysis of Hindko stops

Articulatory analysis of stops shows that Hindko has 12 oral stops. These sounds are uttered at four places, bilabial, dental, alveolar and velar. Each place has three sounds, unaspirated, voiced and aspirated sounds. Conversely, English has six oral stops including /p/, /b/, /t/, /d/, /k/ and /g/, which are produced at three places, bilabial, alveolar and velar.

Like many other languages of sub- continent such as Urdu, Punjabi, Hindi and Pahari, Hindko also allows distributional occurrence of stops word initially, medially and finally. Likewise, Hindko also includes voicing features. Thus, these results of voicing in Tanoli Hindko are similar to many studies. Such as the works of Ladefoged (2001, 2003) Ashby and Maidment (2005) and Clark, et al. (2007) among others show that though voicing is found in most of the languages, however, it is not a universal phenomenon.

Ashby and Maidment (2005) further state that many Australian languages have voiced and voiceless sounds but cannot occur contrastively. For example, in Dyirbal language, the word /*t*iban/ (stone) where initial /t/ is a voiceless and medial /b/ is a voiced but the occurrence of voiced /d/ in the word /*d*iban/ cannot change the meaning. Such words give further versions within the words like /tipan/ and /dipan/. On the contrary, French, Greek, Russian, Hungarian, Turkish, Vietnams and Zulu allow voicing. Likewise, Kong (2009) adds that French, Spanish, English and Thai have true voicing contrast. The phonetic feature of voicing in Hindko is contrastive which allows the use of differences in voiceless and voiced stops.

In English, voiceless and voiced sounds show different phonetic feature. Such as word initially, they often realized as aspirated sound whereas at word medially, the same sound becomes fully voiced. On the contrary, Hindko stops have similar phonetic features at different positions. Hindko, as opposed to English, has three ways stop contrast, among voiced /b/, unaspiarated /p/ and aspirated /pʰ/ stops (a typical VOT contrast), whereas in English the voiced /b/ and unaspirated /p/ stops are allophones of each other in complimentary distribution.

In English, the phoneme /p/ is realized as /pʰ/ in the beginning of words, as /p/ sound word initially if found with following /s/ and as /p˺/ word finally. Thus, each one is in complementary distribution. Whereas in Hindko /p/ is realized as /p/ at three positions and phoneme /pʰ/ is realized as /pʰ/ word initially, medially and finally as well. In fact, at the phonemic level of Hindko speakers, phonemes /pʰ/ and /p/ are two different elements and are realized differently. Thus, /pʰ/ is not an allophone of /p/ rather it is a separate phoneme and /p/ can make the contrast with the sound /pʰ/ and both sounds have different phonemic qualities.

Awan (2004) identifies 16 stops in Hindko including /p/, /p̆/, /pʰ/, /b/ /t̪/, /t̪̆/, /t̪ʰ/, /d̪/, /t/, /t̆/, /tʰ/, /d/, /k/, /k̆/, /kʰ/ and /g/. However, in the present study, the researcher has found that

Hindko has 12 stops. This claim in the present study is based on the analysis of data in terms of minimal pairs and distributional study of the segments. Though additional phonemes, but actually the alphabets, by Awan, i.e. /p̆/, /t̪̆/, /t̆/ and /k̆/ make minimal pairs, e.g. /p̆all/ 'see', /t̪̆aɽɽ/ 'body', /t̆akk/ 'close' and /k̆arr/ 'home', yet their occurrences are limited only at word initial position. The symbol of extra-short (˘) over word initial sounds, he used, indicate somewhat /h/ sound right after initial plosives. If, these alphabets are considered as phonemes, but not considered in the present study, Tanoli dialect has also /b̆/ sound in /b̆a:ri:/ 'mop' and /ğ/ sound in /ğaɽi/ 'small heap of hay'. It seems that the alphabets with a diacritic are not required on the grounds that the alphabet does not represent a variant of the sound. The confusion seems to stem from the fact that the vowels following the consonant carry a low tone which makes it a different word. For instance, the Hindko word / ta:l/ means 'heap of wood' and if the same word is spoken with the low tone on the vowel following the first consonant, it means 'descent'.

Unlike Hindko, Urdu allows aspiration not only with voiceless sounds but also with voiced sounds, e.g. /b^h/, /$d̪^h$/, /d^h/ and /g^h/. Like Hindko, Punjabi and Pahari have also three ways of voicing and both are tonal languages. Karnahi (2007) carried out a research on the phonetics of Pahari language. He identifies sounds on the basis of minimal pairs and claims that Pahari has 24 stops (p.136). However, Khan (2012) identifies that Pahari includes 12 stops, i.e. /p/, /p^h/, /b/, /t̪/, /$t̪^h$/, /d̪/, /t/, /t^h/, /d/, /k/, /k^h/ and /g/. According to Khan, the claim of 24 stops does not represent the sound rather the vowels following the consonants, i.e. /p/, /t̪/, /t/ and /k/ carry tones which make the words different. Similarly, Baart (n.d) states that in Punjabi type languages, this phenomenon occurs due to the tone. Thus, it is hard to resolve this controversial issue at the moment, because the objectives of the present thesis are to describe phonemes and syllable structure of Tanoli Hindko. The actual results may be carried out if other linguistic features such as tones and stress pattern are included. Thus, researcher suggests that there is intense need to conduct a separate detailed experimental research in Hindko to find out the real position of this phenomenon.

4.2.3 Acoustic analysis of Hindko oral stops

Articulatory analysis shows that 12 Hindko stops, having four places of articulation, contain three ways of sounds in form of unaspirated, voiced and aspirated. The acoustical analysis of these sounds is carried out in the following section:

Earlier than the statistical measurement, stop spectrograms were visually analyzed to know their characteristics. A sample for each sound spectrogram with waveform is displayed for orientation purpose. For the ease of spectrographic analysis, stops were categorized into three groups according to three ways of articulation, i.e. spectrograms of voiced, unaspirated and aspirated respectively.

4.2.4 Spectrographic analysis of Hindko oral stops

During spectrographic analysis, Hindko stops were mainly analyzed in light of voice bar, release burst, formant transitions and locus which cover both parts of articulation, i.e. manners and places. These acoustic features are widely used by phoneticians for the acoustic analysis of stop sounds (see Section, 2.5.1). In addition to the sample, spectrograms displayed for reference purpose in the study, each utterance of stop sound during the analysis was examined for the accuracy of the results. First, voiced sounds are analyzed spectrographically.

Voiced stop segments

In Hindko, four voiced sounds are articulated at bilabial, dental, alveolar and velar places. Spectrograms are displayed in the following figure:

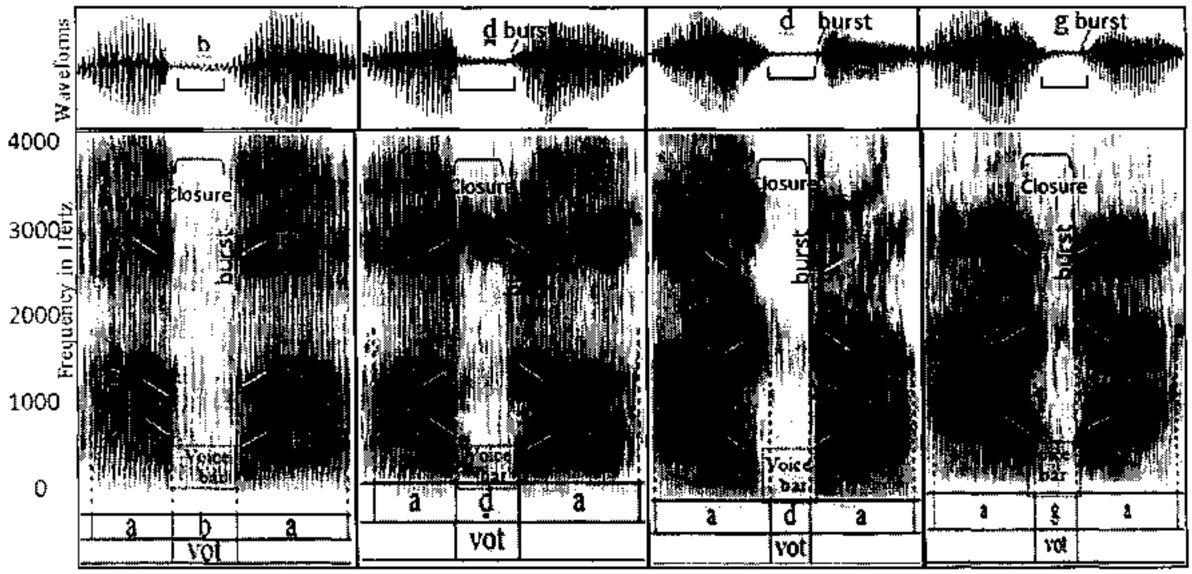


Figure 4.1 Waveforms and spectrograms of voiced oral stops

The above figure 4.1 shows the spectrograms of Hindko stop sounds, i.e. /b/, /d̪/, /d/ and /g/. Bilabial /b/ has maximum whereas alveolar /d/ has minimum closure duration. The waveforms also indicate regular scratchy line, i.e. periodic wave-forms that refer to voiced sounds. Waveform of bilabial has the strongest and compact bars than dental, velar and alveolar voiced sounds respectively.

In the lower part of the Figure, spectrograms display low band energy in the region of 250 Hz, termed as voice bar. It remains evident throughout the di-syllables. A narrow view of spectrograms is displayed separately to show the voicing feature in form of pitch contours (see Appendix, B). However, during the analysis, it was encountered that some of voiced sound spectrograms were not fully voiced during the closure. It has mostly been observed during the utterances of females. It may be due to the common fact that a female has shorter oral cavity than a male. Therefore, periodic waves, the presence of voice bar and pitch contour are the indications of voiced stops /b/, /d̪/, /d/ and /g/.

Spectrograms show acoustic cue of vertical spikes known as release burst. Spectrograms of /d/ and /g/ display longer burst than /b/ and /d̪/. Overall, release burst lasts for a few milliseconds and these results are similar to the ideas of Ladefoged and Maddieson (1996), and Lisker and Abramson (1964).

Duration of the previous and following vowels cue reveals that vowels have longer duration, more sonority and intensity than stops. So far acoustic cues identified voiced sounds according to the manner while the following part shows the visual analysis of these sounds according to place of articulation.

The places acoustic feature, stop burst of the alveolar and the velar are more prominent than the dental and the bilabial. More specifically, the burst of the alveolar is stronger than the velar and the burst of dental is more energetic than bilabial. Overall, the burst cue is fainter in the voiced bilabial and the dental sounds than the alveolar and the velar sounds which can be seen in waveforms and spectrograms. By and large, vertical spikes in all the voiced sounds are weak to observe.

In the same way, Yavas (2011) identifies that voiced sounds contain less evident burst spikes (see Section, 2.5.1). During the analysis, it was found that some of the spectrograms of dentals and bilabials either have weak energies at the place of release, rarely visible on the spectrograms, or they do not show stop burst at all. However, during the analysis, the expanded view of voiced sound spectrograms showed stop burst frequencies between the range of 1800 Hz to 3300 Hz for the bilabial, 1500 Hz to 3500 Hz for the dental, 1300 Hz to 2800 Hz for the alveolar and 800 Hz to 3200 Hz for the velar sound. The burst duration of the bilabial, the dental and the velar voiced sound is found around 0.003 (sec.) whereas the alveolar sound shows more duration about 0.004 (sec.).

During the hold phase, vocal folds vibrate before the release of voiced sounds which refer to VOT of the voiced plosive consonantal utterance. The marked boundaries for VOT show that all the four spectrograms have negative VOT. Thus, negative VOT during the closure duration reflect that they are fully voiced sounds.

Formant transitions of bilabial /b/ show that F1, F2 and F3 fall at the offset of the preceding vowel and rises at the onset position. Dental /d̪/ reveals the transition of F1 in falling position whereas F2 in rising position at the offset of preceding vowel. However, F3 increases during the utterance of preceding vowel but at the offset position, transition shows level or fall of formants. Contrary to preceding vowel of dental /d̪/, transitions of F1, F3 of its following vowel increase and F2 decrease towards the end of utterance.

In Hindko, the alveolar /d/, F1 and F3 move downward at the end of preceding vowel and increase at the beginning of the following vowel. On the other hand, F2 of /d/ rises before the consonant and falls after the consonant. However, F2 shows slightly increase at offset position but in some utterances this formant remains consistent at the following vowel. Velar /g/ formant transitions depict much clear view in which F1 and F3 at onset position fall and F2 slightly rises whereas F1 and F3 of the following vowel rise and F2 falls.

The findings of alveolar voiced and velar voiced sounds are almost similar. However, the difference between both voiced sounds shows that F2 of /d/ at the beginning of following vowel has less falling slope than /g/ sound. Similarly, F1 of /g/ depicts more falling and rising slop at offset and onset positions than /d/ sound. Falling of F3 of /d/ sound at the initial consonantal position is almost connected with F2 at the offset of the preceding vowel while F3 of /g/ sound occur at a higher frequency. Similarly, F3 of velar /g/ rises prominently with stronger energy during the utterance of the following vowel whereas F3 of /d/ shows weaker energy with almost unclear direction of formant transition. Moreover, formants of the adjacent segments, F1 and F2 of /d/ sound occur at a higher position than /g/ sound.

Locus feature of Hindko voiced sounds in CV sequence of bilabial sound /b/ reveals rising direction as minus transition while the locus of dental /d̪/ F2 and F3 shows falling position as plus transition. On the other hand, the locus of the alveolar sound /d/ F2 and F3 depict almost level position while velar /g/ F2 falls and F3 rises, thus termed as plus and minus transitions respectively.

Unaspirated sounds

Similar to Hindko voiced sounds, analysis of unaspirated sounds is also carried out firstly in terms of manner acoustic cue and then place features.

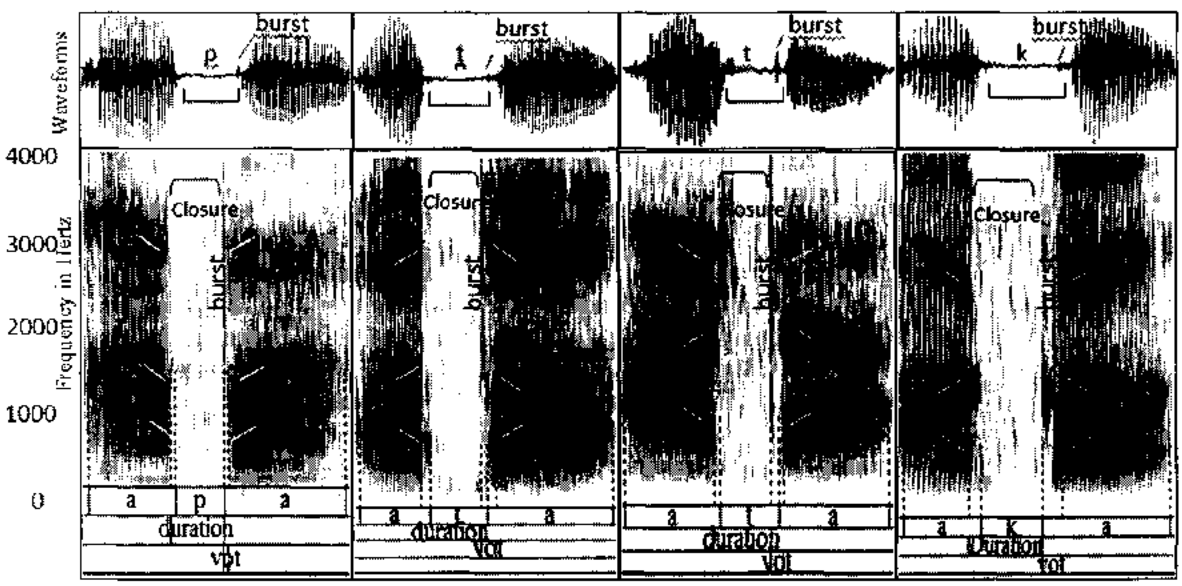


Figure 4. 2 Waveforms and spectrograms of unaspirated oral stops

The above figure 4.2 presents spectrograms of unaspirated sounds, /p/, /t̪/, /d/ and /k/. In all these sounds, voicing remains ceased during the closure duration and again starts with the release of stops which refers to unaspirated sounds. Closure duration of velar sound has maximum and alveolar has minimum duration. Likewise, bilabial /p/ has more utterance gap than dental /t̪/ sound.

The analysis shows consistent result that unaspirated sounds lack pitch contour since vibration of the vocal folds is ceased. However, with the release of constriction, vocal folds again start vibration like previous vowel and thus voicing resumes. Durational gap of these sounds has aperiodic waves which are the characteristic of voicelessness. Additionally, silent gap of bilabial and dental sounds depicts less energy than velar and alveolar sounds. In addition to spectrograms, the waveforms have irregular striation too. Thus, waveforms and spectrograms rightly differentiate the voicing feature of Hindko stops.

The cue of release burst is clearly found in all of unaspirated stops. Unlike voiced sounds of Hindko, spectrograms of unaspirated sounds have more prominent spikes. Likewise, Yavas (2011) denotes that voiceless sounds have more energetic spikes than voiced (see Section, 2.5.1). These vertical spikes of unaspirated sounds also cover broader area. The burst of /t/ is stronger than other stops and found in compact form while unaspirated /k/ has weaker vertical spike. Therefore, longer closure duration, lack of horizontal voice bar and energetic vertical spikes and longer duration clearly indicate that /p, t̪, t, k/ are unaspirated sounds.

In contrast to Hindko voiced sounds, the place cue, i.e. the stop burst of bilabial sound remains throughout the frequency of the spectrograms. Its waveform also shows striation at the position of stop burst. However, waveform burst striations of dentals and velars are weaker than bilabials whereas alveolars show strongest spike among all places. Thus, alveolar stop has energetic burst but takes less duration. On the other hand, the burst of dental carries more time and regular striation with dark bands throughout the spectrogram. However, burst of velar can been seen in the spectrograms in aperiodic waves with less energy. Stop burst of unaspirated sound is found between the frequencies of 1200 Hz to 3500 Hz for bilabial sounds, 1300 Hz to 4000 Hz for dental phoneme, 1500 Hz to 4000 Hz for alveolar segments and 800 Hz to 2000 Hz for velar sound. The burst duration is found about 0.0025 (sec.) for bilabial sound, 0.003 (sec.) for dental and velar stop segments whereas duration of unaspirated alveolar stop burst is found around 0.005 (sec.).

Another acoustic cue for place is VOT followed by the closure in the unaspirated sounds. In voiceless sounds, the release of the stops and VOT occur simultaneously. Thus, VOT after closure duration and before the beginning of voicing refer to positive VOT.

The acoustic cue of formant transitions in the unaspirated sounds display that F1, F2 and F3 of /p/ fall at offset position of preceding vowel and rise at onset position of the following vowel. Dental /t̪/ reveals that F1 decreases at the offset and increases at the onset position while F2 somewhat rises at the beginning and falls by the end of the consonantal sound. However, F3 of /t̪/ sound remains more or less consistent by the end of preceding vowel and in the beginning of the following vowel. Unaspirated alveolar /t/ sound shows that F1 and F3 fall at the end of the preceding vowel and rise at the onset of the following vowel while F2 rises at offset position and falls at onset position. F1 and F3 of /k/ sound show falling at onset and rising at offset position while F2 rises in the beginning of velar consonant and falls at its final position. Thus, both unaspirated alveolar and velar sounds have similar formant transition; however, F3 and F2 of the alveolar sound almost connect by the end of preceding vowel and then rise of F3 in the following vowel but with less striation. On the other hand, F3 of velar sound does not connect with F2 at offset position and again rises with higher frequencies at the following vowel with more striation. Likewise, F2 of velar sound has more falling slope than the alveolar. In addition, F2 of alveolar is higher than F2 of velar while F1 of alveolar is lesser than F1 of velar at both positions.

The cue of locus in the unaspirated sounds refer to the minus transition for bilabial sound, i.e. increasing of F2 and F3 in CV context and falling of F2, F3 for dental sound that refer to plus transition, i.e. the point of locus begin from and go to upside. On the other hand, F2 of alveolar has level position while F3 increases from the locus point and velar formant transitions of F2 and F3 have downward and upward directions that implies plus transition and minus transition from locus point towards the steady-state of the following vowel.

Aspirated sounds

This group of sounds has almost similar features to unaspirated segments, yet feature of aspiration makes it a different class of stops.

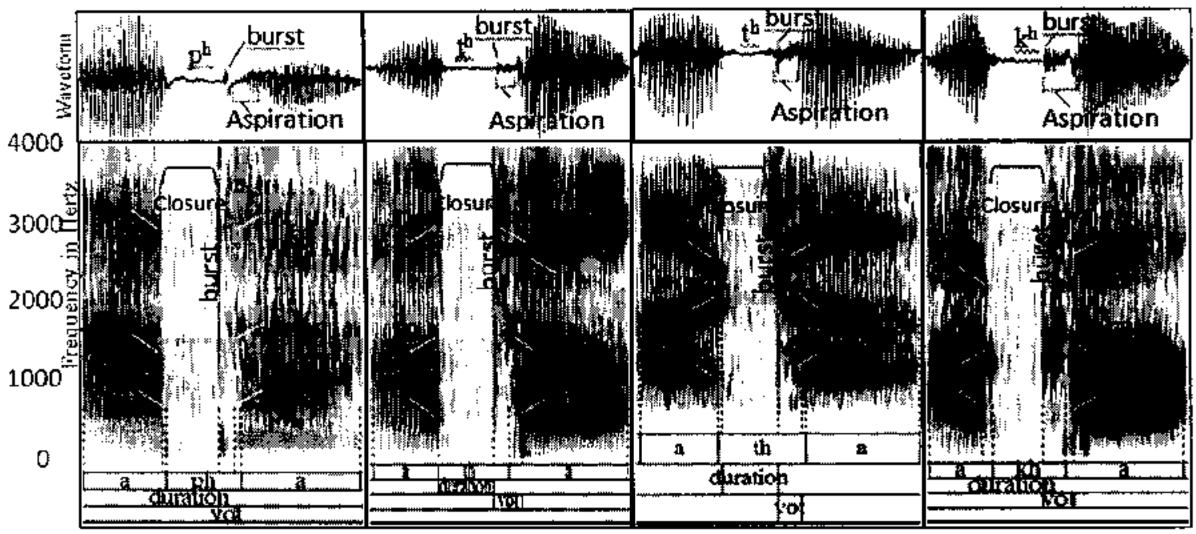


Figure 4. 3 Waveforms and spectrograms of aspirated oral stops

The above figure 4.3 illustrates the spectrograms and waveforms of Hindko /p^h/, /$\underline{t}^h$/, /t^h/ and /k^h/ sounds. Both waveforms and spectrograms clearly indicate the significant delay between the release of stops and following onset voicing. It implies that these four sounds have aspirations which entail a little puff of the air. Duration of the stop gap in the aspirated sounds is longer than voiced but less than unaspirated sounds. However, /pʰ/ has maximum and /tʰ/ shows minimum duration with a gradual decrease from bilabial to alveolar and it increases again in the velar /kʰ/ sound.

Unlike voiced but like unaspirated sounds, there is absence of voicing during the closure of aspirated sounds too. Thus, in the production of these sounds, vocal folds vibration is ceased and at the release of aspirated sounds, vocal folds do not start vibration having a substantial delay and subsequently start vibration at the position of onset of the following vowels. Spectrograms display the absence of voicing bar at the bottom in the region of consonantal sounds. Similarly, all aspirated sounds lack pitch contours during closure (see Appendix, B).

The cue of release burst can be seen prominently in all of the waveforms and spectrograms of aspirated sounds. Unlike Hindko unaspirated sounds, vertical spikes in aspirated sounds cover broader areas and range of frequencies in the spectrograms. In addition, mark of burst in the waveform of aspirated sound has stronger position with compact striation. Thus, bursts of aspirated sounds are prominent and last for more time than other sounds. In addition, adjacent vowels duration also specify that both vowels have longer duration than the aspirated voiced sounds. By and large, according to the manner of articulation, aspirated sounds have longer silent gap, potential stop burst and more energetic articulation of stop sounds.

On the other hand, the place feature, i.e. stop burst shows that the regular striation of bilabial /pʰ/ is found in spread form while in other sounds; frequency can be seen between 2500 Hz to 4000 Hz for dental /t̪ʰ/, 1300 Hz to 3300 Hz for alveolar /tʰ/ and 1100 Hz to 1700 Hz for velar /kʰ/. Burst duration for these sounds is found between 0.0045 (sec.) and 0.0065 (sec.). However, bilabial shows burst in spread and weakest form while alveolar /t^h/ displays strongest burst with higher frequency.

Another place cue, i.e. VOT of aspirated sounds is positive but longer than unaspirated sounds. Furthermore, VOT of velar /k^h/ has higher values than bilabial /p^h/, and dental /$\underline{t}^h$/ has more VOT than alveolar /t^h/ respectively. The next cue for the places of articulation is the formant transition. Bilabial aspirated sound shows transition of F1, F2 and F3 that fall at the offset position while rise at the onset of following vowel. For dental aspirated segment, F1 falls and F2, F3 rise at the offset of the preceding vowel and at the onset position F1, F3 rise and F2 falls. In the alveolar aspirated sound, F1, F3 fall and F2 rises at the offset of preceding vowel. Conversely, at the onset of the following vowel, F1, F3 rise and F2 falls. The velar aspirated sound shows that frequency of F1 and F3 fall and F2 rises at the end of the preceding vowel whereas at the beginning of the following vowel, the transitions of F1, F2 and F3 show the mirror image of corresponding formants. Similar to unaspirated sounds, F2 of aspirated sounds remain higher during the utterance of alveolar than velar. Likewise, unlike velar sound, alveolar F2 and F3 connect at the end of the preceding vowel and alveolar F2 has less slope in the following vowel than the velar. In addition, locus cue, the origin point of transitions of F2 and F3 rise in bilabial aspirated sound in CV sequence as minus transition, F2 and F3 have falling of dental as plus transition, alveolar has falling of F2 and rising of F3 as plus and minus transition, and velar F2 falls while F3 rises as plus and minus transitions.

4.2.5 Discussion on the spectrographic analysis of Hindko oral stops

Stop spectrograms were acoustically analyzed according to manner and place of articulation. Analysis shows that the cue of manner of articulation, i.e. the silent gap of Hindko voiced sounds is shorter than unaspirated and aspirated sounds. These results are relative to the general tendency of voicing (see Section, 2.5.1). Results also show that voicing runs throughout the utterance of voiced stops, preceded and followed by vowels, thus, termed as fully voiced sounds. However, due to the fast speed of females' utterances, some spectrograms do not show voicing bar during the closure duration. This result is consistent with the views of Roach (2000) that in fast speed, voicing does not occur.

The closure duration of Hindko bilabial sounds display weaker energy in the articulation. Similarly, Mees and Collins (2003) indentify that the spectrograms of /b, d, g/ show less energy (see Section, 2.5.1). On the contrary, in the utterances of unaspirated sounds, voicing ceases during the silent gap and resumes simultaneously with the release of /p/, /t̪/, /t/, /k/. Likewise, in aspirated sounds, during the closure period, voicing is ceased but spectrograms show delay between the release of aspirated sounds and onset of the following vowels. Therefore, all Hindko unaspirated and aspirated sounds lack voicing bars and pitch contours as well. However, in these sounds, bars occur at higher position than voiced sounds. Thus, these features show that /p/, /t̪/, /t/ and /k/ are unaspirated sounds in Hindko. Similarly, Cruttenden (2001) and Mees, et al. (2003) state that English voiceless sounds have lower frequency than voiced sounds. Unlike /b/, /d/, and /g/, /p/, /t/ and /k/ are voiceless sounds.

The release bursts of Hindko unaspirated sounds are stronger than voiced sounds. Yavas (2011) refers to English stops that voiceless sounds have stronger burst than voiced sounds. Overall, in some utterances, bursts were not much prominent. This may be due to medial position of stop sounds as VCV. Hayward (2000) also denotes that a stop at initial position shows stronger than other places of the utterances, i.e. medially and finally. Duration of preceding and following vowels is longer than all stop sounds. Furthermore, all stop utterances show that vowels are sonorous sounds than stops. Thus, these results are consistent with the earlier mentioned stop feature, i.e. duration of previous vowel (see Section, 2.5.1).

Hindko alveolar sounds show strongest stop burst among other stops. The vertical spikes of these sounds also carry maximum frequency which starts from the region of 1400 Hz average and go up to 3400 Hz average. The horizontal duration of voiced alveolar is around 0.004 (sec.), 0.005 (sec.) for alveolar unaspirated and 0.006 (sec.) for alveolar aspirated sound.

The burst of Hindko velar sounds begins from the lowest part of spectrograms, i.e. around 800 Hz for unaspirated sounds and 1100 Hz for aspirated sound. However, in the unaspirated sounds, the vertical spikes of burst go up to 1700 Hz for /k^h/ and 2000 Hz for /k/ sounds whereas in voiced sound, spike carries highest frequency up to 3200 Hz. Horizontal duration of unaspirated velar sounds is about 0.003 (sec.) whereas aspirated sound has 0.006 (sec.). Moreover, like alveolar sounds, Hindko dental sounds also show much frequencies like unaspirated sounds contain between average frequencies of 1400 Hz to 3800 Hz and dental aspirated sound frequency is found in the region of 2500 Hz to 4000 Hz. Thus, it implies that dental stop burst have higher frequencies than alveolar sounds. Likewise, Horizontal duration of dental unaspirated sounds is about 0.003 (sec.) while aspirated sound shows 0.0045 (sec.).

In addition, stop burst of Hindko bilabial sounds is found in spread form. Bilabial voiced sounds show the frequencies in the medial part of the spectrograms, between 1800 Hz to 3300 Hz whereas the spikes of bilabial unaspirated sounds cover more part, between 1200 Hz to 3500 Hz. Similarly, aspirated bilabial sounds show the spike frequencies between 1200 Hz to 3700 Hz. Duration of unaspirated sounds is found 0.003 (sec.) and aspirated sounds show 0.005 (sec.).

Overall, it can be concluded that stop bursts of Hindko velar sounds occur at lower part of the spectrograms, dental sounds in the highest region, alveolar sounds in the medial part and bilabial sounds somewhat higher than alveolar but lower than dental sounds. Contrary to Hindko stop burst findings , Greenberg (2004) states that bilabial voiced sound has lower frequency, higher frequency for alveolar voiced sound and middle frequency for velar burst (see Section, 2.5.1).

The movements of formants in the adjacent segments refer to different places of articulation. Likewise, analysis of Hindko bilabial sounds /b/, /p/ and /p^h/ show that transitions of F1, F2 and F3 fall at the offset of preceding vowel /a/ and to rise at onset position of following vowel /a/. These findings are similar to the statement of Hayward (2000) and Yavas (2006) that in case of English, the transitions of F2 and F3 fall in VC context while rise in CV sequence (see Section, 2.5.1). Furthermore, in bilabial sounds, loci of F1, F2 and F3 show minus transition in VC and CV sequences. Thus, these findings are similar to English bilabial sounds.

Spectrograms of Hindko dental sounds show falling of F1 at the offset of preceding vowel and rising at the onset of following vowel whereas movement of F2 shows the mirror image. However, the position of F3 at the end of preceding vowel is somewhat complicated, which shows level or rise in the transition, but unquestionably transition of this formant rises at the beginning of the following vowel. Moreover, in CVC sequence of dental sounds, locus of F1and F3 is minus while F2 has plus locus.

The analysis of formant transitions of Hindko alveolar sounds present that F1 and F3 move down at the end of preceding vowel and at the onset position both formants move upward whereas the movement of F2 rises at offset position and falls at onset position.

Similarly, Yavas (2006) indicates that in VC sequence of alveolar sounds; F2 decreases whereas F3 increases during the transitions (see Section, 2.5.1). Furthermore, locus of alveolar F1 and F3 is minus transition in CVC sequence and F2 has plus transition. Likewise, Cruttenden (2001) also indicates plus transition for F2 of alveolar sounds.

Movement of Hindko velar sounds reveal the transitions that F1 and F3 fall at the end of preceding vowel and rise at the onset position. Conversely, F2 of stop velar rises at offset position and falls at onset position. Likewise, Yavas (2006) refers to English velar stops that F2 falls and F3 rises in CV sequence like alveolar sounds. Nevertheless, velar sounds show more narrowing position of formants than alveolar stops (see Section, 2.5.1). In addition, locus of F2 of Hindko velar sounds is minus at initial position and plus transition at consonantal final position. On the other hand, loci of F1 and F3 have mirror image of velar F2 in VCV sequence. Likewise, Cruttenden (2001) also denote that English /k/ and /g/ have plus transition for F2 and minus transition for F3 in CV context and figure also display similar result of the second formant (see Section, 4.2.3).

Thus, formant transitions of neighbouring vowels of Hindko stop consonants give useful information about places of articulation. The results of the present study are consistent to theories discussed previously (see Section, 2.5.1). However, transitions of Hindko alveolar and velar sounds are almost similar to each other. In this regard, Yavas (2011) recommends that the transitions of F2 and F3 can provide more information about the places (see Section, 2.5.1). Consequently, to see the difference between the places of alveolar and velar sounds, some peripheral information about the formant transitions values are taken into account that Hindko alveolar F2 and F3 get connected at the offset position while velar formats remains apart at similar position. In addition, alveolar transitional slopes of F2 are less than velar sounds. Alveolar F2 frequencies of vowels are higher than velar F2 in both neighbouring vowels.

Spectrographic analysis of VOT shows that Hindko has three ways of voicing. Voiced sounds are fully voiced and have negative VOTs; unaspirated sounds show a little positive VOTs and aspirated sounds have longer VOT (for further detail, see Section, 4.2.7).

4.2.6 Statistical measurement of Hindko oral stops in terms of VOT

In addition to the spectrographic analysis, Hindko stops were also measured statistically to know the mean values in terms of VOT and closure duration respectively. This cue is concerned with the timing of stops to differentiate among voiced, unaspirated and aspirated sounds and places of stops articulation. The results of each sound are tabulated in the following table:

Table 4.9 VOT values of Hindko stops (seconds), Means, Std. Dev., Coefficient of Variation

Stops	Places	No. of tokens	Means	Std. Dev.	Co.Var.
p		36	0.0211	0.0048	22.8612
b	Bilabial	36	-0.0885	0.0094	10.6251
p^h		36	0.0533	0.0043	8.1843
t̪		36	0.0206	0.0031	15.0671
d̪	Dental	36	-0.0934	0.0134	14.3951
t̪^{h}		36	0.0513	0.0073	14.2551
t		36	0.0176	0.0035	20.0676
d	Alveolar	36	-0.0835	0.0101	12.1405
t^h		36	0.0489	0.0085	17.3697
k		36	0.0298	0.0042	14.0939
g	Velar	36	-0.0953	0.0145	15.2567
k^h		36	0.0693	0.0104	15.0229

The above table 4.9 shows average mean value of Hindko stops including their standard deviation and coefficient variation. Four sounds, /b/, /d̪/, /d/ and /g/ have negative VOT values (showing minus sign) whereas other segments show positive VOT mean values. Each place of articulation has three segments wherein two have positive and one negative values. These average mean values are further categorized according to places of articulation and voicing features to know the characteristic of each type:

Table 4. 10 Means VOT results by places and voicing feature, (measured in sec.)

Places	Voiced	Unaspirated	Aspirated
Bilabials	-0.0885	0.0211	0.0533
Dental	-0.0934	0.0206	0.0513
Alveolar	-0.0835	0.0176	0.0489
Velar	-0.0953	0.0298	0.0693

Table 4.10 shows three types of voicing including voiced, unaspirated and aspirated sounds with four different places, bilabial, dental, alveolar and velar. All voiced sounds show negative VOT, unaspirated and aspirated sounds depict positive VOT. However, aspirated sounds have longer VOT than unaspirated. The above given VOT means are further verified by ANOVA to see the difference within the values of stops in the following section:

Table 4. 11 ANOVA for unaspirated stop segments in terms of VOT

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000992	3	0.000331	20.91903	1.42E-08	2.816466
Within Groups	0.000696	44	1.58E-05			
Total	0.001688	47				

The results of one-way ANOVA Table 4.11 confirm that the p-value is smaller than 0.01 which shows significant difference among VOTs of four unaspirated stops. Thus, further analysis is carried out using LSD test to see which pairs of unaspirated segments are different from others.

$$LSD = t_{\alpha/2(n-1)} \times \sqrt{\frac{2MSE}{r}}$$ LSD=0.003573

Segments	t	t̪	p	k
Vot mean values	0.017609	0.020669	0.021147	0.029829

The straight line, under voiceless stops /t/, /t̪/, /p/, indicates that the pairs of /t, t̪/, /t, p/ and /t̪, p/ are similar in terms of VOT whereas pairs of /k, t/, /k, t̪/ and /k, p/ have different mean values. It reflects that alveolar /t/ takes least VOT than others stops while velar /k/ carries maximum time among others. Intermediate groups, alveolar /t/ and dental /t̪/ have less VOT values than the front bilabial /p/ and back velar /k/. These findings of unaspirated sounds, therefore, contradict the general concept about the place of articulation, e.g. VOT is increased as it goes further in the back of oral cavity.

The results of LSD test throughout the following study are indicated by line (s). It is a statistical method to show the similarities and differences within the pairs without giving detailed description. The reason for using this statistical method, i.e. underlining the pairs, is comprehensive in nature that gives complete view of the results. The above explanation of LSD test of unaspirated sounds is given as a reference point. Therefore, the results of LSD test are just indicated by a line in the following sections (where required).

Table 4. 12 ANOVA for aspirated stops

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.003066	3	0.001022	16.12371	3.26E-07	2.816466
Within Groups	0.002789	44	6.34E-05			
Total	0.005856	47				

The above ANOVA table, 4.12, indicates significant VOT difference of aspirated as p-value is less than 0.01. Since the results reveal significant difference, therefore, the LSD test is applied to distinguish the discrepancies among pairs of aspirated sounds.

LSD=0.007154

Segments	t^h	t̪^h	p^h	k^h
VOT mean values	0.048956	0.051381	0.053398	0.069343

The above given results of aspirated sounds are similar to unaspirated sounds as the velar /k^h/ has maximum VOT and the alveolar /t^h / has the minimum.

Table 4. 13 ANOVA for voiced stops

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.001012	3	0.000337	2.31314	0.08906	2.816466
Within Groups	0.006418	44	0.000146			
Total	0.00743	47				

As p-value, 0.08906 is greater than 1% and 5% level of significance, thus, it can be said that voiced stops are not different from one another at these level of significance. However, it shows difference for voiced stops at 10% level of significance as the p-value is less than 0.10. In addition to the statistical measurements, cue of VOT is further set out in terms of voicing and place features respectively in pictorial form in the following section:

VOT by Voicing feature of Hindko stops

In the preceding section, articulatory analysis of Hindko stops shows that Hindko has three ways of voicing, i.e. voiced, unaspirated and aspirated. Similarly, in this part of the study, the measurements of VOT mean values also present three ways of voicing for Hindko. Previous studies show (see Section, 2.5.1) that voiced sounds include negative VOT; unaspirated stops reveal little VOT and aspirated sounds denote maximum VOT. Likewise, Hindko voiced sounds /b/, /d̪/, /d/ and /g/ also show negative VOT; thus, they refer to as fully voiced sounds during the closure period (see Table, 4.10 & Figure, 4.1). Unaspirated segments /p/, /t̪/, /t/ and /k/ have positive yet less VOT (see Figure, 4.2) and aspirated phonemes, /pʰ/, /t̪ʰ/, /tʰ/ and /kʰ/ include the positive and maximum VOT among stops (see Table 4.10). The following figure presents the average VOT mean values of the voicing feature:

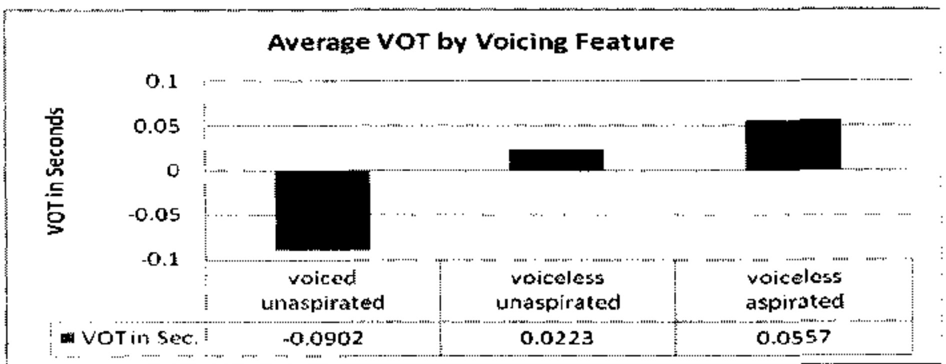


Figure 4. 4 The average VOT of stop sounds

The above figure 4.4 presents the average VOT mean values for each type of voicing. Voiced sounds show negative VOT -0.0902 (sec). Unaspirated segments have positive VOT 0.0223 (sec). The third type, aspirated sounds have also positive VOT 0.0557 (sec) which is longer than voiceless sounds. It can be concluded, therefore, that voiced sounds have negative VOT while voiceless stops include positive VOT.

VOT by places of articulation

Like voicing feature of stops, VOT mean values also differentiate the places of articulation of sounds as shown in the following figure:

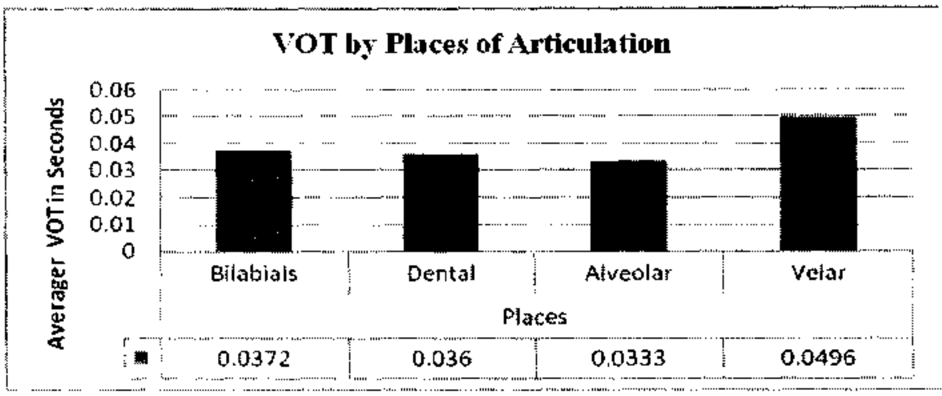


Figure 4. 5 The average VOT of Hindko stops by places of articulation

Figure 4.5 displays the average mean values of unaspirated and aspirated sounds. VOT of two types of voicing, unaspirated and aspirated, were measured for places because the third type of voicing, voiced have the negative VOT, thus, were excluded for places. It reveals the time ranging between 0.0333 (sec) to 0.0496 (sec). It implies that the back part of the oral cavity, the velar has maximum VOT and the intermediate places, the alveolar and the dental, have the minimum VOT respectively while the front part of bilabial shows more time than the alveolar and the dental but less than the velar. This difference of places is also determined by one way ANOVA test.

Table 4. 14 ANOVA for places of stops in terms of VOT

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.001879	3	0.000626	31.78809	4.34E-11	2.816466
Within Groups	0.000867	44	1.97E-05			
Total	0.002746	47				

ANOVA results in Table 4.14 show significant VOT differences for places of articulation as p-values are less than 0.01. Furthermore, LSD test applied on the pairs of places shows the following values:

LSD=0.003988

Places	Alveolar	Dental	Bilabial	Velar
Average VOT mean values	0.033283	0.036025	0.037273	0.049586

In addition to places of articulation and three ways of voicing in the above mentioned sections, VOT mean values are also drawn in the form of a graph to see differences within each stop.

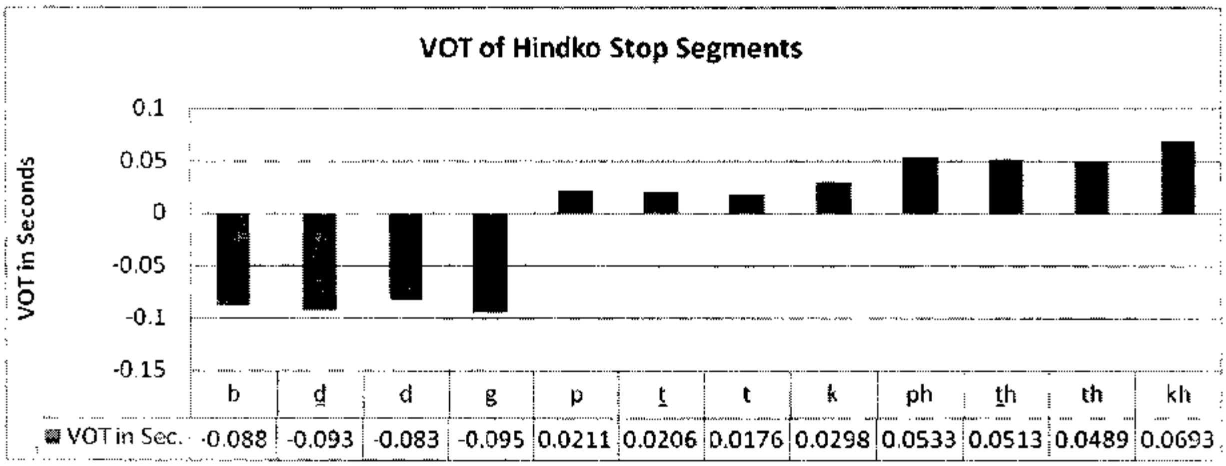
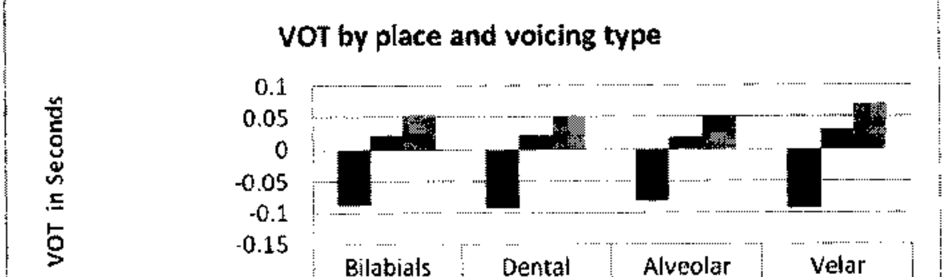


Figure 4. 6 VOT of each Hindko stop

Figure 4.6 shows differences among three ways of voicing. Left pairs of the figure, /b/, /d̪/, /d/ and /g/ have negative VOT. In this group, /g/ shows maximum VOT during the closure stage and /d/ has the minimum VOT. Thus, being negative VOT, ranging from -0.0835 (alveolar) to -0.0953 (velar), all voiced stops are fully voiced during the closure duration. Medial group of the figure, /p/, /t̪/, /t/ and /k/ have the positive VOT but they show the minimum VOT among the others. Like the /d/ sound, the /t/ sound also shows the minimum VOT and the velar /k/ has the maximum VOT. The time for the unaspirated stops, ranges from 0.0176 (sec) to 0.0298 (sec). The right group of the figure, i.e. the sounds /pʰ/, /t̪ʰ/, /tʰ/, /kʰ/, has also positive VOT. However, these aspirated stops have the maximum VOT as compared to their counterparts, i.e. unaspirated and voiced sounds, that ranges from /tʰ/ 0.0489 (sec) to /kʰ/ 0.0693 (sec). Like /g/ and /k/, segment /kʰ/ takes the maximum time whereas /tʰ/ takes the minimum time duration. In addition to the segmental differences, the VOT comparison according to the places of articulation and voicing features is given in the following figure:



	Bilabials	Dental	Alveolar	Velar
voiced unaspirated	-0.0885	-0.0934	-0.0835	-0.0953
voiceless unaspirated	0.0211	0.0206	0.0176	0.0298
voiceless aspirated	0.0533	0.0513	0.0489	0.0693

Figure 4.7 Average VOT of Hindko stops by places and voicing type

Figure 4.7 shows each type of stops in terms of places of articulation and voicing. It clearly depicts that the velar has the longest VOT in three ways of voicing. In contrast, the alveolar sounds take the shortest time during the articulation of the stops in three ways of voicing. Unlike voiceless sounds, all voiced sounds show the negative VOT. Overall, the velars are longer than the bilabials, the bilabials are longer than the dentals and the dentals are longer than the alveolars. Thus, Hindko stops follow this hierarchy: velar > bilabial > dental > alveolar.

4.2.7 Discussion on VOT of Hindko stops

The VOT measurement remains a quite successful acoustic parameter to differentiate Hindko stops such as voiced and voiceless sounds. It also indicates that the timing boundaries for four groups of Hindko stops according to place of articulation, including bilabial, dental, alveolar and velar.

Lisker and Abramson (1964) state that some languages have two ways of voicing while others have three ways of voicing. Languages such as English, Japanese, and Spanish have two ways of voicing whereas Punjabi, Pahari, Thai and Hindko allow three ways of voicing features. The results of VOT mean values of Hindko stops reveal that the unaspirated sounds have less positive VOT than the aspirated sounds, and the voiced sounds include the negative VOT. Thus, these results are similar to the previous studies that voiced sounds have negative VOT, unaspirated sounds carry less VOT and aspirated sounds take the maximum VOT (see Section, 2.5.1). Overall, Hindko allows the following patterns in voicing: aspirated > unaspirated > voiced.

Unlike negative VOT mean values for voiced sounds in many languages including Hindko, some languages like English allow positive VOT for voiced segments. Lisker and Abramson (1964) refer to VOT mean values of American English: /b/, /d/ and /g/ have 1ms, 5ms and 21ms respectively and unaspirated stops /p/, /t/, /k/ have 58ms, 70ms and 80ms. They refer to Thai language that shows VOT of voiced sounds, i.e. /b/, /d/ with -97 ms and -78ms and unaspirated sounds /p/, /t/, /k/ have 6ms, 9ms and 25ms respectively. Similarly, for Canadian English speakers, Macleod (2005) finds out the average VOT mean values for voiced /b/, /d/ 19.8ms and unaspirated stops; /p/, /t/ 87.9ms. As a result, both voiced and voiceless sounds have positive VOT. On the contrary, Spanish voiced sounds have negative VOT while VOTs of voiceless sounds are between zero to 10ms (Cho & Ladefoged, 1999).

Hindko aspirated VOT mean values range from 0.0489 to 0.0693 (sec) and these results are equivalent with the typical VOT values for aspirated plosives between 0.050 (sec) and 0.080 (sec) as given by Gussenhoven and Jackob (1998). Hindko unaspirated sounds also allow positive VOT ranges from 0.0176 to 0.0298 (sec) while voiced VOT refer to negative values ranging from -0.0835 to -0.0953 (sec). These results show that there is more VOT for Hindko unaspirated than voiced. This supports the views of Cho and Ladefoged (1999) and Hewlett and Beck (2006). They have stated that voiceless stops have more VOT than voiced. Moreover, VOT of aspirated velar stops in Navajo is more than 150 ms while in Scottish Gaelic same sounds have 75 ms (see Section, 2.5.1).

Hindko VOT measurements clearly differentiate each type of voicing and these findings are similar to some other languages like English and Thai. However, there are languages whose voicing types cannot be differentiated only by VOT such as Korean and Japanese (Kong, 2009). Each place group of Hindko stops have consistent results such as the velar voiced, unvoiced, and aspirated. They have longer VOT, all alveolar stops include shorter VOT, and the same pattern is found in the dental and the bilabial.

In addition to voicing feature, VOT measurement also differentiates places of stops articulation. The previous studies such as Lisker and Abramson (1964), Cho and Ladefoged (1999) and Ladefoged (2003) show that VOT of stops is increased as its goes further in the back part of the oral cavity, from the bilabial to the velar. Contrary to it, Mandarin language does not follow this general VOT pattern (see Section, 2.5.1).

Similarly, this cross-linguistic generalization is not employed in Hindko. Its bilabial sounds show more VOT than the dental and the alveolar but all places have less VOT than the velar. Hindko, therefore, allows the following hierarchy in stop places: velar > bilabial > dental > alveolar. In contrast to it, English follows this hierarchy: velar > alveolar > bilabial. For Pahari, a sister language of Hindko, Khan and Bukhari (2011) claims the following hierarchy: velar > bilabial > alveolar > dental. It can be concluded that Hindko, Pahari and Mandarin language also do not follow the general concept of the places of articulation, i.e. VOT of stops is increased from the bilabial to the velar.

The findings show that only one group of stop, i.e. the velar, carries the longest time for all types of voicing. These results of present study are similar to the previous studies in that the velar stops have the maximum VOT. The results show that there is not much difference among VOTs of the bilabial, the dental and the alveolar; rather, the graph gradually decreases from the bilabial to the alveolar with insignificant difference of timings (see Figure, 4.7).

4.2.8 Statistical measurements of Hindko oral stops in terms of closure duration

In addition to VOT, Hindko stops are measured in terms of closure duration. The following table shows mean values of closure duration of stops:

Table 4. 15 Closure duration values of Hindko stops (sec); Means, Std. Dev. & Co. Var.

Stops	Places	No. of Tokens	Means	Std. Dev.	Co.Var.
p	Bilabials	36	0.1078	0.0147	13.7426
b	Bilabials	36	0.0886	0.0094	10.6251
p^h	Bilabials	36	0.1061	0.0141	13.2416
t̪	Dental	36	0.109	0.0185	16.9618
d̪	Dental	36	0.0934	0.0134	14.3951
t̪^{h}	Dental	36	0.1036	0.0159	15.0505
t	Alveolar	36	0.102	0.0110	10.8482
d	Alveolar	36	0.0834	0.0101	12.1405
t^h	Alveolar	36	0.0902	0.0088	9.7347
k	Velar	36	0.1122	0.0105	9.3603

g	Velar	36	0.0952	0.0145	15.2567
k^h	Velar	36	0.0888	0.0109	12.3681

Table 4.15 reveals the mean values of closure duration of stops. The measurements show that Hindko unaspirated and aspirated sounds are longer than voiced sounds. Average closure duration values are further determined by ANOVA.

Table 4. 16 ANOVA for stop segments in term of closure duration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.009077	11	0.000825	4.360489	1.75E-05	1.86929
Within Groups	0.02271	120	0.000189			
Total	0.031787	131				

The ANOVA table 4.16 presents significant statistics as p-value is less than 0.01. This statistics is further measured by LSD test to find out similarity and difference within segmental groups.

LSD=0.012361

d	b	k^h	t^h	d̪	g	t	$t̪^h$	p^h	p	t̪	k
0.0834	0.0885	0.0888	0.0902	0.0934	0.0952	0.1019	0.1035	0.1061	0.1068	0.1090	0.1122

In addition to the tabulated description, average mean values are given in the following graph for more clear view and to see the relation within segments in terms of closure duration values.

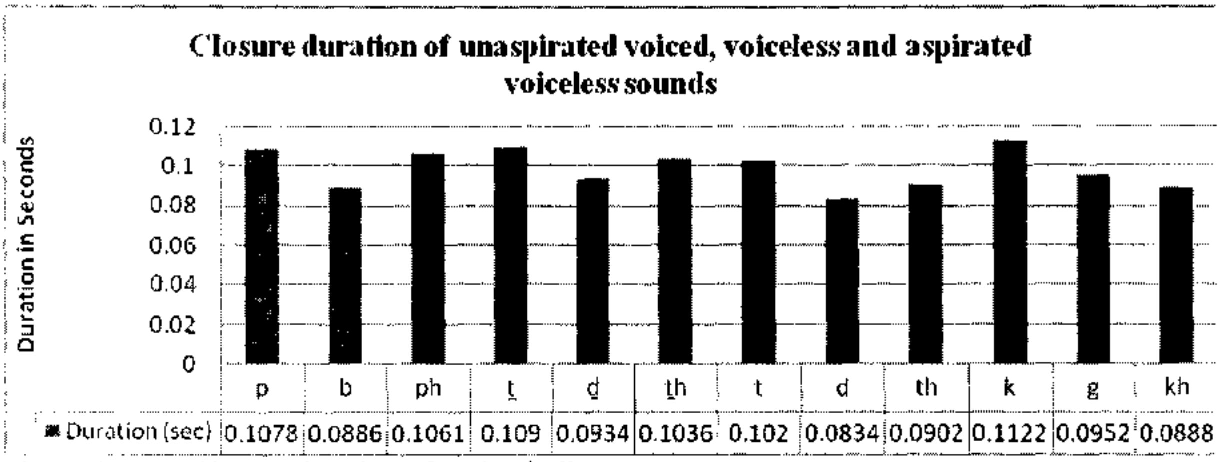


Figure 4. 8 Closure duration of each Hindko stop

Figure 4.8 shows average mean values of stops. The segments clearly indicate the difference among segments that voiced sound /b/, /d̪/, /d/ have less duration than aspirated sounds /p^h/, /$t̪^h$/,/t^h/ while /g/ has more duration than /k^h/ sound. On the other hand, unaspirated phonemes, /p/, /t̪/, /t/ and /k/ have maximum duration than those of the counterparts. Overall, unaspirated /k/ carries most durational time and /d/ has least closure duration among stop group.

Closure duration of Hindko stops in terms of voicing feature

The following figure shows average mean values of stops according to voicing:

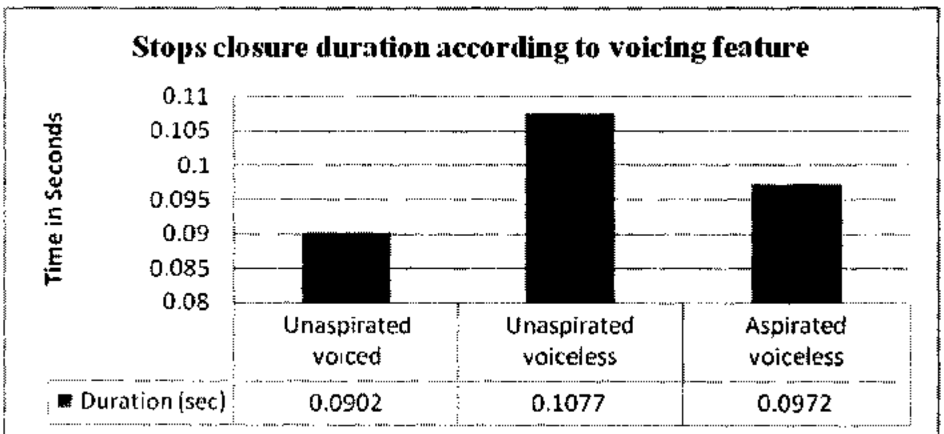


Figure 4. 9 Closure duration in terms of voicing

The above figure 4.9 shows the average values of voiced, unaspirated and aspirated sounds. Like the individual stops, the voicing average values also show maximum closure duration for unaspirated sounds and minimum duration for voiced sounds whereas aspirated sounds has medial duration. Therefore, like VOT, closure duration is also a helpful acoustic feature to distinguish the stops in terms of voicing. In addition to voicing type, this feature is also analyzed according to the places of articulation.

Table 4. 17 ANOVA for voicing feature in terms of closure duration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.00061	2	0.000305	7.226693	0.013433	4.256495
Within Groups	0.00038	9	4.22E-05			
Total	0.000989	11				

The above ANOVA table 4.17 reflects that voicing feature in terms of closure duration is not significant at 0.01% level of significance but it shows difference at 0.05% level of significance. Therefore, further analysis is required using LSD test to see which pairs are actually different.

LSD=0.010805

Voicing	Voiced	Aspirated	Unaspirated
Mean values	0.090181	0.097213	0.107536

The acoustic cue of closure duration help to identify not only voicing features in stops but also it provides a statistical platform about the places of articulation.

Closure duration of Hindko stops in terms of places

In addition to the segmental differnces and average values of voicing , ANOVA is employed also for the places of articulation in light ofclosure duration values.

Table 4. 18 ANOVA for places stops in terms of closure duration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.00072	3	0.00024	2.231632	0.097837	2.816466
Within Groups	0.004733	44	0.000108			
Total	0.005453	47				

As p-value 0.097837 is greater than 0.01% and 0.05% level of significance, so it can be concluded that places of articulation of Hindko stops in light of closure duration are not different from one another. However, ANOVA table presents difference for the places of stop sounds at 10% level of significance as the p-value is less than 0.10. In addition, LSD test is taken into account to find out which pairs are different.

LSD=0.00932

Places	Alveolar	Velar	Bilabial	Dental
Mean values	0.091896	0.098801	0.10053	0.102009

These values of places of articulation are further tabulated in the following graph:

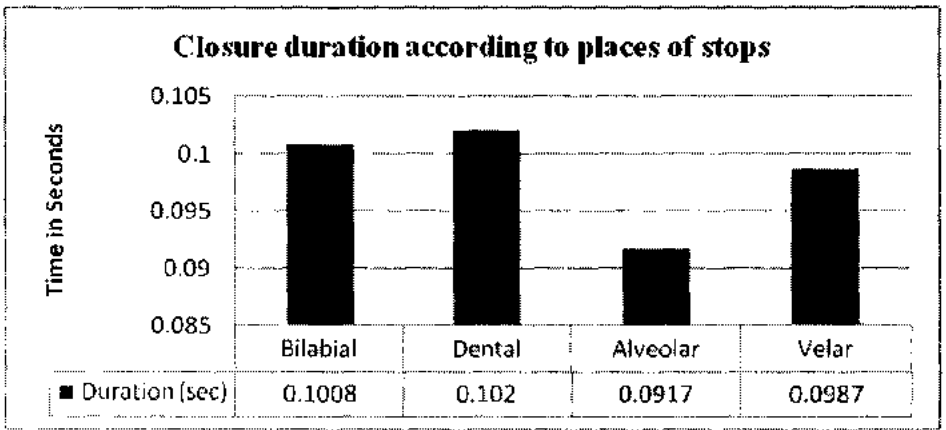
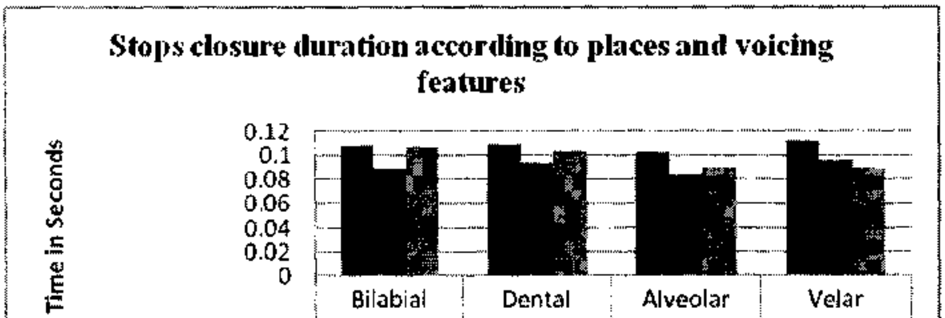


Figure 4. 10Hindko stops closure duration by places

Figure 4.10 reveals that Hindko dental sounds carry maximum time duration during the closure period. On the other hand, alveolar sounds show minimum closure duration. Similarly, Hindko VOT analysis also shows that alveolar takes least time. Although a small, yet there is difference that front bilabial has less duration than dental and velar has longer duration than alveolar. It implies that Hindko alveolar sounds are articulated in minimum time. Thus, Hindko stops are found in terms of closure duration as: dental > bilabial > velar > alveolar. The following chart shows the comparison of stops in terms of both types, i.e. places and voicing:



	Bilabial	Dental	Alveolar	Velar
Unaspirated voiceless	0.1078	0.109	0.102	0.1122
Unaspirated voiced	0.0886	0.0934	0.0834	0.0952
Aspirated voiceless	0.1061	0.1036	0.0902	0.0888

Figure 4.11 Hindko stops closure duration by places and voicing

The Figure 4.11 shows that unaspirated sounds have almost similar duration. However, velar unaspirated sound carries maximum duration while bilabial and dental unaspirated have almost comparable closure duration. Likewise, bilabial and dental aspirated sounds are also equivalent in duration and alvelar and velar aspirated sounds are almost in the same level. However, bilabial and alveolar voiced sounds have almost paralell duration. Similarly, dental and velar sounds have similar clousre duration. Overall, alveolar voiced sound carries minimum closur during the utterance.

4.2.9 Discussion on stops closure duration

Analysis of closure duration shows that unaspirated sounds take maximum and voiced sounds take minimum duration among stop sounds group (see Figure, 4.8). Similarly, according to voicing feature in terms of overall average mean values, unaspirated sounds has more duration than aspirated and voiced sounds (see Figure, 4.9). Likewise, Kingston and Diehl (1994) state that voiced obstruents are shorter than voiceless (see Section, 2.5.3).

Places in terms of closure duration show that front sounds take longer time than back sounds and alveolar has the leaset duration (see Figure, 4.1). These results are similar to VOT mean values (see Figure, 4.5). The findings reflect that like VOT, cue of closure duration of Hindko alveolar sounds carry minimum time and frequency among stop group. Overall, on the basis of the above results, if the comparison of stops in terms of VOT and closure duration time is taken into account, Hindko allows shorter VOT but longer closure duration for all sounds.

4.3 Hindko nasal stops

Phonemic inventory of Hindko on the basis of minimal pairs shows four nasal consonants (see Table, 4.1). Analysis of these sounds is taken into account in the following:

4.3.1 Articulatory phonetic analysis of Hindko nasal stops

Data in the following table shows the places of articulation of Hindko nasals and their voicing quality.

Table 4. 19 Contrast in places of nasal sounds (/m/, /n/, /ɳ/, /ŋ/)

Position of sounds	Bilabial voiced	Gloss	Alveolar voiced	Gloss	Retroflex voiced	Gloss	Velar voiced	Gloss
Initial	makk	Me	nakk	Nose	N/A		N/A	
Medial	kãmmi:	Lapses	kãnni:	Separate	kãɳɽi:	Drops	kãŋgi:	Combs
Final	kãmm	Task	kãnn	Ear	kãɳɳ	Dripping	kãŋg	Annoyance

Table 4.19 shows that each nasal phoneme makes freely contrast in places with other phonemes. Sound /m/ is produced with the involvement of lips at bilabial position and /n/ is

uttered while tongue tip touches the alveolar ridge. Sound /ɳ/ is articulated with curled tongue tip at retroflex position while during the utterance of /ŋ/, back of the tongue connects to the velum position at velar place. In addition, during the utterance of each nasal sound, velum remains lowered and air goes out through the nasal cavity. Like most of the world languages, Hindko nasal stops are also voiced. Each word has different lexical items and differs from others only by one sound. Two segments /m/ and /n/ can contrast with each other word initially but other two phonemes /ɳ/ and /ŋ/ cannot make contrast with the preceding two segments. Therefore, Hindko allows the contrastive distribution through commutation test within the nasal stops word medially and finally and /m/ and /n/ also allow word initially. Moreover, like places contrasts, nasal sounds are also examined in terms of distribution.

Table 4. 20 Distribution of Hindko nasal sounds

Sounds	Initial	Gloss	Medial	Gloss	Final	Gloss
/m/	moɽɽ	Turn	kãmʧĩ:	Small stick	kãmm	Work
/n/	næ:ɽa:	Near	kãnni:	Separate	ʧãnn	Moon
/ŋ/	NA		bã:ŋgi:	Big cock	bã:ŋ	Prayer call
/ɳ/	NA		t̪ã:ɳã:	Straight	mã:ɳ	Pride

Table 4.20 reflects distributional occurrences of nasal consonants. In Hindko, segments bilabial /m/ and alveolar /n/ can be found word initially, medially and finally. On the contrary, two nasal segments, retroflex /ɳ/ and velar /ŋ/ can be found word medially and finally but not word initially.

4.3.2 Discussion on articulatory analysis of Hindko nasal stops

Hindko allows four nasal segments articulated somewhat at different places from oral stops (see Table, 4.2). English has three nasal stops and have the same places of articulation like English plosives. Hindko nasals /m/ and /n/ can occur word initially, medially and finally while /ɳ/ and /ŋ/ are found at word medial and final positions. In addition, these two nasal segments /ɳ/ and /ŋ/ are the most commonly used sounds of Tanoli dialect, e.g. /pã:ɳ/ 'balanced level of iron', /nã:ɳ/, 'do not bring', /ã:ɳ/, 'bring', /mã:ŋ/, 'fiancée', /dũ:ŋga:/, 'deep', /bĩŋga:/, 'bended' etc.

Like Urdu and English, Hindko /m/, /n/ can occur at three possible positions of the words while the occurrence of /ŋ/ is possible word medially and finally (see Table, 4. 20). However, some languages like Vietnamese and Burmese allow /ŋ/ sound word initially as well (Davenport and Hannahs, 2010).

Moreover, Hussain (n.d) states that in Urdu, /^{h}/ sound is followed by nasals, such as /m^h/, /n^h/ and /ŋ^h/. Saleem et al. (2002) (cited in Hussain, n.d) state the existence of these nasal sounds is still not determined, are not considered any further (p.2). Likewise, Hindko also allows combination of two nasals, /m/ and /n/ with /^{h}/ in words like /m^{h}æ:ɽ/ 'drain' and /n^{h}æ:r/ 'bad event'. However, like Hindko stops (see Section, 4.2.2), nasals /m/ and /n/ in form of /m^h/ and /n^h/ occur only word initially. Awan's (2004) work lacks these nasals as a separate phoneme whereas the case of these two sounds /m^h/ and /n^h/ in Tanoli dialect is similar to stops /p̌/, /ʈ̌/, /ť/ and /ǩ/ for Peshawar Hindko (see Section, 4.2.2). It may be that Peshawar Hindko lacks these features in nasal consonants. On the other hand, Karnahi (2007) identifies that /m^h/ and /n^h/ are phonemes in Pahari. As mentioned earlier about stops (see Section, 4.2.2), this phenomenon of /m^h/ and /n^h/ needs to be investigated whether these are separate phonemes or have tonal effect. Thus, in addition to the suggested experimental study for stops, nasals /m/ and /n/ may also be included to find out their actual position. Awan (2004) states that /n/ is a dental sound and there are three nasal consonants in Peshawari Hindko whereas the present study shows that /n/ is an alveolar sound and overall there are four nasals in Tanoli Hindko.

4.3.3 Acoustic analysis of Hindko nasal stops

In addition to the articulatory phonetics, the acoustic study is a good tool for identification of nasal consonants because on auditory basis, sometime, it is hard to hear the nasal consonants. In the following section, first, Hindko nasals are investigated qualitatively through spectrographic analysis. Secondly, the quantitative analysis is carried out through statistical measurements of the first three formants of nasal sounds and neighbouring segments as well.

4.3.4 Spectrographic analysis of Hindko nasal stops

Unlike other consonants, nasal consonants carry the acoustic cue of base line at around 200 Hz. The following figure shows the nasal stops of Hindko:

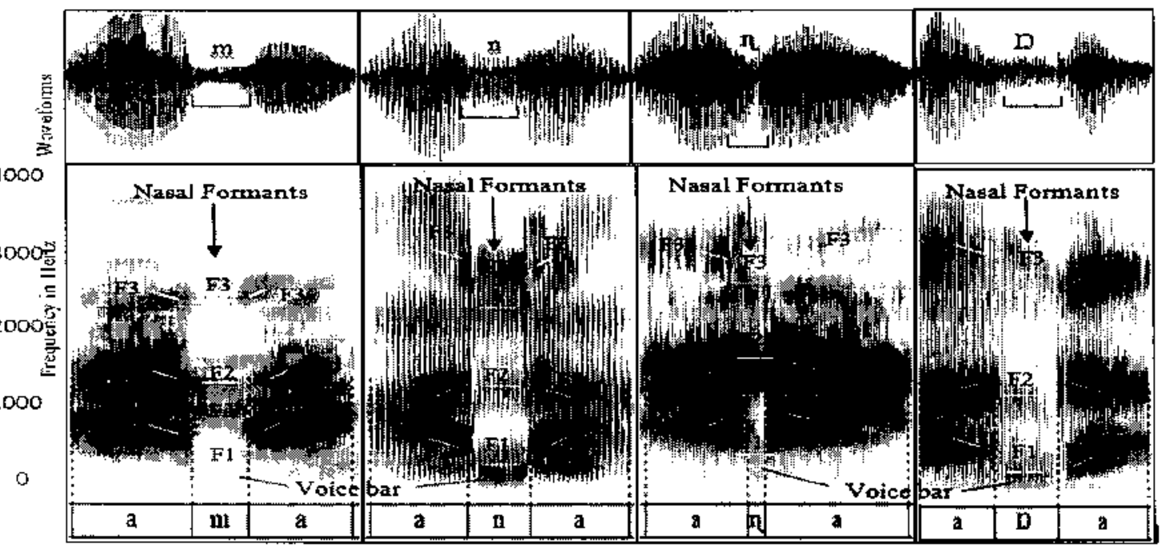


Figure 4. 12 Waveforms and spectrograms of Hindko nasal consonants

The spectrogram of /m/ displays the nasal formant in the baseline having lower and less energy than the preceding and following vowels. Medial part of the utterance /ama/

clearly indicates the weaker striation and remains fainter than neighbouring segments. Unlike other nasal segments, upper region of spectrogram, above 3000 Hz, has no resonances. The nasal formants occur at lower position than neighbouring formants. Formant transitions of bilabial nasal show falling of F1, F2 and F3 at offset position and rising at onset position. Therefore, in CV sequence, all three formants show minus transition and locus of F2 is found in the region of around 1200 Hz. The waveform indicates much constriction at the consonantal portion of utterance that refers to its voiced sound feature.

Like bilabial /m/, alveolar /n/ sound shows similar tendency of extra energy at the very lower level. Sound /n/ has less striation during closure gap and in the upper part of the spectrogram. Thus, like other nasals, consonantal part of /n/ is also quiet faint. Place cue, formant transitions of F1 and F3 of alveolar sound decrease at the end of preceding vowel and increase at the beginning of following vowel. On the contrary, F2 of preceding vowel rises before the nasal formants whereas it falls after that. In addition, F1 and F2 of the preceding vowel are very near to each other in the range of 1000 Hertz and while there is a significant gap between F2 and F3. Unlike bilabial nasals, /n/ F2 has little difference than neighbouring segments formants rather have higher frequency. Furthermore, /m/ gets more duration and energy than nasal /n/ sound. The pitch of /m/ sound rises throughout the articulation while for /n/ sound it remains consistent but lower than /m/.

Unlike other nasal consonants, during the spectrgraphic analysis of /ɳ/ sound, the difficulties encountered whether it is a vowel or a consonant due to its higher sonorous characteristics and energetic resonances. However, some differences have been observed in the upper part of the spectrograms. That in the region of 2000 Hz, there is less energy when tongue curls back and touches the hard palate, therefore, makes the closure of the air.

Moreover, like other consonants, /ɳ/ sound also shows duration but too short. Nevertheless, in some of the utterances, closure duration was not observable. Overall, F2 is the most resonating formants of /ɳ/ sound and among nasal consonants. Close analysis of formant transitions shows that F1 and F2 rise while F3 falls at the offset position of preceding vowel. On the other hand, at the onset of following vowel, F1 and F2 are in level or rising position whereas F3 rises. Therefore, F1, F2 and F3 have minus transition in CV sequence. Furthermore, locus of retroflex nasal sound shows in the region of about 1700 Hz. The intensity line of /ɳ/ sound gets slight down at the medial part unlike other nasals.

Likewise, Figure 4.12 depicts velar /ŋ/ sound of Hindko. Unlike its counterparts, it shows a weak burst, a vertical spike, between 1000 and 3000 Hertz like a dashed line. During the total duration of the nasal /ŋ/, towards the end of the nasal sound, it's almost 30% part remain fainter. Unlike other nasal consonants, this gap before the following vowel, specifically above 800 Hz, is found typically in all of /ŋ/ spectrograms. However, at the bottom of spectrogram, in the region of F1, and between the level of 2500 Hz and 3000 Hz frequency, there is much resonating energy in the area of F3. Overall, F3 of /ŋ/ has prominent resonances than other velar nasal formants. Additionally, in some of the velar utterances, nasal F3 is disconnected at the offset of preceding vowel. Moreover, waveform noticeably presents the much striation at the utterance of nasal sound which is the reflection of its voiced sound.

Formant transitions of velar /ŋ/ show that F1and F3 of the preceding vowel moves downward while at the onset position of following vowel, these formants moves upward. Similarly, F2 at the offset of preceding vowel shows level or rising whereas it falls before the steady state of the vowel utterance. Thus, in CV sequence, velar nasal /ŋ/ has minus transition for F1 and F3 whereas F2 has plus transition. Moreover, the locus point of F2 is found in the region of around 1250 Hz.

In the summary of the nasal spectrographic analysis, each spectrogram illustrates particular nasal formants having less energy at lower level to the preceding and the following vowels and the less amplitude as well. The typical pattern of nasal consonants is that F2 entails fainter position than other formants. On the other hand, Hindko nasals spectra display that F2 has similar energy to F1 and F3.

4.3.5 Statistical measurement of Hindko nasal stops

Hindko nasals were statistically measured to see nasals formant frequencies and average formant values of their neighbouring segments. This investigation highlighted formants differences between vowels and nasal consonants. It also distinguished frequency difference within nasal sounds as well.

Table 4. 21 Formants values of Hindko nasal stops (Hz) ; Means, Std. Dev. & Co. Var.

Nasal	Tokens	F1	Std.Dev	Co.Var.	F2	Std. Dev.	Co.Var.	F3	Std. Dev.	Co.Var.
m	36	350	33.339	9.504	1199	95.746	7.979	2502	0.0140	13.241
n	36	407	46.378	11.371	1460	115.291	7.896	2599	0.0155	15.05
ɳ	36	618	77.751	12.580	1443	123.903	8.586	2544	0.0087	9.734
ŋ	36	489	84.882	17.340	1322	100.889	7.631	2601	0.0109	12.368

The above table 4.21 depicts nasal consonant formants; F1, F2 and F3 average mean values, with standard deviation and coefficient of variation. These values are further confirmed by ANOVA in the following:

Table 4. 22 ANOVA for nasal consonants in terms of F1

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	447095.1	3	149031.7	33.62881	5.09E-11	2.838745
Within Groups	177266.7	40	4431.667			
Total	624361.8	43				

The above ANOVA table 4.22 shows significant difference of F1 among four nasal consonants as the p-value is less than 0.01. Thus, further analysis is carried out by using LSD test to examine the nasal consonantal differences within pairs.

LSD=59.09

Segments	m	n	ŋ	ɳ
Means of F1	350.7778	407.8333	489.5	618.0493

Table 4. 23 ANOVA for nasal consonants in terms of F2

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	437288.2	3	145762.8	12.17016	8.47E-06	2.838745
Within Groups	479082.5	40	11977.06			
Total	916370.8	43				

ANOVA Table 4.23 depicts the mean values of F2 with significant difference as the p-value is less than 0.01. LSD is employed in the following to see which pairs are actually different.

LSD=98.3376

Segments	m	ŋ	ɳ	n
Means of F2	1199.917	1322.028	1442.972	1460.111

Table 4. 24 ANOVA for nasal consonants in terms of F3

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	483955.2	3	161318.4	39.07729	1.81E-12	2.816466
Within Groups	181640.3	44	4128.188			
Total	665595.4	47				

The above table 4.24 reveals ANOVA results that nasal consonants in terms of F3 are significantly different as p-value is less than 0.01. Further, LSD test is applied to investigate which nasal consonantal pairs are dissimilar.

LSD=57.733

Segments	m	ɳ	n	ŋ
Mean values of F3	2502.417	2544.361	2598.972	2600.778

Statistically identified mean values of nasal consonantal formants are further described in form of charts in the following:

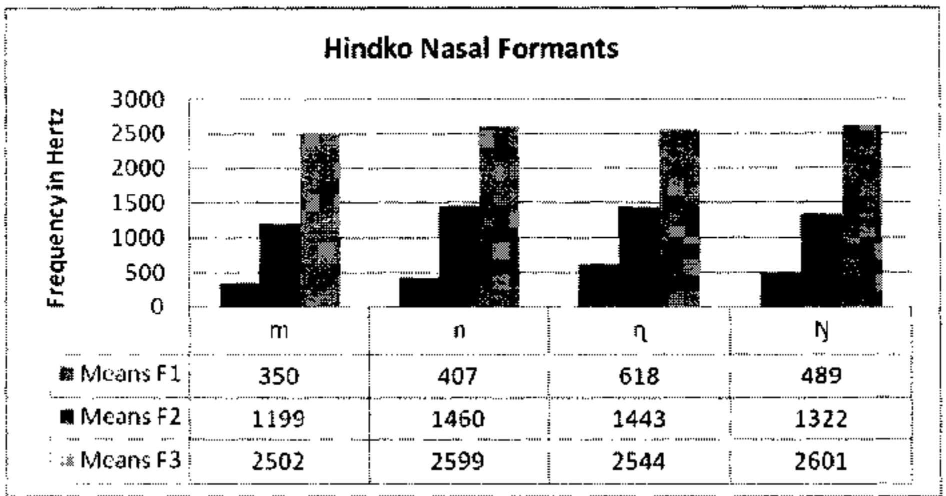


Figure 4. 13 F1, F2 and F3 means values of nasal consonants

The Figure 4.13 shows variations in the mean frequencies values that F1 values, the formant of the height of tongue in the articulation, gradually increase from bilabial to retroflex but again show decrease at velar place. F2, i.e. the formant of tongue position, has maximum value for alveolar and minimum frequency for bilabial. Front nasal has the lowest F3 mean values whereas back nasal has the highest frequency. Therefore, it implies that front nasal /m/ has less frequency values than back nasal consonants. Moreover, alveolar F2 is at the highest position but the lowest for bilabial. Similarly, F2 of nasal retroflex has measurably higher frequency than velar sound. The result of nasal F2 shows that the position of tongue during the utterance of nasal alveolar consonants remains higher than retroflex, and velar has higher position than bilabial. However, unlike these findings, Ladefoged (2003) states that major function of F2 in the nasal consonants correspond to a resonance of the air behind the closure, frequencies increases as the closure move back and the size of the body of the air decreases that tongue moves back for the back sounds. In case of F3, velar and alveolar values are almost similar while retroflex and bilabial have less frequency respectively.

In addition to the individual formant, average formants mean values are also given in the following chart:

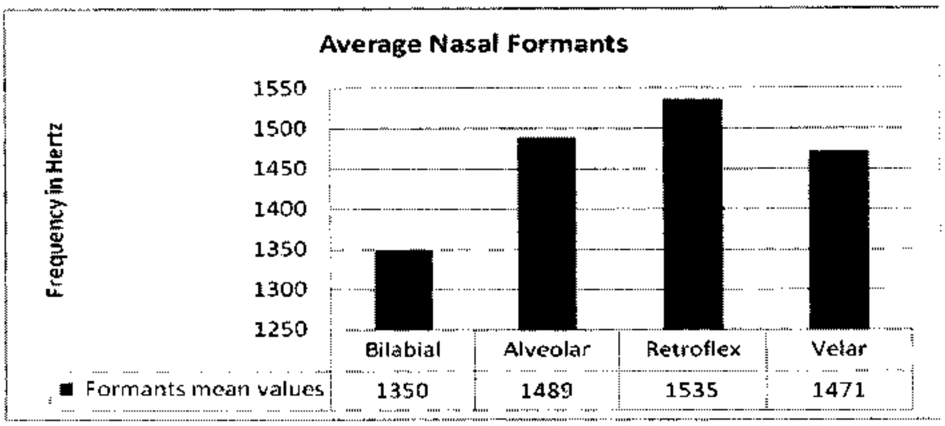


Figure 4. 14 Average mean values of nasal formants by places

The above figure 4.14 presents minimum aveargae means values for bilabial and maximum for retroflex nasals sound. Thus, there is symmetry in rising formant frequencies from front of the oral cavity till the back retroflex place of articulation. However, there is again decrease in the further back nasal sound, i.e. velar place formants show less frequency mean values than alveolar and retroflex respectively.

In addition to nasal formants, the mean formant frequencies of the preceding and following vowels were measured to see formants position at the disyllables. The following table and chart illustrates formants measurement of preceding vowels to nasal consonants.

Table 4. 25 Preceding vowel values of Hindko nasals (Hz); Means, Std. Dev. & Co. Var.

Nasals	Tokens	F1	Co.Var.	Std.Dev.	F2	Co.Var.	Std.Dev	F3	Co.Var.	Std. Dev
m	36	844	79.174	9.386	1299	139.704	10.757	2461	285.964	11.618
n	36	854	122.614	14.362	1333	147.645	11.073	2377	245.192	10.316
ɳ	36	855	85.981	10.052	1326	134.442	10.139	2496	264.208	10.583
ŋ	36	822	74.926	9.1097	1318	125.874	9.551	2417	281.156	11.632

Table 4.25 depicts measurements of preceding vowels to nasal consonants. The results shows frequency average mean values of three formants with standard deviation and coefficient variation. In addition to individual vowels frequency values, nasals and preceding vowels formants were compared in the following chart to see the differences in their frequencies.

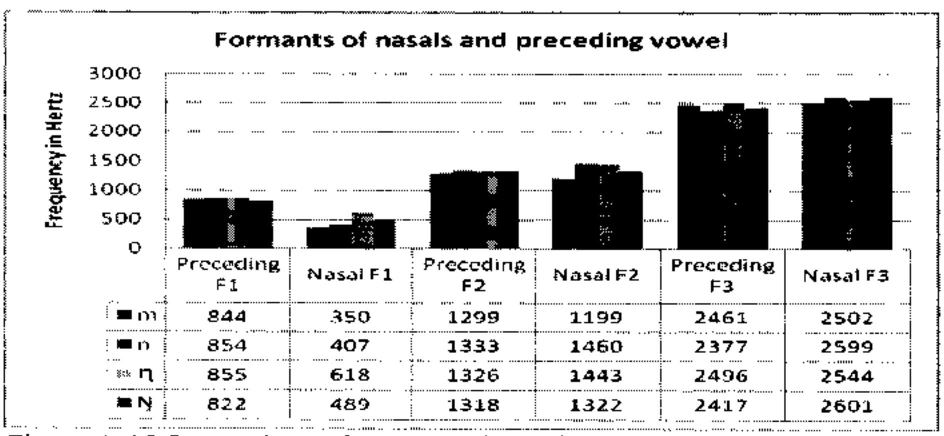


Figure 4. 15 Comparison of F1, F2 and F3 of nasals and preceding vowels

Figure 4.15 presents a significant difference between the frequencies of F1. All nasal formants have lower frequency value than preceding vowel. Similarly, second formant of bilabial nasal is lower than preceding vowel formants as well. On the other hand, other all nasal formants have higher frequency values than preceding vowel. However, velar F2 shows minor difference between preceding vowel and nasal formant while velar F3 has significant mean value difference. Furthermore, nasal formants are compared with the following vowel:

Table 4. 26 Following vowels values of Hindko nasals (Hz); Means, Std. Dev. & Co. Var.

Nasals	Tokens	F1	Std.Dev.	Co.var.	F2	Std.Dev.	Co.var.	F3	Std.Dev.	Co.var.
m	36	808	103.938	12.864	1251	133.678	10.689	2397	193.726	8.088
n	36	807	113.641	14.074	1376	151.005	10.970	2329	266.854	11.459
ɳ	36	820	95.990	12.938	1392	157.169	11.218	2232	191.463	7.799
ŋ	36	742	118.865	14.499	1401	166.923	11.987	2455	258.72	11.592

Table 4.26 reflects the results of following vowel formants with standard deviation and coefficient variation. The formants of nasals and following vowels are compared in the following chart to see the difference in terms of consonants and vowels.

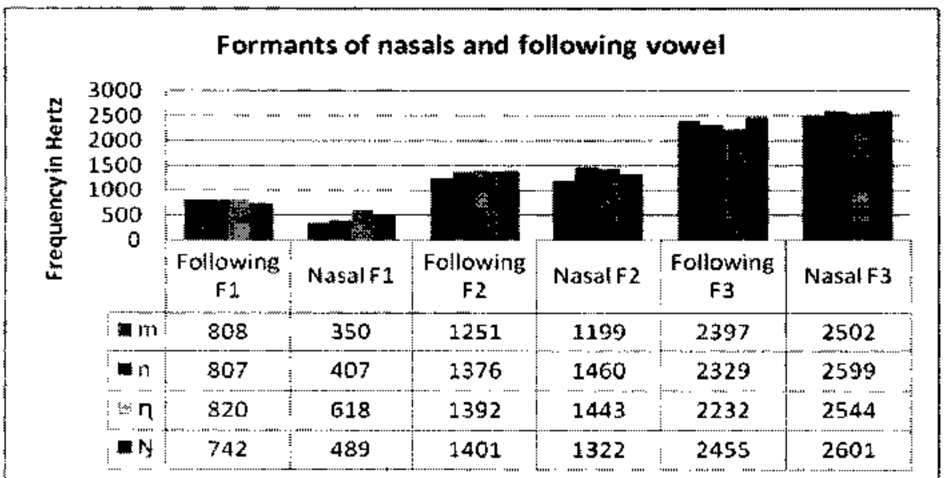
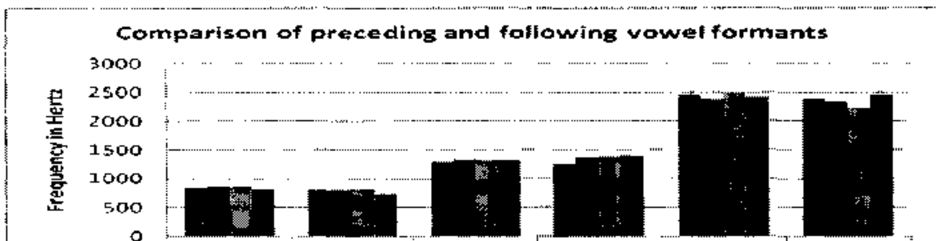


Figure 4. 16 Comparison of F1, F2 and F3 of nasals and following vowels

The above figure 4.16 shows comparison of nasal formants and following vowel formants. Like previous graph, the results of this figure are also evident with a great difference of F1 mean values. That following vowel has higher frequency than nasal formants. Nasal F2 of bilabial and velar are shorter than following vowel while in case of alveolar and retroflex sounds, figure 4.16 shows the mirror image. There is a substantial difference of F3 mean values that all nasals consonants have higher average frequency than following vowel. In addition, the average mean values of both preceding and following vowels are compared in the following chart:



	Preceding F1	Following F1	Preceding F2	Following F2	Preceding F3	Following F3
m	844	808	1299	1251	2461	2397
n	854	807	1333	1376	2377	2329
ɳ	855	820	1326	1392	2496	2232
Ŋ	822	742	1318	1401	2417	2455

Figure 4. 17 Comparison of F1, F2 and F3 of preceding and following vowels

Figure 4.17 shows F1and F3 average mean values of preceding vowels to nasals are higher than following vowels except F3 of /ŋ/ sound. Likewise, bilabial F2 of preceding vowel has more frequency than following vowel whereas following vowels of alveolar, retroflex and velar sounds have higher average mean values than preceding vowels.

4.3.6 Discussion on acoustic analysis of Hindko nasal stops

Related literature of nasal consonants, generally, shows that nasal sounds are easily analyzed acoustically. However, during the acoustic analysis of present study, the intense care was employed because in most of the spectrograms, nasal formants were not visible, specifically in velar sound. Thus, to find out the accurate location of these formants, nasal sounds are measured thrice to see the most common trends.

Like many other languages, Hindko bilabial /m/ sound has lower nasal formants than adjoining vowels. Similarly, bilabial formants values and locus are also lower than that of other nasal consonants. These findings are similar to the traditional notion that bilabial sound has low locus and front nasal formants have lower values than back nasals formants (Ladefoged, 2003). Analysis shows that F2 of bilabial has visible frequency like F1 and F3 resonances. Contrary to it, Yavas (2006) states that nasal F2 remains invisible on spectrograms. Moreover, Hindko nasal bilabial frequency mean value is almost similar to mean values given by Davenport and Hannahs (2010) (see Table, 4.4 & Section, 2.5.2).

Like the general formant transitions trend and Hindko bilabial plosives, nasal /m/ of the dialect has similar transitions pattern, i.e. the preceding vowel formants fall at the offset position while rises at the onset of the following vowel. Similarly, in case of Hindko alveolar /n/, the nasal formants have less striation than the neighbouring vowels. This occurrence is similar to the idea of Ladefoged (2003) (see Section, 2.5.2). Unlike the bilabial /m/, F1 and F3 of the alveolar /n/ have more energy than F2 which is similar to English /n/ sound (see Section, 2.5.2). Similarly, average measurement frequencies of F2 and F3 of Hindko nasals are also similar to general nasal formant frequencies, i.e. nasal formant F2 has 1500 Hz and F3 shows 2400 Hz (see Section, 2.5.2).

However, F1 of Hindko alveolar sound has somehow higher frequency than the frequency stated by Ladefoged and Davenport and Hannahs (see Section, 2.5.2). On the other hand, F1 mean values of adjacent vowels are similar to the general concept that F1 of the neighbouring nasals' vowels contain higher values than nasals F1. Contrary to it, the alveolar

F2 and F3 have higher frequencies than the neighbouring segment formants. Thus, these findings of Hindko nasal alveolar contradict to the theory of Ladefoged (2003) that nasal consonants have lower amplitude than vowel.

Moreover, Hindko alveolar has more closure gap than bilabial, i.e. back /n/ formants have higher frequency than front /m/ formants (see Figure, 4.13). In addition, findings of formant transitions of Hindko alveolar nasal are similar to Hayward's (2000) theory that F1 and F3 fall in VC sequence and F2 rises while in VC sequence it has mirror image (see Section, 2.5.2). These formant transitions are similar to Hindko alveolar stops as well. Likewise, Ladefoged (2003) also states that nasal formant transitions are similar to stops. Additionally, formant transitions of bilabial and alveolar are evident to differentiate between /m/ and /n/ sounds.

Furthermore, spectrographic analysis shows that Hindko retroflex /ɳ/ is the most sonorous sound among nasals. Unlike the general tendency of nasal sounds, its nasal formants are quite visible on a spectrogram. However, above 3300 Hz there is no energy throughout the utterance which differ it from other nasals. Furthermore, its formants average means values, i.e. F2 (1326 Hz) and F3 (2544 Hz) are almost similar to general nasal formants values stated by Ladefoged (2003) and Davenport and Hannahs (2010) (see Section, 2.5.2).

Nevertheless, /ɳ/ sound has the highest F1 mean value which is significantly different from general pattern. It implies that the height of tongue in Hindko retroflex sound remains higher than other nasals. Moreover, F2 and F3 frequency means values of Hindko retroflex /ɳ/ contradict to the values of English and traditional notion as well that back nasal frequency increases due to the decrease of air (see Section, 2.5.2). In consequence, Hindko front nasal alveolar has more value than back nasal retroflex.

Contrary to the views of Yavas (2006), F2 of Hindko retroflex /ɳ/ sound is more visible than F1 and F3. Retroflex formant transitions show rising of F1 and F2 at initial and final position of /ɳ/ while falling and rising of F3 respectively. Similarly, Ladefoged (2003) displays spectrogram of /ɳ/ sound of Malayalam language with rise of F2 and F3 at both positions (p.163). Thus, F3 of Malayalam differs from Hindko F3 at offset position of preceding vowel. However, it may be due to the fact that spectrographic analysis was carried out for Malayalam word /kʌɳɳi/ 'link in chain' that intervocalic nasal /ɳ/ was followed by /i/ while in case of Hindko /ɳ/ was followed by /a/. Furthermore, for the occurrence of intervocalic nasals formants, Yavas (2006) states that they have discontinuity with adjacent sound. On the contrary, Hindko retroflex /ɳ/ sound on spectrograms show continuity which is may be the result of its little closure duration.

The findings of Hindko nasal velar /ŋ/ show gap between nasal and vowel which are similar to the view of Yavas (2006) (see Section, 2.5.2). Additionally, contrary to other nasal sounds, velar nasal formants have less resonating energy. Its F2 fainter position is similar to English velar sound (see Section, 2.5.2). Overall, its nasal formants were not observable in most of the spectrograms.

In addition, F1 and F2 frequencies means values of /ŋ/ sound show more decrease than retroflex but F3 go at highest position among nasals. Thus, like retroflex sound, these results also contradict to traditional notion about increasing frequencies in the back nasals. Nevertheless, velar F3 carries maximum frequency. By and large, its formants values are not much different from the general nasal formants values.

Similarly, Hindko nasal velar formant transitions are similar to the previous literature that F1, F3 show fall and rise while F2 displays rise and fall of transitional slop. However, unlike the views of Hayward (2000) and Ladefoged (2003), there is a substantial gap between F2 and F3 frequencies. Similar results have also been found during the analysis of Hindko stops. Like alveolar and velar stops, alveolar and velar nasals in Tanoli Hindko have also similar formant transitions. However, some specific properties differentiate between both places. Like, alveolar F1 and F2 are very close to each other at both positions while velar formants F1 and F2 have gap at offset and onset positions. Furthermore, velar preceding vowel formants are almost in level and its F3 occurs at higher frequency in level, without slop towards F2 at offset position, while alveolar has mirror image.

4.4 Chapter summary

This chapter has investigated consonantal phonemes of Hindko. Findings of the analysis show that Hindko has 31 consonants including 12 oral stops, 4 nasal stops, 8 fricatives, 3 affricates and 4 approximants.

The results of the articulatory analysis have shown that oral stops allow three types of sounds in Hindko including 4 unaspirated, 4 voiced and 4 aspirated sounds. Oral stops are articulated at bilabial, dental, alveolar and velar positions and can occur at three positions of a word. All nasal stops are voiced and have no counterparts. These are articulated at four places of articulation such as bilabial, alveolar, retroflex and velar.

The qualitative and quantitative analyses in acoustic phonetics have shown that acoustic cues of oral stops and nasal consonants differentiate among the classes of sounds such as closure duration of stops, VOT and burst feature. The cue of voice bar or pitch contour also remained a quite successful parameter to differentiate between voiceless and voiced sounds. Acoustic properties of 4 nasal consonants show extra resonances but weaker than vowels. Similarly, acoustic cue of formant transitions of neighbouring segments indicate the place of each segment. However, the researcher recommends that places of articulation of Hindko consonants should be identified through palatography[10].

The following chapter deals with the analysis of fricatives, affricates and approximants.

[10] Palatography is a nineteenth century technique that has now been developed so that it is capable of providing a great deal of information on tongue gestures (Ladefoged, 2003, p.36).

CHAPTER 5

ANALYSIS OF HINDKO FRICATVIES, AFFRICATES AND APPROXIMANTS

This chapter shows articulatory analysis of Hindko fricatives, affricates and approximants in terms of places of articulation, distribution of occurrences, and voicing features. It also elaborates the acoustic analysis of these segments qualitatively and quantitatively in terms of spectrograms and statistical measurements respectively. Each section is followed by discussion with specific reference to English and some other languages to find out the similarities and differences among languages. Finally, it also shows the distinctive features of all Hindko consonants.

5.1 Hindko fricatives

In the preceding chapter, it has been identified that Hindko has eight fricatives including /f/, /v/, /s/, /z/, /ʃ/, /x/, /ɣ/, /ɦ/ (see Tables, 4.1 & 4. 2). Analysis of these segments is carried out in the following section:

5.1.1 Articulatory phonetic analysis of Hindko fricatives

In the following table, examples are given to identify places of Hindko fricatives:

Table 5. 1 Contrast in places of Hindko fricative sounds

Labio-dental Words	Gloss	Alveolar Words	Gloss	Palatal Word	Gloss	Velar Words	Gloss	Glottal	Gloss
/f/- fæ:l	Fail	/s/- sæ:l	Visit	/ʃ/- ʃall	Crumble	/x/- xæ:l	Care	i/- ɦæ:l	Habitual
/v/-va:r	Number	/z/- za:r	Curse	N/A	-	/ɣ/- ɣar	Cave	N/A	-

Table 5.1 shows data of fricatives articulated at five different places. Hindko labio-dental /f/ and /v/ are uttered with the movement of lower lip toward upper front teeth. Alveolar sounds /s/ and /z/ are articulated by creating a narrow passage between tip of the tongue and alveolar ridge. Palatal /ʃ/ is produced by raising tongue blade towards back palatal area of hard palate. Velar /x/ and /ɣ/ are articulated by lifting tongue blade toward velar part of mouth and /ɦ/ is uttered from glottal part of mouth. Labiodentals, alveolar and velar fricatives allow pairs but palatal and glottal fricatives stand alone in Tanoli dialect.

Like Hindko plosives, fricatives have also voicing feature. However, unlike plosives, all Hindko fricatives have no pairs. Segments, which have pairs, are illustrated in the following section to differentiate between voiced or voiceless fricatives. Each pair is described at different distributional positions to identify voicing feature.

Table 5. 2 Contrast in voicing of fricative labio-dental sounds (/f/, /v/)

Position of sounds	Labio-dental voiceless	Gloss	Labio-dental voiced	Gloss
Initial	fatt	Instant	vatt	Pick
Medial	sa:fa:	Handkerchief	sa:va:	Green
Final	N/A	-	N/A	-

Table 5.2 shows examples of two Hindko labio-dental fricatives /f/ and /v/. Both are in voicing contrastive position with different lexical items. In the articulation of phoneme /f/, vocal folds do not vibrate which reflects that it is a voiceless sound. On the contrary, during the utterance of /v/, the air goes out with the vibration of vocal folds and voiced sound is articulated. Furthermore, in pairs of voicing, both sounds can be found word initially and

medially but not finally. Thus, it can be said that /f/ is a voiceless and /v/ is a voiced sound in Hindko.

Table 5. 3 Contrast in voicing of alveolar fricative sounds (/s/, /z/)

Position of sounds	Alveolar voiceless	Gloss	Alveolar voiced	Gloss
Initial	sa:r	Wooden beam	za:r	Curse
Medial	bassa:r	Forget	bazza:r	Bazar
Final	ra:s	Fine	ra:z	Secret

Table 5.3 displays pair of /s/ and /z/ contrastively. Unlike labio-dental segments, data of alveolar fricatives shows that both /s/ and /z/ can make voicing contrast word initially, medially and finally. Moreover, /s/ is produced with the opened glottis whereas /z/ is uttered with narrowed glottis. Therefore, /s/ is termed as voiceless and /z/ as voiced sound in Hindko.

Table 5. 4 Contrast in voicing of Hindko fricative velar sounds (/x/, /ɣ/)

Position of sounds	Velar voiceless	Gloss	Velar voiced	Gloss
Initial	xo:l	Open	ɣo:l	Circular
Medial	N/A	-	NA	-
Final	NA	-	NA	-

The above table 5.4 displays fricative velar sounds of Hindko that is /x/ and /ɣ/ make contrasting pairs in voicing. These phonemes can make pair word initially but not medially and finally in voicing. In the articulation of /x/, vocal folds remain open and voiceless sound is uttered. Contrary to it, during the utterance of /ɣ/, vocal folds make vibration and voiced sound is articulated. As a result, it can be concluded that Hindko /x/ is a voiceless and /ɣ/ is a voiced sound.

Two segments, palatal /ʃ/ and glottal /ɦ/ which have no phonemic pairs; rather they stand as single segment in the palatal and glottal fricative columns of the sound chart. Phoneme /ʃ/ in words like /ʃɪɽɽakk/ 'road' is articulated without the vibration of vocal folds as a voiceless sound whereas /ɦ/ in word like /ɦaɽɽ/ means 'measure' is produced with the vibration of vocal folds as a voiced sound.

In addition to places and voicing features, parallel distribution is applied in the following table to know the various positions of occurrence of fricatives in the words.

Table 5. 5 Distribution of Hindko fricative sounds

Sounds	Initial	Gloss	Medial	Gloss	Final	Gloss
/f/	fæ:ra:	Round	xaffa:	Angry	t̪arraff	Side
/v/	vass	Commendation	sa:va:	Green	ga:v	Core part of wood
/s/	sadʒdʒra:	Fresh	passa:r	Veranda	ʧo:rass	Square
/z/	za:r	Curse	va:za:	Expected arrival	ra:z	Secret
/ʃ/	ʃadʒdʒra:	Lineage	baʃʃra:	Face	ʧaʃʃ	Ecstasy
/x/	xra:b	Spoilt	laxxat̪	Small stick	ʃa:x	Branch
/ɣ/	ɣo:l	Round /Circle	naɣɣa:ra:	Drum	d̪a:ɣ	Stain
/ɦ/	ɦatʰtʰa:	Support	d̪o:ɦa:r	Borrow	ra:ɦ	Plough

Table 5.5 shows data of fricative sounds in different positions, word initially, medially and finally. Hindko fricatives, /f/, /v/, /s/, /z/, /ʃ/, /x/, /ɣ/ and /ɦ/ occupy all three positions of occurrence of sounds. Each sound has different lexical items at different positions. In addition, in case of fricative voicing pairs, the sounds like voiceless /f/, voiced /v/ and voiceless /x/, voiced /ɣ/ have limited examples of the distributional occurrence in Tanoli Hindko (see Tables, 2.14 & 2.16). Nonetheless, in the above case, if distributional case of

fricatives is investigated individually, these sounds can freely occur at different positions of the words.

5.1.2 Discussion on articulatory analysis of Hindko fricatives

In view of the above data analysis, Hindko has eight distinctive fricatives articulated at five different places. Among other Hindko consonants, fricatives occupy the maximum articulatory places in the vocal tract from lips to glottis. In case of voicing, labiodentals /f/ and /v/, alveolar /s/ and /z/, velar /x/ and /ɣ/ are found in pairs for voicing contrast but palatal /ʃ/ and glottal /ɦ/ have no segmental pairs. Unlike other fricatives, Hindko velar /x/ and /ɣ/ make few minimal pairs word initially that differ only in terms of voicing while these sounds, /x/ and /ɣ/, make various contrastive pairs with other distinctive sounds word initially, medially and finally. In addition, velar fricatives are commonly found in Pashto, Persian, Punjabi, Pahari, Urdu and Arabic among others whereas English has no /x/ and /ɣ/ sounds. However, English allows dental fricatives but Hindko does not. Hence, English has nine fricatives while Hindko has eight. Furthermore, Hindko fricatives are found at all the possible positions.

Awan (2004) also indicates eight fricatives in Peshawari Hindko. However, he identified /h/ as a voiceless sound while in the present study; it is analyzed acoustically and found as a voiced /ɦ/ segment (see Section, 5.1.4). The chart drawn by him shows the places of /s/ and /z/ at the dental position (see Table, 2.1) whereas present study shows them as the alveolar fricatives.

5.1.3 Acoustic analysis of Hindko fricatives

In this section, various acoustic cues are scrutinized to know major acoustic properties of Tanoli Hindko fricatives. Before measuring the mean values, qualitative analysis of the spectrograms were taken into account in the following section:

5.1.4 Spectrographic analysis of Hindko fricatives

The spectrographic analysis shows both intrinsic and extrinsic characteristics of Tanoli Hindko fricatives. During the analysis, all tokens were visually examined and the most common trends found among speakers were described. Unlike other consonants, fricative spectrograms and waveforms are displayed in pairs, i.e. voiceless vs. voiced sounds in the following section:

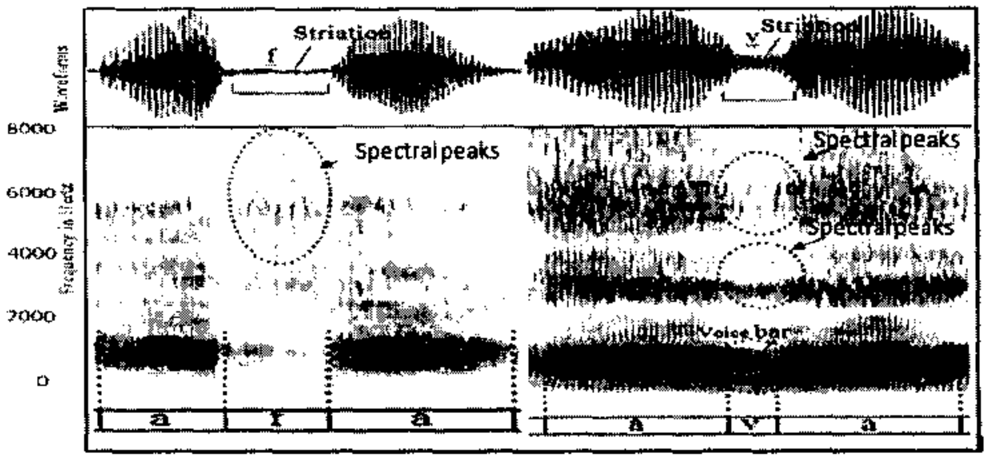


Figure 5. 1 Waveforms and spectrograms of fricative labio-dental sounds

The above figure 5.1 displays sound waveforms and spectrograms of /f/ and /v/. Spectrogram of /f/ displays energy mainly at three different places. In the bottom of the spectrogram, the onset of /f/ has more energy than the offset side. Weak energy and discontinuity in horizontal bottom lines reflects that it is voiceless sound. Having such acoustic forms are the indication of sound articulation without vibration of vocal folds.

Unlike the lower frequency in the bottom line, in the upper part of the spectrogram, striation is found at the offset of /f/ whereas onset position is almost faint. At the second stage, the prominent spikes of frication start in the region of around 2700 Hz but soon get faint. However, again irregular frication begins from 5000 Hz and remains up to 8000 Hz. The energy above 5000 Hz appears darker than lower part. More intensity in higher frequencies of the spectrogram is due to the energy of airstream in the production of /f/ through open glottis. Similarly, in the sound waveform, consonantal part between vowels clearly displays irregular scratchy lines, i.e. aperiodic waveform. The longer duration in the waveform also reflects that /f/ is a voiceless sound.

In the text gridline, the central part of the spectrogram shows consonantal duration of /f/ sound. Marked boundaries, before and after /f/ in the text gridline, show that duration of the preceding /a/ is less than the following /a/. F1 and F2 of the preceding vowel are slightly higher than the following vowel but both formants seem in steady state. Furthermore, feature of formant transitions reveal that F1 and F2 slightly fall at the offset of the preceding vowel and rise at the onset of the following vowel. However, F3 is found in almost in level or the slightest falling and rising position.

The Figure 5.1 also exhibits the spectrogram and waveform of Hindko /v/ segment. Unlike its counterpart labio-dental /f/, the spectrogram of /v/ sound shows strong low-frequency energy at the bottom line. This horizontal bar appears on the spectrogram due to the vibration of vocal folds. Likewise, pitch contour throughout vowels and consonant provides further support to /v/ as a voiced sound (see Appendix, B). Contrary to voiceless sound, there is less intensity in the upper part of spectrogram because of the vibration of vocal folds. Moreover, waveform indicates that during the articulation of /v/, vocal fold vibrates which shows the periodic waveform.

Apart from the low- frequency, in the upper part of the spectrogram, the spectral properties can be observed at two places: first is ranging from around 2800 Hz to 4000 Hz and second part starts from 5000 Hz and remains up to 6500 Hz; however, strongest resonances are found in the region of around 3000 Hz. Similarly, in the lower part of /v/ sound, the resonances seem almost similar to the neighbouring vowel formants. Unlike the preceding spectrogram of /f/, duration of /v/ has darker vertical lines throughout the onset to the offset position. Nevertheless, these irregular striations are found in a less area, and most of the consonantal part remains white on the spectrogram. Moreover, in /f/ sound, the dark vertical lines are found till 8000 Hz but in /v/ sound, these lines are completely disappeared above 6500 Hz.

In the extrinsic properties of /v/, F1 and F2 of the preceding vowel are lower than the following. The place feature, formant transitions of F1, F2 and F3 slightly fall at the offset position of the preceding vowel and then rise at the onset position of the following vowel. Likewise, F3 of the preceding vowel shows falling transition but rising by the end of the following vowel; however, F4 seems almost in steady state. In addition, the duration of both vowels is also almost same. The waveform of /v/ indicates less utterance duration than its counterpart /f/.

It can be summarized, therefore, that voiceless fricative has more resonances and longer duration than voiced. Formant transitions for both labio-dental sounds are almost similar to each other.

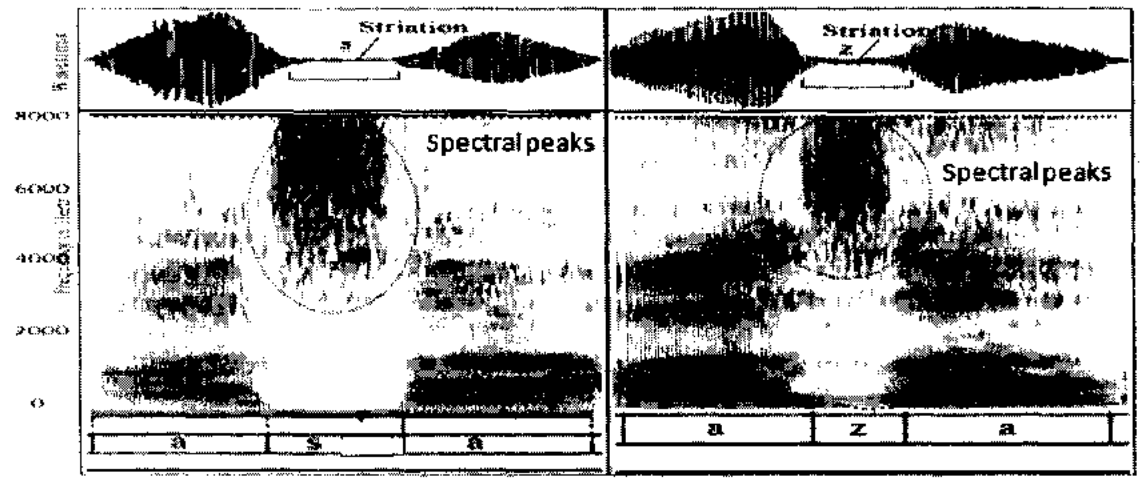


Figure 5. 2 Waveforms and spectrograms of fricative alveolar sounds

The above figure 5.2 depicts Hindko fricatives /s/ and /z/ sounds. The spectrogram of /s/ displays the strongest spectral peak starting from the region of 3700 Hz. This striation remains in steady state throughout its vertical and horizontal position of the spectrogram. The lower area of /s/ sound has absence of energy, which indicates it as a voiceless sound. The pitch contour of /s/, (see Appendix, B), irregular striation in the waveform and longer utterance duration confirm that it is a voiceless sound.

In addition to cues of voicing and spectral peak, the place cue, formant transitions of neighbouring vowels reveal that F1 by the end of the preceding vowel falls then rises at the onset position of the following vowel. On the contrary, F2 rises during the preceding vowel and falls during the following vowel. Similarly, F3 shows rising and falling or level at both positions of vowels.

Another acoustic feature of /s/ sound is its utterance duration. The marked gridlines of the Figure 5.2 clearly display that duration of preceding vowel is shorter than the following vowel. Moreover, being a voiceless sound, duration of the consonantal part in the spectrogram and waveform is quite long in aperiodic form. Thus, Hindko /s/ comprises of longer duration with irregular striation in the waveform and its main resonances are found in the region of 3500 Hz to 8000 Hz.

The Figure 5.2 also shows the spectrogram and the waveform of Hindko /z/ sound. The voice bar at the bottom of the spectrogram shows continuous connection between the preceding and the following vowel. Similarly, the pitch contour remains evident throughout the vowels (see Appendix, B). Likewise, due to the short duration of /z/ sound, waveform in the Figure displays regular vibration of vocal folds throughout the closure. Thus, evidences like continuous voicing during the utterance of vowel-consonant-vowel; continuous pitch and presence of voice bar reveal that /z/ is a voiced sound in Hindko. From the mid of the spectrogram, spectral energy begins at the level of around 4200 Hz which remains constant till 8000 Hz.

Formant transitions show that F2 and F3 rise during the preceding vowel and slope of formant transitions fall at the onset of the consonant whereas again slope of F2 and F3 rise at the offset of /z/. On the other hand, slope of F1 reveals falling by the end of the preceding vowel and rising at the onset of the following vowel. Both preceding and following vowels are almost in similar duration. Utterance duration of /z/ is shorter than its counterpart /s/.

Thus, the acoustic properties such as shorter closure duration of /z/, presence of voice bar with pitch contour and regular striation in the waveform reveal that it is a voiced sound. Contrary to it, voiceless /s/ has longer duration and lack of pitch contour. In addition, spectral peak in both sounds almost start from the same region; however, energy of /z/ is higher than /s/ sound. The place acoustic feature in fricative alveolar sound reveals that F1 show falling at the offset of the preceding and rising at the onset of the following vowels whereas F2 and F3 display mirror image at both positions.

At palatal position, a voiceless fricative /ʃ/ sound is produced in Hindko which is analyzed in the following section:

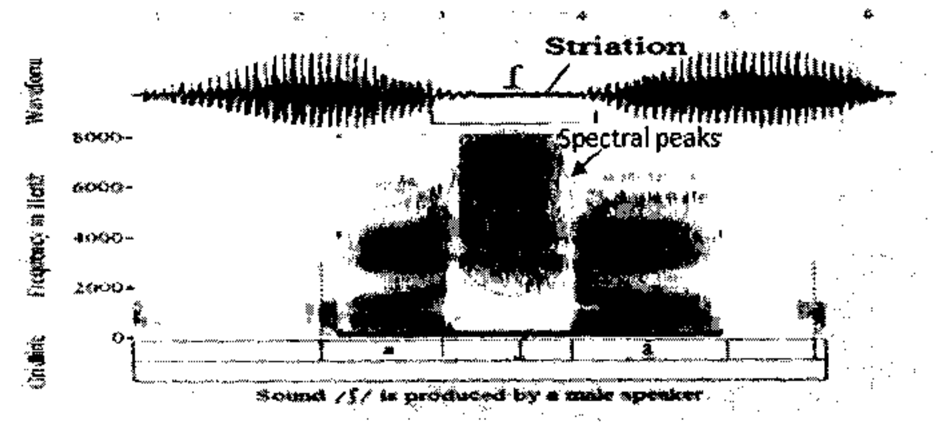


Figure 5. 3 Waveform and spectrogram of fricative palatal sound

The utterance of fricative /ʃ/ in the above figure shows the absence of voicing during the closure of consonantal sound. Aperiodic waves in the waveform reflect that /ʃ/ is articulated without vibration of vocal folds. Similarly, waveform also shows the longer closure duration. Unlike its neighbouring vowels, the pitch contour remains absent during the closure period of /ʃ/ sound (see Appendix, B). Thus, these various factors indicate the voicelessness of /ʃ/ sound. The main resonances of /ʃ/ start between the region of 2000 and 2500 Hz and remain consistent throughout the spectrogram.

The acoustic cue of formant transitions display that F1 and F3 fall at the offset of the preceding and rise at the onset of following vowels. Contrary to it, F2 rises at the offset and falls at the onset of the following vowel. Duration of preceding vowel is more than the following vowel. The waveform of the sound shows duration of the utterance /ʃ/ with aperiodic component. Therefore, spectral characteristic of /ʃ/ reveals that it is a voiceless sound, and its major resonances start from 2200 Hz and remains till 8000 Hz.

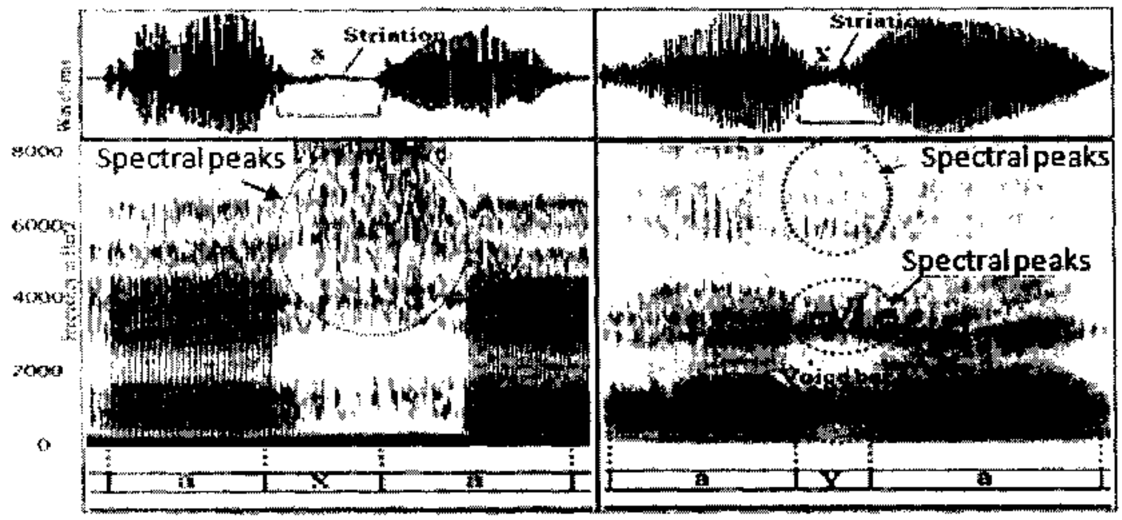


Figure 5. 4 Waveforms and spectrograms of fricative velar sounds

Figure 5.4 reveals acoustic characteristic of /x/ and /ɣ/ sounds. At the very beginning of /x/ spectrogram, the bottom voice bar has discontinuity of energy and some part completely lacks the spikes. The pitch contour in /x/ sound also shows the absence of stability (see Appendix, B). Similarly, interval between vowels in waveform also displays aperiodic component that refers to irregular vibration of vocal folds; therefore, these evidences correspond that /x/ in Hindko is a voiceless sound.

The spectral peak of /x/ starts from 2749 Hz and disappears at around 3700 Hz in a few spectrograms and again starts at 5137 Hz and remains throughout vertically in the spectrogram. However, most of the spectrograms of /x/ display spectral peaks from 2749 Hz to 8000 Hz. Overall, the spectrogram of /x/ has somehow irregular vertical and horizontal spikes. Thus, the weak energy in a spread form at higher frequency is the characteristics of non-sibilant fricatives.

The cue of formant transitions of /x/ shows that F1 a little rises and then falls, F2 falls or levels and then rises or levels, F3 rises or levels and falls or levels during the offset of the preceding and the onset of the following vowel.

Another acoustic cue of fricatives is its utterance duration. Both spectrogram and waveform of /x/ indicates a longer duration which is the property of a voiceless sound. The Figure 5.4 also presents duration and amplitude of the preceding vowel is longer than the following vowel. Fricative /x/ lacks the strong voice bar and shows longer duration, which is uttered with open glottis, and termed as a voiceless sound.

Figure 5.4 also shows spectrogram and waveform of utterance /ɣ/. It displays resonances of noise in the wider part of the consonant. In other words, more region of consonantal section is occupied with energy. The spectrogram of /ɣ/ shows spectral peaks at three different places. At the lower part, there is more striation than upper parts but the preceding and the following vowels have more energy than the consonant. The strongest resonances in the consonantal part at the bottom of spectrogram corresponds it as a voiced sound. Similarly, the pitch contour also remains continue throughout the utterance (see Appendix, B). In addition to these spectrographic evidences, its waveform also shows regular striation which reflects that /ɣ/ is a voiced sound.

At the second stage of this spectrogram, the cue of spectral peak is found between 2500 Hz and 4000 Hz. The area between 4000 Hz and 5000 Hz is quite white but again above 5000 Hz energy begins and remains till the top of the spectrogram. However, it is weaker than other parts of the spectrogram. Overall, spectral peak of /ɣ/ starts at around 2500 Hz.

The cue of formant transitions shows that both F1 and F3 slightly rises during the onset of /ɣ/ and then falls at the offset position; however, F3 more rises than F1. On the contrary, F2 falls at the offset of the preceding vowel while rises at the onset of the following vowel. The amplitude and duration of the preceding and the following vowels are almost similar. The consonantal area of /ɣ/ contains duration than its counterpart voiceless /x/.

As a result, /x/ is a voiceless sound due to longer duration. It lacks pitch contour, much resonances in the upper region and higher frequency spectral peak while /ɣ/ has faint formants, shorter duration and regular striation, thus, termed as voiced sound. Both sounds have transitions slops of F1 and F3 in the direction of falling while F2 in rising position at the offset of the preceding vowel. Conversely, at the onset position, formants have mirror image.

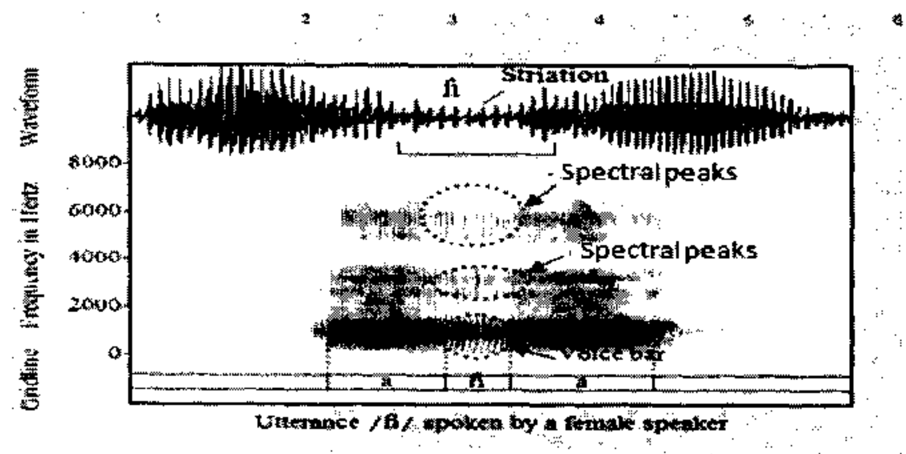


Figure 5. 5 Waveform and spectrogram of fricative glottal sound

Figure 5.5 shows the spectrogram of Hindko fricative /ɦ/ sound. Its resonating region is lighter than other Hindko fricatives. Similarly, unlike others fricatives, its striation is also spread over a narrow range of frequencies. Moreover, the spectral peak can be seen at three different stages of the spectrogram. In the lower part, there is more energy at around 900 Hz than the upper parts. The strongest resonance in the lower area was typical in all of /ɦ/ utterances. However, at two other places, there is also spectral peak between 2600 Hz to 3500 Hz which is more prominent than the third stage in the area of 5000 Hz. The irregular striations of /ɦ/ permanently disappear above 6200 Hz.

In the above spectrogram, pitch contour remains continue throughout the utterance of /ɦ/ (see Appendix, B). In addition to the spectrogram, the waveform also displays this consonantal sound between vowels in a periodic component. Thus, the presence of voice bar, regular waveform and the pitch contour correspond that /ɦ/ is a voiced sound in Hindko.

Formant transitions of /ɦ/ can be seen in the spectrogram that reveals slightly rising of F1 at the offset of preceding vowel while falling at the onset of the following vowels. Contrary to it, F2 has mirror image. On the other hand, F3 is almost in steady state throughout the utterance. Moreover, acoustic cue of duration shows that both vowels have almost similar duration. Therefore, it can be concluded that Hindko /ɦ/ displays flat spectra with low-frequency spectral peak. Due to the increase of oral cavity, its main resonances are found in the lower region than other fricatives. Moreover, voiced /ɦ/ sound shows weaker energy in a spread form.

In addition to the intrinsic and extrinsic properties of fricatives through visual analysis, statistical measurements are carried out to know fricatives characteristics in terms of average mean values in the following section:

5.1.5 Statistical measurements of Hindko fricatives

The temporal measurements of Tanoli Hindko fricatives are given in the following section in terms of spectral measurements (frequency measures), fricatives duration and neighbouring vowels duration. Out of the eight fricatives, three fricatives, i.e. /v/, /ɣ/, and /ɦ/ have spectral properties (strong frications) at two places of the spectrograms including in the high and the middle regions of spectrograms (see Figures, 5.1, 5.4 & 5.5). Similarly, some of the /x/ sound also displayed spectral peaks at two places of the spectrogram, i.e. 2700-3800 Hz and 5000-8000 Hz respectively. However, in most of the /x/ spectrograms, there was continuity of spectral energy ranging from 2700 Hz to 8000 Hz. The other four fricatives /f/, /s/, /z/ and /ʃ/ have spectral peaks at one place of the spectrograms (see Figures, 5.1, 5.2 &

5.3). The spectral measurements of all the eight fricatives were taken into account by clicking in the bottom of aperiodic vibration of the spectrograms and tabulated in the Table, 5.6.

Table 5. 6 Spectral measurements values of fricatives; Means, Std. Dev. & Co. Var.

Fricatives	Token	Voicing	Spectral measurements	Std. Dev.	Co.Var.
f	36	Voiceless	5084	203.9451	4.0112
v	36	Voiced	2822	220.8758	7.8258
s	36	Voiceless	3757	227.5976	6.0577
z	36	Voiced	4270	464.4003	10.8737
ʃ	36	Voiceless	2202	241.0821	10.9452
x	36	Voiceless	2749	236.0335	8.5832
ɣ	36	Voiced	2584	258.8271	10.0137
ɦ	36	Voiced	2603	154.4899	5.9331

Table 5.6 reveals the measurement of Hindko fricatives in light of spectral measurements. The Table shows that mean values of the same group voiceless /s/ (3757 Hz), voiced /z/ (4270 Hz) and voiceless /x/ (2749 Hz), voiced /ɣ/ (2584 Hz) are almost nearer to each other in frequency measures. However, resonances of voiceless /s/ starts lower than its counterpart voiced /z/ but voiceless /x/ displays spectral energy higher than its pair voiced /ɣ/. Spectrographic analysis of /s/ and /z/ show continuity in the spectral peaks from the starting point to the top of the spectrogram, i.e., up to 8000 Hz. Similarly, voiceless /x/ sound also shows continuity throughout spectral peak starting from 2700 Hz to the top of spectrogram; however, spectrographic and statistical analyses of its counterpart voiced /ɣ/ sound depicts spectral peaks at two places of the spectrogram, first between 2584 Hz to 3700 Hz and then again energies start at around 5027 Hz and remain up to 8000 Hz.

Spectral peak of /ʃ/ sound starts from 2203 Hz and remains up to 8000 Hz. Spectrographic analysis of these three fricatives /s/, /z/ and /ʃ/ exhibit more resonances than the rest of Hindko fricatives (see Section, 5. 1. 2). Hindko voiceless /f/ sound shows the starting point of spectral peak at the very highest point among Hindko fricatives, i.e., 5084 Hz and its counterpart /v/ displays resonances at two places of the spectrogram. The results of the average mean values of /v/ show spectral peak starting point first at 2822 Hz and then at 5030 Hz. Spectrographic analysis of /v/ reveals that the first spectral energy remains between 2800 Hz and 3800 Hz, and then between 5030 Hz and 6500 Hz (see Figure, 5.1).

The spectrogram of voiced sound /ɦ/ also shows spectral peaks at two places. The above table shows that spectral energies start from 2603 Hz, and the spectrographic analysis reveals it up to 3500 Hz, and again displays energy between 5100 Hz and 6200 Hz.

Mean values of these fricatives are further confirmed by ANOVA.

Table 5. 7 ANOVA for fricatives in terms of friction

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	84642111	7	12091730	227.1325	1.74E-53	2.115472
Within Groups	4684808	88	53236.45			
Total	89326919	95				

ANOVA Table 5.7 ANOVA Table 5.7 reveals that as p-value is less than 0.01, thus, there is significant difference among average mean values of fricatives. Further, LSD test is applied to measure the pair similarities and differences in the following section:

LSD=292.5703895

ʃ	ɣ	ɦ	x	v	s	z	f
2202.611	2584.722	2603.833	2749.917	2822.389	3757.111	4270.833	5084.361

The results reflect that little fraction values are also important in differentiating fricative sounds.

In addition to resonances cue, fricatives duration was measured to distinguish among sounds.

Table 5. 8 Duration of Hindko fricatives (sec); Means, Std. Dev. & Co. Var.

Fricatives	Tokens	Voicing	Duration (sec)	Std. Dev.	Co.Var.
f	36	Voiceless	0.107	0.0111	10.4364
v	36	Voiced	0.084	0.0199	23.8190
s	36	Voiceless	0.127	0.0157	12.3745
z	36	Voiced	0.099	0.0137	13.8802
ʃ	36	Voiceless	0.115	0.0106	9.26350
x	36	Voiceless	0.11	0.0149	13.5568
ɣ	36	Voiced	0.086	0.0143	16.5546
ɦ	36	Voiced	0.104	0.0238	22.9342

Table 5.8 presents average means values of fricatives utterance duration with standard deviation and coefficient variation. These values are further determined by ANOVA.

Table 5. 9 ANOVA for fricatives in terms of duration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.017121	7	0.002446	9.454009	1.07E-08	2.115472
Within Groups	0.022766	88	0.000259			
Total	0.039887	95				

The above ANOVA table 5.9 confirms that there is significant difference among fricative duration as p-value is less than 0.01. In addition, LSD test is carried out to see which pair is different from other.

LSD=0.014453

Segments	V	ɣ	z	ɦ	f	x	ʃ	S
Means of duration	0.083864	0.086383	0.09923	0.104117	0.106672	0.109965	0.114852	0.126971

The average means values for fricative duration is placed in the following bar graph for more comprehensive view:

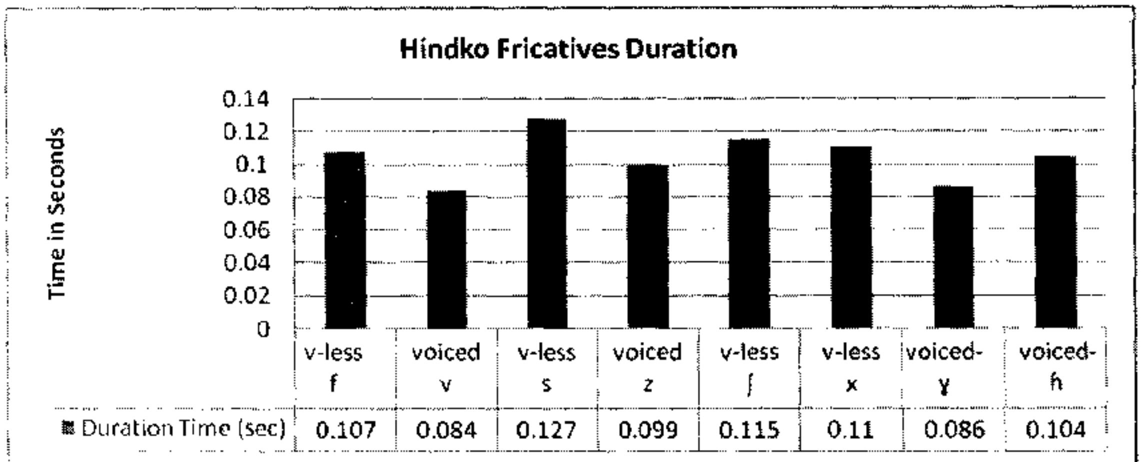


Figure 5. 6 Utterance duration of Hindko fricatives

Figure 5.6 displays that voiceless /f/ has more duration than its counterpart voiced /v/. Similarly, voiced /z/ has less duration than voiceless /s/. Likewise, /x/ has longer duration than its counterpart voiced /ɣ/. Moreover, two pairless sounds, voiceless /ʃ/ and voiced /ɦ/ show their closure duration. Glottal /ɦ/ sound shows longer duration than other voiced sounds and voiceless /ʃ/ carries maximum duration in voiceless sounds but less than voiceless /s/. Thus, it can be concluded that voiceless sounds have more duration than voiced sounds.

The following bar chart displays the difference between voiced and voiceless sounds:

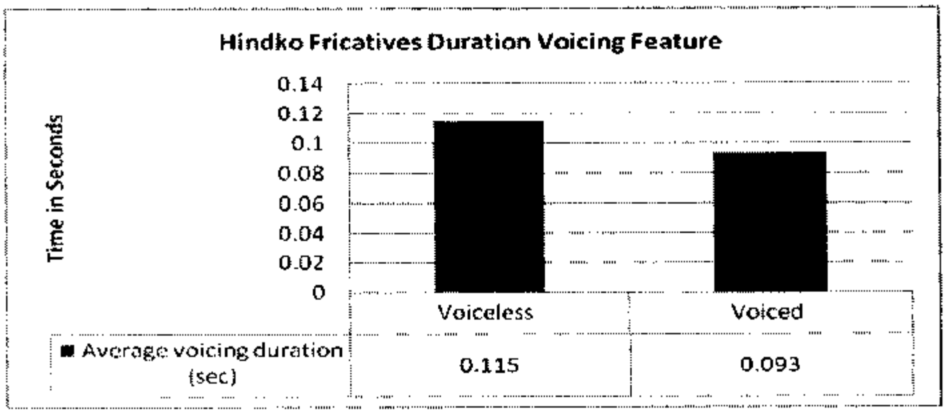


Figure 5. 7 Average mean values of fricatives utterance time by voicing

Figure 5.7 shows average mean values of voiceless /f/, /s/, /ʃ/, /x/ and voiced /v/, /z/, /ɣ/, /ɦ/sounds. It shows Hindko voiceless sounds carry more time than voiced during the utterance. In addition to the voicing difference, the feature of fricatives duration can also be compared according to the places of articulation in the following bar chart. Since palatal and glottal have single fricative, thus, average of other pairs was taken into account so that uniformity may remain consistent in places.

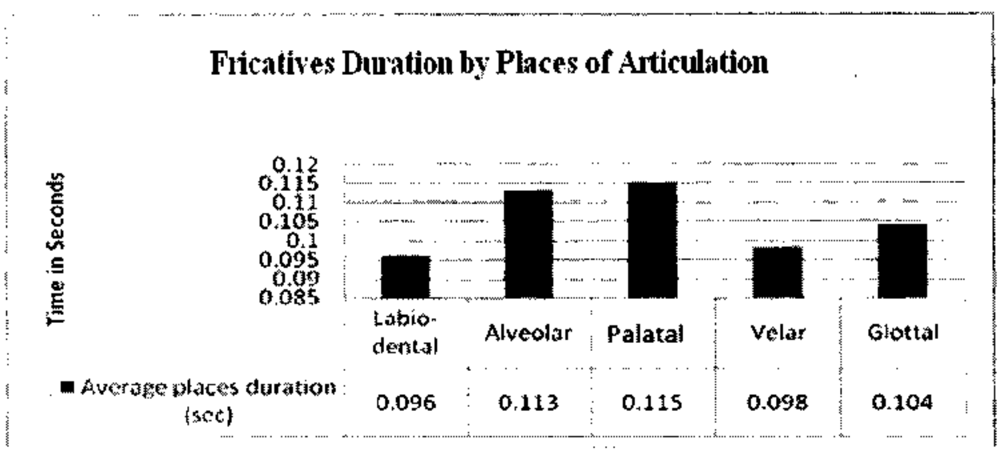


Figure 5. 8 Average mean values of fricatives duration by places

Figure 5. 8 displays the significant difference among all places of fricatives articulation. It clearly presents that front sounds; labio-dental has the least duration and increase gradually towards palatal fricative which has maximum duration. However, there is decrease in the velar place but again duration increases during the utterance of glottal fricative. Thus, palatal has maximum duration while labio-dental has least duration. In addition to individual analysis in terms of voicing and places, following chart shows contrast between voicing and places of fricatives:

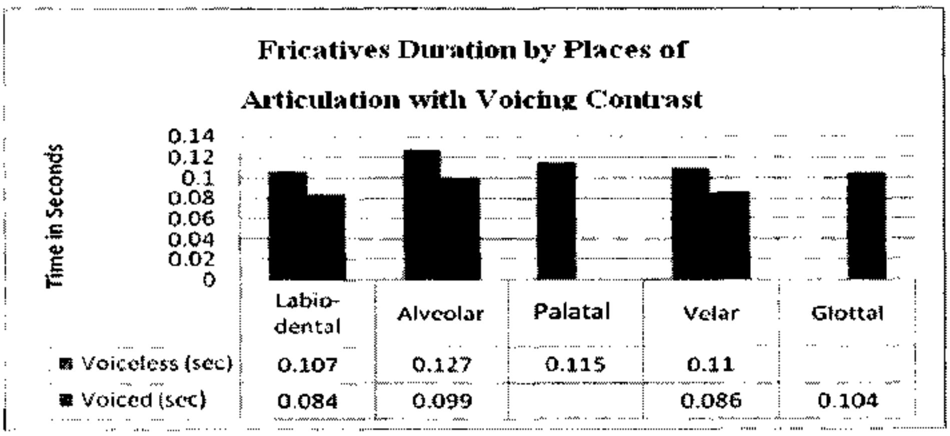


Figure 5. 9 Fricatives utterance time contrast of places and voicing

The above figure 5.9 depicts alveolar voiceless sibilant segment is the longest Hindko fricative. On the other hand, labio-dental voiceless non-sibilant segment has least duration. Back voiceless fricatives, i.e. palatal voiceless sibilant sound and velar voiceless non-sibilant phonemes are longer than front labio-dental voiceless sound but shorter than alveolar voiceless sound.

In case of voiced sounds, glottal voiced non-sibilant segment is the longest sound whereas labio-dental voiced non-sibilant is the shortest sound among Hindko fricatives. However, alveolar voiced sibilant has more duration than velar voiced non-sibilant sound.

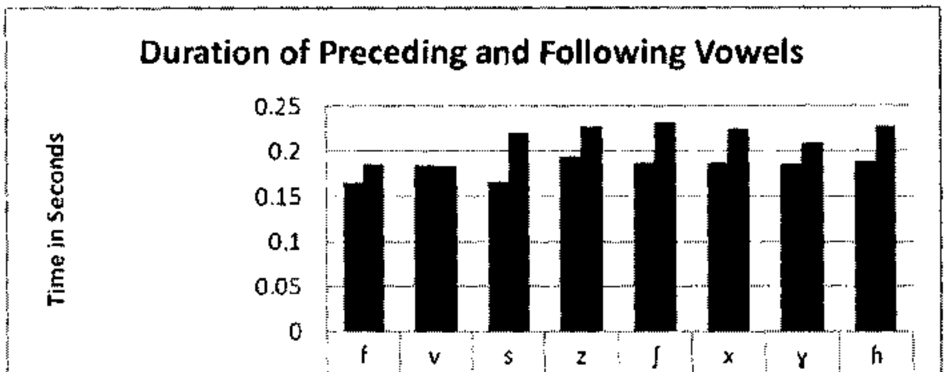
Thus, results reflect that voiced sounds are shorter than voiceless sounds and medial sounds, alveolar and palatal carry more duration than front and back sounds.

In addition to acoustic cues of spectral measures and fricative duration, the cues of neighbouring vowels are also statistically investigated in the following part:

Table 5. 10 Duration of adjacent vowels to fricatives (sec); Means, Std. Dev. & Co. Var.

Sounds	Voicing	Preceding vowel	Std. Dev.	Co.Var.	Following vowel	Std.Dev.	Co.Var.
f	Voiceless	0.165	0.0253	15.3075	0.185	0.0344	18.6318
v	Voiced	0.184	0.0268	14.6268	0.182	0.0339	18.6254
s	Voiceless	0.166	0.0296	17.8789	0.210	0.0392	17.8813
z	Voiced	0.193	0.0337	17.4126	0.226	0.0428	18.9969
ʃ	Voiceless	0.185	0.0395	21.3999	0.230	0.0608	26.4663
x	Voiceless	0.186	0.0436	23.4318	0.224	0.0416	18.6236
ɣ	Voiced	0.185	0.0353	19.1002	0.209	0.0463	22.1632
ɦ	Voiced	0.188	0.0316	16.8475	0.227	0.0329	14.5470

Table 5.10 shows the comparison of neighbouring vowels duration to fricatives. Results show that mean values, standard deviation and coefficient variation of the following vowels to fricatives are higher than the preceding vowels. A chart of this comparison is drawn in the following:



	f	v	s	z	ʃ	x	ɣ	ɦ
Preceding vowels (sec)	0.165	0.184	0.166	0.194	0.186	0.186	0.185	0.188
Following vowels (sec)	0.185	0.182	0.219	0.226	0.23	0.224	0.209	0.227

Figure 5. 10 Fricatives adjacent vowels duration

Figure 5.10 shows that all preceding vowels have less duration than following vowels. However, /v/ is the only sound in Hindko fricatives whose neighbouring vowels durations are almost same, rather following vowel has slightly less duration than preceding vowel. In addition, preceding vowel for voiced /z/ has maximum duration among all fricatives while voiceless /ʃ/ has maximum duration for following vowel. Generally, there is a little difference between the duration of preceding and following vowels to fricatives. Therefore, the present results are similar to general trend that preceding vowels remain less than following vowels.

5.1.6 Discussion on acoustic analysis of Hindko fricatives

The analysis shows that most of the acoustic features of Hindko fricatives are similar to the general notion about the acoustic cues of fricatives sounds. Since Yavas (2006) denotes that fricative spectrograms contain irregular spikes both horizontally and vertically, (see Section, 2.5.3). Similarly, Hindko fricative spectrograms have indistinguishable results (see Section, 5.1.2). Duration of voiceless Hindko /s/ and /ʃ/ are longer than voiceless /f/ and /x/; and voiced /v/ and /ɣ/ are shorter than voiced /z/ and /ɦ/ sounds. Likewise, for English fricatives, Behrens and Blumstein (1988) identify that noise duration of voiceless /s/ and /ʃ/

are longer than voiceless /f/ and /h/ and in voiced sound /v/ is shorter than /z/ (see Section, 2.5.3). Furthermore, they state that sibilants fricatives in English, i.e. /s,z, ʃ,ʒ/ are longer than non-sibilant, i.e. /f, v, ð, θ, h/. Unlike English voiceless /h/, Hindko has voiced /ɦ/ sound. Contrary to English /h/, Hindko /ɦ/ has the longest duration among voiced fricatives of Hindko.

Jongman (1989) states that English voiceless fricatives have longer duration than voiced (see Section, 2.5.3). Similarly, Hindko voiced fricatives have shorter duration than voiceless. Duration of the anterior labio-dental voiceless /f/ and the posterior velar /x/ is very close to each other in Hindko. The labio-dental anterior voiced /v/ and posterior velar /ɣ/ also display a little durational difference of 0.002 seconds. Thus, both front fricatives have minor decrease than back fricatives respectively.

Generally, in the articulation of Hindko consonants, labio-dental is the second place of articulation from the front of the oral cavity and the velar is the second last place of articulation from the back of the oral cavity but both places have almost same duration. In addition, a front sibilant voiceless fricative /s/ has longer duration than back voiceless /ʃ/, /x/ sounds, and voiced /z/ has more duration than the back voiced /ɣ/ fricative.

Spectral measurements of sibilants /s/, /z/ and /ʃ/ sounds show clearly higher frequency with more intense energy. These findings are similar to the views of Yavas (2006) (see Section, 2.5.3). The uppermost part of spectrogram for /ʃ/ has irregular striation while alveolar /s/ and /z/ have regular energy in that part. Mean values show that voiceless /s/ spectral peak starts lower than voiced /z/ (see Table, 5. 6). Similar to sibilant sounds, spectral energy in Hindko non-sibilant /f/ sound has close resemblance to the resonances of English /f/ indicated by Davenport and Hannahs (2010) (see Section, 2.5.3). Spectrogram of voiceless /x/

shows spectral peak starting from 2749 Hz, which remains up to 8000 Hz. However, upper part of the spectrogram has stronger striation than lower part and show in some way irregular vertical and horizontal spikes. However, in a few spectrograms of /x/, spectral energy was found at two places. At the first stage, irregular striation starts from 2749 Hz to 3700 Hz and at the second stage between 5137 Hz to 8000 Hz.

Spectral peaks of /v/, /x/, and /ɦ/ are found at two places of spectrograms including the bottom region energy, which refers to the properties of voiced sounds. Average mean values of these sounds show that spectral peaks start from 2822 Hz for /v/, 2584 Hz for /ɣ/ and 2603 Hz for /ɦ/. These resonances remain in the medial part of spectrograms for 1000 to 1500 Hz. Then spectrograms display white areas and again energy starts from the region of 5030 Hz to 6500 Hz for /v/, 5027 Hz to 8000 Hz for /ɣ/ and 5103 Hz to 6200 Hz for /ɦ/ sounds. Overall, unlike sibilant sounds, Hindko non-sibilant sounds have weak energy in spread from in the upper part of spectrograms. In addition, non-sibilant fricatives in Hindko display flat spectra while non- sibilant sounds have high-frequency spectral peak. Thus, these results are quite similar to the general pattern of fricatives (e.g.Yavas, 2006; Raphael, et al., 2007; & Gut, 2009) (see Section, 2.5.3).

However, unlike Hindko voiced /ɦ/ sound, English has voiceless /h/ sound. Davenport and Hannahs (2010) state that major resonating energy of /h/ is found in the region of 1000 Hz. For other English fricatives, they identify the strongest resonances in the regions of about 3000 Hz for /ʃ/, 4000 Hz for /s/ and 4500 Hz for /f/ (see Section, 2.5.3). Analysis of Hindko fricatives shows that spectral energy starts at 2202 Hz for /ʃ/, 3757 Hz for /s/, 4270 Hz for /z/ and 5084 Hz for /f/ (see Table, 5.6). The findings of Hindko fricatives duration are in line with English fricatives duration whereas Hindko fricative spectral measures are not much similar to English fricative sounds.

Like the general trend, resonances of Hindko voiceless /f/ and /x/ cover more energy than their counterparts voiced /v/ and /ɣ/. Pairless voiceless /ʃ/ sound has energetic resonances while voiced /ɦ/ shows weak spectrographic energy. However, resonances for voiced /z/ and voiceless /s/ are almost similar (see Section, 5.1.4). Unlike analysis of other consonants, fricatives neighbouring segment vowels, F1 and F2 are closer to each other. Both formants (F1 & F2) have higher resonances whereas F3 and F4 are found in the upper frequency of spectrograms and remain quite fainter.

The analysis of formant transitions of preceding and following vowels for labio-dental fricatives show slightly falling of F1 and F2 by the end of preceding vowel and rising in the beginning of following vowel. However, F3 is almost either in steady state or slightest falling and rising at vowels offset and onset positions. Contrary to it, transitions of alveolar /s/ and /z/ present falling and rising of F1, rising and falling of F2 and F3 at offset and onset positions of vowels. Formants movement of /ʃ/ are falling and rising for F1 and F3 while F2 has mirror image. Neighbouring segments in the formant patterns of Hindko velar sounds reflect that F1 and F3 rise by the end of preceding vowel and fall at the onset of following vowel while F2 shows mirror image. The findings of fricatives adjacent vowels are similar to the general notion that preceding vowels take less duration than the following vowels (see Figure, 5.10).

Under KP Text Book Board, a committee for standardization of Hindko Alphabets approved nine fricatives including /ʒ/ sound (see Appendix, A). However, during the present study, the researcher recorded this sound for acoustic analysis as it supposed to be in articulatory phonetics, e.g. /ʒallãmm/, /ʒo:k/, but both intrinsic and extrinsic properties of the

/ʒ/ spectrogram were found similar to Hindko glide /j/. Therefore, it is concluded that the existence of /ʒ/ sound is not possible in Hindko. The TBB committee may be included /ʒ/ in Hindko (see Section, 2.1) due to the influence of Urdu, e.g. Hussain (n.d) states that Urdu allows nine fricative sounds, i.e. /f/, /v/, /s/, /z/, /ʃ/, /ʒ/, /x/, /ɣ/ and /h/.

5.2 Hindko affricates

Three Hindko affricates, /ʧ/, /ʤ/ and /ʧʰ/ were identified on the basis of minimal pairs (see Table, 4.1).

5.2.1 Articulatory phonetic analysis of Hindko affricates

Like other obstruents, i.e. stops and fricatives, Hindko affricates can also be distinguished by voicing:

Table 5. 11 Contrast in places and voicing of Hindko affricates (/ʧ/, /ʤ/, /ʧʰ/)

Position of sounds	Alveolar unaspirated	Gloss	Alveolar voiced	Gloss	Alveolar aspirated	Gloss
Initial	ʧa:l	Gait	ʤa:l	Net	ʧʰa:l	Sore/Jump
Medial	baʧʧa:	Child	baʤʤa:	Beat up	baʧʰʧʰa:	Cow calf
Final	raʧʧ	Build	raʤʤ	Eat to fill	raʧʰʧʰ	Feat/Action (in negative sense)

Data in the Table 5.11 shows three Hindko affricate sounds, /ʧ/, /ʤ/ and /ʧʰ/. These sounds can freely contrast with one another. The phoneme /ʧ/ contrasts with /ʤ/ as in the words /ʧa:l/ and /ʤa:l/. It signifies that /ʧ/ is a voiceless affricate while /ʤ/ is a voiced affricate. In addition, Table also reveals contrast of these two segments with /ʧʰ/ at three possible positions as well. Unlike other two affricates, /ʧʰ/ is produced with an audible puff of air at the release stage which marks it as an aspirated sound. Thus, it can be concluded that in Hindko, affricate /ʧ/ is an unaspirated, /ʤ/ is a voiced and /ʧʰ/ is an aspirated sound.

Like many other languages, Hindko affricates have similar places of articulation, as /ʧ/ is an alveolar voiceless sound; /ʤ/ is an alveolar voiced and /ʧʰ/ is an alveolar aspirated sound. Thus, each affricate sound is found in commutation test. Affricates are also analyzed in terms of different possible occurrence in the following table:

Table 5. 12 Distribution of Hindko affricates

Sounds	Initial	Gloss	Medial	Gloss	Final	Gloss
/ʤ/	ʤott	Combat	naʤʤo:ɽ	Sick	la:ʤʤ	Treatment
/ʧ/	ʧabb	Bite	kaʧʧa:	Raw	raʧʧ	Assemble
/ʧʰ/	ʧʰaʈʈ	Roof	baʧʰʧʰa:	Cow calf	kaʧʰʧʰ	Measure

Data in the Table 5.12 shows that Hindko affricates /ʤ/, /ʧ/ and /ʧʰ/ can freely occur word initially, medially and finally. All the occurrence of affricates at different positions in Hindko is not strange because the occurrence of such sounds is also possible in other languages of subcontinent, like Punjabi, Urdu, Hindi and Pahari etc.

5.2.2 Discussion on articulatory analysis of Hindko affricates

Articulatory analysis shows that there are three affricates, voiceless alveolar /ʧ/, its counterpart voiced /ʤ/ and aspirated /ʧʰ/ sounds. All segments can freely make contrast of phonemes, contrasting in voicing and distribution at three possible positions with different lexical items. In case of English, there are two affricate sounds voiceless and voiced. Both sounds can occur word initially, medially and finally.

Davenport and Hannahs (2010) refer to other languages that affricates are found in many languages with different places of articulation. Such as, "German has voiceless labio-dental /p^f/ in pferd 'horse' and voiceless alveolar /t^s/ in zug 'train'; Italian has a voiced alveolar /dz/ in zona 'zone'" (p.27). Reetz and Jongman (2009) denote that /t^s/ in German freely occurs word initially, medially and finally. Similar to Hindko, three affricates, voiceless, aspirated and voiced, are commonly found in the languages of sub-continent at three different positions such as Urdu, Punjabi and Pahari etc.

Moreover, Reetz and Jongman (2009) state that IPA has no separate symbols for affricates but combines plosive and fricative and this procedure reduces the number of symbols that have to be remembered.

5.2.3 Acoustic analysis of Hindko affricate sounds

Hindko affricates are acoustically analyzed in the following section:

5.2.4 Spectrographic analysis of Hindko affricates

Due to some specific acoustic features, affricates have their own identity. Therefore, visual analysis of these spectrograms specifies those particular characteristics of Hindko affricates.

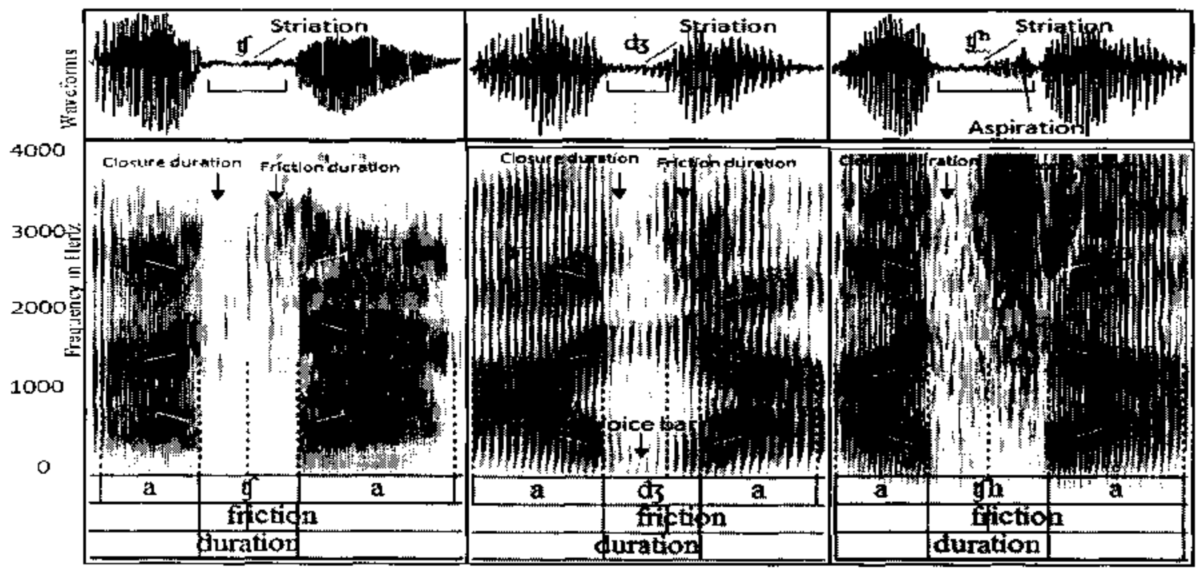


Figure 5. 11 Waveforms and spectrograms of Hindko affricates

Figure 5.11 shows waveforms and spectrograms of /ʧ/, /ʤ/ and /ʧʰ/. The marked boundaries clearly indicate the parts of affricate sounds. That overall duration of sounds have two parts, i.e. complete closure before the release of sound and friction of sounds respectively. Since silent gap is the feature of stop sounds while friction is the feature of fricative sound. Thus, combination of these two cues makes them affricates.

Unlike /ʧ/ and /ʧʰ/, /ʤ/ has horizontal voice bar in the bottom of the spectrogram which refers to the voicing feature. Likewise, /ʤ/ sound also shows pitch contour throughout the utterance whereas /ʧ/ and /ʧʰ/ lack this acoustic feature (see Appendix, B). Similarly, waveform of the consonantal part /ʤ/ displays more striation than the bars of /ʧ/ and /ʧʰ/. Though before the following vowel, waveform bar of /ʧʰ/ has strongest constriction, yet that is due to the aspiration of sound. These features reflect that /ʤ/ is a voiced and /ʧ/ and /ʧʰ/ are voiceless sounds. Unlike /ʧʰ/, neither spectrograms nor waveform bars of /ʧ/ and /ʤ/ have any delaying signs between the release of consonantal phonemes and onset position of following vowel. Therefore, /ʧ/ and /ʤ/ are termed as unaspirated and voiced phonemes, and /ʧʰ/ as an aspirated sound. In addition, air combination of aspiration and fricative part of /ʧʰ/ sound, i.e. /ʃ/ makes the upper part of spectrogram including its waveform as a more energetic part of the sound. The first part of /ʧ/ is /t/ which is an alveolar unaspirated stop, whereas the first of the symbol /ʤ/ is /d/ which is an alveolar voiced stop. Spectrogram of voiced /d/ shows more evident harmonics than unaspirated /t/. On the other hand, fricative part of unaspirated affricate /ʧ/ is /ʃ/, a fricative unaspirated sound, which displays the energy above F2 continuously till the top of spectrogram whereas fricative part of voiced affricate /ʤ/ is /ʒ/, i.e. fricative voiced sound which shows discontinuity in the bands. Overall, all the spectrograms show frication to full amplitude.

Spectrograms of sound /ʧ/ and /ʧʰ/ show equal duration for silent gap and frication part while /ʤ/ has less horizontal duration for frictional noise part than silent gap of sound. Like general tendency, duration of voiced part is shorter than unaspirated while aspirated sound has the longest duration. Before the frication noise, there is abrupt release of the closed air in form of a burst which is prominent in unaspirated sounds than voiced. The place cue, formant transitions have similar function in all sounds that preceding F1, F3 fall and F2 rises at the offset of preceding vowels whereas at the onset of following vowels transitions show mirror image. Such formant transitions are the characteristics of alveolar sound.

5.2.5 Statistical measurements of Hindko affricates

In addition to spectrographic analysis, affricates data was statistically measured in terms of frication duration and closure duration respectively in the following section:

Table 5. 13 Frication duration values of Hindko affricates; Means, Std. Dev. & Co. Var.

Affricates	No. of Tokens	Means (sec)	Std. Dev.	Co.Var.
ʧ	36	0.0597	0.0136	22.8216
ʤ	36	0.0423	0.0058	13.8027
ʧʰ	36	0.0798	0.0117	14.7081

Table 5.13 shows the average mean values of frication duration in affricates with standard deviation and coefficient variation. Average mean values are further determined by ANOVA.

Table 5. 14 ANOVA for frication duration of affricates

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.008454	2	0.004227	35.43611	6.07E-09	3.284918
Within Groups	0.003936	33	0.000119			
Total	0.01239	35				

ANOVA Table 5.14 show significant statistics as p-value is less than 0.01. Moreover, LSD test is employed to measure the discrepancies within affricate pairs.

LSD=0.009814

Segments	ʤ	ʧ	ʧh
Frication duration Means	0.042302	0.059755	0.079808

Furthermore, mean values of frication time were put into chart form to see difference through bars:

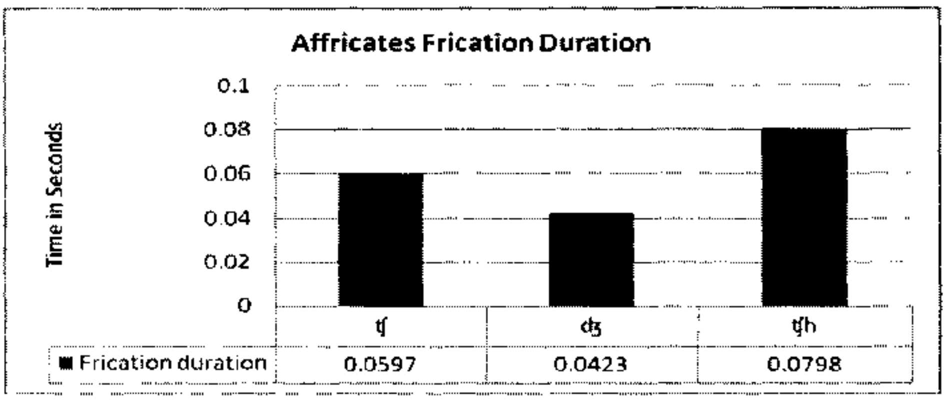


Figure 5. 12 Hindko affricate sounds in terms of frication

Figure 5.12 reveals frication duration that aspirated /ʧʰ/ has maximum frication duration almost double to voiced /ʤ/ sound whereas unaspirated /ʧ/ carries frication time in mid of both sounds. Consequently, like general concept, Hindko voiced affricate has less frication duration than unaspirated and aspirated sound get more time than unaspirated.

Table 5. 15 Closure duration values of Hindko affricates; Means, Std. Dev. & Co. Var.

Affricates	No. of Tokens	Means (sec)	Std. Dev.	Co.Var.
ʧ	36	0.0815	0.0133	16.3500
ʤ	36	0.0564	0.0069	12.3085
ʧʰ	36	0.0763	0.0116	15.2533

Table 5.15 reveals that average mean values of affricates closure duration with standard deviations and coefficient variation. Average mean values are further analyzed by ANOVA.

Table 5. 16 ANOVA for closure duration of affricates

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.00421	2	0.002105	17.46526	6.71E-06	3.284918
Within Groups	0.003977	33	0.000121			
Total	0.008187	35				

Results of ANOVA table show significant difference among affricates as p-value is less than 0.01. In addition, pairs of affricates are further investigated by LSD test to see the difference within pairs.

LSD=0.009865

Segments	ʤ	ʧʰ	ʧ
Means of closure duration	0.056449	0.076298	0.081564

Average mean values carried out by Pratt software and then confirmed by ANOVA are drawn in the bar graphs in the following:

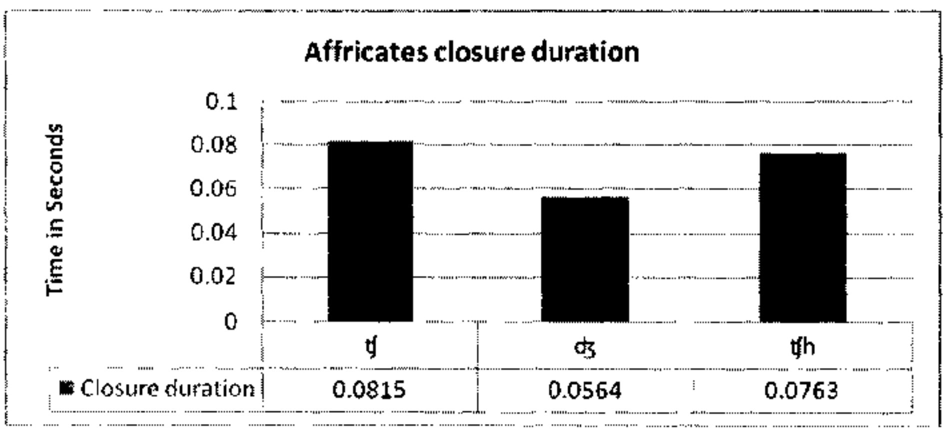


Figure 5. 13 Hindko affricate sounds in terms of closure duration

Figure 5.13 shows maximum closure duration for unaspirated /ʧ/ sound, aspirated /ʧʰ/ takes less closure time than unaspirated but more than voiced sound. Thus, /ʤ/ has minimum closure than other affricates. Like Hindko plosives, affricates voiced sound takes shorter closure duration than unaspirated sounds. In the following part, affricates were investigated by considering overall duration.

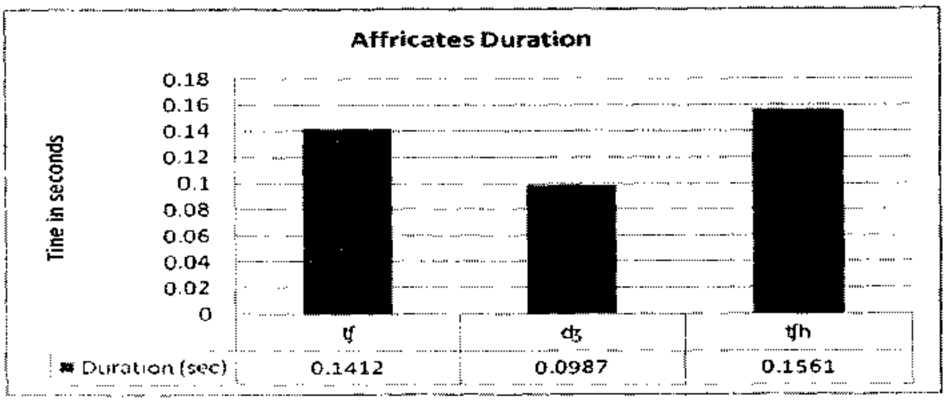


Figure 5.14 Hindko affricate sounds in terms of duration

Figure 5.14 displays overall duration of Hindko affricates. Aspirated sound carries longer duration than unaspirated sound. However, voiced sound shows the shortest duration.

5.2.6 Discussion on acoustic analysis of Hindko affricates

The acoustic measurement shows that /ʧ/ in Hindko is an unaspirated; /ʤ/ is a voiced whereas /ʧʰ/ is an aspirated segments. Like other languages of the world, Hindko affricates are also articulated from alveolar place of articulation.

Hayward (2000) states that silence period of affricates remains less than stops and noise period of affricates also take shorter time than that of fricatives (see Section, 2.5.4). He gave an example of English /ʧ/ and /ʃ/ with the duration of (236 ms) and (212ms) respectively which reveals that total duration affricate /ʧ/ is slightly longer than single fricative /ʃ/. The results show that Hindko affricates have shorter duration than that of stop and fricative. That silent gap duration for voiceless /ʧ/ is 0.0815 (sec) while stop /t/ shows 0.102 (sec), voiced /ʤ/ has 0.0564 (sec) and stop /d/ shows 0.0683 (sec), aspirated /$ʧ^h$/ has 0.0763 (sec) while stop aspirated /t^h/ shows 0.0902 (sec). Similarly, Hindko fricative /ʃ/ has 0.115 (sec) frication duration while Hindko affricate noise period duration is 0.0597 (sec). However, Hindko has no /ʒ/ fricative, thus, not been given its measurement to match with affricate. Overall, it can be concluded that affricates silent gap period take less time than stops. Similarly, noise part of affricates is shorter than fricatives.

5.3 Hindko approximants

Four Hindko approximations were established on the basis of minimal pairs (see Table, 4.1). These approximants comprise of one glide /j/, two liquids /l/ and /r/ and one flap /ɽ/. Liquids are also said as lateral /l/ and trill /r/. Unlike stops and fricatives but like nasal consonants, all approximants are voiced and sonorant sounds.

5.3.1 Articulatory analysis of Hindko approximants

Hindko approximants; /j/, /l/, /r/ and /ɽ/ are tabulated in the following table to see their characteristics:

Table 5. 17 Data based on approximant sounds, contrast for places

Sounds	Alveolar voiced	Gloss	Palatal voiced	Gloss	Retroflex voiced	Gloss	Alveolar voiced	Gloss
/l/ , /j/	la:ʃ	Corpse	ja:ʃ	Profligate	N/A	N/A	N/A	N/A
/j/, /r/	N/A	N/A	jʊll	Cockroach	N/A	N/A	rʊll	Nomadic
/l/,/j/,/r/	la:ra:	To wait	ja:ra:	Oh friend!	N/A	N/A	ra:ra:	This side
/r/ , /ɽ/	gʊll	Flower	N/A	N/A	gʊɽɽ	Sweetie	gʊrr	Trick

Data in the Table 5.17, /l/ and /j/; /j/ and /r/; /l/, /j/ and /r/ are compared contrastively for the places of articulation. However, data of /ɽ/ sound is compared word finally in the table because it cannot occur word initially in the dialect. In the places of articulation, the above analysis shows that glide /j/ is a palatal sound. During its production, the front part of the tongue touches to the palatal area of oral cavity and articulated without any obstruction. On the other hand, /l/ and /r/ are produced at with some obstruction but not like stops. There is no difference in places of /l/ and /r/, both are alveolar sounds, but in manner of articulation, the former segment is a lateral and latter a trill sound. For the alveolar lateral /l/, the blade of the tongue approaches to the alveolar ridge whereas trill /r/ is produced with the tip of tongue. Generally, during the production of these two sounds, the air goes out from the sides of the tongue and central part of the tongue remains in touch with the passive articulators. In the articulation of retroflex flap /ɽ/ sound, the tip of the tongue touches to the hard palate and gets immediate return and the tongue is curled back and reaches behind the alveolar ridge.

Description of approximants in terms of distributional differences is given below:

Table 5. 18 Data for distribution of Hindko approximants

Sounds	Initial	Gloss	Medial	Gloss	Final	Gloss
/r/	ra:t̪	Night	t̪a:ra:	Star	ʧi:r	Tear
/l/	laʧʰʧʰa:	Bunch	ɣo:li:	Shell	ʃarro:l	A type of tree
/j/	ja:ʃ	Profligate	maija:	Song	N/A	
/ɽ/	N/A		ʧa:ɽi:	Clapping	t̪a:ɽ	See

Table 5.18 presents that glide /j/ can occur at two places in Tanoli Hindko, word initially and medially. At word initial position, its occurrence is commonly found but rare examples exist at word medial position in Tanoli Hindko. Usually, occurrence of /j/ word medially and finally becomes /æ:/. Data shows that /l/ and /r/ can occur word initially,

medially and finally. On the other hand, the retroflex /ɽ/ can occur word medially and finally but not word initially. It has been observed that the use of /ɽ/ is comparatively more common than other segments in the dialect. Unlike stops and fricatives but like nasal consonants, all Hindko approximants are voiced and sonorant sounds.

5.3.2 Discussion on articulatory analysis of Hindko approximants

Hindko /j/, in the distributional occurrence is a possible sound word initially and medially; however, in case of a syllable, instead of /j/, it turns into a vowel /æː/ due to its vowel like features. In a similar study, Hussain (n.d) states that in Urdu, glide /j/ turns into a long vowel at word medial position and functions as the nucleus of the syllable. Hayward (2000) states that when /j/ occurs as nuclei in the syllable structure, it functions like a vowel while at onset and coda positions it works as a semivowel.

Hindko /r/ can be heard at three positions; however, word finally, as in /barr/ 'fly' /narr/ 'active' and /ʃarr/ 'dispute' etc, the tongue blade makes more vibration repeatedly against the alveolar ridge. On the other hand, in case of English, Davenport and Hannahs (2010) state that if /r/ is pronounced word initially, medially and finally in a variety of English it is known as rhotic accent of English whereas when /r/ is not pronounced word finally (as in bea*r*) and before a consonant (as in ca*r*t), it is called non-rhotic accent of English.

In case of the place of articulation of liquids and glides, the results of the present study show that /l/ and /r/ are produced at alveolar ridge and /j/ is articulated at palatal part of the oral cavity. On the contrary, Awan (2004) states that in Peshawari Hindko, /l/ and /r/ are articulated at dental position while /j/ is produced at a velar position (p.55).

5.3.3 Acoustic analysis of Hindko approximants

Hindko approximants, i.e., glide, lateral, liquid and flap, are acoustically analyzed in the following section:

5.3.4 Spectrographic analysis of Hindko approximants

Through the spectrographic analysis, intrinsic and extrinsic characteristics of Hindko approximants are scrutinized one by one in the following figures:

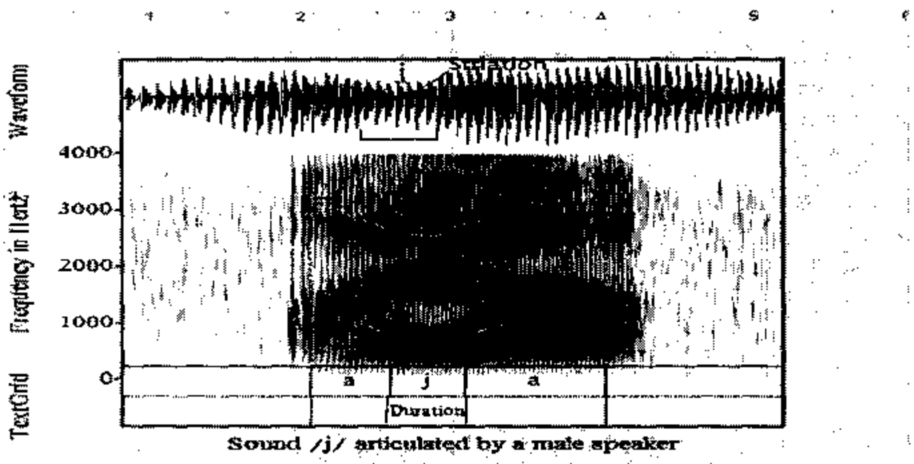


Figure 5. 15 Waveform and spectrogram of Hindko glide sound

Glide /j/ is the most widespread sound cross-linguistically. This sound can easily be distinguished from other consonants in the sense that its adjacent vowel formants, F1 and F2 connect with identical formants of /j/ having the same outstanding dark harmonics in the region of consonantal part and make an oval lips shape. However, the space within formants encircling part lingers somewhat white. Consequently, occurrence of formants dark energy in the region of /j/ is parallel to vowel feature.

F1 of intervocalic glide /j/ shows almost steady state or decrease, while neighbouring F1 remains slightly higher. Nevertheless, in case of preceding vowel /a/, F2 rises to the midpoint of consonant and then it falls towards onset of the following vowel. As a result, F2 reveals the highest point of the tongue raised toward the hard palate. The major spectrographic difference of /j/ is rise and fall of F2 on regular interval. Similarly, F3 of /j/ rises higher in the medial part while the preceding vowel formant falls at offset position and rises at onset of the following vowel. The horizontal black bar during the utterance of /j/ and pitch contour throughout the spectrogram shows that it has a voiced sound. Its waveform also shows regular striation which refers to the sonority and voicing feature of glide like vowels. The intensity bar (a yellow bar) remains higher at vowels position but lower at glide position (see Appendix, B).

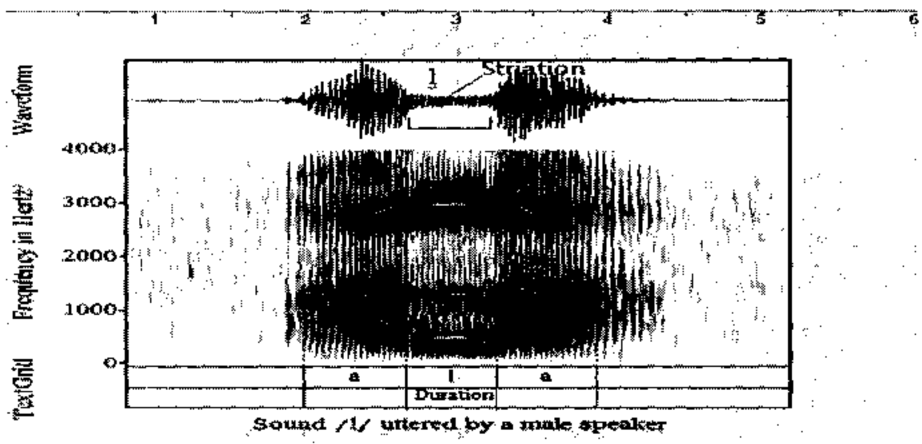


Figure 5. 16 Waveform and spectrogram of Hindko lateral sound

Figure 5.16 displays that F2 and F3 of lateral /l/ have steady state like its adjoining vowels. However, there is a quiet gap between both formants. F1 of lateral /l/ gets comparatively a lower position at the central place than preceding and following vowels. The difference between vowel and lateral can easily be observed in the spectrogram that adjacent vowels are darker than the consonantal part and the duration of /l/ is almost equal to both vowels. In addition, waveform gives a clear view of the difference between vowel and consonant. The place cues, formant transitions of F1 and F2 at both vowels are in level and F3 rises at offset position of the preceding vowel and falls at onset position of the following vowel. Spectrogram presents pitch contour that refers to the quality of voiced sound (see Appendix, B).

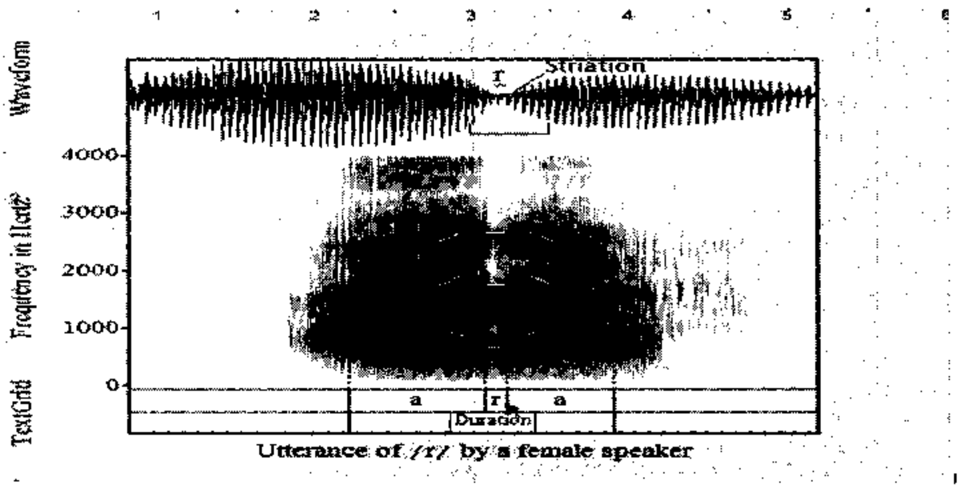


Figure 5. 17 Waveform and spectrogram of Hindko liquid sound

Figure 5.17 shows spectrogram of /r/ sound of Hindko and its formants of intervocalic part can be seen lighter than that of vowels. Unlike other approximants, harmonics of /r/ utterance are found in broken form. Moreover, above 3000 Hz, at the shear of left hand of /r/ towards the end of utterance, a small whitened part is an indication of liquid /r/ sound. Articulation of /r/ takes least duration not only among the approximants but also in all Hindko consonants. Like spectrogram, its waveform also indicates a small gap of consonantal part between neighbouring vowels. In some of the utterances, it was hard to distinguish consonantal part due to the less duration and the effect of preceding and following vowels. Furthermore, unlike /l/, the occurrence of F3 in /r/ is not much higher than F2. Formant transitions show rising of F2 and F3 at offset position of the preceding vowel while onset position shows mirror image. F1 at offset position shows level while a little falling during the following vowel. The pitch contour and intensity bar show falling and rising position at medial part of the consonant. Like other approximants, consistency in the pitch contour (see Appendix, B) and strong striation at waveform of /r/ reflects that it has a voiced sound.

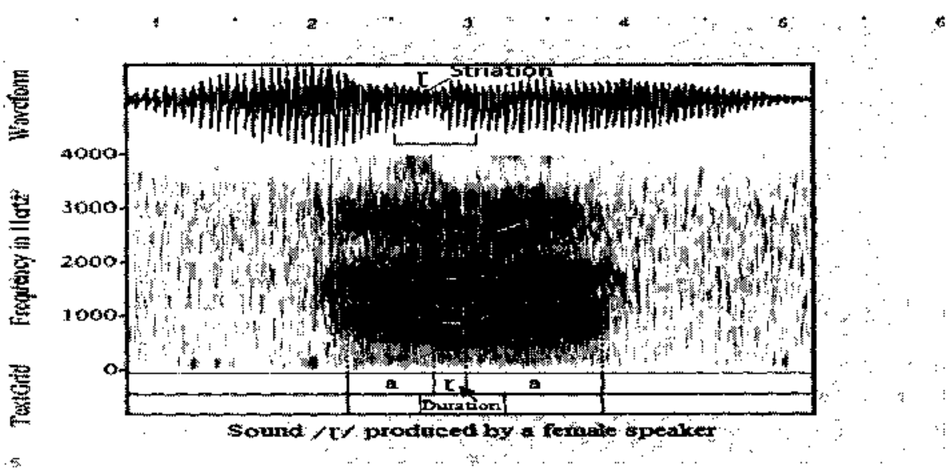


Figure 5. 18 Waveform and spectrogram of Hindko flap sound

The spectrogram of the flap /ɽ/ is almost similar to liquid /r/. However, its F2 has strong resonances which are similar to vowels. Overall, its position is darker like preceding and following vowels but in its upper part, there is a small whitish part in the beginning like liquid /r/ sound. However, it does not show a straight vertical line like /r/ at the offset of the preceding vowel rather white part has equal distribution at both sides.

Formant transitions show at the offset of preceding vowel, falling of F3 and rising of F2 whereas at the onset position, rising of F3 and falling of F2. On the contrary, F1 at the offset and onset positions show a little falling and rising but overall, like other approximants, it has a level position. The pitch contour (see Appendix, B) and the voice bar at the bottom of the spectrogram and a strong constriction in the waveform reflect that /ɽ/ in Hindko is a voiced sound.

5.3.5 Statistical measurement of Hindko approximant sounds

In addition to the visual representation, Hindko approximants were examined statistically by means of their first three formants.

Table 5. 19 Formants values of Hindko approximants (Hz); Means, Std. Dev. & Co. Var

Sounds	F1	Std. Dev.	Co.Var.	F2	Std. Dev.	Co.Var.	F3	Std. Dev.	Co.Var.
j	558	188.183	33.724	1779	126.574	7.113	2438	242.989	9.968
l	463	154.970	33.493	1419	166.881	11.759	2486	165.532	6.659
r	559	193.236	34.549	1490	166.678	11.187	2409	123.313	5.119
ɽ	592	209.344	35.337	1428	140.257	9.819	2246	246.717	10.982

The above table 5.19 presents frequency mean values of approximant formants, F1, F2 and F3 with standard deviation (Std. Dev.) and coefficient variation (Co. Var.). The coefficient variations of F1 are almost identical for all the sounds but quite higher than F2 and F3. On the other hand, coefficient variation of F2 and F3 are very much balanced. The following tables show the results of ANOVA test.

Table 5. 20 ANOVA for approximant sounds in terms of F1

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	112597.9	3	37532.62	1.067828	0.37248	2.816466
Within Groups	1546538	44	35148.58			
Total	1659135	47				

ANOVA table reveals p.value of F1 for approximant sounds is higher which depicts that F1 values are very similar to each other. Therefore, further analysis of pair test is not carried out.

Table 5. 21 ANOVA for approximant sounds in terms of F2

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1036870	3	345623.4	15.13827	6.57E-07	2.816466
Within Groups	1004569	44	22831.1			
Total	2041439	47				

The above ANOVA table shows that average mean values of F2 has significant difference as p-value is less than 0.01. In addition, LSD test is examined to view the discrepancies within the pairs.

LSD=135.7713

Segments	l	ɽ	r	j
Means of F2	1419.11	1428.359	1489.927	1779.349

The line, under /l/, /ɽ/, /r/, indicates that pairs of /l, ɽ/, /l, r/ and /ɽ, r/ are similar in terms of F2 whereas pairs of /j, l/, /j, ɽ/ and /j, r/ have different mean values. It reflects that /l/ takes least formant frequencies than others approximants whereas /j/ carries maximum frequency among others.

Table 5. 22 ANOVA for approximant sounds in terms of F3

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	388134.1	3	129378	3.184283	0.032943	2.816466
Within Groups	1787728	44	40630.19			
Total	2175862	47				

As p-value indicates that the approximantal sounds of Hindko are significantly different from one another at 0.05% but not at 0.01% level of significance. Therefore, LSD test is applied for further analysis.

LSD=181.121

Segments ɽ r j l

Means of F3	2246.376	2408.756	2437.646	2485.818

The test reveals that pairs of /ɽ, r/, /r, j/, /r, l/, /j, l/ have similar while /j, ɽ/, /l, ɽ/ carry different mean values. It shows that /ɽ/ get minimum and /l/ takes maximum formant frequencies. The measured mean values of approximants are put into a bar chart in the following section:

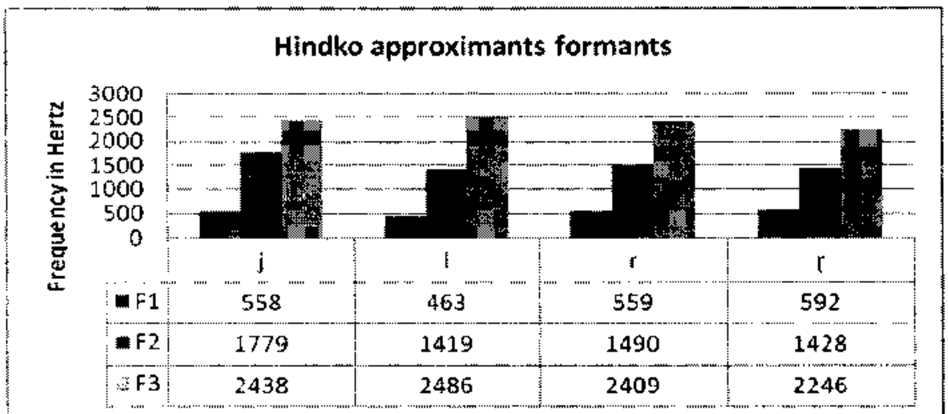


Figure 5. 19 Formant frequencies of Hindko approximants

The results in the figure 5.19 reflect that the low frequency value, F1 of glide /j/ is higher than F1 of lateral /l/ but lower than other two sounds. On the contrary, mean value of F2 of /j/ can be seen at the highest point among all segments. Average mean frequency of F3 for glide is shown without a prominent difference with lateral /l/ and liquid /r/ while flap retroflex /ɽ/ sound shows the difference of around 200 Hz than other sounds.

The results of lateral /l/ have the lowest means frequency of F1 and F2 than other segments whereas F3 is at the highest position in means frequencies. Liquid /r/ has higher mean values for F1 than /j/ and /l/, yet it is lower than /ɽ/. On the other hand, F2 is lower than /j/ but higher than /l/ and /ɽ/. Similarly, F3 is higher than /ɽ/ but lower than /j/ and /l/. Flap /ɽ/ has least mean frequency for F1 and F3 than others segments but F2 is higher than /l/ and less than /j/ and /r/ sounds.

In addition to the formant measurements, duration was measured statistically to distinguish approximants through utterance length. Average mean values are tabularized below:

Table 5. 23 Duration values of Hindko approximants; Means, Std. Dev. & Co. Var.

Approximants	Duration	Std. Dev.	Co.Var.
j	0.1179	0.0178	15.0836
l	0.0969	0.0083	8.6239
r	0.0425	0.0138	32.4085
ɽ	0.0458	0.0103	22.5817

Table 5.23 exhibits approximants mean values with standard deviation and coefficient variation. Duration of /j/ is longer than other approximants and /r/ carries minimum duration but coefficient variation of /r/ is more than other segments. The average means of these approximants are further verified by applying ANOVA test.

Table 5. 24 ANOVA for duration of approximant sounds

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.050787	3	0.016929	99.12516	1.34E-19	2.816466
Within Groups	0.007515	44	0.000171			
Total	0.058302	47				

As p-value is less than 0.01, therefore, all approximantal sounds are significantly different from one another. Further, LSD test is employed to examine similarities and differences within pairs of Hindko approximants.

LSD=0.011742735

Segments	r	ɽ	l	j
Means of Duration	0.04176	0.043933	0.096362	0.11912

The test shows that the pair of /r, ɽ/ have similar utterance duration whereas other pairs are different from one another. Furthermore, duration mean values of approximants are shown through bar chart for more clear view in the following:

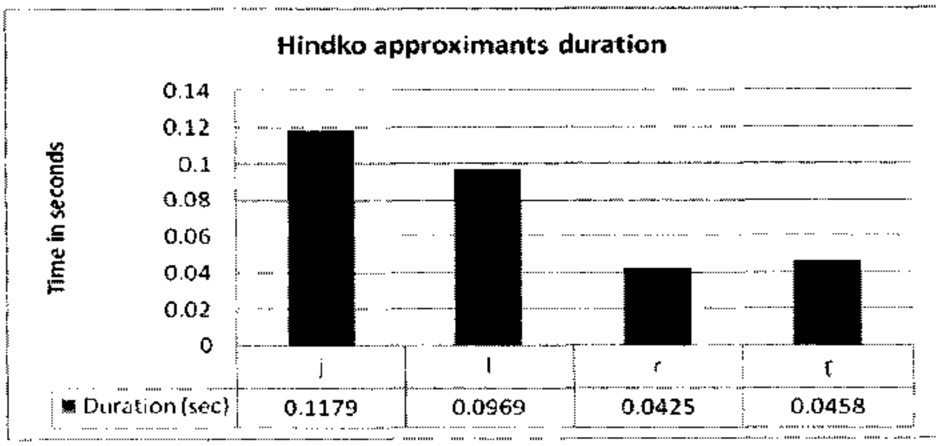


Figure 5. 20 Duration of Hindko approximants

Figure 5.20 shows that Hindko palatal /j/ takes maximum time during the utterance and alveolar /l/ carries less time than glide but more than retroflex /ɽ/. However, alveolar /r/ and retroflex /ɽ/ have relatively similar duration during the articulation. Overall, /r/ carries least duration among Hindko consonants.

Therefore, approximant sounds duration can be concluded in the following hierarchy: glide > lateral > flap > liquid. It can be said that temporal characteristic is also a helpful acoustic cue for Hindko approximants seeing that measurements reflect substantial difference among sounds articulation time.

5.3.6 Discussion on acoustic analysis of Hindko approximants

The analysis reflects that formant frequencies of approximants are found in the spectrographic region of 0-4000 Hz. Similarly, Harrington and Cassidy (1999) also state that formants of approximants occur within 4000 Hz. Hayes (2004) denotes that acoustic theories of approximants should be investigated through their formant structure (see Section, 2.5.5).

Thus, Hindko approximants were measured through their formant frequencies. It was also found that all Hindko approximants have low F1 like F1 of vowels. Yavas (2006) also indicates that approximant sounds carry low F1 like vowels (see Section, 2.5.5).

F2 of glide /j/, among all Hindko approximants, is at the highest position. It has (1779 Hz) frequency mean values which is somehow lower than Hindko oral vowel /i:/(2196 Hz). It implies that during the articulation of Hindko glide /j/, the tongue remains on high front position. Yavas (2006), Pisoni (2008) and Ladefoged (2003) denote that English /j/ has high F2 which is parallel to high front vowel /i:/ (see Section, 2.5.5). F1 of Hindko /j/ is higher than Hindko /i:/ and /I/ whereas F2 is lower than Hindko /i:/ but higher than /I/ (see Figure, 5). Nolan (1983) and Lehiste (1964) state that generally glide /j/ include lower F1 and higher F2 frequency than /i:/ and /I/ sounds.

The spectrographic analysis of Hindko /l/ sound lacks the acoustic energy above 500 Hz. Nolan (1983) and Lehiste (1964) also states that /l/ sound carries less acoustic energy. F1 of Hindko /l/ can be seen at the lowest position among approximants while means frequency of F3 remains at the highest position. However, utterance duration of glide /j/ carries more time than lateral /l/.

The spectrographic analysis of /r/ and /ɽ/ are almost identical. Nonetheless, major cue is the transition of F3 which falls during the preceding vowel of /ɽ/ and rises at its following vowel. On the other hand, transition of /r/ has mirror image. Similarly, /ɽ/ segment has wider part of whitish colour on its left side above 3000 Hz which is found in more horizontal position than vertical. F2 and F3 of /ɽ/ remain lower than /r/ sounds whereas F1 of /r/ is higher than /ɽ/ and both sounds carry less duration among others.

The results of formant transitions at adjacent positions, which is the place cue, show that F1 of approximants are almost in level position; F2 of three approximants /j/, /r/ and /ɽ/ show rising and falling positions while /l/ has level position. F3 of /j/ and /ɽ/ has falling and rising positions whereas /l/ and /r/ sounds have mirror image. Overall, spectrogram of /l/ carries less energy than other approximants and the spectrogram of /r/ was almost similar to neighbouring vowels due to its strong energy and short duration.

Comparison of approximantal consonants and vowels reveals that F1 of approximants is almost near to high Hindko vowels /i:, ɪ, e:/ but F2 is somehow different from vowels due to the front and back positions of vowels. These facts reflect that some acoustic cues are common between Hindko approximants and vowels (see Tables, 5.19 and 6.3). Findings of temporal analysis reflect that glide /j/ has maximum and /r/ carries minimum utterance time. Durational difference between flap /ɽ/ and trill /r/ is almost parallel, such as a minor utterance difference of 0.0033 seconds is found between these two sounds. On the whole, statistical measurements remained a quite helpful technique to show formants structure and temporal characteristics of Hindko approximants.

5.4 Segmental features of Hindko consonants

A segment is not a single entity rather a composition of various features. Since years, the use of features for the description of speech sounds remained a common practice among linguists. Linguists named them on various grounds such as acoustic, phonetic and distinctive features etc. The most elaboration of the features on a case-by-case basis is found in the works of Jakobson and Halle's (1956) distinctive features, Chomsky and Halle's (1968) articulatory features and Fant's (1973) acoustic features and so on. However, Calrk, et al. (2007) state that universal feature systems for sounds are based on the works of Jakobson and Halle (1956) and

Chomsky and Halle (1968). There are many other works which show relative description of sound features such as Giegerich (1993), Gussenhoven and Jacobs (1998), Ladefoged (2006) and Davenport and Hannahs (2010) etc. However, in the present study, the distinctive features are applied due to its binary nature.

According to Ashby and Maidment (2005), these features are like a checklist of sound properties. This list provides phonetic description of sounds and the most startling notion of these features are to be binary which reflect the values in form of plus (+) and minus (-). Plus shows that phonemes have the distinctive features whereas minus values negate the distinctive features of phonemes. Each sound has its own identity which shares simultaneously common and uncommon properties. For example, /p/ and /b/ are different in terms of the function of vocal cords, thus, /p/ is marked as – which refers to negation indicating that it is a voiceless sound and + is placed for /b/ sound showing that it is voiced sound and other features of both sounds are similar including manner of and places articulation. Furthermore, Cruttenden (2001) states that the distinctive feature matrices explain all the contrasts of a language having around 12 to 13 distinctions and these are common for all the languages.

Additionally, regarding the use of sound features, Clark, et al. (2007) argue, "Features are not uncontroversial labels for objective characteristics of speech but may be used in various ways to indicate the nature, status and functions of sounds within a linguist system" (p.373).

In light of discussed works, a brief detailed of these features is given in the following. However, the below given description of features is adapted from Davenport and Hannahs (2010, p. 94). These features are italicized with colons in this part of the study and then explanation is given one by one. *Syllabic:* In this feature, syllabic sounds are distinguished from non-syllabic segments. Vowels are the syllabic sounds which occur as nucleus in a syllable. *Consonantal:* Feature of consonants deal with those sounds that are articulated with the obstruction of air such as obstruent, liquids and nasals. *Sonorant:* Sonorous sounds, vowels, nasals, glides and liquids, allow differentiating them from non-sonorous sounds such as fricatives, affricates and stops. *Voiced:* Articulation of sounds related to glottal setting with vocal-fold vibration. *Anterior:* The production of sounds in front of the hard palate. *Coronal:* The utterance of segments with the blade of the tongue raised above its neutral position. *Continuant:* This feature deals with the articulation of sounds with free airflow in the oral cavity. *Nasal:* The sounds are produced with a lowered velum which allows the air stream to escape through the nose. *Strident:* Sounds which make frication during articulation. *Lateral:* The articulation of segments with the air obstruction in the central part of oral cavity and its air is released on either side of the tongue. *Delayed release:* This feature indicates the utterance of sounds with stop closure and frication. Keeping in view the above given segmental features, Hindko phonemes are tabulated in the following:

Distinctive Features	Features	Hindko Consonants																														
		p	b	pʰ	ɪ	ɖ	ʈʰ	ʈ	d	tʰ	k	g	kʰ	m	n	ɳ	ŋ	ʧ	ʤ	ʧʰ	f	v	s	z	ʃ	x	ɣ	ɦ	r	ɽ	j	l
Syllabic	Major classes	-	-	-	-	-	-		-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Consonantal		+	+	+	-	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sonorant		-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+
Voiced	Voi	-	+	-	-	+	-	-	+	-	-	+	-	+	+	+	+	-	+	-	-	+	-	+	-	-	+	-	+	+	-	+
Anterior	Places	+	+	+	+	+	+	+	+	+	-	-	-	+	+	-	-	+	+	+	+	+	+	+	-	-	-	-	+	-	-	-
Coronal		-	-	-	+	+	+	+	+	+	-	-	-	-	+	+	-	+	+	+	-	-	+	+	+	-	-	-	+	+	+	+
Continuant	Manner features	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	+	+	-	+	+	+	+
Nasals		-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Strident		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
Laterals		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Delayed release		-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-

Figure 5. 21 Distinctive features of Hindko consonants

The above figure 5.21 reflects that three consonants /m/, /ɳ/ and /l/ are syllabic while other 28 sounds are non-syllabic. Out of 31 consonantal sounds of the dialect, eight are sonorous sounds including nasals and approximants. All nasals and approximants of the dialect are voiced sounds. Similarly, four stops, one affricate and four fricatives are uttered with the vibration of vocal folds. Majority of the consonants are anterior, articulated at front part of hard palate and 18 coronal sounds are produced with the blade of the tongue. Continuant sounds, fricatives and approximants of the dialect are uttered with free air flow in the oral cavity and four nasals are articulated with lowering the velum. Affricates and fricatives of the dialect are strident segments having the involvement of frication in the articulation. All affricates sounds are uttered with delayed release that refers to frication and closure of air.

5.5 Chapter summary

The articulatory analysis of this chapter shows that Hindko has fricatives voiced and voiceless sounds. Two fricatives, voiceless /ʃ/ and voiced /ɦ/, lack the pairs while other six fricatives are found in pairs, as voiceless and voiced sounds. Overall, four are voiceless and four are voiced sounds. It has been found that Hindko affricates have three ways of voicing. Hindko approximants including glide, liquids and flap which are voiced sound and have no counterparts. Acoustic analysis has shown that 8 fricatives of the dialect include frictions; 3 affricates have also friction like fricatives and closure like stops; and 4 Hindko approximants have strong formant resonances, yet a little weaker than vocalic sounds.

In the following Chapter, Hindko vocalic inventory is developed on articulatory basis and then acoustically analyzed in the same Chapter.

CHAPTER 6

ANALYSIS OF HINDKO VOWELS

This chapter describes Hindko vowels system in terms of articulatory and acoustic phonetics. It shows the analysis of Hindko oral vowels, diphthongs and nasal vowels in articulatory phonetics. Oral vowels and diphthongs are further analyzed acoustically. It also presents distinctive features of oral vowels. Each section of the chapter shows discussions on the findings of the study.

6.1 Hindko oral vowels

In the vowel system, Hindko allows oral vowels, nasal vowels and diphthongs. Articulatory and acoustic phonetics analysis of oral vowels is taken into account in the following section:

6.1.1 Articulatory phonetics analysis of Hindko oral vowels

First, vowels of Tanoli Hindko are investigated in light of articulatory phonetics. This analysis is carried out in light of above mentioned concepts and theories regarding monophthongs, diphthongs and nasalization system of language (see Section, 2.4). Like consonantal part of the study, vowels are also identified on the basis of minimal pairs. Then investigated sounds are further evaluated in articulatory terms of distribution of vowel word initially, medially and finally. In this regard, Ladefoged (2001) describes that the best tool for the identification of vowels is to search them by contrasting sounds and also through the sets of words that rhyme. A list of minimal pair is prepared to identify oral vowels of the dialect in the following table:

Table 6. 1 Data of minimal pairs for Hindko oral vowels

Serial No	Vowels	Hindko Words	Gloss	Hindko Words	Gloss
1	/a/	att	Corner	ɪtt	Brick
2	/ɪ/	kaʈʈ ɪʈʰʈʰã:	Weave Here	ka:ʈ ʊʈʰʈʰã:	Big scissor There
3	/i:/	ʧʰɪpp bi:ɽa:	Big stone Button	ʧʰapp bɪɽa:	Hide Courtyard
4	/a:/	i:ɾi: a:kaɽɽ	His Pride	u:ɾi: ʊkaɽɽ	Him Remove
5	/o:/	ʈa:r o:lle:	Sunday/Cable There	ʈarr alle:	Swim Alas
6	/ʊ/	ʧo:r ʊtʰtʰ	Thief Stand up	ʧɪrr atʰtʰ	Crack Eight
7	/u:/	d̪ʊxx u:ɽi:	Pain Theirs	d̪æ:x o:ɽi:	See Big log
8	/æ:/	ku:ɾa: æ:ʤa:	Filth/liar Like this	ki:ɾa: o:ʤa:	Worm Like that
9	/e:/	sæ:r pe:	Kilogram Father	sa:r pæ:	Beam Follow/beat

The above table 6.1 shows different vowel pairs of Hindko. The contrastive sounds show nine oral vowels in Hindko, i.e. /i:/, /ɪ/, /e:/, /æ:/, /a:/, /a/, /o:/, /u/ and /u:/. The oral vowel inventory through minimal pairs shows the actual number of vowels of Hindko without any contradiction to each other. Each vowel emerges in identical phonetic environment and show single phonetic difference between the two lexical items. The table reveals not only the pair of words against each vowel but also the pairs of their distributional words. However, the vowel /e:/ has limited occurrence in Tanoli Hindko. A separate table for the distribution of sounds is given below in order to see the occurrence of vowels in different environments.

Table 6. 2 Data for distribution of Hindko oral vowels

Sounds	Word initial	Gloss	Word Medial	Gloss	Word Final	Gloss
/a/	att	Corner	kall	Yesterday	**NA**	
/ɪ/	ɪt̪ʰt̪ʰã:	Here	ʧʰɪpp	Big stone	**NA**	
/i:/	i:ɽi:	His/hers	bi:ɽa:	Button	gaddi:	Vehicle
/a/	a:la:	Hole	t̪a:r	Sunday/Cable	batta:	Stone
/o:/	o:le:	There	ʧo:r	Thief	ro:	Weep
/ʊ/	ʊtʰtʰ	Stand up	d̪ʊxx	Pain	**NA**	
/u:/	ʊdda:r	Birds' Cluster	ku:ɽa:	Filth	ru:	Writ
/æ:/	æ:ra:	Foundation	bæ:ra:	A piece of meat	sæ:	Porcupine
/e:/	NA		NA		ke:	What

Table 6.2 presents Hindko vowels in different environments. The position of each vowel is shown word initially, medially and finally. The distribution of segments /i:/, /a:/, /o:/, /æ:/ and /u:/ are found at each position of words. On the other hand, vowels /ə/, /u/ and /ɪ/ can occur at word initial and medial positions and /e:/ is found only word final position. Thus, structurally identified distribution shows the occurrence of the vowels at different possible positions.

Similarly, Awan (2004) has also investigated nine oral vowels for Peshawari dialect of Hindko including /a:/, /a/, /E/, /e/, /i:/, /i/, /o:/, /u:/, /u/. He identified these vowels on articulatory basis (see Appendix, A). He states that actual position of vowels is not possible without the use of machine. In Peshawari Hindko, vowel /e:/ can occur word medially whereas in Tanoli Hindko this sound has limited use and always occur word finally. Moreover, he used a vowel symbol /E/ which is unclear whether it is /æ:/ or /ɛ/. The identified oral vowels of Tanoli Hindko are further investigated in terms of acoustic phonetics in the following section:

6.1.2 Acoustic analysis of Hindko oral vowels

Like consonantal part of the study, Hindko oral vowels are also analyzed in terms of spectrographic analysis and statistical measurements. A view of spectrograms through visual analysis is given in the following part:

6.1.3 Spectrograms of Hindko oral vowels

A sample of Hindko vowel spectrograms is given below to show formants position of vowel segments.

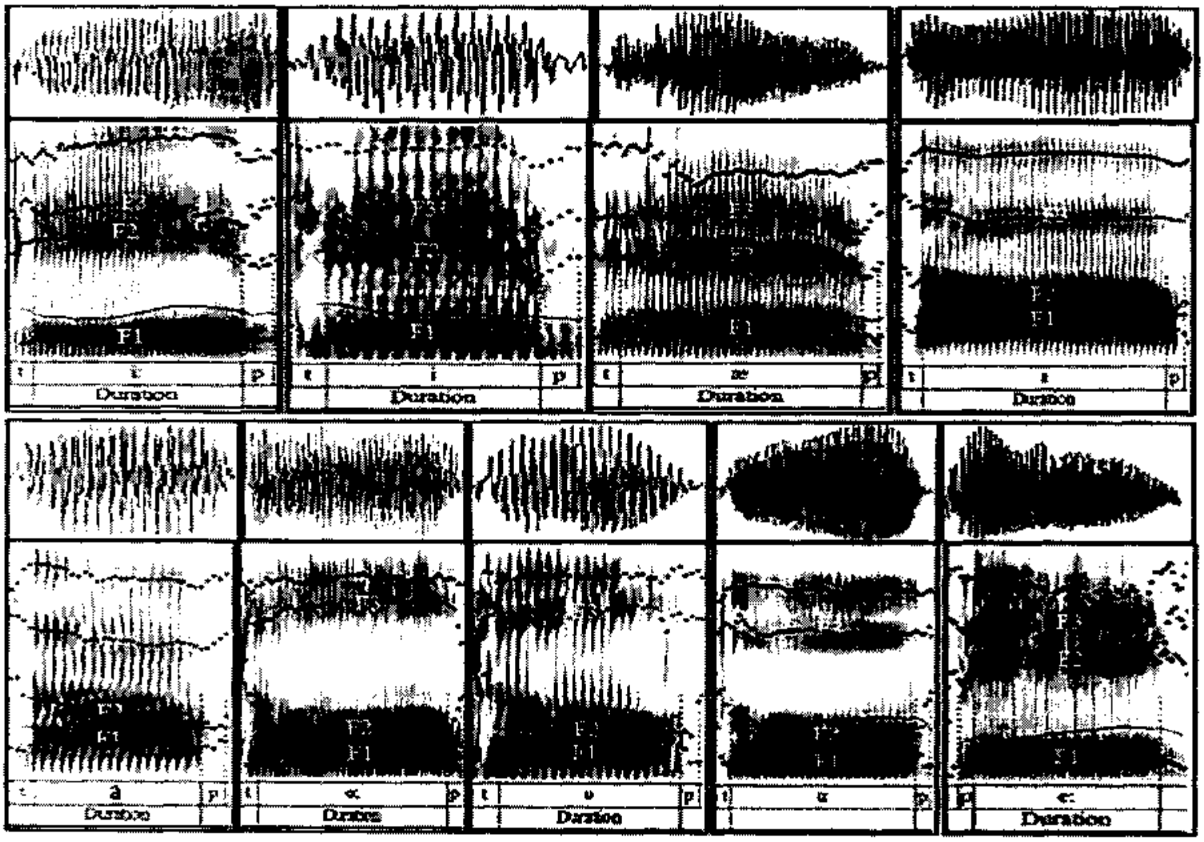


Figure 6. 1 Spectrograms and waveforms of all Hindko oral vowels

The above figure 6.1 shows the spectrograms of all Hindko oral vowels. The text grids in the lower part of each spectrogram clearly indicate the boundaries for CVC and duration of the utterances. The formant contours can be prominently seen in all oral vowels. Front vowel /i:/ and back vowel /u:/ show the lowest F1 while the highest F2 for /i:/ but the lowest for /u:/. F1 for the central vowels, /a/ and /a:/, remains higher than all other vowels and their F2 is close to each other. Furthermore, F1 of /æ:/ and /o:/ seems almost in same level. Spectrogram of back vowel /ʊ/ shows higher F1 contour than its front counterpart /ɪ/. However, /e:/ vowel show higher F2 but less F1 than its position as it supposed to be. At the same time as shown in its spectrogram, this sound has different consonant, i.e. /p/ initially and /e:/ finally in CV sequence instead of CVC sequence, t-vowel-p, because Tanoli Hindko allows /e:/ sound only word finally not word medially or initially. In addition, waveforms show periodic waves which refer to the vocal folds vibration during vowel utterance while adjacent consonants lack this feature. Furthermore, formant contours reflect that F3 of front vowels is lower than back vowels.

6.1.4 Statistical measurements of Hindko oral vowels

Hindko oral vowels are statistically measured to know the mean values of first two formants. The numerical summary of F1 and F2 with standard deviation and coefficient variation are tabulated in the following table:

Table 6. 3 F1 & F2 values of Hindko oral vowels (Hz); Mean, Std. Dev. & Co. Var.

Vowels	Formant 1 Means	Std.Dev.	Co.Var.	Formant 2 Means	Std.Dev.	Co.Var.
i:	385	69.879	18.153	2196	94.413	4.299
ɪ	487	58.644	12.033	1981	198.146	10.003
e:	458	37.813	8.251	2113	216.335	10.236

æ:	601	78.069	12.992	1878	149.918	7.982
a:	774	87.390	11.298	1309	166.873	12.752
a	735	69.779	9.488	1360	166.024	12.207
o:	602	79.239	13.168	1028	134.354	13.063
ʊ	560	83.4769	14.910	1086	113.680	10.468
u:	492	62.67663	14.421	1002	72.437	7.226

The above table 6.3 depicts the average mean frequencies of F1 and F2 of oral vowels with standard deviation and coefficient variation. These means values are further determined by ANOVA in the following:

Table 6. 4 ANOVA for oral vowels in terms of F1

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1843049	8	230381.1	49.68085	9.25E-33	2.025247
Within Groups	500820	108	4637.222			
Total	2343869	116				

Similar to the previous test in table 6.4, ANOVA table also confirms that there is significant difference of average mean frequencies values of F1 for oral vowels. Therefore, further analysis is carried out by LSD test.

LSD=61.189

Segments	/i:/	/u:/	/e:/	/ɪ/	/ʊ/	/æ:/	/o:/	/a/	/a:/
Means of F1	384	434	458	487	559	600	601	735	773

Table 6. 5 ANOVA for oral vowels in terms of F2

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	22913778	8	2864222	123.2897	5.74E-48	2.033295
Within Groups	2299933	99	23231.64			
Total	25213711	107				

ANOVA Table for F2 shows significant difference as p-value is less than 0.01. Thus, it confirms that oral vowels have different frequencies for F2. Furthermore, LSD test is employed to find out the differences within pairs.

LSD=136.9570418

Segments	/u:/	/o:/	/ʊ/	/a:/	/a/	/æ:/	/ɪ/	/e:/	/i:/
Means of F2	1002	1028	1085	1308	1360	1878	1980	2113	2196

The above mentioned description shows that average mean frequency values of the tongue height, i.e. F1 increases from /i:/ to /a:/ and then gradually decrease to the last vowel /u:/. On the other hand, average mean frequency of the tongue position during the utterance, i.e. F2 shows maximum frequency in upper vowels of the table while minimum mean values in lower vowels. The relation between the values of each segment can be seen more clearly in the following chart:

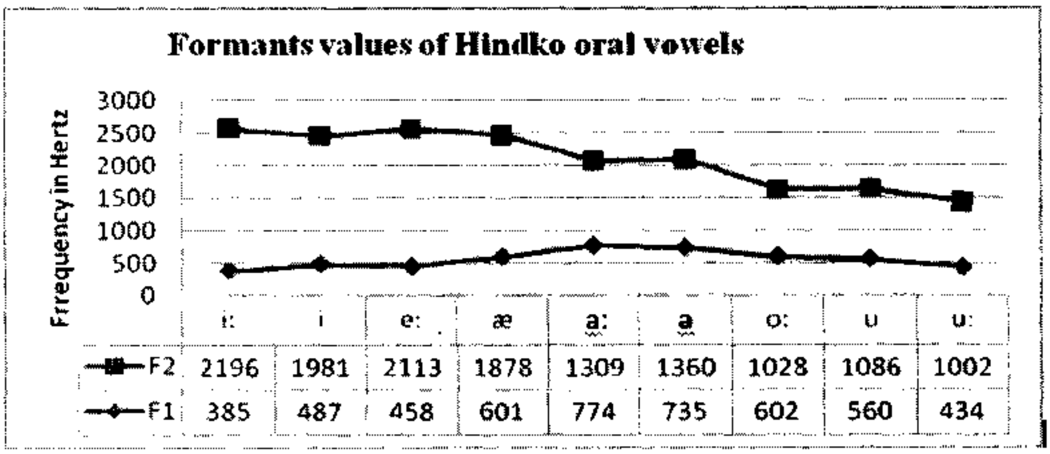


Figure 6. 2 Sequential comparison of formant values

Figure 6.2 exhibits that F2 of front vowels, at the left hand, have higher mean frequency while back vowels, at the right hand, have minimum means frequency values. In case of F1, front and back vowels have less mean frequency than central vowels. In the following section, for the quadrilateral of vowels, frequency of F1 is plotted on the vertical axis while F2 is placed on the horizontal axis as shown in figure 6.3:

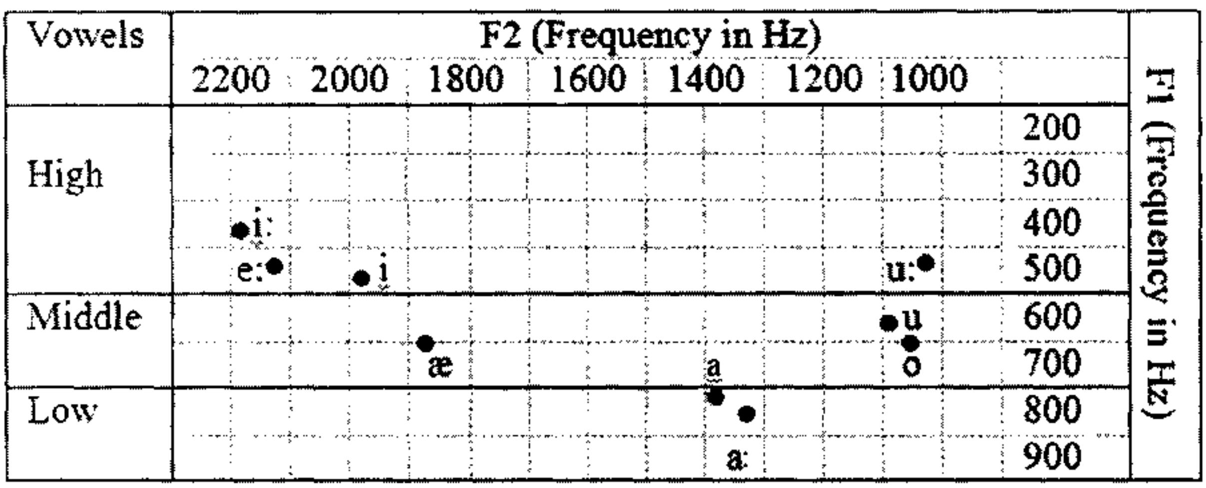


Figure 6. 3 Plot of Tanoli Hindko oral vowels

Figure 6.3 reveals the vertical and horizontal location of each vowel. Thus, in light of above developed plot, the spectral characteristics of the oral vowels are drawn in the following quadrilateral to know right position of each segment in the vowel space. The function of F1 is to identify in terms of height of vowels, i.e. either low, mid, or high vowels; or high vowels verses low vowels and open vowels verses and close vowels; while F2 shows the relationship front vowels verses back vowels.

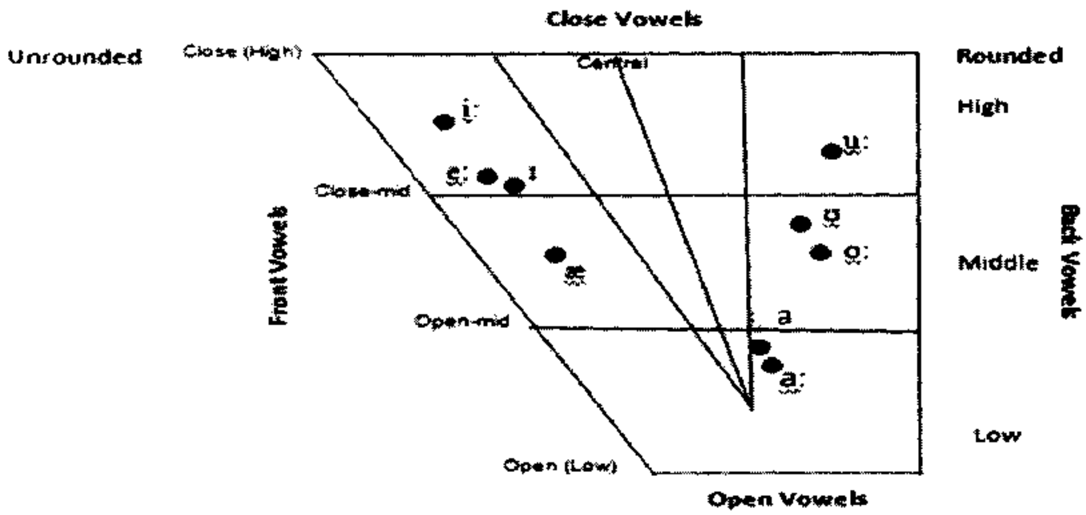


Figure 6. 4 Tanoli Hindko vowels quadrilateral

Figure 6.4 depicts the location of each vowel in the diagram. Generally speaking, vowels are produced by raising the some part of tongue toward the upper part of the oral cavity. The quadrilateral shows the height of the vowels in form of F1, i.e. high vowels, /i:/, /ɪ/, /e:/, /ʊ/ and /u:/ have low F1 whereas low vowels /a/ and /a:/ have high F1 frequency (see Table, 4.9). On the other hand, horizontal location of the vowels is identified on the basis of F2 frequency which refers to the part of tongue in the articulation of vowels. Front vowels have high F2 frequency while back vowels have low F2 frequency (see Table, 4.9). Therefore, on the basis of F1 and F2 values, vowels get their location in vowel trapezium.

The quadrilateral shows four vowels height such as close, close-mid, open-mid, and open vowels. Hindko front unrounded /i:/ is the high close vowel while /e:/ and /ɪ/ are close-mid vowels. The segment /i:/ is located higher than /e:/ and /ɪ/ sounds and stand as the most front close vowel. Thus, these are maximum vowels in a part of vowel trapezium. In contrast, back rounded vowel /u:/ is located at the left higher part of diagram near to close-mid vowel. It is the most back vowel in the quadrilateral.

Hindko has four high vowels, three are produced at front position while one is at the back region of oral cavity in horizontal position which has been pointed out by F2 measurement whereas vertically, these vowels such as /i:/ remains higher than /u:/ and /ɪ/ stands lower than /e:/ in the quadrilateral measured by F1.

Middle part of quadrilateral shows /æ:/ sound located between the region of close-mid and open- mid vowels somewhat back to front part of trapezium. Likewise, back rounded /o:/ vowel is also found with the same height as front /æ:/ located in the same level of the diagram. Similarly, in the back middle part of the figure, sound /ʊ/ is found higher than /o:/ near to the mid-close position yet a bit far from the right corner to the central part.

Therefore, horizontally /æ:/ occurs at the one end while /o:/ at the other end of the quadrilateral and /ʊ/ has a little more frequency than /o:/ sound. On the other hand, vertical position of middle sounds show higher frequency for /ʊ/ than /æ:/ and /o:/ sounds.

The lower part of figure has two sounds, i.e. /a/ and /a:/ near to the open-mid location in the central position of the diagram. In horizontal position, /a:/ has less frequency than /a/ sound, thus, marked in more back part of the figure. On the contrary, vertically, /a/ has less frequency than /a:/ sound and get higher location in the vowel trapezium.

Rashid (2011) investigated nine vowels through acoustic analysis of Hindko dialect of Azad Jammu and Kashmir. These vowels are /i/, /I/, /e/, /æ/, /a/, /ə/, /o/, /ʊ/ and /u/. However, vowels location of Kashmiri Hindko dialect is different from the present study (see Appendix, Λ). In summary, in light of the preceding acoustic analysis, the qualities of vowels are categorized in the following table:

Table 6. 6 Spectral characteristics of Hindko oral vowels

Vowels	Height of Tongue -F1	Position of Tongue-F2	Lips position
/i:/	Front	High	Unrounded
/ɪ/	Front	Close-mid	Unrounded
/e:/	Front	Close-mid	Unrounded
/æ:/	Front	Mid	Unrounded
/a:/	Central	Open-mid	Neutral
/a/	Central	Open-mid	Neutral
/o:/	Back	Mid	Rounded
/ʊ/	Back	Close-mid	Rounded
/u:/	Back	Close-mid	Rounded

Table 6.6 shows the qualities of nine Hindko oral vowels with the position of tongue, height of tongue and the lips position. Statistically measured oral vowels, indicated by a dot and symbols on the quadrilateral, reflect the quality of each vowel which refers to vertical (F1), i.e. height of tongue and horizontal (F2), i.e. positions of the tongue. The above table also shows the description of lip positions whereas the quadrilateral lacks the lip position. It is possible, therefore, to observe the lips during the utterance of vowels. According to Ashby and Maidment (2005), vowels quadrilateral do not reveals the lip position yet it can be considered the position of the tongue within the mouth with lip position that establish the vowel quality.

In a nutshell, Hindko has four front unrounded vowels with high, close-mid and mid positions. Conversely, there are three back rounded vowels with high, close-mid and mid positions whereas two vowels are neutral having open-mid and central location on the vowel space.

6.1.5 Temporal characteristics of Hindko oral vowels

In the present study, in addition to the acoustic analysis of the vowels qualities in terms of frequencies, duration of the oral vowels was also measured. The procedure applied for formants frequencies measurement was also employed to measure the temporal characteristics of oral vowels. However, statistically vowels formants are measured through the central frequencies whereas vowels duration is measured by the length of the vowel utterances. The results of durational measurements are tabulated in the following table:

Table 6. 7 Duration values of long and short vowels (sec); Mean, Std. Dev. & Co. Var.

Vowels	Length of Vowels	Means in Seconds	Std. Dev.	Co.Var.
/i:/	Long	0.203	0.033	16.767
/ɪ/	Short	0.098	0.013	13.770
/e:/	Long	0.256	0.037	14.724
/æ:/	Long	0.222	0.026	12.020
/a:/	Long	0.226	0.028	12.566
/a/	Short	0.11	0.022	20.093
/o:/	Long	0.232	0.036	15.622
/ʊ/	Short	0.103	0.021	20.706
/u:/	Long	0.21	0.042	20.285

The above table 6.7 depicts average mean values of the utterance time of oral vowels with standard deviation and coefficient variation. Difference of duration within oral vowels is further verified by ANOVA.

Table 6. 8 ANOVA for oral vowels in terms of duration

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.371225	8	0.046403	50.02961	1.96E-31	2.033295
Within Groups	0.091824	99	0.000928			
Total	0.463049	107				

The above table indicates p-value for vowels duration is less than 0.01. It confirms that duration of vowel sounds has significant difference. This difference is further analyzed by LSD test to find out which pairs have similarities and differences from one another.

LSD=0.027366

Segments	/ɪ/	/ʊ/	/a/	/i:/	/u:/	/æ:/	/a:/	/o:/	/e:/
Means of duration	0.098	0.103	0.110	0.202	0.209	0.221	0.226	0.232	0.255

The results show that pairs of short vowels have similar duration and have different values form the pairs of long vowels. This contrast between short and long Hindko vowels is given in the following chart:

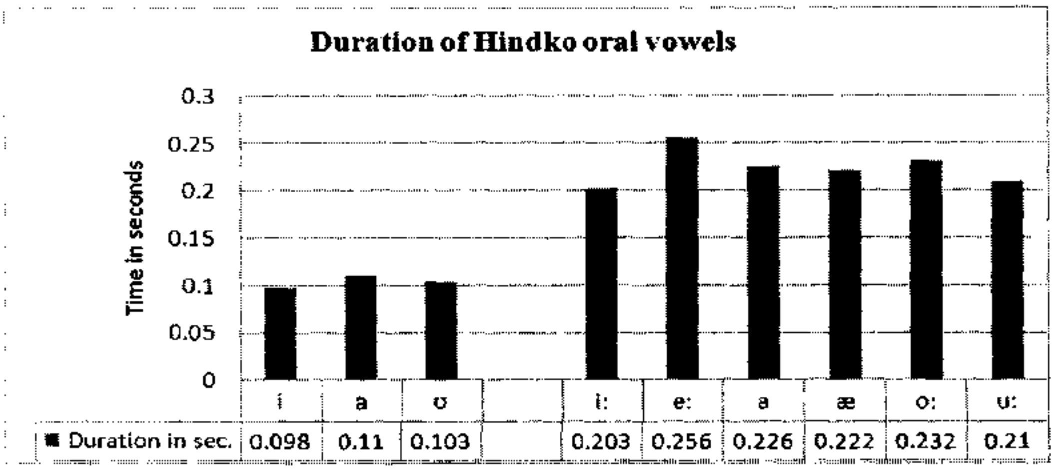


Figure 6.5 Spectral characteristics of Tanoli Hindko oral vowels

Hindko oral vowels are categorized into two lengths, short and long. Three vowels, /ɪ/, /a/ and /ʊ/ are short in duration whereas six vowels, i.e. /i:/, /e:/, /æ:/, /a:/, /o:/ and /u:/ have long duration. The result shows that short vowels have half duration of their longer counterpart sounds as indicated in terms of means and bars in the above figure. Such as long /i:/ and /ɪ/ vowels, /a:/ and /a/ sounds, /ʊ/ and /u:/ segments. Thus, it is interesting that the long vowels have double duration than the short. The front unrounded /e:/ sound shows the longest duration which is may be due to the presence of this sound in the data in CV sequence. On the other hand, all the long vowels carry almost similar durational time and the short vowels too. In CVC sequence, minute observation reveals that low vowels tend to be longer than Hindko high vowels. In light of investigated data, Hindko oral vowels are also described in terms of features.

6.1.6 Hindko vocalic features

General description of the sound features and specifically about consonants is given in the previous chapter (see Section, 5.4). The vocalic features of vowels including height, backness, roundedness and length are set out in the following section:

The works of many linguists depict the description of vowel qualities in terms of binary features. In this regard, Ashby and Maidment (2005) indicate that in addition to class feature, i.e. syllabic and consonantal, the major features of vowels are /+/- high/, /+/- low/, /+/- back/, /+/- round/. They also state that it is obvious, segments which have neither high nor low position in the vowel space, would be the middle sound. Davenport and Hannahs (2010) describe high, low, back, front, round and tense features for vowels. Thus, Hindko vowels are analyzed in light of these features in the following:

Table 6.9 Distinctive features of Tanoli Hindko oral vowels

Features	Hindko vowels								
	/iː/	/ɪ/	/eː/	/æː/	/aː/	/a/	/oː/	/ʊ/	/uː/
Syllabic	+	+	+	+	+	+	+	+	+
Consonantal	-	-	-	-	-	-	-	-	-
High	+	+	+	-	-	-	-	-	+
Low	-	-	-	-	+	+	-	-	-
Back	-	-	-	-	-	-	+	+	+
Front	+	+	+	+	-	-	-	-	-
Round	-	-	-	-	-	-	+	+	+
Tense	+	+	+	+	+	-	+	-	+

The above table 6.12 reveals the binary features of Hindko vocalic part. The checklist shows plus values in the syllabic feature of the table, thus, all vowels are syllabic whereas consonantal part shows minus values that refer to non-consonantal sounds. The vocalic features in form of plus values (+) reflect that four vowels carry high place in the vowel space, two vowels get low positions, three vowels are articulated at the back part of mouth, four sounds are uttered at the front part of oral cavity, lips positions are get rounded for three segments, and seven vowels have long duration in the utterance. Contrary to it, all minus values (-) against the features negate that features in vocalic sounds. In addition, two sounds /a:/ and /a/ have minus and plus values for both back and front features meaning that they are central sounds. Similarly, /æ:/, /o:/ and /ʊ/ sounds have minus values for low and high features representing that they are middle sounds.

6.1.7 Discussion on the analysis of Hindko oral vowels

During the articulatory analysis, phonemes of Hindko oral vowels were identified by finding a contrast between vocalic sounds. The analysis established nine oral vowels in Tanoli Hindko. One long vowel /e:/ occurs only at word final position and three short vowels, /ɪ/, /a/ and /ʊ/ are found word initially and medially, while other vowels /i:/, /e:/, /æ:/, /a:/, /o:/ and /ʊ/ occur word initially, medially and finally. Awan (2004) in Peshawari Hindko and Rashid (2011) in Kashmri Hindko also identified nine oral vowels.

Studies on other dialects of the language also show the same oral vowel inventory. For example, Awan (2004), on Peshawari dialect of Hindko, and Rashid (2011), on Kashmri dialect of Hindko, report nine oral vowels. There is a discrepancy in the use of the symbol for the vowel sound, for example, found in the word /məll/ or /mall/ 'rub'. According to Awan, it is a short vowel /a/ whereas Rashid writes it schwa /ə/. In the researcher's opinion, the symbol /a/ is more appropriate than schwa /ə/ and, thus, used in the present study. According to Pullum and Ladusas (1996, p. 3), /a/ is universally used by indologists for the short mid (or lower-mid) central unrounded vowel of Indic languages such as Hindi. They mention Fairbanks and Misra (1966) who write ‹kab› for the Hindi word meaning 'when' as IPA [kəb] or [kɐb]. The sound /a/ in Hindi word ‹kab› is quite similar to Hindko sound /a/. In some

American writings, /a/ is used as a low back unrounded vowel but for Crothes (1978), it is a low central vowel, IPA shows it as [ɐ] (p.3).

The researcher had lengthy discussions on this issue with colleagues and teachers in Pakistan as well as Professor at SOAS, University of London (whether it was /a/, /ɐ/, or /ə/ sound). Keeping in view the place of this tricky vowel at the vowel trapezium in Tanoli Hindko (see Figure, 6.4), the sound seemed to be quite closer to the symbol *Turned A*, i.e. /ɐ/. The revised version of IPA 1996 shows it as central unrounded vowel; higher than Cardinal 4, lower than Cardinal 3 (see Pullum & Ladusas, 1996, p. 295); however, this symbol /ɐ/ is rare in practice (p. 6).

Based on its articulatory and acoustic aspects (both temporal and spectral characteristics through the process of plotting); therefore, the symbol /a/ is used in the present research which is a short low central vowel in Tanoli Hindko (see Figure, 6.4).

In case of Urdu language, Kachru (1987) (cited in Fatima & Aden, n.d), and Hussain's (1997) studies show ten oral vowels, three are short and seven are long. In Hindko dialects, there is no difference in the vowels inventory but comparing the vowel inventory of Hindko with Urdu, there is a little variation. In case of vowels of other languages of the world, Ladefoged (2001) states that languages have much variation in the number of vowels such as aboriginal languages of Australia has three vowels, Hawaiian and Zulu have five vowels. He also states that about 20% of world languages have five contrasting vowels. He further states that German and Swedish have greater number of vowels and the Dutch dialect of Weert has 28 vowels in which 12 are long, 10 are short and 6 are diphthongs. English has also rich vowels phonemic inventory containing 12 pure vowels (Roach, 2000). Comparing Hindko vowels with English and some other languages show that there is much variation in number of vowels inventory and their temporal characteristics.

In the present study, the results of the statistical measurement of nine vowels show the location of Hindko oral vowels in vowel space. The quadrilateral reveals three high front vowels, i.e. /i:/, /e:/ and /ɪ/. However, majority of languages has two sounds, /i:/ and /ɪ/ at right top front corner of vowel space, i.e. between cardinal vowels 1 and 2. Each language has its own vowels characteristics such as /i:/ in German take higher position in vowel space than English in terms of F1 and F2 (Davenport and Hannahs, 2010).

Tanoli Hindko long unrounded /i:/ sound occurs lower and more central than these two English and German. Referring to the primary cardinal vowel 1, the quality of Hindko /i:/ vowel indicates medial position between close and close-mid, and in the centre of front and central vowel. Rashid (2011) identifies means frequency for /i:/ sound, i.e. F1-351 Hz and F2-1350 Hz and its counterpart /ɪ/ has F1-440 Hz and F2-1371 Hz in Hindko dialect of Kashmir. Thus, in case of F1, both Hindko dialects are almost near to each other while F2 of Kashmiri dialect is quite different from Tanoli Hindko (see Table, 6.3).

Like many languages, Hindko tense vowel /i:/ has its lax counterpart /ɪ/ segment. Both monophthongs are found in the possible space of the cardinal vowel no 1. Thus, /ɪ/ occurs very near to the primary cardinal vowel no 2, and remains more central than front position. Rashid's works shows that /ɪ/ vowel in Kashmiri Hindko carries somewhat higher and more central position than Tanoli Hindko. However, English /ɪ/ sound remains higher than Tanoli Hindko in terms of F1 but almost equal in F2.

Hindko allows front unrounded long /e:/ sound but its occurrence in the vowel space is quite different from many other languages. English has short /e/ vowel between the region of cardinal vowels 2 and 3. Similarly, in most of the languages, this sound occurs between close-mid and open-mid vowels in the trapezium. However, the findings of Kashmiri Hindko by Rashid shows the position of /e/ sound which is quite similar to the present study in terms of F1-460 Hz but different in position of tongue, i.e. F2-1289 Hz (see Table, 6.3). Likewise, Bradlow (1995) compares the mean frequency of Spanish and General American English vowels and he describes that Spanish has /e/ sound while General American English has both /ɪ/ and /e/ segments. Average means frequency values for Spanish /e/ vowel is F1-458 Hz and F2-1814 Hz while General American English /e/ segment has F1-430 Hz and F2-2200 Hz. Therefore, like Spanish, Tanoli Hindko has very similar vowels height in terms of F1, articulatory speaking which represents vowel height, but somewhat different in case of F2 in vowel position (see Table, 6.3).

General American English has lower mean frequency for /ɪ/ vowel, i.e. F1-463 Hz and F2-1995 Hz. Therefore, similar to General American English, Tanoli Hindko has higher mean frequency for /ɪ/ vowel in terms of F1-463 Hz and F2-1981 Hz than Hindko long /e:/ segment, i.e. F1-458 Hz and F2-2113 Hz. Similarly, Italian /e/ and Irish /e:/ also occur above cardinal vowel 2 in the vowel formants charts.

In the vertical hierarchy, results displayed in Hindko vowels quadrilateral (see Figure, 6.4) that /ɪ/ occurs lower than /e:/. It is also quite similar to the results of Californian English (see Figure, 2.3). However, these results are different from cardinal vowel 2 that Hindko /e:/ occurs higher than /ɪ/ sound, i.e. above close-mid position in the vowel space. However, /e:/ occupies more anterior position than /ɪ/ segment. Overall, high frontal portion of Hindko vowel trapezium is rich in segments. As mentioned earlier, that /e:/ in Tanoli Hindko cannot occur word medially and initially rather takes place only word finally. That's why data for identification of /e:/ had been recorded in CV sequence not in CVC sequence as the data for was recorded for other vowels of the study. Hence, due to the sequential change, /e:/ shows the highest length among vowels (see Figure, 6. 5). Similarly, Hayes (2009) denotes, "Vowels are typical shorter when they are followed by consonants in their syllable" (p.251). Awan (2004) and Rashid (2011) describe /e/ sound as mid-front vowel in Peshawari and Kashmiri Hindko. Rashid recorded data for /e/ sound word medially which reflects that it is possible sound at word medial position in Kashmiri Hindko.

This phenomenon of vowel occurrence not at medial position is quite complicated for native speakers of Tanoli Hindko while they speak in English because their vocal system does not allow them to utter the front mid /e/ vowel at ease, and at the right place in CVC sequence. It has also been observed while they speak in English, they produce such sounds by using extra energy of the air pressure from the lungs; however, it's easy for them to produce /e:/ word finally.

Hindko allows rounded long /u:/ sound at the back of the quadrilateral in the parallel location of unrounded high front vowels. It has minimum frequency in terms of position of tongue and gets the most back part of vowel space. Formants chart of English and many other languages show two sounds, long /u:/ and its short version /ʊ/ located at the top upper right side of the chart. Hindko also allows the primary cardinal vowel 8 and its counterpart /ʊ/. Hindko /u:/ occurs at the possible space of the cardinal vowel 8 whereas /ʊ/ finds place in the middle of vowel space between primary cardinal vowels 6 and 7. Vowel /u:/ is located near to the close-mid than close. Therefore, its vertical location, i.e. vowel height is lower and less back in vowel position than General American, Californian and British English.

Additionally, vertical location of Hindko rounded short /ʊ/ is different not only from Englishes but also other languages of the world. The findings of /ʊ/ in Kashmiri Hindko also reveal less F1 frequency (F1-433 Hz) than Tanoli Hindko but almost similar frequency in terms of vowel position, i.e. F2- 1036 Hz whereas Tanoli Hindko means frequencies are F1-560 and F2-1086 Hz. Therefore, the present analysis reveals the position of /ʊ/ sound lower than close-mid vowel and more central than back. Hence, higher mean frequency of /ʊ/ in terms of F1 shows that Tanoli Hindko rounded lax /ʊ/ has a distinctive position in the realm of formant charts.

Hindko oral vowels quadrilateral shows /æ:/ sound in the middle part of the trapezium between vowel cardinal vowels 2 and 3. However, IPA shows this vowel higher than Cardinal vowel 4 (IPA [a]), more open than Cardinal vowel 3(IPA [ɛ]) (Pullum & Ladusaw, 1996, p.12). In British English, its position is found in the lower region termed as low open-mid vowel and in Californian English indicates this sound near to open vowel region. Yavas (2011) describes the location of /æ:/ sound low open-mid and more centralized in Dutch, middle front open-mid for French, middle close-mid and central for Cantonese (see Figure, 2. 2). In case of Kashmiri Hindko, Rashid indentifies average mean values for /æ:/ sound, i.e. F1-521 Hz and F2-1251 Hz, which is different from Tanoli Hindko (see Table, 6.3 & see Appendix, A). Overall, it can be concluded that location of Tanoli Hindko /æ:/ sound is very near to French and Cantonese.

Furthermore, the unrounded back counterpart of /æ:/ is a long /o:/ sound which occur between cardinal vowels 6 and 7. Thus, Tanoli Hindko /o:/ stands for the cardinal vowel 7. Interestingly, both sounds, /æ:/ and /o:/, have similar mean values for F1 which refers to the vertical dimension in the vowel space. Both segments, /æ:/ being unrounded long anterior vowel and /o:/ as rounded long posterior vowel take very central position in the vowel space region (see Figure, 6.4). Long /o:/ of English occurs higher in vertical position and more back in horizontal location than Tanoli Hindko /o:/. However, in some languages such as Sindhi, /o:/ stands as rounded high vowel. Tanoli Hindko high /ʊ/ becomes mid vowel while Sindhi mid /o:/ becomes high vowel. Thus, these results confirm that vowel location vary in the languages. Rashid investigated F1- 490 Hz and F2-970 Hz for /o:/in Kashmiri Hindko, thus, F1 of both dialects are quite different but almost similar in terms of F2 (see Table, 6.3).

Of the remaining two segments, long /a:/ and its short counterpart /a/ cannot be marked as front or back vowels because they get the medial position at the bottom side of the quadrilateral (see Figure, 6.4). Both vowels are located in the central part of the quadrilateral between cardinal vowels 5 and 6. In addition, segment /a/ is found higher than /a:/ and both vowels get distinct location in the vowel place and much different from other vowels due to the acoustic parameters F1 and F2. Tanoli Hindko /a:/ is also found at central position but it is not similar to cardinal vowel no 4 and 5 rather it has its own identity that both sounds occur in the same region. In Tanoli Hindko, like other languages such as Chinese, /a:/ is different than cardinal and English vowels as it is at more central position. The previous study carried out by Rashid (2011) shows these two vowels as central sounds indicating their values as F1-647 and F2-1136 Hz for /ə/, and F1-671 Hz and F2-1130 Hz for /a:/ sound.

The acoustic analysis shows that Tanoli Hindko has centripetal vowel system which is similar to English. For the position of English vowels in the quadrilateral, Saadah (2011) states that many studies show that English has centripetal vowel pattern which implies that occurrence of vowels is near the centre of vowel space. On the other hand, he also opines that

Tamil, Russian and Spanish have centrifugal system which refers to occurrence of vowels at the periphery of the acoustic space and Arabic vowel system falls in between both systems.

Overall, Acoustic analysis is a successful parameter in distinguishing the position and height of the vowels in the vowel trapezium. The qualitative and quantitative differences of Hindko oral vowels to reference cardinal vowels and English vowels systems show it a distinct vowel system. Ashby and Maidment (2005) states that vowels quadrilateral is a good tool for investigating the quality of the vowels yet have more inclination towards the auditory space than the accurate articulatory one.

In case of duration of vowel, Hindko long vowels have almost double duration than the short vowels. Davenport and Hannahs (2010) highlight that long vowels mostly remain 50-100 percent longer than the short vowels. Generally, all analyzed vowels of Hindko have normal duration in between 0.09 and 0.25 seconds because recoded data include unaspirated stops at the both sides of vowels such as /ti:p/, /to:p/ etc. Similarly, about the effect of adjacent unaspirated consonants, Ashby and Maidment (2005) describe that English word /ice/ has shorter duration than that in /eyes/ because the preceding word has diphthong /ai/ followed by /s/ as /ais/ whereas following words is followed by /z/ as /aiz/. They further describe that this difference in the voicing is due to the final consonants, termed as pre-fortis clipping; and it is the regular features of many languages including majority of English accents. Therefore, it reflects that voiced consonants in the following of a vowel lengthen its utterance duration.

Hindko oral vowel also includes combination of two vowels that refers to diphthongs.

6.2 Hindko Diphthongs

There are two types of diphthongs, phonemic and phonetics diphthongs. Phonetics diphthongs seem the by-product of morphophonemic operation, which is beyond the limitations of the present study. However, a brief view is also given in the present part of the study for the orientation purposes. On the other hand, phonemic diphthongs are analyzed phonetically and acoustically respectively.

6.2.1 Articulatory analysis of Hindko diphthongs

In the following section, minimal pairs are developed for diphthongal sounds of Tanoli Hindko:

Table 6. 10 Data of minimal pairs for Hindko diphthongs

Sounds	Words in Hindko	Gloss	Words in Hindko	Gloss
/ei/	kei	Hoe	kai	A type of tree
/ai/	bai	An arm of cot	bei	Stale

The above table 6.10 indicates the minimal pairs of Hindko diphthongs. Both diphthongs have contrastive sounds and phonemic in nature. Moreover, these diphthongs are not found in different environments such as word initially, medially and finally rather they occur only word finally. However, morphologically Hindko also allows the occurrence of /ai/ at word medial position, e.g. /maija:/ 'song', /kaija:/ 'try'. In addition to the minimal pairs, some more examples are also given for the justification of these two diphthongs as phonemes.

Diphthong /ei/ is found in words like /makkei/ 'maze', /rei/ 'left', /sei/ 'ink/know', /pei/ 'all right' and /laɽɽei/ 'unarranged heap of wood' etc. Similarly, second diphthong, /ai/ occurs as a phoneme in words like /lukka:i:/ 'slope', /t̪a:i:/ 'uncle's wife', /na:i:/ 'barber',

/ʧʰa:i:/ 'ashes' and /t̪alla:i:/ 'mattress' etc. Though Hindko allows these two diphthongs, yet their occurrences are limited in the language. Additionally, in some cases these sounds also occur due to morphological operation. For example, diphthong /bai/ has a root word /ba:/ 'lay down', /rai/ has root word /ra/ 'pertaining to cultivation'.

Contrary to it, some more diphthongs are found in Hindko on phonetic grounds. Such as Hindko allows /i:/ sound at word final position, with the unification of /ʊ/, yet pronounced as single sound, which is the marker of feminine gender. Like /ʧʊi:/ 'female-rat', /bʊi:/ 'brown coloured female', /kʰʊi:/, 'small well' etc. On the other hand, the occurrence of /a:/ sound with /ʊ/ at final position mark masculine, e.g. /ʧʊa:/ 'rat-male', /bʊa:/ 'brown coloured male', /kʰʊa:/, 'big well' etc. Therefore, combination of /i:/ and /a:/ with /ʊ/ make the sounds as /ʊi:/ and /ʊa/ in Hindko, and /i:/ inflects for feminine and /a:/ for masculine.

Similarly, these two vowels, /i:/ and /a:/, are also found diphthong finally with vowel /o:/ and the occurrences of these two vowels with root words in verbal cases, mark past and future tense respectively. For example, if /i:/ is added with the following root words, /mallo:/ 'mix', /pro:/ 'weave', it will be turned to past tense in the form of /mallo:i:/ 'mixed', /pro:i:/ 'weaved', /no:i:/ 'not had been done'. Conversely, if /a:/ is placed with the same root words, it becomes future tense. Like, /mallo:a:/ 'to be mixed', /pro:a:/ 'to be weaved', /no:a:/ 'may not be done'. Additionally, by adding /i:/ with /o:/ in root words refers to feminine gender in past tense, e. g. /mo:/ 'die' and /mo:i:/ 'died-female' as well. Hence, unification of /i:/ and /a:/ with /o:/ termed as /o:i:/ and /o:a:/ in Hindko. Preceding combination inflects past tense while following indicates future tense.

In addition, the use of /a:/ with root words and some common words ending with /o:/ termed as singular while /e:/ represents plural. For instance, /po:a:/ 'a type of plant' /po:e:/

'plants', /d̪o:a:/ 'second thing/person', /d̪o:e:/ 'second things/persons' and /to:a/ 'touch', /to:e/ 'touches'. Moreover, by placing /e:/ to the root word in verbal case also indicates masculine gender in past tense such as /ko:/ 'slaughter' and /ko:e:/ 'slaughtered masculine animals'. Thus, /a:/ at final position of a word with /o:/ can be marked as /o:a/ singular and /e:/ refers to plural as /o:e:/ and combination of /e:/ with /o:/ inflects plural.

By placing /e:/ after /a:/ of a root word in a verb also refers to past tense and plural as well. Such as /ba:/ 'put-present', /ba:e:/ 'put-past', /na:/ 'do not come', /na:e:/ 'did not come'. Similarly, by adding of /e:/ at the end of verbal root word after /i:/ and /a/, a singular word changes into plural as a politeness marker as well. For example, /pi:/ 'drink-singular' and /pi:e:/ 'drink-plural/please drink', /ʤi:/ 'live long', /ʤi:e:/ 'live long-plural/may live long', /kha:/ 'eat-singular', /kha:e:/ 'eat-plural/please eat. Hence, /e:/ makes the combination of /a:e:/ and /i:e:/ in form of diphthong.

Likewise, after /a:/ in root verbal words, the use of /u:/ inflects noun/adjective in Tanoli Hindko, /kʰa:u:/ 'glutton', /la:u: buʤʤa:u:/ 'trouble maker', /pʰra:u:/ 'aim without target', /ʧa:u:/ 'a person who lifts weight'. Hindko has also verb containing /e:/ word finally. Such words are changed by placing /i:a:/ in place of /e:/ and make them interrogative words. For example, /se:/ 'sleep' is the root word and by placing /i:a:/ instead of /e:/, it becomes interrogative /si:a:/ 'sleep?', /ni:a:/ 'come?', /tʰi:a:/ 'present ?' etc. In addition to interrogative inflection, this operation also refers to presence or availability of the marked thing or person.

In addition to the combination of oral vowels, nasal vowels also make diphthongs on the basis of phonetics. For example, /aũ:/ is found in words like /kʰaũ:/ 'eat', /ʧaũ:/ 'lift/pick', /baũ:/ 'lie down', /nasaũ:/ 'let it escapes', /o:ĩ: / in /kaɳso:ĩ:/ 'listening to others in hidden way' and /i:ã/ occurs in words like /d̪i:ã/ 'tomorrow', /si:ã/ 'lion', /ki:ã/ 'how' and /pi:ã/

'drink' etc. Thus, three phonetic diphthong, /aũ:/, /o:ĩ: / and /i:ã/ in Hindko nasalization are found.

However, if diphthongs are taken into account on the basis of phonetics and morphological grounds, the following diphthongs occur in Hindko: /ʊi:/, /ʊa/, /o:i:/, /o:a/, /o:a/, /o:e:/, /ae:/, /i:e:/, /o:a/, /o:e:/, /ae:/, /i:e:/, /aũ:/, /o:ĩ:/ and /i:ã/. If further analysis is carried out which include the morphology of Hindko; various more functions of vowels combination are anticipated. Generally, the objective of the present study is to identify phonemes of Hindko without including its morphology. In a nutshell, phonemically only two diphthongs, /ai/ and /ei/ were investigated in Hindko. Both diphthongs are also analyzed acoustically in the following section:

6.2.2 Acoustic analysis of Hindko diphthongs

Like consonants and oral vowels of Tanoli Hindko, diphthongal segments are also analyzed acoustically.

6.2.3 Spectrographic analysis of Hindko diphthongs

The spectrograms of two diphthongs are displayed in the following for visual purpose:

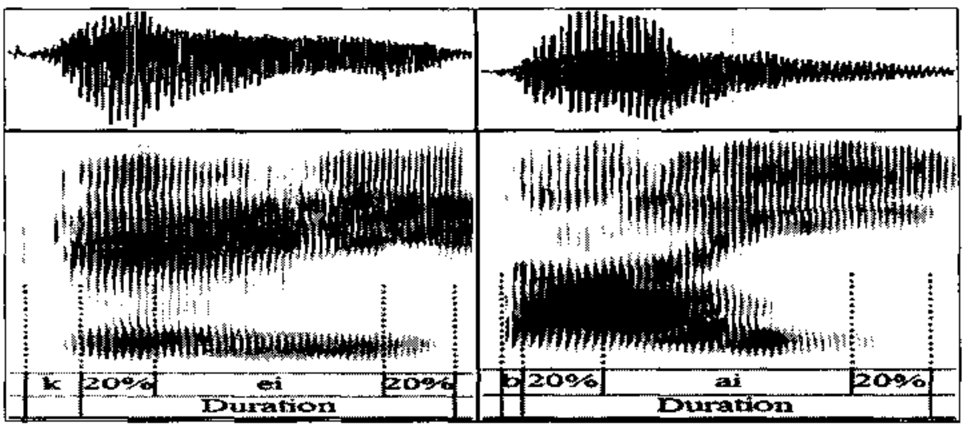


Figure 6.6 Waveforms and spectrograms of Hindko diphthongs

The figure 6.6 shows the spectrograms and waveforms of Tanoli Hindko diphthongs. F1 in both cases has higher position in the beginning than the ending part of the utterances. It is due to the movement of diphthong from a low quality to high one. Conversely, F2 at the first part of sounds have lower frequency than second part of the sounds. It implies that frequency moves from low to high. Both diphthongs have continuous glides in starting and ending points throughout the utterances. The first part of both sounds shows up formants as more dark bands than the second part. At the very beginning, both sounds have stop consonants /k/ and /b/ respectively. Thus, within a syllable, the utterance of combined vowels, i.e. diphthong shows change from one quality to another over the course of duration.

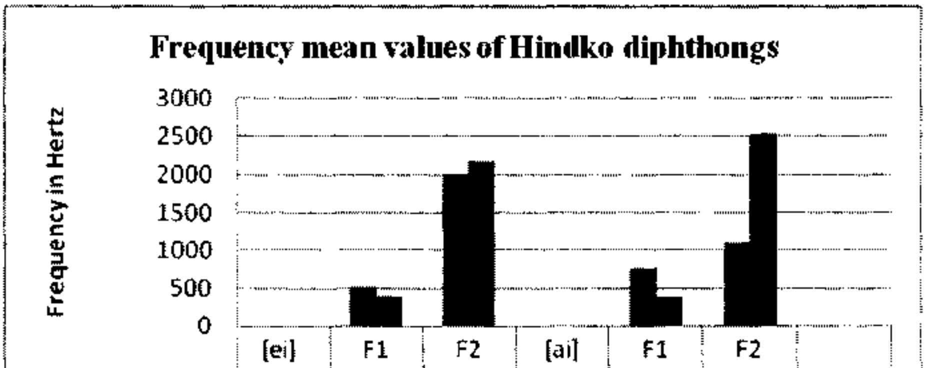
6.2.4 Statistical measurements of Hindko diphthongs

Diphthongs are measured statistically in terms of F1 and F2 to see the formants position. Average mean frequencies are given in the following table:

Table 6. 11 Hindko diphthongs, F1 & F2 frequencies in Hertz and duration in seconds

Sounds	Points	F-1	F-2	Total Duration
/ei/	Starting	520	1988	0.302 sec.
	Starting	402	2171	
/ai/	Ending	752	1102	0.27 sec.
	Ending	373	2536	

Table 6.11 reveals average mean frequency values of Hindko diphthongs /ei/ and /ai/. The following graph presents comparison of these values.



	[ei]	F1	F2	[ai]	F1	F2
Starting point		520	1988		752	1102
Ending point		402	2171		373	2536

Figure 6.7 Formants comparison within diphthongs

The figure 6.7 depicts bars with mean values of two diphthongs, i.e. /ei/ and /ai/ sounds. During the articulation of /e:/, the close-mid sound, and /i:/, almost high sound , height of the tongue , i. e. F1 remains very near to each other because both are front unrounded sounds. In case of position of the tongue, i.e. F2, both sounds occurs very near to each other. Therefore, the present results of the combination of both vowels /e:/ and /i:/ in form of diphthong /ei/ show that F1 starts at high position and descends to low position and F2 begins from the low position in the starting point and rises to high position in the region of ending point. In addition, the lips posture remained unrounded during the articulation of /ei/. However, F1 frequencies of both sounds /e:/ and /i:/ in form of diphthong /ei/ are higher than single utterance whereas F2 frequencies are lower in double sound than single.

Other diphthong /ai/ is the combination of central and front vowels. The central vowel /a:/ has higher F1 and front vowel /i:/ has low F1 which descends from high to low position. On the contrary, F2 of central vowel /a:/ shows lower position and front vowel /i:/ gets higher mean frequencies values. Hence, in case of F1, diphthong /ai/ moves from low quality to high quality whereas in terms of F2, the tongue moves from the central position to front one and lips are changed from almost rounded position to unrounded posture. Both diphthong makes the combination of long vowels such as Vowels- Vowel, (abbreviated as VV) template.

6.2.5 Discussion on Hindko diphthongs

The articulatory and acoustic descriptions of diphthongs show that Tanoli Hindko has two diphthongs as a phonemic entity. Although these diphthongs exist in Hindko, yet phonemically, they have limited use in the language. However, morphologically, it is commonly found in Hindko. Thus, these results show the facts of sub-continent languages that lack the use of diphthongal sounds as a phoneme. Such as Bokhari (1991) and Alam (1997) state that phonemically Urdu language has no diphthong. Likwise, Hussain (n.d) states that diphthongs in Urdu are still to be explored. Awan's (2004) does not show diphthongs for Peshawar Hindko while Rashid (2011) investigates three diphthongs in Kashmiri Hindko dialect, i.e. /oɪ/, /aɪ/, /ʊa/: However, the present study finds two diphthongs, i.e. /aɪ/ and /ei/ while /oɪ/ and /ʊa/ are used phonetically not phonemically. On the other hand, unlike Hindko English allows eight diphthongs.

Maddieson (1984) denotes that diphthongs are rarely found in the phonemic inventory of the world's languages (see Section, 2.4.2). Similarly, Clark and Yellop (1995) state that if a language has less than ten vowels; it may not have diphthong (see Section, 2.4.2). Therefore, English allows more than ten oral vowels and it has phonemic inventory of 8 diphthongs (Roach, 2000). On the other hand, Hindko has nine and Urdu include ten oral vowels, thus, rarely allow diphthongs.

From this, it can be said that languages of sub-continent have very limited use of diphthongs on phonemic ground. However, if diphthongs are investigated phonetically or morphologically, more diphthongs are expected in Tanoli Hindko. Such as Rashid (2011) identified five more diphthongs in addition to three phonemic diphthongs, i.e. /ʊɪ/, /oe/, /ae/, /aʊ/, /ɪə/ in Kashmiri Hindko dialect. Likewise, Waqar and Waqar (2003) identified 13 vowels in Urdu on the same basis.

The acoustical investigation of diphthongs in the present study shows that vowels of starting points are darker than the ending points. These findings are similar to the views of Ladefoged (2001). Spectrograms show that Hindko diphthongs have continuity in glides. Similarly, Brinton and Brinton (2010) also state that diphthongs are articulated as continuous segment (see Section, 2.5.7).

6.3 Hindko nasal vowels

In combination with single and double vowels, Hindko includes nasal vowels as distinctive segments and nasalized vowels, i.e. assimilation of nasal consonants. These vowels are analyzed in the following section:

6.3.1 Articulatory analysis of Hindko nasal vowels

Hindko nasal vowels are investigated on the basis of minimal pairs in the following:

Table 6. 12 Data of minimal pairs for Hindko nasal vowels

Sounds	Words in Hindko	Gloss	Words in Hindko	Gloss
/ã:/	d̪ã:	Dodge	d̪ĩ:	Sun
/ĩ:/	rĩ:	A type of tree	rã:	Deer
/ũ:/	lũ:	Shivering	lẽ:	Weeping
/õ:/	ʤõ:	A type of crop	ʤũ:	Lice
/ẽ:/	d̪ẽ:	Curd	d̪ĩ:	Sun
/ʊ̃/	kʊ̃nd	Curve	kãnd	Waist
/æ̃:/	ræ̃:nd̪a:	Residing	rõ:nd̪a:	Weeping
/ə̃/	bə̃ɳɳ	Make deal	bõɳɳ	Weave
/ɪ̃/	bɪ̃ŋg	Bend	bã:ŋ	Crow

The above table 6.12 reveals that Hindko vowels system has also characteristic of nasalization. Each vowel, either nasal or nasalized, can be found in minimal pairs. The given examples of contrastive sounds reflect five nasal vowels, i.e. /ã:/, /ĩ:/, /ũ:/, /õ:/, /ẽ:/. These sounds are found without adjacent nasal stops; therefore, they are phonemic in nature. In addition to the above tabulated examples, some more words are also added for these phonemes. Such as /ã:/ (/ã:/-really ?, /rã:/- deer, /t̪ã:/- that's why, /bã:/- arm, /hã:/- ok), /ĩ:/ (/rĩ:/- a type of tree, /sĩ:/- lion, /tĩ:/- pertaining to weeping), /ũ:/ (/ʤũ:/- lice, /a:rũ:/- peach, /t̪ũ:/- you), /õ:/ (/sa t̪t̪õ:/- a type of flour, /ʤõ:/- a type of crop), /ẽ:/ (/ẽ:/- how, /hẽ:/ what, /nẽ:/-not available) .

Data also shows the minimal pairs of other four vowels, i.e. /æ̃:/, /ʊ̃/, /ə̃/, /ɪ̃/. Unlike the preceding discussed nasal vowels, these sounds cannot stand-alone as nasal vowels rather get effect by the nasal features of the adjacent consonants. In other words, there is regressive effect on these vowels. Hence, these sounds, one long /æ̃:/ and three short vowels /ʊ̃/, /ə̃/, /ɪ̃/, are termed as nasalized vowels.

Unlike English language, these nasalized vowels make effect on the meaning of the words in Hindko. Furthermore, most of the time these nasalized vowels are in complementary distribution with oral vowels. Such as two sounds, a nasalized vowel and an oral vowel cannot occur in the same environment. Overall, it can be concluded that Hindko has five nasal vowels and four nasalized vowels.

For further classification of nasalization, these vowels are distributed in different position of occurrence in the following table:

Table 6. 13 Data for distribution of Hindko nasal vowels

Sounds	Word initial	Gloss	Word Medial	Gloss	Word Final	Gloss
/ã:/	ã:m	Ordinary	t̪ã:ɳã:	Straight	bã:	Arm
/ĩ:/	**NA**		rĩ:ŋ	Crying	sĩ:	Lion
/ũ:/	ũ:nd̪a:	Theirs	t̪ʰũ:m	Garlic	t̪ũ:	You
/õ:/	õ:d̪a:	Pig	rõ:ɳã	Weeping	sat̪t̪õ:	Flour of barley
/ẽ:/	**NA**		**NA**		mẽ:	I
/æ̃:/	æ̃:nd̪a:	Coming	sæ̃:nd̪a:	Sleeping	**NA**	
/ĩ/	ĩnnã:	Him (polite sense)	bĩŋg	Bend	**NA**	
/ã/	ãmm	Mango	ʧãnd	Sharp	**NA**	
/õ/	õnnã:	Them	mõnd	Foundation	**NA**	

Table 6.13 shows that /ã:/, /ũ:/, /õ:/ can found word initially, medially and finally. However, nasal /ĩ:/ cannot occur word initially whereas /ẽ:/ gets position only word finally. On the other hand, all nasalized vowels, /æ̃:/, /ĩ/, /ã/ and /õ/, hold positions word initially and medially but not word finally.

In addition to the minimal pairs and distribution of sounds, a contrast between oral and nasal vowels is also carried out in the following part:

Table 6. 14 Data for contrast of oral and nasal vowels

Sounds	Words	Gloss	Words	Gloss
/ã:/	bã:	Arm	ba:	Lay down
/ĩ:/	tʰĩ:	Available	tʰi:	Is
/ũ:/	bũ:	Buzzing	bu:	Stench
/õ:/	ʤõ:	Barley	ʤo:	Whichever
/ẽ:/	lẽ:	Weeping	le:	Plough

Table 6.14 presents contrast between oral and nasal vowels. Therefore, only nasal vowels can make contrast with their oral counterparts. Nasal /ã:/ is commonly found in Hindko in contrastive position with its oral counterpart /a:/ such as /ba:/ 'lay down', /bã:/ 'arm' , /ʧa:/ 'tea', /ʧã:/ 'hold', /ra:/ 'way', /rã:/ 'ploughing' etc. Other nasal vowels also make freely contrast with oral vowels but their occurrences are limited in Hindko. On the other hand, nasalized vowels do not make contrast with oral vowels.

6.3.2 Discussion on Hindko nasal vowels

The articulatory analysis of nasalization system of vowels shows that Tanoli Hindko has five nasal and four nasalized vowels. Five nasal vowels and one nasalized vowel have longer utterance duration while three nasalized vowels take shorter duration. Nasal vowels can contrast with oral counterparts whereas nasalized vowels cannot. Similarly, nasal vowels are found progressively and regressively as well while nasalized vowels get only regressive effect of adjacent consonants.

Three short Hindko oral vowels /ɪ/, /a/, /ʊ/ and one long vowel /æ:/ are allophonically nasalized when adjoining to nasal consonants. Furthermore, if a vowel is followed by nasal consonants, it becomes nasalized vowel in Hindko. Overall, in Hindko, many words cannot be transcribed without nasal or nasalized vowels. Therefore, it can be said that it is an obligatory part of Hindko.

The findings of the present study are similar to nasal sounds identified by Awan (2004) in Peshawari Hindko. He identifies nine nasal vowels by showing nasal counterparts for each oral vowel. However, his study lacks the classification of these sounds in terms of nasal and nasalized sounds. Rashid (2011) identifies five nasal vowels in Kashmiri Hindko but does not give any detail of nasalized vowels.

Contrary to the findings of nasal part of Hindko, English does not allow nasal vowels. Ball and Rahilly (1999) state that English has no nasal phonemes. Ladefoged (2003) argues that English nasalized vowels make no distinction in lexicon of oral and nasal vowels. Conversely, some other languages such as French, Portuguese, Polish and Navanjo allow contrast between nasal and oral vowels with different lexical items (Davenport & Hannahs, 2010). Similarly, the phenomenon of nasal vowels as phonemes is commonly found in languages of subcontinent such as Urdu, Punjabi, Hindi and Pahari etc. In summary, it can be concluded that five nasal vowels of Hindko are phonemic in nature and these segments are the part of its phonemic inventory.

For the acoustic analysis of Hindko nasal vowels, the researcher recorded the data by developing a list in the following sequence, CV, CVC and CV. The detail of the recoding list is as follows:

Sound	Recording	Gloss	Sound	Recording	Gloss
/ã:/	/d̪ã:/	Dodge	/æ̃:/	/læ̃:ɳ/	Deal
/õ:/	/t̪õ:nd̪/	Fog	/ʊ̃/	/ʊ̃nd̪a:/	Theirs
/ũ:/	/lũ:nɽ/	Salt	/ɪ̃/	/ɪ̃nd̪a:/	His/Her
/ẽ:/	/mẽ:/	I	/ə̃/	/ə̃nɽĩ:/	A small bone in body
/ĩ:/	/d̪ĩ:/	Sun			

The data was recorded in Praat software and analyzed F1 and F2 of nasal sounds. The results show that F1 values of nasal vowels were higher than the oral vowels whereas F2 mean values of nasal vowels were lower than the oral vowels. The formant values of both nasal and oral vowels are given in the following. The results can be compared for discrepancies.

Nasal vowels	F1	F2	Oral vowels	F1	F2
ĩ:	485	2013	i:	385	2196
ɪ̃	421	1590	ɪ	487	1981
ẽ:	640	1210	e:	458	2113
æ̃:	728	1742	æ:	601	1878
ã:	840	1378	a:	774	1309
ã	775	1445	a	735	1360
õ:	730	1182	o:	602	1028
ʊ̃	433	1405	ʊ	560	1086
ũ:	637	1110	u:	492	1002

The comparison of both nasal and oral vowels shows that F1 values of nasal vowels, except /ɪ̃/, is higher than that of oral vowels. On the contrary, F2 values of nasal vowels, except /ã:/, /æ̃/ and /õ:/, is lower than F2 of oral vowels which are against the general concepts of nasality in existing literature on nasalization. For example, Johnson (2003) argues that the oral tract (oral vowels) has resonances at about 500, 1500 and 2500 Hz while the nasal tract (nasal vowels) has resonances at about 400, 1200 and 2000 Hz. This means that the mean values of nasal vowels should be lower than that of the oral vowels. However, the measurements of Tanoli Hindko nasals show major variation in the high raised values of F1. The F2 values of some nasal vowels correspond to the existing literature on nasality. Ladefoged (2001) states that the second formant of nasal vowels is found at lower level than that of oral vowels.

It is suggested that a detailed acoustic study on Hindko vowel nasalization system should be carried out separately, which may address the question of nasality. Furthermore, the study may focus on the features of Hindko nasalization.

6.4 Chapter summary

Results of vowels inventory show that Hindko spoken in Tanawal allows nine oral vowels, five nasal vowels and two diphthongs. In addition to the nasal vowels, the study also reflects four nasalized vowels in Tanoli Hindko. Acoustical results of oral vowels show three short and six long vowels. Five long vowels, /i:/, /æ:/, /a:/, /o:/, /u:/ can occur word initially, medially and finally whereas one vowel /e:/ gets only word finally position. Contrary to it, short vowels /ɪ/, /a/ and /ʊ/ are found word initially and medially but not finally. Analysis also indicates that oral vowels differ in terms of vertical location and horizontal position, i.e. height and backness of vowels in the vowel space. Therefore, it can be said that oral vowels contrasts are based not only on temporal characteristics but also vowel qualities. Similarly, five nasal vowels are phonemic in nature and can contrast with oral counterparts (see Table, 6.14). Besides, four nasalized vowels have regressive effect due to the following nasal consonants.

The spectral characteristics of Hindko vowels reveal distinct results for the occurrences of /e:/ segment which is higher than /ɪ/. Likewise, findings of /ʊ/ sound show higher means frequency in terms of F1 than other languages. Most probably, this research has brought to describe a new tendency in the languages that the occurrence of /e:/ only word finally and higher height of the tongue for /ʊ/ sound in the vowel quadrilateral. Moreover, in terms of F2, results of study also show that Hindko has centripetal vowel system that refers to more inclination of vowel positions towards the central part of vowel trapezium.

The acoustical measurements of diphthongs show the continuity of glides and prominent dark bands in the falling diphthong than rising diphthong. The preceding part of diphthong, i.e. /e/ or /a/ of /ei, ai/, also indicates less duration than following /i/. The acoustic phonetics analysis has further validated the two diphthongs of the dialect identified in the articulatory phonetics.

The following Chapter deals with the phonological part of the study. It shows the analysis of the suprasegmental feature, i.e. syllable structure and syllabification system of Tanoli Hindko.

CHAPTER 7

SYLLABLES AND SYLLABIFICATION IN HINDKO

This chapter deals with the analysis of syllables and syllabification system of the Tanoli Hindko. It aims to analyze the data to find out maximum syllables in the root words, syllabic consonants, syllabic templates, and consonant clusters of Tanoli Hindko. The chapter also reveals syllabification structure of Tanoli Hindko in light of Maximal Onset Principle and Sonority Sequencing Principle. Finally, it offers gemination system of the dialect.

7.1 Syllables in Hindko

Generally, the root words structure of languages allow one, two, three, and more syllables. The data of the dialect shows maximum three syllables in its root words structure.

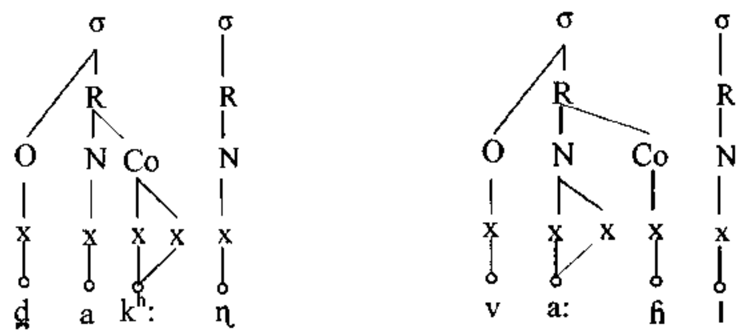
Table 7. 1 Maximum syllables found in root words of Tanoli Hindko

Words	Syllables	Templates	Number of Syllables	Gloss
na:	na:	CVV	One syllable	Do not come
baḓɦa:r	baḓ. ɦa:r	CVC. CVVC	Two syllables	Wednesday
ɣalɣo:za:	ɣal. ɣo:. za:	CVC. CVV. CVV	Three syllables	Pine-nut

The examples in the above table reveal that the dialect allows maximum three syllables in its root words. The first example shows one syllable, second consists of two syllables and third example has three syllables. However, data shows that monosyllables and bi-syllables are more in frequency than tri- syllables. As mentioned above (see Section, 3.4) that V refers to short vowels, VV for long vowels, and C for consonant. Obviously, syllables are made up of nucleus (V), and preceded or followed by consonant (C).

In addition to vowels as syllabic sounds, consonants can also become syllabic in some languages (see Section, 2.6.1), and Hindko is one of them. Some examples of such consonants are given in the following Diagram 7.1 and Table 7. 2:

Diagram 7. 1 (a) (b)



A place where sun lights for a time — Responsibility

Diagrams show that consonants /ɳ/ and /l/ become syllabic at word final position. This structure is possible with both short and long vowels in the first syllable of a word such as /a/ and /u:/ are shown in the above examples. Further data for syllabic consonants is given in the following Table 7. 2.

Table 7. 2 Data for Hindko syllabic consonants, CVCC. C̩ Templates

Words	Syllables	Templates	Syllabic Consonants	Gloss
va:ɦl̩	va:ɦ. l̩	CVVC. C̩	l̩	Responsibility
ra:ɦl̩	ra:ɦ. l̩	CVVC. C̩	l̩	Pertaining to cultivation
kʰʊkʰkʰɳ̩	kʰʊkʰkʰ. ɳ̩	CVCC. C̩	ɳ̩	A kind of bean
d̪akʰkʰɳ̩	d̪akʰkʰ. ɳ̩	CVCC. C̩	ɳ̩	A place where sun lights for a time
ga:ɦm̩	ga:ɦ. m̩	CVVC. C̩	m̩	Long step/ stride
ra:ɦm̩	ra:ɦ. m̩	CVVC. C̩	m̩	Illegal

Table 7.2 reveals that Hindko permits the consonants, liquid /l/, nasals /m/ and /ɳ/ as syllabic consonants. Syllabic consonantal segments have similar properties of a syllable, i.e. melody like nuclei. However, words having syllabic consonants are not great in number in the dialect.

Hindko has a range of syllabic templates in form of open and closed syllables. The following section shows the analysis of these templates:

7.2 Syllabic templates in Hindko

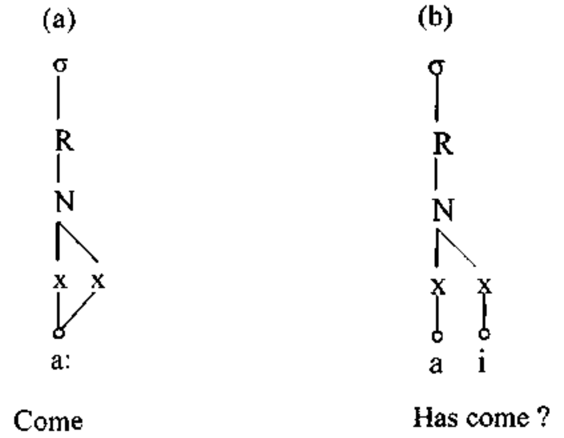
The dialect allows various types of syllabic templates. It includes short vowels, long vowels and diphthongs[11]. During the analysis, a diagrammatical sample in light of OR theory is drawn before providing the description of the data in the Tables. In the present study, according to OR model, all long vowels and geminate consonants are structured as two skeletons (xx) while short vowels are represented as single skeleton (x) and each case has single root node. Conversely, in diphthongal case, both melodies (e.g. ai, see Diagram, 7.2b) have separate root nodes .

Simple rhyme in Hindko (VV)

First, the templates of the simple rhyme in terms of long vowels and diphthongs are structured in the Diagram 7. 2.

[11] We have seen a few instances of the split among English vocalic elements into two classes: simplex or short vowels and complex or long vowels and diphthongs. The phonetic distinction into three groups we noted at the outset reduces to a phonological division into just two classes. The complex nuclei form a single group and hence we need a mechanism for treating them as a unit: referring to a disjunction of long nuclei *and* diphthongs fails to achieve this aim, since a class of two objects could, in principle, comprise any two groups (Gussmann, p.22).

Diagram 7. 2



In simple syllabic templates, the dialect allows the simple rhyme of long vowel and diphthong. These results are in line with common held views that simple rhyme subsumes one constituent without coda. In Diagram 7.2 (a), rhyme stands in non-branching[12] form which is possible for a well-formed syllable to be without branching while in (b), a nucleus position permits branching. Further data is given in the following Table 7. 3:

Table 7. 3 Data for single simple syllable, VV templates

Examples	Gloss	Templates	Examples	Gloss	Templates
a:	Come	VV	ũ:	Not possible	VV
æ:	See/how	VV	ẽ:	How	VV
o:	That/he/she	VV	ai	Has come	VV
ã:	Yes/Really	VV	ei	This one	VV

Table 7.3 displays syllables containing vowels and diphthongs. Long oral and nasal vowels function as nucleus in non-branching positions. Data, therefore, in the above table have non-branching but due to have the quality of heavy syllables, they get two skeletons and

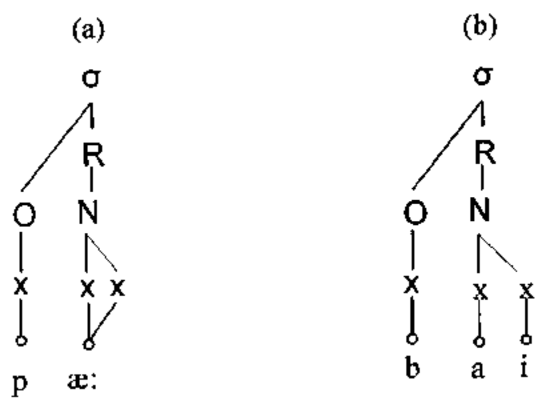
[12] Nucleus which makes two skeletal slots in a syllable is termed as branching while one skeletal slot is called as non-branching.

single root like the Diagram 7.2 (a). Similarly, diphthongal data in the Table such as /ai/ and /ei/ also allows branching at the skeletal position like the Diagram 7.2 (b). All the above given examples are in open syllable form and such examples of oral and nasal vowels are commonly found in Tanoli Hindko.

Simple syllables in open form (CVV)

Tanoli dialect also allows open syllables in form of CVV. An example of CVV templates is structured in the following Diagram 7.3:

Diagram 7. 3



Beat/ follow

An arm of a cot

The above diagrams 7.3 depict syllables containing onset and nucleus but no coda. In 7.3 (a), nucleus has two skeletons while in 7.3 (b), nucleus shows branching. More data with each Hindko consonant is given in the following table to support the similar templates:

Table 7. 4 Data for single open syllable, onset and nucleus, CVV templates

Examples	Gloss	Examples	Gloss	Examples	Gloss	Examples	Gloss
pæ:	Beat/follow	to:	Touch	va:	Fine	ʤi:	Yes
ba:	Put	ko:	Slaughter	fu:	Totally (destroyed)	ʧa:	Take
p^hæ:	A tool of wood	dæ:	Leakage	ɣã:	Speak	$ʧ^h$e:	Hide

ṯa:	Irritation	k^ha:	Eat	zæ:	Peep	ræ:	Stay
$\underline{t}^hi$:	Is	ga:	Go	sæ:	Sleep	le:	Plough
t^hi:	Stand up	ɦo:	Why	ma:	Mother	ja:	Or
d̪e:	Give	ʃa:	Bride	na:	Don't come	bai	Arm of a cot
rei	Leave	kei	A tool	bei	Stale	gai	Muddling

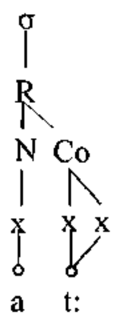
The above table 7.4 shows open syllable in form of onset and nucleus. It depicts that the dialect includes CVV patterns in its syllable structure. A single example with each consonant in the above table reveals that most of Hindko consonantal segments occupy the onset position word initially. There are, however, rare sounds like /ɽ/, /ŋ/, /ɳ/ do not function as onset word initially in the dialect. The data in the Table also shows that all long vowels can occur at syllable final position in the open syllables.

Simple syllables in terms of nucleus and coda (VC)

In addition to onset and nucleus templates, Hindko has also nucleus and coda templates.

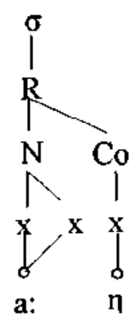
Diagram 7. 4

(a)



Corner

(b)



Bring

The above diagrams 7.4 show short and long vowels at nuclei position. In 7.4 (a), geminate consonant /t:/[13] (CC) is preceded by a short vowel while in 7.4 (b) a singleton C is preceded by a long vowel. Therefore, the coda in the diagram (a) gets two skeletons whereas in the diagram (b) nucleus takes two skeletons. More data is given in the following Table:

Table 7. 5 Data for single syllable, nucleus and coda, VCC and VVC templates

Examples	Templates	Gloss	Examples	Templates	Gloss
att	VCC	Corner	u:k	VVC	Guess
akk	VCC	Tired	ã:ɳ	VVC	Bring
ɪtt	VCC	Brick	a:ʤ	VVC	Today
ɪss	VCC	This	o:g	VVC	A small sharp piece(s) of wood
ʊll	VCC	Get off	æ:l	VVC	Tame

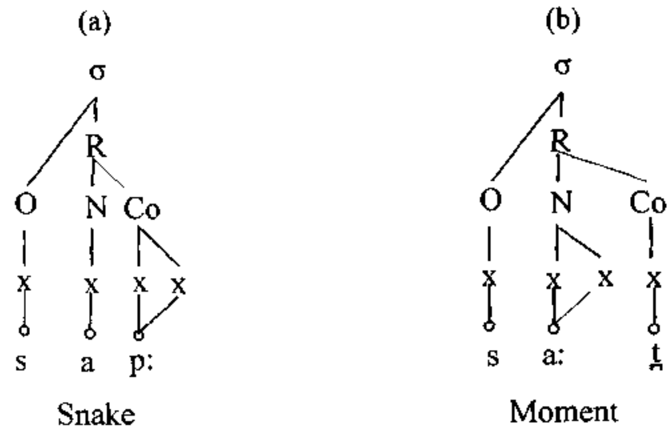
The above table 7.5 presents two types of templates, i.e. the short and the long vowels with the coda. The given examples show that the short vowels have single V followed by geminate consonants (CC) in form of VCC templates whereas long vowels (VV) are followed by singleton (C) as VVC. In such type of pattern, all short vowels can occur at nucleus position, and all consonants can occupy the position of coda (see Appendix, F). Clements and Keyser (1983) term the combination of nucleus and coda as rhyme.

[13] Ewen and van der Hulst (2001) recommend colon (:) after geminate consonants like long vowels (p.155, see diagram, 87b & 92 c, P.157). Similarly, for moraic theory, they state, a geminate consonants is always lexically associated with a mora; i.e. the difference between a geminate and single consonants is the fact that geminates always contribute to the weight of syllables (p.156).

Simple syllables in closed form (CVC)

In addition to the open syllables in the simple syllable pattern, Tanoli Hindko dialect also allows onset, nucleus and coda, i.e. closed syllables.

Diagram 7. 5



The above diagrams 7.5 show closed syllables that V is preceded and followed by consonants. In the diagram (a), the coda /p/ takes two skeletons and the nucleus /a/ shows single skeleton while in the diagram (b), the structure of the simple closed syllable get reversed that nucleus /a:/ has two skeletons and following /t̪/ at the coda position shows one skeleton. Further data for closed syllable is given in Table 7.6:

Table 7. 6 Data for closed syllables, onset, nucleus and coda, CVCC and CVVC templates

Examples	Templates	Gloss	Examples	Templates	Gloss
nɪt̪t̪	CVCC	Daily	rã:m	CVVC	Rest
sʊkk	CVCC	Get dried	lo:ɽ	CVVC	Search
sapp	CVCC	Snake	li:k	CVVC	Line
tʊrr	CVCC	Walk	lũ:ɳ	CVVC	Salt
nat̪ʰt̪ʰ	CVCC	Bridle	d̪æ:x	CVVC	See
sɪll	CVCC	Stone	sa:t̪	CVVC	Moment

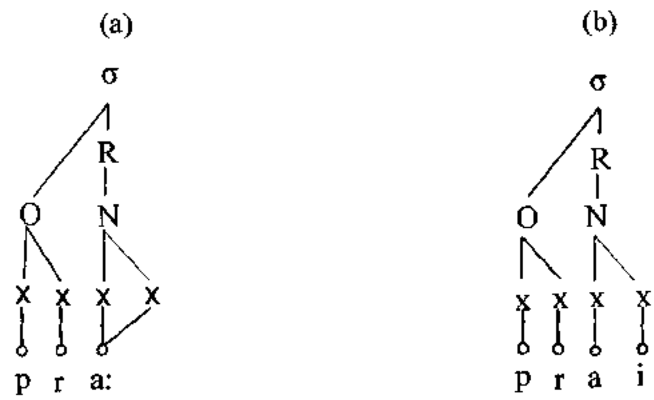
Table 7.6 depicts onset, nucleus and coda in form of CVCC and CVVC templates. As mentioned above, all Hindko consonants word finally are well-formed segments at coda position. However, sounds like /j/ do not get coda position in the dialect but it freely occurs word initially. Similarly, as given examples show except /e:/, all vocalic segments function as nuclei in closed syllables. As data given in the previous Tables, Hindko short Vs show one skeleton while long Vs depict two skeletons at nucleus position in Table 7.6.

So far, simple syllable structure has been discussed and found that Hindko permits open and closed syllables in form of following templates: VV, CVV, VCC, VVC, CVCC and CVVC. Besides, in Tanoli Hindko, a nucleus can also be preceded by more than one non-syllabic element at the onset position which refers to the category of bipartite consonant clusters. First, data is analyzed which occupies two consonants at its onset position.

Complex syllables in open form (CCVV)

Tanoli Hindko dialect has also words containing complex onset in open form. Such words can be structured in the following way:

Diagram 7. 6



A part of wooden roof — Pertaining to someone else

Unlike the previous templates, Diagram 7.6 shows branching at onset position. Similar to the previous data of open syllables, both long vowels and diphthong represent a two-point structure at nuclei position. More data for similar syllabic patterns is illustrated in Table 7.7:

Table 7. 7 Data for open syllable, onset branching, CCVV templates

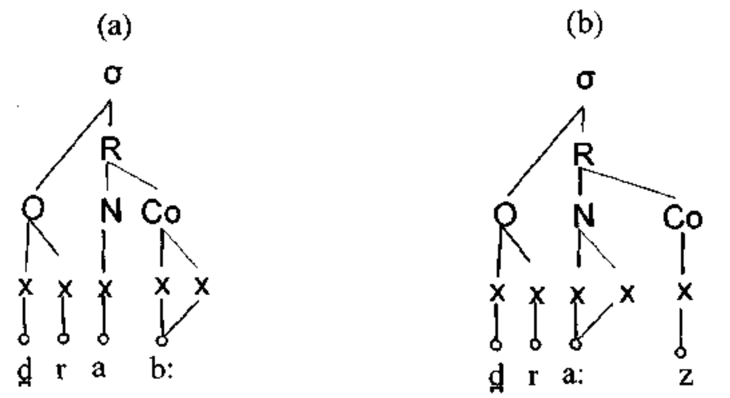
Examples	Templates	Gloss	Examples	Templates	Gloss
sla:	CCVV	Suggest	t̪ræ:	CCVV	Thirst
pro:	CCVV	Weaving	ʃru:	CCVV	Start
t̪ri:	CCVV	Thirty	prai	CCVV	Someone else

The above table 7.7 exhibits the examples of Hindko words in form of branching at onset position followed by V with two skeletons. This idea of branching is similar to nuclei, specifically diphthong, that an onset also makes two positions instead of one in a syllable, i.e. a constitute make two slots skeletally. Such type of bipartite consonant clusters is not much in frequency in Tanoli Hindko. However, all Hindko long vowels and diphthongs can be found in such templates. It can be said, therefore, that Hindko permits the templates of CCVV which refers to word initially well-formed consonantal clusters.

Complex syllables in closed form (CCVC)

Similar to open syllables, Hindko allows bipartite consonant cluster at onset position in closed syllables.

Diagram 7. 7



Severely beating

Drawer

Diagram 7.7 (a) shows short while (b) has long vowels preceded by CC and followed by C. More data for similar syllabic patterns is provided in Table 7.8:

Table 7. 8 Data for closed syllable, onset branching, CCVCC and CCVVC templates

Words	Templates	Gloss	Words	Templates	Gloss
d̪rabb	CCVCC	Beat	d̪ra:z	CCVVC	Drawer
pɽɪʧʰʧʰ	CCVCC	Catch	xla:m	CCVVC	Small cave
pɽakk	CCVCC	Instant	ʧro:k	CCVVC	Time ago
praʈʈ	CCVCC	Turn	ʈræ:ɽ	CCVVC	Dew/cracks

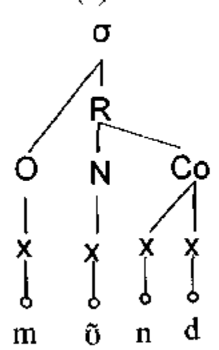
Table 7.8 shows the templates of bipartite consonant cluster at onset position followed by short and long vowels at the nucleus position. Tanoli Hindko consonants at the coda position geminate if preceded by a short vowel while the nucleus in form of a long vowel itself geminates means it occupies two skeletons and, thus, its following C never geminates in the dialect. It can be concluded, therefore, that Hindko allows closed syllable with the templates of CCVCC and CCVVC.

Complex syllables in terms of coda branching

Some syllabic templates in the closed syllables are also found in form of bipartite consonant cluster without gemination word finally in Hindko.

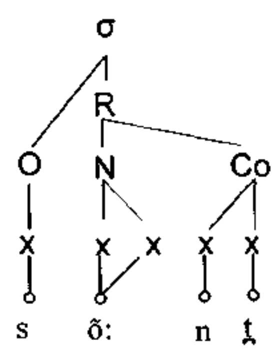
Diagram 7. 8

(a)



Bottom of tree/wall

(b)



Clean up

Unlike the previous structure of syllabic templates, the above diagram 7.8 shows branching of consonants word finally. Further examples are provided in the following table to show the similar syllabic pattern in the dialect:

Table 7. 9 Data for closed syllable, coda branching, CVCC and CVVCC Templates

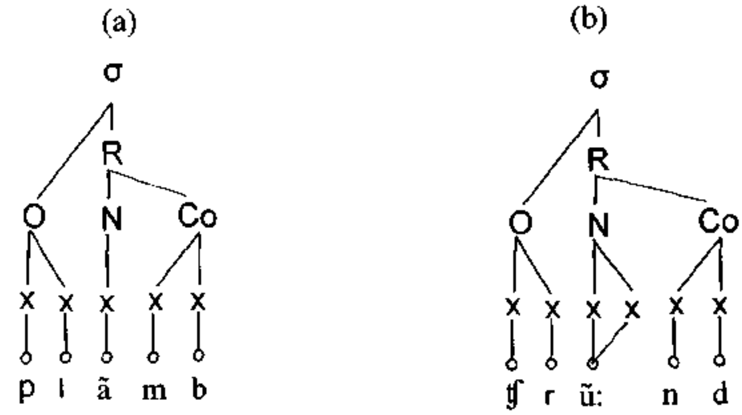
Words	Templates	Gloss	Words	Templates	Gloss
mɔ̃nd	CVCC	Bottom	saxt̪	CVCC	Hard
kæ̃:nt̪ʰ	CVCC	A type of plant	bæ:st̪	CVVCC	Embarrassment
hãmb	CVCC	Sudden attack	ʃɪʃt̪	CVCC	Aim/Target
ʧɔ̃:nt̪	CVVCC	Rumour	mĩ:nʤ	CVVCC	Leather

Table 7.9 presents the examples containing coda clusters with the basic template of syllable structure. In the dialect, the coda clusters show that nasal consonants are followed by stops and affricates; and fricatvies are followed by stops (see Section, 7.3.2). The data reveals that single consonant at onset position is followed by nucleus, V or VV, followed by a coda cluster. Short vowels show the templates in CVCC form while long vowels have CVVCC templates.

Complex syllables in form of onset and coda branching (CCVCC)

Maximum syllabic templates (MaxST) in the dialect are CCVCC or CCVVCC. At nucleus position, short vowels are found in form of single skeleton while long vowels occur as double skeletons. The structures of both types are drawn in the following:

Diagram 7. 9



Climb up

Eating savagely

Given examples, /plãmb/ and /ʧrũ:nd/ have consonant clusters at the onset and the coda positions. However, the words which allow combination at both positions of nucleus are very low in the frequency in Tanoli dialect. Overall, it can be said that Hindko also permits the pattern of CCVCC and CCVVCC.

In summary, the syllabic pattern in the category of bipartite consonant clusters, Hindko allows the templates of CCVV, CCVCC - CCVVC, CVCC - CVVCC and CCVCC - CCVVCC.

7.2.1 Discussion on Hindko syllabic templates

The analysis of Hindko templates shows that short vowel represents single skeleton while long vowels and diphthongs show two skeletons with single root node. These results of the present study are, therefore, in line with the views of Gussmann (2002) that short vowel corresponds to a single skeletal point while both a long one and a diphthong represent a two-skeletal point structure. The analysis of Tanoli Hindko data exhibits constraints on the occurrence of vowels that short vowels neither make simple rhyme nor can occur in open syllables while all long vowels and diphthongs make simple rhyme. Similarly, in English, a short vowel cannot stand alone as a syllable while long vowels and diphthongs can (see Section, 2.8).

The occurrence of consonants at onset position followed by long vowels in Hindko is line with universals held view (Clements and Keyser, 1983) that all languages have CV templates. Similar to other world languages, this basic syllable structure[14] is frequently used in Hindko. The existence of this syllable format, therefore, also supports the idea of (Kenstowicz, 1994) that CV template is found in all languages of the world. The findings show that Tanoli Hindko also allows coda in both categories of the syllables, i.e. open and closed syllables. The coda can be found in form of C or CC.

Regarding the onset, nucleus and coda, Gussmann (2002) argue that syllables can be segregated in form of onset and the rhyme, and the second part of the syllable is the vocalic nucleus. However, vocalic nucleus consists of a complement in the form of a coda, termed as the rhymal complement. On the subject of coda occurrence, Burquest (2006) states that some consonants are allowed only at coda position in languages, and some are restricted only for onset position. For example, like Angas, twenty six consonants get the place of onset while only ten consonants can occur in coda position. It is due to the fact of their strong and weak positions; the former is related to large inventory while the latter shows heavy restriction on the occurrence. Similarly, he argues that in Asheninka spoken in Peru, all consonants can occur word initially while only nasals are allowed at the coda position. In another language of Peru Cashinahua, he states that only fricative get place at the coda position; in Taiwanese all fourteen can occur at the onset while only seven consonants, nasals and plosives, can occur at

[14] According to OR model, long vowel stands as VV, i.e. two skeletons, thus, the structure of onset (C) and vowel (V) in the open syllable is termed as CVV in the dialect whereas short vowel V cannot occur in open syllable)

the coda position. Coda position is, therefore, considered as weak due to the heavily restricted inventory of segments.

The occurrence of the coda in Tanoli Hindko is richer than the onset in the sense that all consonantal sounds, except /j/, are well-formed sound at the coda position. Out of thirty one consonants, one sound /ŋ/ can neither occur word initially nor syllable initially whereas two segments /ɽ/, /ɳ/ are impossible sounds word initially but possible syllable initially.

The analysis also reflects that the onset and the coda permit branching. Both positions, the onset and the coda, allow maximally binary branching. Conversely, English and Polish allow maximum three consonants cluster at onset position and four consonants at coda position. Pashto, the major language of KP, allows tripartite consonant cluster at the onset position but bipartite consonant cluster at coda position (Khan, 2012). However, Urdu, national language of Pakistan, lacks clusters at onset position but makes bipartite consonant cluster at coda position (Ghazali, 2002).

Regarding nucleus position in the syllables, short vowels of the dialect do not allow branching skeletally while long vowels permit two skeletons. Diphthongs of Tanoli dialect of Hindko also allow binary branching. Similarly, in case of diphthongal sounds, English also permits branching (see Section, 2.8). However, data shows that most of the syllable in Tanoli Hindko have non-branching on its onset and coda positions (see Sections, 7.3.1 & 2).

In a nutshell, Hindko syllabic templates come under the umbrella of fourth type of syllabic templates proposed by Clements and Keyser (1983) including CV, V, CVC, VC pattern. Similarly, English also permits fourth type of syllabic templates (see Section, 2. 8). In this manner, both English and Tanoli Hindko are similar to each other. The dialect has 13 syllabic templates, such as VV, CVV, VCC, VVC, CVCC, CVVC, CCVV, CCVCC, CCVVC, CVCC, CVVCC, CCVCC and CCVVCC. English allows 20 templates in syllable structure (see Section, 2.8).

Rashid (2011) identifies the syllabic templates in Hindko spoken in AJK on the basis of monosyllabic words as CV and CVC, in bi-syllabic words such as CV.CVC and CVC.CV and in polysyllabic words, as CV.CV.CV. He concludes that Hindko has five syllabic templates V, VC, CV, CVC and CVCC. Rashid's study shows that no syllabic templates allow consonantal cluster word initially. In case of Urdu, Ghazali (2002) identifies 11 syllabic templates including CV, CVC, CVCC, CVV, CVVC, CVVCC, V, VC, CVV, VV and VVC.

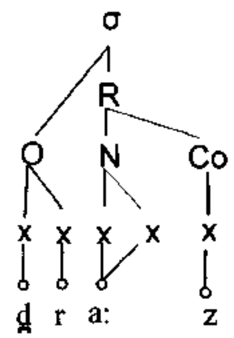
7.3 Consonant clusters in Hindko

In Hindko, consonant clusters are possible word initially (onset position), word medially and word finally (coda position). First, the analysis of the consonant clusters is carried word initially.

7.3.1 Consonant clusters at onset position in Hindko

In Hindko, maximum two consonants cluster are permissible at onset position of a syllable. The following diagram, developed in light of OR model, shows the stop /ɖ/ followed by liquid /r/.

Diagram 7. 10



The Diagram shows a Hindko word /ɖra:z/ 'drawer' in form of branching at onset (O) position and its rhymal part (R) includes nucleus (N) with two skeletons (X) and the coda

(Co). It reveals that Hindko permits bipartite consonantal cluster at onset position of a word. More data for well-formed consonant clusters word initially is given in Table 7.10. Regarding the onset cluster, first, the analysis is carried out to describe the stops followed by other consonants and each cluster is shown with two examples.

Table 7. 10 Word Initial Clusters (Plosives + Others)

Type	Clusters	Examples	English Translation
Plosives + Liquids	pl	plãmb	Climb
		plæ:r	Fence
	bl	bla:	Giant
		blɪtt	Rolling on land
	t̪l	t̪lai	Matters
		t̪lãŋga:	Uncivilized
	d̪l	d̪læ:r	Brave
		d̪la:sa:	Politely
	kl	klæ:ɽ	A type of vegetable
		$klat^{h}t^{h}$	A type of pulse
	gl	gla:b	Rose
		glæ:r	Spread/ free
	pr	prat̪t̪	Turn
		pro:	Weaving beads
	br	brĩndʒi:	A long and sharp nail
		brã:ndi:	Rain coat
	t̪r	t̪ra:mbɽa:	Lid of a pot
		t̪rɪbbɽi:	Cucumber
	d̪r	d̪ra:t	Sickle

		ɖræ:k	A tree having bitter taste
	tr	tra:ʧa:	An animal small in stature etc
		trakk	Truck
	dr	dro:kall	Coward
		dra:	Fear
	kr	kri:ɽi:	Hail
		krõnd	Probe someone
	gr	$gra\text{ʧ}^h\text{ʧ}^ha$:	A type of plant having yellow fruit
		grabb	Sudden attack
Plosives + Flap	pɽ	$p\text{ɽɪʧ}^h\text{ʧ}^h$	Catch
		pɽakk	Glimpse / Instantly
	bɽ	bɽa:l	Laying a blanket
		bɽĩŋga:	Twisted
	kɽ	kɽãmm	Jam
		kɽʊkki:	A trap for rats
	gɽ	gɽãŋg	Heavy stone
		gɽa:	Mating of animals
Plosives aspirated + Liquids	p^hr	p^hra:	Spread
		p^hrau:	Target without aiming
	p^hl	p^hla:ɽ	A plant with thorn
		p^hlo:r	Probe/Search
	p^hɽ	p^hɽɪʈʈa:	A trap for birds
	t^hr	t^hra:	Stop/being cold
	k^hr	k^hrʊppa:	A tool for gardening
		k^hrɪtta:	Foot (Negative use)
	k^hl	k^hlæ:r	Lay

	k^hla:ra:	Scattered form
k^hɽ	k^hɽã:m	Shoes
	k^hɽa:k	Fight

Table 7.10 shows that all unaspirated and voiced plosives combine binary branching at onset position with liquids /l/, /r/ and flap /ɽ/. Plosives /p/, /b/, /t̪/, /d̪/, /k/ and /g/ make combination with liquids /l/ and /r/; however, /t/ and /d/ plosives also permit clusters with /r/. Only four plosives, /p/, /b/, /k/ and /g/ allow clusters with flap /ɽ/. Regarding aspirated sounds, the analysis reveals that /p^h/ and /k^h/ allow clusters at initial position with /l/, /r/ and /ɽ/ whereas /t^h/ is a possible sound only with liquid /r/ segment. Above all, only one aspirated plosive, dental /$t̪^h$/ does not make any combination with any segment in Tanoli Hindko.

The results show that liquid /r/ occur with maximum stops while flap /ɽ/ allows combination with minimum stops. The findings of the data show 25 onset clusters of stops followed by approximants. Therefore, the possible stops onset cluster in Tanoli Hindko are: pl, bl, t̪l, d̪l, kl,gl, pr, br, t̪r, d̪r, tr, dr, kr, gr, pɽ, bɽ, kɽ, gɽ, p^hɽ,p^hr, p^hl, t^hr, k^hr, k^hl and k^hɽ. However, in this type of combination, some clusters are impermissible in the dialect such as *$t̪^h$r, *$t̪^h$l, *$t̪^h$ɽ, *t^hl, *t^hɽ, *tl, *dl, *t̪ɽ, *d̪ɽ, *tɽ, *dɽ. Overall, it can be summarized that except glide /j/, all of the other three approximants in Tanoli Hindko allow clusters preceded by plosives, i.e. plosives + approximants.

In addition to stop clusters, Tanoli Hindko also permits onset combination of nasal /m/ with /l/ and /r/. The examples are shown in the following table:

Table 7. 11 Word Initial Clusters (Nasals + Others)

Type	Cluster	Examples	English Translation
Nasals + Liquids	ml	mlã:ɳã:	Religious scholar
		mla:p	Approach
	mr	mri:d̪	Disciple
		mro:ɽ	To bend

Table 7.11 shows words containing nasal /m/ with liquids /l/ and /r/ at onset position of syllables in form of branching. The combination of /ml/ and /mr/ are, therefore, well-formed clusters word initially in the dialect. Other nasals /n/, /ɳ/ and /ŋ/ do not make clusters with any segment, and the combination of /m/ with /ɽ/ *mɽ is also an ill-formed cluster in Tanoli Hindko. Like nasals and stops, some fricatives also make clusters word initially as can be seen from the Table 7.12 below:

Table 7. 12 Word Initial Clusters (Fricatives + Others)

Type	Cluster	Examples	English Translation
Fricatives + Liquids	sr	sradd	Hay
		sræ:la:	Dry flower of Hay
	sl	sla:	Suggestion
		slu:ɳã:	Salty
	xr	xra:b	Spoil
		xra:t̪	Charity
	xl	xlã:m	A small cave
		xla:s	Open/separate

	ɦr	ɦra:	Defeat
	ɦl	ɦla:ʈ	Condition
		ɦla:	Move
	ɣl	ɣla:ɽa:	A small piece of stone
		ɣla:m	Slave
	ɣr	ɣrabb	Sudden attack
	fl	flã:ɳã:	That one
	fr	frãŋg	Manoeuvring
		fræ:ɖ	Cry
	ʃl	ʃlɪbbɽa:	A piece of meat
		ʃlakk	Tree's skin
	ʃr	ʃru:	Begin
		ʃri:ʈ	Islamic principles
Fricatives + flap	ʃɽ	ʃɽõn.nĩ:	Humiliate
		ʃɽãŋg	Jiggle
	ɣɽ	ɣɽapp	Interpose

The above table 7.12 exhibits consonant cluster of fricatives with liquids and flap. The analysis of data presents that /ʃ/ and /ɣ/ occur with /l/, /r/ and /ɽ/, whereas some other fricatives, /s/, /x/, /ɦ/ and /f/ allow combination with liquids. The results reflect if a fricative allows /l/, it also permits /r/. Generally, the fricatives allow clusters more with liquids but less with flap. The results of fricatives with approximants show 14 clusters at onset position in

Tanoli Hindko such as sl, sr, xl, xr, ɦl, ɦr, ɣr, ɣl, ɣɽ, fr, fl, ʃɽ, ʃr and ʃl while ill-formed clusters are *fɽ, *vl, *vr, *vɽ, *sɽ, *zr,*zl, *zɽ, *xɽ and *ɦɽ.

Similar to stops, fricatives and nasals, Hindko affricates also allow consonantal branching word initially. Some examples are given in Table 7.13.

Table 7. 13 Word initial clusters (Affricates + Others)

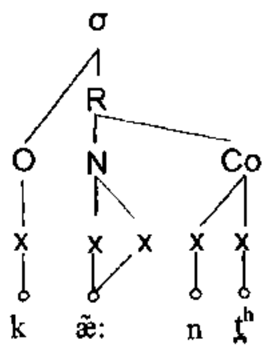
Type	Cluster	Examples	English Translation
Affricates + Liquids	ʧl	ʧla:k	Clever
		ʧla:	Operate
	ʧr	ʧro:ɽa:	Unripe peach
		ʧro:ka:	Days ago
	ʤl	ʤlatta:	Bitter
		ʤla:b	Motion
	ʤr	ʤra:b	Socks
Affricate Aspirated + Liquids	ʧʰl	ʧʰlãŋg	Spread
		ʧʰlakka:	Sea wave
	ʧʰr	ʧʰra:	Open the stopped water etc

The above table 7.13 depicts that all Hindko affricates combine two consonants cluster at word initial position with liquids /l/ and /r/. These clusters are six in number including ʧl, ʧr, ʤl, ʤr, ʧʰl and ʧʰr. Unlike some fricatives and stops but like nasals, affricates permit combination of consonants only with liquids. It can be said, therefore, that affricates and liquids are well formed whereas affricates and flap are ill-formed clusters at onset position of Tanoli dialect of Hindko.

7.3.2 Consonant clusters at coda position in Hindko

In Hindko, a few words have consonant clusters word finally at coda position. These clusters subsume combination of nasals and fricatives followed by stops, affricates and fricatives. According to OR model, a word of coda cluster is structured in the following way:

Diagram 7. 11



A type of plant

Further examples of word final cluster are illustrated in the following table:

Table 7. 14 Word final clusters (Nasals + Others)

Type	Cluster	Examples	English Translation
Nasals + Plosives	mb	ɦãmb	Sudden attack
		plãmb	Climb
	nʈ	sõ:nʈ	Clean up
		ʧõ:nʈ	Secret
	nʈʰ	kæ̃:nʈʰ	A type of plant
	nɖ	bãnɖ	Close
		kãnɖ	Wall
	nd	pʰãnd	Small bag of luggage
		ʃãnd	Barren
	nt	ʤũ:nt	Yoke
	ntʰ	ʈræ̃:ntʰ	Sixty three

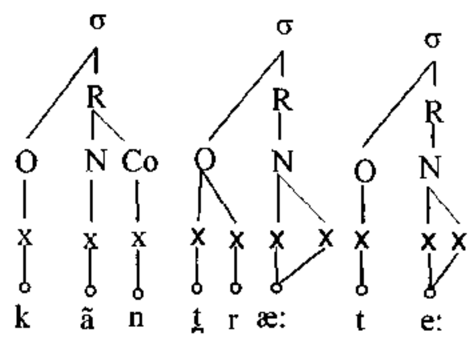
		pæ̃:ntʰ	Sixty five
	ŋk	xõ:ŋk	A kind of partridge
		põ:ŋk	Bark
	ŋg	kʰãŋg	Coughing
		sãŋg	Throat
Nasal + Fricative	ns	ɦõ:ns	Desire to eat something
		bã:ns	Bamboo
Nasal + Affricate	ndʒ	kʊ̃ndʒ	Fold
		pʰʊ̃ndʒ	Hand made flower of thread
Fricatives + plosives	ʃt̪	paʃt̪	Defeated severely
		ʃɪʃt̪	Target
	st̪	d̪ast̪	Motion
		bæ:st̪	Embarrassment
	xt̪	saxt̪	Hard
	ft̪	muft̪	Free

The above table 7.14 shows bipartite consonantal cluster at coda position. In most of the examples, only nasal /n/ is preceded by the right edge C of the coda cluster. An example of /m/ and /b/ cluster is also found in the dialect. Similarly, combination of some fricatives and dental /t̪/ is also possible in Hindko; however, the utterance of these combinations varies among native speakers. It has been observed that sometime some speakers insert /a/ segment in-between coda clusters while at other time they combine well-formed strings of /ʃt̪/, /st̪/, /xt̪/ and/ft̪/ word finally. Therefore, cause of deletion or insertion of /a/ in-between coda clusters are needed to be further investigated. It can be concluded that bipartite cluster word finally are 15 in number such as mb, nt̪, nt̪ʰ, nd̪, nd, nt, ntʰ, ŋk, ŋg, ns, ndʒ, ʃt̪, st̪, xt̪, and ft̪. Overall, the majority of the data reflects that nasal consonants are followed by plosives, fricatives, and affricates at coda position of syllables.

7.3.3 Consonant clusters at word medial position in Hindko

As mentioned earlier that only root words are taken into account for the syllable structure analysis of Tanoli Hindko. Similarly, data for medial consonant cluster is also mostly based on root words; however, in some cases, to know whether medial clusters are possible or not, the morphological operation of the words is also considered. The reason for adding such data is, therefore, to show the possible clusters in Hindko that refers to the constraints on (ill-formed and well-formed) consonantal clusters. In this way, most of the data come across in form of concatenated gemination. Overall, Hindko allows clusters at three possible positions of words, like initial, medial and final. Like the onset and the coda clusters, a diagram for word medial cluster is also structured in the following: llllll

Diagram 7. 12



The diagram shows three syllable of the Hindko word /kãnʈræ:te:/ means 'mumps'. It exhibits branching, /-ʈr-/ a medial consonant cluster CC, at the onset position of the second syllable whereas other constituents show non-branching of the segments. More Hindko data is given in the following Table for medial consonant cluster.

Table 7. 15 Word medial clusters (Plosives + Others)

Type	Clusters	Examples	Syllables	Templates	English Translation
Plosives+ Liquids	pr	ʧʰappri:	ʧʰap.pri:	CVC.CCVV	Cottage
		kʊppri:	kʊp.pri:	CVC.CCVV	A high place in land
	br	tabbri:	tab. bri:	CVC.CCVV	Wife
		babbri:	bab.bri:	CVC.CCVV	A kind of goat
	t̪r	blæ:t̪ra:	blæ:. t̪ra:	CCVV.CCVV	A toll used in ploughing
		kãnt̪ræ:te:	kãn.t̪ræ:.te:	CVC.CCVV.CVV	Mumps
	d̪r	kad̪d̪ra:	kad̪. d̪ra:	CVC. CCVV	Comparatively
		gad̪d̪ro:ɽ	gad̪. d̪ro:ɽ	CVCC.CCVVC	Old and torn clothes
	t̪ʰr	sʊt̪ʰt̪ʰra:	sʊt̪ʰ. t̪ʰra:	CVC.CCV	Clean
		mʊt̪ʰt̪ʰri:	mʊt̪ʰ. t̪ʰri:	CVC.CCV	Defeated badly
	dr	kãndru:	kãn. dru:	CVC. CCVV	A type of tree
		kãndrat̪t̪	kãn.drat̪t̪	CVC. CCVCC	Uncultivated
	kr	ʃikkra:	ʃik. kra:	CVC.CCVV	Hawk
		maʃkrĩ:	maʃ. krĩ:	CVC.CCVV	Jokes
	gr	dɪggra:	dɪg. gra:	CVC.CCVV	Trouser in a big size
		pæ:gra:	pæ:. gra:	CVC.CCVV	A kind of bird
	t̪l	pæ:t̪li:	pæ:. t̪li:	CVC.CCVV	Deep
		pat̪t̪la:	pat̪. t̪la:	CVC.CCVV	Skinny
	dl	mãndla:	mãn.dla:	CVC.CCVV	A toll used to keep loaves
		ɣãnd̪lã:	ɣãn. d̪lã:	CVC.CCVV	Young stems of mustard
	tʰl	sɪtʰ.tʰli:	sɪtʰ.tʰli:	CVC.CCVV	Backbiting by a female
		nɪtʰ.tʰli:	nɪtʰ.tʰli:	CVC.CCVV	Escaping (feminine)
	kl	t̪rakkla:	t̪rak.kla:	CCVC.CCVV	A sharp needle of iron

		maṱṱʊkkla:	maṱ.ṱʊk.kla:	CVC.CVC.CCVV	Thick and small stick
	gl	kãŋgla:	kãŋ.gla:	CVC.CCVV	Having no money
		bãŋgla:	bãŋ.gla:	CVC.CCVV	A well-build house
	kʰl	ʊkʰ.kʰli:	u:kʰ.kʰli:	VC.CCVV	Large wooden mortar
		sɪkʰ.kʰli:	sɪkʰ.kʰli:	CVC.CCVV	Get trained
Plosives + Flap	pɽ	tʰappɽã:	tʰap.pɽã:	CVC.CCVV	A tool used for compressing soil etc
		kappɽa:	kap.pɽa:	CVC.CCVV	Cloth
	bɽ	ʧʰabbɽi:	ʧʰab.bɽi:	CVC.CCVV	A tool used to keep loaves
		ṱɽa:mbɽa:	ṱɽa:m.bɽa:	CCVVCC.CCVV	Lid of a pot
	pʰɽ	ʧapʰpʰɽa:	ʧapʰ. pʰɽa:	CVC. CCVV	Flat/ horizontal
		ʧʰapʰpʰɽa:	ʧʰapʰ. pʰɽa:	CVC. CCVV	Stagnant water with mud
	ṱɽ	kʊṱṱɽa:	kʊṱ. ṱɽa:	CVC. CCVV	Puppy
		kattɽa:	kattɽa:	CVC.CCVV	Buffalo calf
	ḓɽ	kaḓḓɽa:	kaḓ.ḓɽa:	CVC.CCVV	A type of vegetable
	ṱʰɽ	kaṱʰṱʰɽa:	kaṱʰ. ṱʰɽa:	CVC. CCVV	A type of grass
	tɽ	attɽa:	at. tɽa:	VC. CCVV	Egg
		kattɽa:	kat.tɽa:	CVC. CCVV	Buffalo calf
	dɽ	laddɽã:	lad. dɽã:	CVC. CCVV	A tool used to tie animals
	tʰɽ	natʰtʰɽã:	natʰ. tʰɽã:	CVC.CCVV	Escapism
	kɽ	ḓʊkkɽa:	ḓʊk. kɽa:	CVC. CCVV	A type of drum
		batkɽa:	bat. kɽa:	CVC.CCVV	Uncivilized man
	gɽ	lãŋgɽa:	lãŋ.gɽa:	CVC.CCVV	Lame
		kã:ŋgɽi:	kãŋ.gɽi:	CVVC.CCVV	Very skinny
	kʰɽ	sakʰkʰɽã	sakʰ. kʰɽã:	CVC. CCVV	Empty hand

Like the onset clusters, word medial clusters in Hindko are also followed by three approximants, /l/, /r/ and /ɽ/. Stops and approximants cluster at word medial position are 26 in number such as pr, br, t̪r, d̪r, t̪ʰr, dr, kr, gr, t̪l, dl, tʰl, kl, gl, kʰl, pɽ, bɽ, pʰɽ, t̪ɽ, d̪ɽ, t̪ʰɽ, tɽ, dɽ, tʰɽ, kɽ, gɽ and kʰɽ. Generally, word initial clusters are also possible word medially; however, except a few, such as dental /t̪ʰr/, is impossible combination word initially but possible word medially. Plosives and flap are possible with six sounds word initially whereas all plosives allow clusters with flap at medial position. The results of medial cluster reflect that first syllable in most of the words are in closed form (CVC) while majority of second syllables is in open form (CV). Overall, three possible approximants and plosives make combination word medially; however, a few clusters are impermissible found in the data such as *tr, *tʰr, *kʰr, *pl, *bl, *tr, *pʰl, *t̪ʰɽ, *tʰr and *t̪ʰl.

In addition to plosives and approximants combination, Tanoli Hindko also allows the clusters of fricatives and affricates with approximants. The examples are illustrated in the below table:

Table 7. 16 Word Medial Clusters (Fricatives and Affricates + Others)

Type	Clusters	Examples	Syllables	Templates	English Translation
Fricatives + lateral	xr	baxxra:	bax.xra:	CVC.CCVV	A part of divided item
		bax.xro:ta:	bax.xro:.ta:	CVC.CCVV.CVV	Goat's kid
	sr	sʊs.sri:	sʊs.sri:	CVC.CCVV	Small sand
		bã:nsri:	bã:n.sri:	CVVC. CCVV	A musical instrument
	fr	naffrat̪t̪	naf.frat̪t̪	CVC.CCVCC	Hatred
	ʃr	baʃʃra:	baʃ.ʃra:	CVC.CCVV	Face
	zr	mʊzzra:	mʊz. zra:	CVC.CCVV	Result
		ʊzzra:	ʊz. zra:	VC.CCVV	Pertaining to condolence

	sl	massla:	mas.sla:	CVC.CCVV	Problem
		nassli:	nas. sli:	CVC.CCVV	Nobility
	xl	saxxla:	sax. xla:	CVC.CCVV	Easy
		d̪a:xla:	d̪a:. xla:	CVV.CCVV	Admission
	fl	nafflã:	naf. flã:	CVC.CCVV	Additional prayer
	ʃl	xaʃʃla:	xaʃ. ʃla:	CVC.CCVV	Much careless person
Fricatives + Flap	sɽ	mas.sɽã:	mas.sɽã	CVC.CCVV	Muddling
		d̪as. sɽã:	d̪as. sɽã:	CVC.CCVV	Showing
	ʃɽ	kʰo:ʃɽa:	kʰo:.ʃɽa:	CVC.CCVV	Torn piece of clothes
		kʰaʃʃɽa:	kʰaʃ. ʃɽa:	CVC.CCVV	The part where buffalo store milk
	fɽ	puffɽa:	puf.fɽa:	CVC.CCVV	Aunt's husband
	xɽ	raxxɽã:	rax.xɽã:	CVC.CCVV	Trouble
Affricates +Lateral	ʤr	saʤʤra:	saʤ. ʤra:	CVC.CCVV	Fresh
		ʃaʤʤra:	ʃaʤ.ʤra:	CVC.CCVV	History
	ʧr	kaʧʧra:	kaʧ. ʧra:	CVC.CCVV	Mule/garbage
	ʧʰr	maʧʰʧʰra:	maʧʰ.ʧʰra:	CVC.CCVV	Mosquito
	ʧl	koʧʧla:	koʧ.ʧla:	CVC.CCVV	Poison
	ʤl	ʧʰaʤʤli:	ʧʰaʤ. ʤli:	CVC.CCVV	A kind of snake
	ʧʰl	ʧʰʊʧʰʧʰla:	ʧʰʊʧʰ.ʧʰla:	CVC.CCVV	Speedy man (used in negative sense)
Affricates + Flap	ʧɽ	baʧʧɽa:	baʧ. ʧɽa:	CVC.CCVV	Child
	ʤɽ	baʤʤɽã:	baʤ.ʤɽã:	CVC.CCVV	Beating
	ʧʰɽ	baʧʰʧʰɽa:	baʧʰ.ʧʰɽa:	CVC.CCVV	Cow calf

Table 7.16 shows that all affricates make clusters with three approximants, /l/, /r/ and /ɽ/ at word medial position, and fricatives /x/, /s/, /f/, /ʃ/ and /z/ allow combination only with /r/ sound. Furthermore, fricative /z/ is not possible combination word initially but possible

word medially. Similar to the occurrence of /z/, dental /t̪ʰr/ is ill-formed cluster word initially but well-formed word medially. Fricative /s/, /f/, /x/ and /ʃ/ make clusters with /l/ and /ɽ/. The frequency shows 22 consonant clusters of fricatives and affricates with approximants /r/, /l/ and /ɽ/ such as fr, sr, zr, ʃr, xr, fl, sl, ʃl, xl, fɽ, sɽ, ʃɽ, xɽ, ʧr, ʤl, ʧʰr, ʧl, ʤr, ʧʰl, ʧɽ, ʤɽ and ʧʰɽ. Conversely, *vr, *ɣr, *ɦr, *vl, *ɣl, *ɦl, *fɽ, *vɽ, *sɽ, *zɽ, *ɣɽ and *ɦɽ are impossible clusters word medially in the dialect. Overall, medial consonant clusters are 48 in Tanoli Hindko. Generally, the findings of initial and medial clusters are almost identical.

7.3.4 Discussion on Hindko consonant clusters

The analysis of consonant clusters shows permissible and impermissible strings of consonants in the syllable structure of Tanoli Hindko. It permits clusters word initially, medially and finally and English allows clusters at three positions of a word as well. This combination maximally goes up to two consonants at each possible position in Hindko while English allows three consonants word initially, for example, screw, spring and four consonants word finally such as prompts, sixths (Roach, 2002). Both languages allow open and closed syllables. In most of the cases, English allows /s/ followed by /l, r, j, w/ (Duanmu, 2008). On the contrary, in case of Hindko, only three segments, /l/, /r/ and /ɽ/ always occupy the second C of initial and medial clusters. Unlike initial and medial clusters, the second C of word final position can be stops, fricatives and affricates.

The results of word initial cluster of the data reveal that except /n/, /ŋ/, /ɳ/, /v/, /l/, /r/, /ɽ/ and /j/ all of the other consonants allow clusters at the left edge of word initially, if combination of consonants is well-formed. There is constraint that /ɳ/, /v/, /l/, /r/, /ɽ/ and /j/ do not allow combination (as the first C of the string) at any position of words while /n/ and /ŋ/ permit cluster word finally by functioning as initial C of the cluster. The findings reflect that most of the strings at coda position have /n/ followed by plosives while a few coda clusters allow /m/ and /ŋ/ + plosives. Likewise, the possible combinations at the coda position also have fricatives + plosives sequences (see Table, 7.14).

In Tanoli Hindko, the combination of nd, ns, xt̪, ŋk and ŋg at word final position are not possible word initially rather this coda string, at word medial position, is split up by a division of the coda and the onset such as n.d, n.s, x.t etc. Thus, possible coda clusters are split up intervocalically. On the other hand, word-initial clusters are also permissible word-medially in the dialect. In some way, findings of Hindko are similar to English, which permits the clusters of final and initial places at medial position of a word such as *description* /diskripʃn/ and *extra* /ekstra/.

The results of clusters show the frequency of well-formed consonantal strings are 47 word initially, 15 word finally and 48 word medially. In case of English, possible bipartite consonant clusters are 58 word-initially (Duanmu, 2008). This description of clusters is given according to the frequency of their occurrence in English such as pr, st, tr, kr, br, gr, sp, sk, fl,fr, kl, pl, bl, sl, kw, dr, sw, sn, gl, nj, sm, pj, tw, θr, kj, dj, mj, fj, tj, hj, sr, bj, sf, vj, dw, gw, lj, θw, sj, θj, sm, sn, sp, ts, pw, pf, ph, zl, km, kn, sr, ps, ps, kv, sv, mw, sw, vw (p.160). He states that in English first cluster /pr/ is found maximally and /vw/ has least occurrence.

In case of English, word final clusters are 51 in numbers including pθ, pt, ps, bd, bz, tθ, ts, dz, kθ, kt, ks, gd, gz, mp, mf, mt, md, mz, nθ, nt, nd, ns, nz, nʃ, ŋθ, ŋt, ŋd, ŋk, ŋg, fθ, ft, fs, vd, vz, θs, sd, sz, sp, st, sk, zd, ʃt, ʃd, lp, lf, lθ, lt, ld, ls, lz, lk (Jone, 1976; Geigerich,1992; & Roach, 2002).

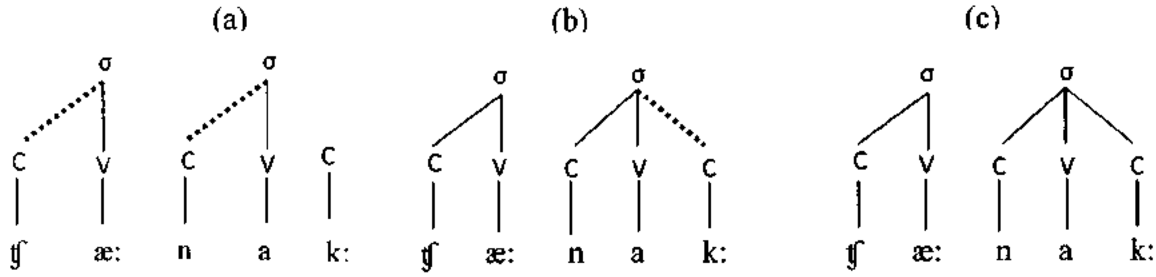
7.4 Syllable boundaries in Hindko

This part describes boundaries of Hindko syllables in terms of MOP. As mentioned above, according to this principle, possible consonants of a syllable are maximized to the left of V (peak) till onset cluster is allowed and then the operation of final consonants is carried out maximally to the right of V (peak). The analysis of the data is shown with the words, which have no consonantal cluster at word medial position.

No consonant cluster word medially in terms of long vowels

The dialect has various types of syllabic patterns. The words, which have simple onset (no consonantal cluster at onset position), are analyzed in the following way (see Diagram 7.13 & 7.17). Both short and long vowels allow syllables in the dialect; however, each type of vowel carries different word structure. First, the data of long vowels in the first syllable of words is provided to find out its syllabification system in light of MOP.

Diagram 7. 13



In the diagram 7.13 above (a), the onsets of both syllables are connected with syllable nodes. In part (b), geminate /k:/ of the coda is connected with second syllable node because there is no further syllable to be marked as the onset of the syllable. Finally, the part (c) shows the complete structure of the word. More data for similar pattern is given in the following table:

Table 7. 17 Data for syllable boundary CVV.CVCC

Words	Boundaries	Gloss	Words	Boundaries	Gloss
ʧæ:nakk	ʧæ: .nakk	Kettle	ʃa:rat̪t̪	ʃa: . rat̪t̪	Sign
ʧo:rass	ʧo: .rass	Square	t̪a:vall	t̪a: .vall	Haste
ɦæ:mat̪t̪	ɦæ:. mat̪t̪	Courage	sa:bat̪t̪	sa: . bat̪t̪	Complete
xa:t̪arr	xa: .t̪arr	Because of	pi:lakk	pi: . lakk	A kind of bird

Table 7.17 shows examples of bi-syllabic words of Hindko. Since word medial consonants are complex phenomenon as whether medial consonants are the onset of the second syllable or the coda of the first syllable; therefore, syllable boundaries of the given words are marked by the application of MOP. According to this principle, it syllabifies the consonant maximally as the onset of the syllable because languages prefer the onset rather than coda (see Section, 2.9). Hindko word /ʧæ:nakk/ 'kettle' is, therefore, not syllabified as*/ʧæ:n.akk/ rather as /ʧæ:. nakk/ because /n/ is the possible onset of a syllable. So, word medial sounds /n/, /r/, /t̪/, /m/, /v/, /b/ and /l/ are placed as the onset of the second syllable not the coda of first syllable.

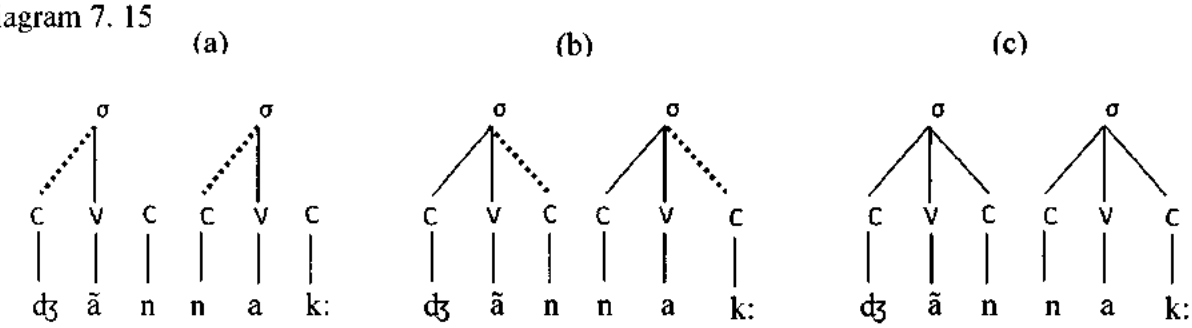
In Hindko, if a short vowel occurs in CVC form, the following consonant geminates as CVCC (e.g. second syllable of the above given examples of Diagram 7.13 & Table 7.17) whereas this rule is not applicable for a long vowel (e.g. first syllable of Diagram 7.13 & Table 7.17). Short vowels in Hindko can only be found in closed syllables while long vowels are permissible in both open and closed syllables.

Data in the above section (Diagram 7.13 & Table 7.17) shows long vowels in the first and short vowels in the second syllables of the words whereas in the following section, (Diagram 7. 14 & Table 7.18), short vowels are displayed in both syllables of the simple onset words.

Medial consonants in terms of short vowels

In case of bi-syllabic words, if there is a short vowel in the first syllable; it attracts the onset of the second syllable and makes the coda of the first syllable and the onset of the second syllable simultaneously in the form of gemination. In the following section of the study, the word final geminated consonants are marked with colon (:) representing gemination of consonants as CC (see Section, 3.4.2), whereas the medial geminated consonants are structured without colon (:) by giving complete symbols (e.g. in Diagram, 7.14). This technique of giving complete symbols at word medial position may give clearer picture of words boundaries.

Diagram 7. 15



The above diagram 7.14 (a) shows that first consonants of both syllables are linked with syllable nodes. Then, in part (b), medial consonant /n/ and final consonant /k/ are marked as the coda of the first and the second syllables respectively. Medial /n/ is not maximized as the onset of second syllable because combination of /n/ and /n/ are not possible consonantal cluster at onset position in the dialect. Geminate /k:/ segments word finally is marked as the coda due to word boundary.

On the subject of such structure of the syllables, Pulgram (1970) and Selkirk (1983) are of the view to change from V.CV to VC.V if the first V is lax and stressed. However, many other studies such as Halle and Vergnaud (1987); Baayen, et al. (1993) strictly follow the rules of MOP (cited in Duanmu, 2008). Regardless of these views, Hindko has different structure for such cases. If a short vowel is found in the first syllable, the onset of the second syllable is geminated and becomes coda of the first syllable and the onset of the second syllable concurrently. More data is given in the following table, which covers all three short vowels of Hindko dialect in the first syllable.

Table 7. 18 Data for syllable boundary CVC.CVCC

Words	Boundaries	Gloss	Words	Boundaries	Gloss
dʒãnnakk	dʒãn. nakk	Children	ʃʊllʊkk	ʃʊl. lʊkk	Move
raʈʈãnn	raʈ.ʈãnn	A kind of red bird	mʊssʊkk	mʊs. sʊkk	Smile
ʈɪʈʈar	ʈɪʈ.ʈarr	Partridge	pʰɪpʰpʰarr	pʰɪpʰ. pʰarr	Lungs

Table 7.18 presents the examples of three short vowels of Hindko /ɪ, a, ʊ/ and the medial consonants of the words geminate and function as the coda of prior and the onset of the subsequent syllable. Hence, law of finals (LOF)[15] is not violated in Hindko rather gemination process occurs. The analysis of the data shows, if the first syllable of a word has /ɪ/, the second syllable always be /a/. However, if the second syllable is open or followed by

[15]Law of Finals (LOF): Word-final rhymes and word-medial rhymes should resemble each other. Law of Initials (LOI): Word-initial onsets and word-medial onsets should resemble each other (Vennemann, 1988, p.32). Syllabification by LOI and LOF: [sɪŋ.ə] *singer, (application of LOI)*, ∗[sɪ. ŋə] *singer* violating of LOI: [ŋ-] is not a word-initial onset and violating LOF: [ɪ] is not found word-finally. Similarly, ∗[æ:tl. əs] *atlas* Violating LOF: [-tl] is not a word-final coda and ∗[æ:.tləs] *atlas* violating LOI: [tl-] is not a word-initial onset (Duanmu, 2008, p.55).

third syllables in a word, the previously mentioned rule may or may not be followed. Conversely, for the other two short vowels, there is no strict rule.

Generally, the syllabification process of marking the syllable boundaries in simple syllable structure (CVCV or CVCVC) is not a complex phenomenon; however, the problem of syllabification rises when a cluster of two or three consonants is found word medially. In addition to simple onset words, Hindko also allows cluster of two consonants (without gemination) at word medial position. These clusters can be found in form of well- formed and ill-formed syllables. First, the analysis of well-formed clusters is carried out in view of MOP in the following section.

Well-formed bi-consonants word medially

In Hindko, when possible bipartite consonant cluster (CC) at intervocalic position in the words is preceded by short vowels; the first C of the intervocalic cluster gets geminated. Thus, the boundaries of such words are marked in light of MOP in the following way:

Diagram 7. 16

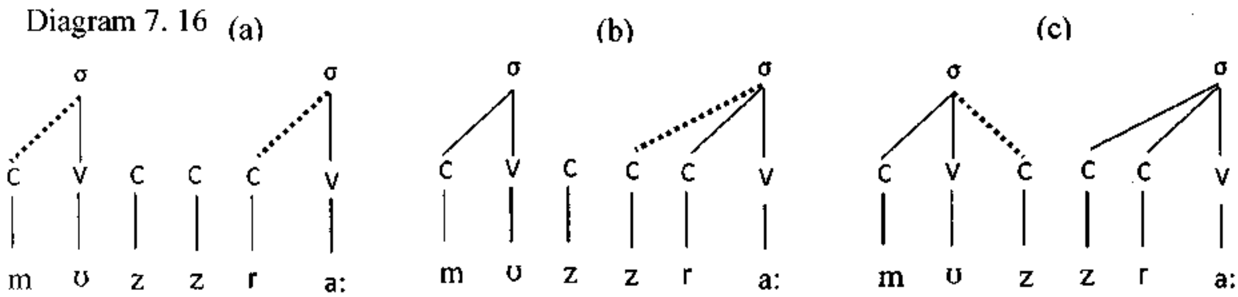


Diagram 7.15 shows that onsets of both syllables are first connected with the syllable nodes. Then word medial /z/ is linked with the second syllable as Hindko allows the cluster of /zr/ word medially. In part (c), geminated /z/ is placed as the coda of the first syllable because in case of intervocalic gemination of consonants, the boundary is marked within gemination

and combination of */zz/ is ill-formed cluster word medially in Hindko. More data is tabulated in the following table to show the boundaries:

Table 7. 19 Data for syllable boundary CVC. CCVV

Words	Boundaries	Gloss	Words	Boundaries	Gloss
tabbri:	tab. bri:	Wife	vakʰkʰra:	vakʰ. kʰra:	Separate
ʧʰappri:	ʧʰap.pri:	Cottage	saʤʤra:	saʤ. ʤra:	Fresh
ʧʰat̪t̪ri:	ʧʰat̪. t̪ri:	Umbrella	ʧʰʊʧʰʧʰla:	ʧʰʊʧʰ. ʧʰla:	Clever
kad̪d̪ra:	kad̪. d̪ra:	Comparatively	kʊʧʧla:	kʊʧ. ʧla:	Poison
mʊt̪ʰt̪ʰri:	mʊt̪ʰ. t̪ʰri:	Defeated badly	massla:	mas. sla:	Problem
kattɽa:	kat.tɽa:	Buffalo calf	mʊzzra:	mʊz. zra:	Result
kad̪d̪ɽa:	kad̪.d̪ɽa:	Swelling	baʃʃra:	baʃ. ʃra:	Face
kʊtʰtʰɽĩ:	kʊtʰ. tʰɽĩ:	A small room	baxxra:	bax. xra:	Part
t̪rakkɽi:	t̪rak. kɽi:	Weight scale			

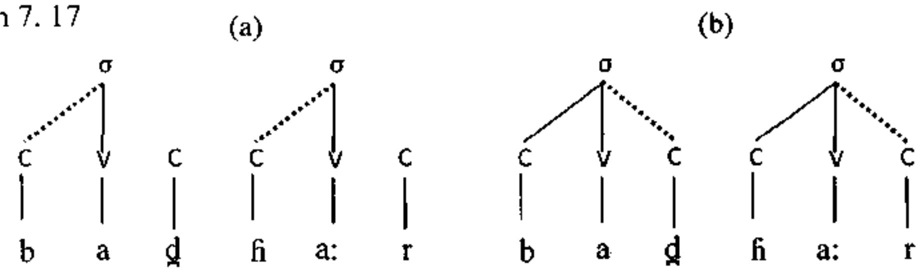
Data in the above table shows some examples containing two consonants word medially. The first syllable in each word consists of onset and coda whereas second syllable has no coda. At intervocalic position of the words, the first C, which is the by-product of gemination, becomes the coda of the preceding syllable whereas the second C gets the position of onset in the following syllable. So, the second C is maximized to the left of the second syllable in light of MOP. Data shows that approximants /l/, /r/ and /ɽ/ with most of Hindko stops, fricatives and affricates at word medial position are possible clusters. Such words are, therefore, found in form of CVC.CCVV templates. Similar to this pattern, collected data also shows some examples in form of closed syllable instead of open syllable, e.g. /naf.frat̪:/'hatred' in form of CVC.CCVCC template.

Some medial consonant clusters in the given examples, e.g. *zr and *tɽ are not found word initially whereas other medial clusters in the given examples are well-formed. Overall, most of the results of the data satisfy the syllabification rule of LOI. Some fricative segments /ɦ, ɣ, v/ do not make consonant clusters word medially that is why the above table does not show examples of these three segments.

Syllabification system for well-formed bi-consonantal cluster, therefore, can be concluded in the following way. When a short vowel occurs in the first syllable of a well-formed bi- consonant cluster word medially, the first C of medial consonant cluster at intervocalic position of a word is geminated, and the boundary for C is marked as the coda of first and the onset of the second syllable respectively. Nevertheless, this rule is not applicable for ill-formed bi-consonantal (see Diagram, 7.16) and tri-consonant clusters (see Diagram, 7.17) word medially.

Unlike well-formed bi-consonantal cluster, syllabification of ill-formed consonantal cluster word medially is different in Tanoli Hindko. The syllable boundaries of such words can be structured in the following diagram:

Diagram 7. 17



In the above structure, intervocalic consonants are ill-formed clusters at word initially in the dialect. Therefore, the first C is placed as the coda of first syllable because MOP allows onsets if clusters are possible. Second C, at intervocalic position of the word is marked as the onset of second syllable. More examples are given below in Table 7.20.

Table 7. 20 Data for syllable boundary CVC.CVVC, CVC.CVV and CVVC. CVV

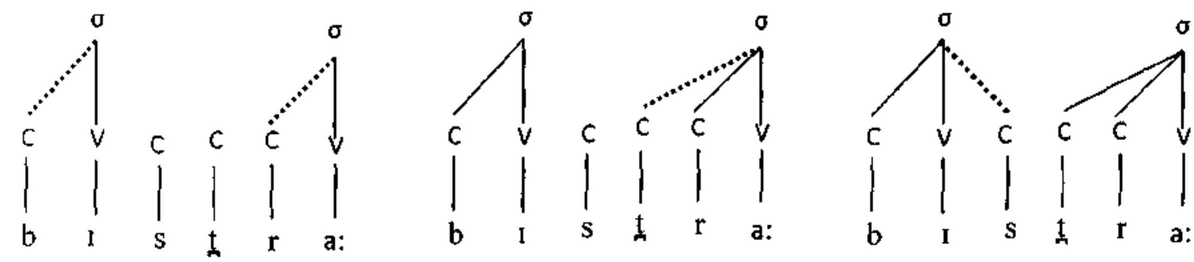
Words	Boundaries	Gloss	Words	Boundaries	Gloss
t̪ãnɦæ:l	t̪ãn. ɦæ:l	Coriander	kʰaʧka:ɽ	kʰaʧ. ka:ɽ	Excessively laughing
kʊft̪ã:n	kʊf. t̪ã:n	Late evening	sabbũ:ɳ	sab.bũ:ɳ	Soap
bu:znã:	bu:z. nã:	Monkey	ɣalbæ:l	ɣal.bæ:l	Sieve (made of leather)
d̪arbu:k	d̪ar. bu:k	Wasp	zãnzi:r	zãn.zi:r	Zip
bad̪ma:ʃ	bad̪. ma:ʃ	Wicked	tɪʧkarr	tɪʧ.karr	Joke
ʧʰo:ɦla:	ʧʰo:ɦ. la:	Quick	fɪt̪nã:	fɪt̪. nã:	Issue
sã:mla:	sã:m.la:	Black	xu:rd̪a:	xu:r. d̪a:	Edible things from sacred places
nʊxs ã:n	nʊx.sã:n	Loss			

Table 7.20 shows syllable boundaries in-between the ill-formed consonant cluster at intervocalic position of the words. First, C of medial cluster is placed as the coda of preceding syllable and then the second C of cluster is marked as the onset of the following syllable. This method of marking boundaries is in line with MOP that if a language allows the cluster, maximize C towards left of V, otherwise place them at the right side of V, i.e. at coda position. In such type of Hindko words, both short and long vowels can be found in the first and the second syllables in the form of open and closed syllables.

Tri-consonant cluster word medially

Hindko has also tri-consonantal cluster word medially. The boundaries of such words are structured in the following way:

Diagram 7. 18 (a) (b) (c)



The above diagram depicts three consonants word medially. First, the onsets of each syllable are marked in 7.17(a). In 7.17(b), onset cluster of /t/ is connected with the second syllable because /t̪r/ is the possible cluster in Hindko word initially. So, it does not violate the syllabification rule of LOI. In part (c), consonant /s/ is marked as the coda of first syllable because the clusters of */str/ is ill-formed in Hindko. Further data for such words is presented in the following table:

Table 7. 21 Data for syllable boundary CVC.CCVV

Words	Boundaries	Gloss	Words	Boundaries	Gloss
bɪst̪ra:	bɪs. t̪ra:	Mattress/quilt	dʒãnd̪ri:	dʒãn. d̪ri:	Flat
ʊstra:	ʊs. t̪ra:	A tool used for shaving	maʃkrĩ:	maʃ. krĩ:	Jokes
daʃkra:	daʃ. kra:	Fashionable young boy	pʰatkɽi:	pʰat. kɽi:	Alum
sãntri:	sãn.t̪ri:	Watchman	bĩnd̪lo:	bĩn.d̪lo:	Firefly
gãndɽi:	gãn. dɽi:	Sack	blɪŋgɽa:	blɪŋ.gɽa:	Zig-zag line
t̪rãŋgɽi:	t̪rãŋ.gɽi:	A net for grass	t̪azkra:	t̪az. kra:	Mentioning
t̪absra:	t̪ab.sra:	Comment			

Table 7.21 displays words containing three consonants cluster word medially; however, such words have low frequency in Hindko. By applying MOP, three consonantal segments at intervocalic position are, first, marked as the onset of second syllable, i.e. first

element within three consonants. The data shows that combination of three consonants is impossible clusters either word medially or initially in Hindko.

Only possible clusters of two consonants are, therefore, connected with second syllable whereas first C of the medial cluster is placed as the coda of first syllable. Similarly, Trommelen (1983) and van der Hulst (1984) state that in Dutch, if a syllable contains tri-consonant clusters word medially and at left edge, it has /s/ followed by obstruent and liquids, it is split up by a division like /mistral as mis.tral/, /castro as cas.tro/ and /esplanade as es.planade/. Conversely, the first C of tri-consonant clusters word medially in Hindko can be stop, fricative, affricate or nasal but third C, at right edge is always liquid or flap.

Empty onset words

Contrasting to the data in the preceding sections, Hindko has also words which start with vowels initially. An example is structured in the following diagram:

Diagram 7. 19

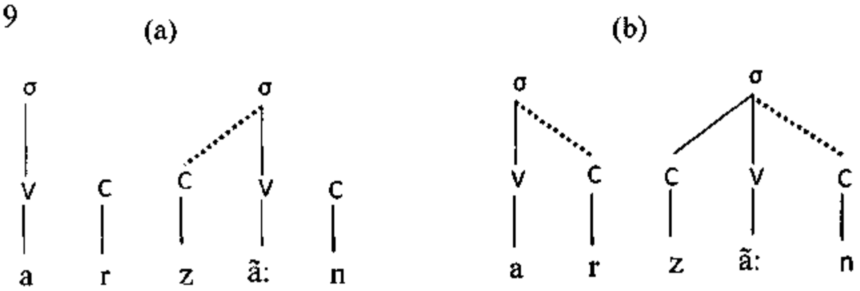


Diagram 7.18 displays a word having vowel initially and second syllable of the word has onset which is linked with syllable node in 7.18 (a). Then, in part (b), medial /r/ is marked as the coda of the first syllable because *rz is no word initial onset, thus, syllabify as /ar. zã:n/ not /a. rzã:n/. Finally, /n/ is marked as the coda of second syllable because it is a closed syllable and there are no further syllables. More data is presented in the following table:

Table 7. 22 Data for syllable boundary for empty onset words

Words	Boundaries	Gloss	Words	Boundaries	Gloss
arzã:n	ar.zã:n	Too much	a:sra:	a:s.ra:	Wait
os̪t̪a:z	os.t̪a:z	Teacher	a:tʰarr	a:.tʰarr	Dry
aʃna:	aʃ.na:	Acquaintance	a:la:	a:.la:	Hole
armã:n	ar.mã:n	Desire	a:s̪t̪a:	a:s.t̪a:	Slow
armã:	ar.mã:	A kind of pulse	ʊt̪t̪ã:	ʊt̪.t̪ã:	Up

Table 7.22 depicts vowels word initially followed by coda whereas onset of the second syllable is followed by V. When there is only one consonant between two vowels, like /a:.la:/ and /a:.tʰarr/, Hindko prefers onset rather than coda, if initial syllable has a long vowel, thus, this rule satisfies syllabification by MOP.

Data shows that some sounds in Tanoli Hindko are not possible word initially, for example, retroflex /ɽ/[16] and /ɳ/ and velar /ŋ/ but possible word medially and finally. However, retroflex /ɽ/ and /ɳ/ can be the possible onset of the second or third syllable of a word. Some examples are given in the following table:

Table 7. 23 Data for syllable boundaries CVC.CVCC and CVC.CVV

Words	Boundaries	Gloss	Words	Boundaries	Gloss
ʧa:ɽi:	ʧa:.ɽi:	Clapping	ku:ɽa:	ku:. ɽa:	Liar
t̪ã:ɳã:	t̪ã:.ɳã:	Flat	mũ:ɳĩ:	mũ:.ɳĩ:	Without tail
kaɽɽakk	kaɽ. ɽakk	Inflexible	gɪɽɽɪgg	gɪɽ. ɽɪgg	A kind of bird
ʃãɳɽakk	ʃãɳ. ɽakk	Flour-kneading basin	kãɳɽakk	kãɳ. ɽakk	Wheat

[16] Occurrence of /ɽ/ word initially is a possible sound in Peshawari Hindko.

Data in Table 7.23 shows syllabification of two sounds /ɽ/ and /ɳ/ at word medial position in the bi-syllabic words of the dialect and it is found as possible onset word medially. Therefore, it shows that this syllabification system in the dialect follows MOP[17] but violates LOI[18]. These sounds are shown in the table with short and long vowels, which are in line with the above mentioned structure of the words, i.e. the following C of short vowels geminates but this process of gemination does not occur with long vowels. During the observation of these two sounds, the native speakers were given many words with short and long vowels and they pronounced each bi-syllable word four to five times. It was found that the occurrence of /ɽ/ and /ɳ/ with long vowels at onset position of the second syllable is clearer than short vowels. However, when /ɳ/ occurs with short vowels in bisyllable words, the coda of first syllable remains as /ɳ/ and its following consonants, i.e. the onset of the second syllable turns into /ɽ/.

Velar /ŋ/ can neither occur word initially nor syllable initially but word medially and word finally. In addition, this is the only consonant in the dialect which cannot occur syllable initially. The structure of /ŋ/ word medially in the bi-syllabic words with short and long vowels is similar that its following sound always carries velar plosive /g/ or /k/, e.g., /xõ:ŋ.kɽĩ:/ 'Feminine partridge', /sã:ŋ.ga:/ 'Field', and /ʧãŋ.ga:/, 'Fine'. This syllabification violates MOP but follows LOF.

Unlike CV templates, Hindko has also VV, VCC, VVC patterns which are not taken into consideration separately because MOP prefers onsets, not codas. In such cases, Hindko

[17] Consonants are preferred at onset position and allow no coda except word finally (Goldsmith, 1990).
[18] According to Law of Initials, If C_0 is not possible word-initially, then C_0 is not possible syllable initially (Blevins, 2003, p. 203) (cited in Duanmu, 2008).

violates principle of maximal onset. Overall, the most of Hindko syllabic templates are occupied by CV, i.e. 10 patterns whereas a few patterns are found in the form of VC, i.e., 3 templates, overall, the dialect allows 13 templates.

7.4.1 Discussion on Hindko syllable boundaries

All long vowels of Hindko can occur at the end of syllables while short vowels cannot but both are possible word initially and medially. The boundaries of analyzed syllables show that short vowels are always followed by a consonant in the form of a closed syllable. Consequently, long vowels are possible to have simple rhyme while short vowels cannot make simple rhyme in the dialect and it follows LOF[19]. It shows that MOP respects LOF in Tanoli Hindko.

The analysis shows that except for /ŋ/ sound, all consonants and possible bi-partite consonant clusters can be marked as the onset of a syllable, which implies that Tanoli dialect follows the principle of maximal onset. In addition to singleton and bi-partite consonant clusters, the dialect also allows three consonants word medially. In such cases, the first C of tri-consonantal cluster is marked as the coda of the first syllable and the other two Cs become the onset of the second syllable. Therefore, these results of tri-consonant clusters are similar to the views of Trommelen (1983) and van der Hulst (1984) (see description of Table 7.21). However, unlike Dutch, in case of Hindko, there are not only /s/ but also plosives, nasals and fricatives can be preceded by obstruent and liquids. Similar to Hindko, three consonant clusters are also found word medially in Urdu and Punjabi.

---

[19] One problem with the Maximal Onset analysis is that it does not respect the Law of Finals (Duanmu, 2008). For example, in [lɛ.mən] lemon the first syllable ends in [ɛ], which is not found word-finally....However, many other studies disregard the Law of Finals and use the Maximal Onset rule strictly (e.g.Halle and Vergnaud 1987, Baayen et al. 1993).

The dialect allows the simple templates such as VV, CVV, VCC, VVC, CVCC and CVVC. In bipartite consonant clusters, templates such as CCVV; CCVCC and CCVVC; CVCC and CVVCC; and CCVCC and CCVVCC are also permissible. Out of these 13 syllabic patterns, therefore, VV, VCC and VVC violate MOP. Regarding onset, Duanmu (2008) states that in case of English, every syllable needs onset and if there is no consonant onset, a glottal stop is added, e.g. out [ʔaut], *Ann* [ʔæ:n] (p. 57). On the contrary, many syllables in Hindko are found without onset but sound of a glottal stop is not heard (see Table, 7. 22).

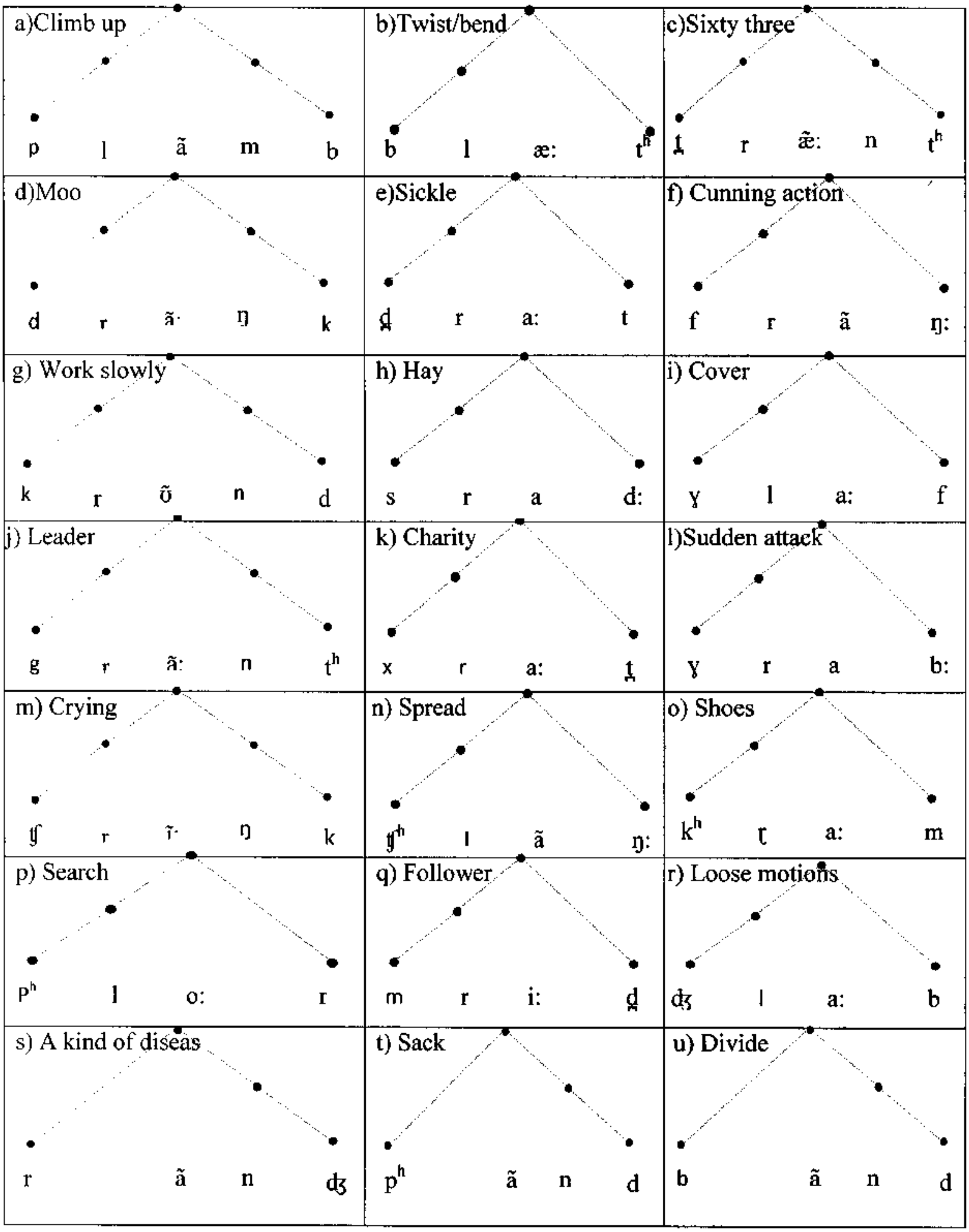
Overall, data shows that Hindko generally allows onset in its syllable structure which is in line with the common assumption that languages prefer onset rather than coda. The findings also show that in case of bi-syllabic words, if /ŋ/ occur at coda position in the first syllable, the onset of the following syllable always begins with /g/ sound. Similarly, in some varieties of English, /ŋ/ is always followed by oral velar stop, for example, 'thiŋk and thiŋg' (Davenport and Hannahs, 2010).

According to van der Hulst and Ritter (1999), the word initial clusters are not necessary to be syllable initial cluster. They refer to some words of Dutch /gnoom, slaaf, tjiftjaf/ and state that initial clusters of the given words /gn, sl, tj/ are split up while they occur word medially like /agnes, ag.nes, Oslo, Os.lo, atjar, at.jar/. Thus, "the possible initial clusters are split up intervocalically. This shows that the only 'real' branching onset are those consisting of an obstruent (excluding /s/ followed by a liquid)" (p.16). Unlike the given structure of Dutch, the results show that Hindko initial cluster can occur in similar form word medially without splitting; however, initial and medial clusters in Tanoli Hindko are always followed by approximants.

7.5 Sonority sequencing principle in Hindko

This section analyzes data of Tanoli Hindko in light of SSP. An example against each Hindko phonemes, in respect of root words, is structured in the following to see whether Tanoli Hindko follows SSP or violates this rule. According to the SSP, diagrams are structured in a way that least sonorous sounds are preceded by more sonorous sounds while the most sonorous sounds reach to climax and then falls towards the final edge of the words having more and least sonority. Therefore, segments progressively increase to peak and then decrease to the margins.

Table 7. 24 Data for sonority sequencing principle



Diagrams in the above table show that the less sonorous sounds in Hindko are followed by more sonorous sounds in rising position, and then in the falling position, more sonorous sounds are preceded by the less sonorous sounds. For example, in diagram (a), a bilabial unaspirated plosive /p/, in the word /plãmb/, is less sonorous sound which is followed by liquid /l/, i.e. more sonorous than the plosive. Then, the vowel /a/, due to its sonority, refers to the peak occurring between the preceding and following consonants. Subsequently, sonority starts the process of falling towards nasal /m/ and /b/ sounds. Since the preceding sound /m/ is more sonorous than the following /b/ sound. Other diagrams such as (c), (d), (g), (j) and (m) follow the same principle. The examples of these diagrams show well-formed consonants clusters word initially and finally which follow the SSP. However, as mentioned above that Hindko does not allow much consonant clusters word finally, for that reason, some words are given in the above table by applying only consonant clusters word initially.

The string of words like /blɪtt/ 'rolling' contains consonant cluster at onset position of the syllable which is in line with SSP. The sound rises from voiced plosive /b/ towards /l/ and gets to the peak /ɪ/ sound. Then, following SSP, sonority of string falls to plosive /t/ which is less sonorous sound. Most of the diagrams including (e), (f), (h), (i), (k), (l), (n), (o), (q) and (r) follow the same rule of SSP at onset position while in the diagrams of (s), (t) and (u), segments follow SSP at coda position. It shows, therefore, the fact of rising and falling sonority adheres to Tanoli Hindko. Overall, the analysis of the data follows sonority sequencing principle and words have not been found which violate the SSP in its root words.

7.5.1 Discussion on SSP in Hindko

The analysis of data in terms of SSP reveals that in Tanoli Hindko, like many other languages, least sonorous sounds are preceded by the most sonorous sounds at the onset position and reverse is found at the coda position in a syllable. Generally, the dialect does not allow much consonant clusters word initially and finally. The possible clusters at the onset position, maximal bipartite clusters, show the occurence of stops, fricatives and affricates, which are followed by /l/, /r/ and /ɽ/; and at the coda position, nasals are followed by stops, fricatives and affricates. The combination of fricatives and stops are also possible at the coda position in the dialect. On the basis of SSP analysis of Tanoli Hindko, therefore, sonority ranking constraints may be proposed in the following way: at onset position, segments of stop, fricative, affricate < approximants and at coda position segments of nasal > stops, fricatives, affricates and segments of fricatives > stops. Tanoli Hindko observes this cross-linguistic universals based on the phenomenon of SSP, which govern the permissible sequences of consonant clusters within syllable, accordingly. Akram (n.d) states that Urdu successfully applies SSP in its syllable structure . English follows SSP; however, it violates this principle in some cases; such as, Davenport and Hannahs (2010) refer to two English words 'stoat' and 'skunk' where the reverse order is found at onset position. Similarly, they also refer to two German words, Sprache /ʃp/ and Strauss /ʃt/ that have also reverse sonority order. In the core syllable of the present study, no syllable has been found which violates SSP.

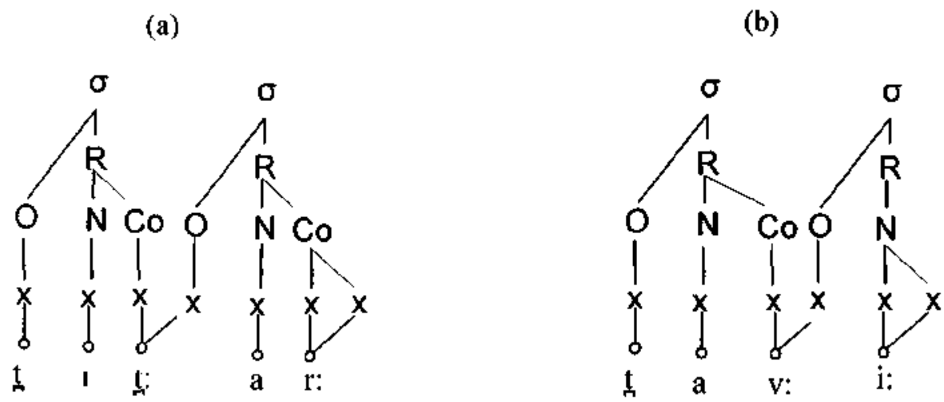
Literature shows (see Section, 2.10) languages violate SSP and if appendages of the syllables are taken into account, violation can be seen more easily. For example, Rubach and Booij (1990) and Rowicka (1999) state that Polish violates SSP because it allows maximum consonant clusters. They indicate a Polish word, /nastmpstf/, which means 'consequence', where SSP violation can easily be observed. Khan (2012) states that Pashto, a major language of KP, includes multiple violations of SSP in bipartite and tripartite clusters both word initially and finally (e.g., /lmar/ 'sun', /sxwanḍar/ 'Bull', /ʃxwanḍ/ 'chewing', /skwaraṭa/ 'ember', /xkwale/ 'beautiful' /ndror/ 'sister-in-law', /aks/ 'contrary' and /habs/ 'humidity').

Tanoli Hindko also allows clusters word finally in form of fricatives and stops (see Section, 7.3.2) so its obstruents keep MSD. Thus, these results are similar to Spanish, which allows MSD within Obstruent (see Section, 2.10).

7.6 Gemination in Hindko

In addition to the previous properties of Hindko syllable structure, data also shows gemination word medially and finally which is tabulated in Tables 7.25 and 7.26 respectively. However, before each table, a sample of gemination system is structured according to Onset-Rhyme theory (see Section, 2.11). The following diagrams represent the incorporated skeleton for two Hindko words containing geminated consonants and long vowels.

Diagram 7. 20



The above diagrams show the structure of two Hindko words in terms of representation of length. In 7.19 (a), medial /ṭ/ and /r/ consonants geminate which shows skeletal tier as (x) whereas Diagram (b) exhibits gemination of medial consonant /v/ and vowel /i/. Segments /ṭ/, /r/, /v/ and /i/ show single root node but due to two skeletal positions, they get the form of /ṭ:/, /r:/, /v:/ and /i:/. Medial consonants in both diagrams occur simultaneously at the coda position of the first and at the onset position of the second syllable.

Conversely, short segments reveal direct association between skeleton and root tier. More data for gemination is given in the following table:

Table 7. 25 Data for gemination word medially

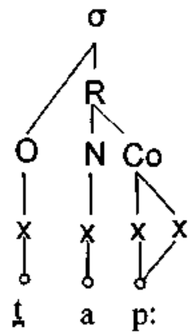
Syllables	Gloss	Syllables	Gloss	Syllables	Gloss
rap.paɽɽ	Field	nɪk. ka:	Small	t̪av.vi:	Soil pane
tab.barr	Family	bɪg.garr	Successfully completed	bas.sa:r	Forget
p^{h}ɪp^h.p^{h}arr	Lungs	k^{h}ak^h.k^{h}aɽɽ	Riped cucumber	naz.zarr	Sight
t̪ɪt̪.t̪arr	Partridge	dʒãn.nakk	Children	haʃ.ʃarr	Gathering
mʊd̪.d̪a:	Duration/time	ʧãm.maɽɽ	Attach	lax.xat̪t̪	A small stick
mat̪^{h}.t̪^{h}a:	Forehead	naʧ.ʧo:ɽ	Squeeze	maɣ.ɣazz	Brain
tat.tu:	Horse	nadʒ.dʒo:ɽ	Sick	nɪr.ra:	Mere
bad.da:	Big	maʧ^h.ʧ^{h}i:	Fish	jal.lãmm	Leech
t^{h}at^h.t^{h}arr	Joke	sɪf.fat̪t̪	Quality	kaɽ.ɽak	Hard

The above table 7.25 reveals some examples of geminated words in Hindko at intervocalic position. All words are disyllabic, and intervocalic consonants geminate in form of the coda of the first and the onset of the second syllable. Table shows examples of gemination with most of the consonants; however, glide /j/ and fricative /ɦ/ do not allow gemination at intervocalic position. The reason of non-gemination of these two segments lies in the fact that Tanoli Hindko glide /j/ word medially and finally changes into /æ:/, and fricative /ɦ/ though occurs word finally but has a vowel like quality such as /a:/ at word or syllable final position. So, may be due to this relevance, /ɦ/ is not a good candidate for gemination.

Flap /ɽ/, nasals /ɳ/ and /ŋ/ are not possible sounds word initially but /ɽ/ and /ɳ/ are permissible segments syllable initially. In gemination process, /ɽ/ is permissible sound at word medial position such as /gɪɽɽɪg/, 'a kind of bird' /ʃɪɽɽɪk/, 'road' whereas in case of /ɳ/ sound, if it is preceded by short vowels word medially, its following consonant, instead of gemination, turns into /ɽ/, like /kãɳ.ɽakk/, 'wheat', /ʃãɳ. ɽakk/ 'Flour-kneading basin'. Thus, retroflex nasal /ɳ/ becomes the coda of first syllable and retroflex flap /ɽ/ get the position of onset of the second syllable. On the other hand, velar nasal /ŋ/ is followed by either /k/ or /g/ in bi-syllabic words such as /xõ:ŋ.kɽĩ:/ 'Red-legged partridge (female)', /sã:ŋ.ga:/ 'a small field for ploughing'. In addition, approximant /r/ geminate word medially but its position remains too weak because /r/ has the least duration among all consonants of Hindko such as 0.0425 seconds (see Figure, 5. 20). Examples of geminate words at intervocalic position are given in the above table irrespective of word category such as noun, verb and adjective. However, data shows that gemination frequency for verb is comparatively less than nouns and adjectives. Generally, all these categories can be found in gemination form at word medial position. In Tanoli Hindko, when a short vowel occurs in the first syllable, the onset of the second syllable gets geminated word medially and if consonant cluster of word final coda or ill-formed consonant cluster is found at word medial position, the process of gemination does not occur. As mentioned above that long vowels do not allow gemination at any position of a word in the dialect.

In addition to word medial gemination, the dialect also allows gemination word finally. An example is structured in the following diagram:

Diagram 7. 21



The above diagram shows that /p:/ geminates word finally in form of single root node but two skeletons. Further examples are tabulated in the following:

Table 7. 26 Data for gemination word finally

Syllables	Gloss	Syllables	Gloss	Syllables	Gloss
t̪app	Get warm	lakk	Waist	ɣazz	Meter
dʊbb	Sink	d̪agg	A flat wood	kaʃʃ	Smoking
d̪apʰpʰ	A kind of drum	kʰakʰkʰ	Cave	jaxx	cold
pɪt̪t̪	Contesting a kind of game	ʧãnn	Moon	ɣaɽɽ	Cave
kad̪d̪	Height	ʤãmm	Birth	barr	Fly
klat̪ʰt̪ʰ	A kind of pulse	bõɳɳ	Weave	jʊll	Cockroach
satt	Fire of gun	frãŋg	Action	bʊʤʤ	Understand
gadd	Mix	saff	Queue	kaʧʧ	A small piece of glass
natʰtʰ	Escape	mass	Muddle	pʊʧʰʧʰ	Ask

Data in the above table 7.26 reveal that almost all Hindko consonantal sounds geminate word finally except two segments /v/ and /ɣ/. The dialect allows word final gemination in verbs and nouns. Each example shows short vowel before CC word finally. It can be said, therefore, if a short vowel is followed by a consonant at word boundary, the following consonant gets geminate as CC.

7.6.1 Discussions on gemination

The analysis of data shows that geminate consonants include two timing slots in light of OR model. Gemination in Tanoli Hindko is possible at two positions, word medially and finally. Literatur shows that some languages allow gemination word medially and a few permits word finally such as Taylor's (1985) reports that out of 29 languages of her sample of the study, 26 allow medial gemination and out of 26 languages, 14 also allows final gemination (see Section, 2.11).

In Tanoli Hindko, word medially gemination includes nouns, adjectives and verbs while word final gemination occur in verbs and nouns. At intervocalic position of the words, the first C, which is the by-product of gemination, becomes the coda of the preceding syllable whereas the second C gets the position of onset in the following syllable. In the first syllable of a word, if there is a short vowel, which is followed by single consonant or well-formed bi-consonants, the coda of the first syllable geminates as CC at word medial position, i.e. the coda of the first syllable and the onset of the second syllable. However, this rule of gemination is not applicable, when well-formed word final clusters of Tanoli Hindko occur at word medial position rather word final coda split up as the coda of the first syllable and the onset of the second syllable.

Moreover, in some of languages, gemination is phonemic such as in Italian, the word /papa/ means 'pope' while /pappa/ means 'daddy' (Ewen & van der Hulst , 2001, p.154). Likewise, Ladefoged (1975) refers to Italian geminate consonants, i.e. /nonno/ means 'grandfather' and /nono/ means 'ninth'. Contrary to it, in Tanoli Hindko, gemination is not phonemic. In case of English, gemination occur across the word boundaries having two morphemes such as book-case or un-known, but in Italian, gemination is possible in single morpheme (Ladefoged, 1975). Therefore, like Italian but unlike English, gemination in Hindko occurs within a single morpheme.

Kawahara (2005) cited in Callender (2006) that glides are rarely geminate due to its sonority. He adds that sonorous sounds are the poor candidates for gemination because their boundaries cannot be distinguished easily. In the same way, keeping in view the general rule of gemination for Tanoli Hindko, the status of nasal velar /ŋ/, in terms of gemination word finally in monosyllable is not very clear, whether it geminates as /ŋŋ/ or occurs as /ŋg/ but currently, treated as /ŋg/, e.g. /bãŋg/ (Bangles) and /bĩŋg/ (Bend). This case, therefore, needs to be further investigated. Contrary to the word final position, the following sound of /ŋ/ turns into /g/ or /k/ at word medial position in bisyllable or trisyllable words, e.g. /pʰĩ:ŋ.garr/ (a small piece of stone/wood), /t̪rĩ:ŋ.gall/ (A toll in form of a fork, used in wheat thrashing) and /xõ:ŋ.kɽĩ:/ 'feminine partridge'. Likewise, the following sound of the retroflex /ɳ/, in the bisyllable or trisyllable words, turns into /ɽ/ at word medial position (structured as ɳɽ) e.g. /ʧʰĩɳ.ɽĩ:/ (chisel).

In Hindko, glide /j/ is changed into /æ:/ at intervocalic and final position of a word that is why it cannot be the part of gemination but it can occur as syllable initially at word medial position, e.g. /t̪a:.ja:/ (uncle). The analysis shows that sonorous sounds geminate but take least duration in articulation. Generally, all nasals and approximants are poor candidates for gemination word finally. Moreover, one fricative /ɦ/ cannot geminate at any position while /v/ and /ɣ/ are not possible geminated sounds word finally. Apart from the above given exceptional cases, voiced and voiceless sounds of the dialect allow gemination. Thus, these results, voiced and voiceless geminated sounds, are in line with the findings of Taylor (1985) (see Section, 2.11).

Paul Ken (1981) states that if a language has word medial gemination and intervocalic consonants clusters, and it has no word initial and final clusters, but has consonants of longer duration at these positions, they are called heavy or tense consonants not geminated consonants. However, Hindko allows clusters word initially and finally, therefore, it can be said that its consonants geminate.

7.7 Chapter summary

The findings of the study show that Tanoli Hindko allows maximum three syllables in its root words. Three consonants including /m/, /ɳ/ and /l/ can become syllabic but always word finally. In Tanoli Hindko, minimum template is VV and maximum syllabic template is CCVCC. Tanoli dialect of Hindko permits the pattern of V, CV, VC and CVC.

Maximum two consonant clusters are well-formed strings in Tanoli Hindko. At word initial and medial positions, the following three approximants, /l/, /r/ and /ɽ/, make clusters if preceded by stops, nasals, fricatives and affricates. However, at coda position, three nasals /n/, /m/ and /ŋ/ allow clusters with stops, affricates and fricatives; and a few fricatives also permit cluster with stops. Clusters word initially and medially are more in frequency than word finally. Thus, these findings are similar to the general concept that languages give preference to onset rather than coda.

In most of the cases, Tanoli Hindko follows the syllabification principle of maximal onset. Sounds like /ɳ/ and /ɽ/ are not possible word initially but possible syllable initially. The boundary of /j/ is connected as the onset of the second syllable not the coda of first syllable. In case of three segments word medially, combination is split into two parts, the first C is linked with the coda while following two consonants are marked as the onset of the second syllable. These results, therefore, reveal that the dialect prefers onset in its syllabification system.

In the present chapter, principle of SSP is also applied on the data to find out the sonority hierarchy of syllables in the dialect. It is found that this universal principle of syllable phonotactics and segment patterning in Hindko is similar to the general concept that least sonorous segments remain far from the peak and the more sonorous sounds get closer to nucleus. This application of segment ranking is found in all the data without a single example of violation of SSP in Tanoli Hindko.

The phonological process for geminate consonants exhibits that language allows gemination word medially and finally. The following consonant of short vowels is always geminated whereas in case of word final coda clusters at intervocalic position, this rule is not applied. Short vowels cannot occur syllable finally while long vowels are possible segments word finally and the adjacent consonants of long vowels do not allow gemination.

This Chapter has described the syllable structure, various syllabification rules and phonotactic constraints in Tanoli Hindko and the following Chapter gives an overall conclusion of study.

CHAPTER 8

CONCLUSIONS

This chapter sums up the whole thesis and throws some light on the scope of future research in the field of Hindko phonology. The research questions posed in the introductory chapter and their answers have been highlighted. From the description of segmental features and syllabification system of Hindko, researcher has drawn the following conclusions.

8.1 Description of Consonants

Consonants of Hindko spoken in Tanawal have been established on the basis of contrastive sounds, i.e. minimal pairs. The study based on articulatory phonetics has found out that Tanoli Hindko has 31 consonants including 12 oral stops, 4 nasal stops, 8 fricatives, 3 affricates and 4 approximant sounds. Tanoli Hindko allows three ways of voicing, i.e. unaspirated, voiced and aspirated. Three ways of voicing are found in the articulation of stops and affricates whereas fricatives contain voiced and unaspirated segments. However, all nasal stops and approximants subsume only voiced sounds. Most of the consonants occur at three possible positions of words but retroflex nasal /ɳ/ and retroflex flap /ɽ/ occupy word medial and final positions. Glide /j/ occurs in the beginning of a syllabl/word whereas it becomes vowel /æ:/ word medially and finally.

Overall, this study verified the Awan's identified phonemes; however, it showed the difference in some cases. Such as, the chart drawn by Awan (see Table, 2.1 & Appendix-A) shows that Hindko has 16 stops, 4 affricates, 3 nasals, 8 fricatives and 4 approximants. It shows the place of /k, k^h, g/ as palatal sounds whereas the present study exhibits them as velar sounds. Awan also shows that each place of articulation of stops and affricates has two unaspirated, one aspirated and one voiced segment. On the contrary, the results of the present study reveals 12 Hindko stops and 3 affricates, and each place of articulation of stop has one unaspirated, one aspirated and one voiced sound (see Table, 4.1).

If the concept of two unaspirated sounds at each place of stop and affricate is taken into consideration as Awan suggested, the phonemic inventory of Hindko dialect of Tanawal can be very rich among all dialects. Along these lines, in addition to the phonemic inventory by Awan, i.e. 35 consonants, some other consonants have also similar status in Tanoli Hindko including stop /b/ (see Section, 4.2.2), two nasals /m/, /n/ (see Section, 4.3.2), two fricatives /s/, /ʃ/ and two approximants /l/, /j/. In this way, there will be 42 consonants for Tanoli Hindko. However, the proposed sounds by Awan, i.e. (p̆, ṱ, ť, ǩ and ťʃ), occurs only word initially in Hindko. Baart (n.d) states that in Punjabi type languages such phenomenon occurs due to the tone (see Section, 4.2.2). Generally, in case of Hindko, the vowels following the consonant carry a low tone which makes it a different word, e.g. the word /ta:l ٹال / means heap of woods etc, and if the same word is spoken with the low tone on the vowel following the first consonant, i.e. /ta:l/ تہل it means 'descent' which reveals the tonal effect in the language.

Awan's chart presents 3 nasals whereas the present study shows 4 nasals (see Table, 4.2). He states that /n/ is a dental segment while the present analysis shows it as alveolar sound. Similarly, he describes that /s, z/, /l/ and /r/ are dental sounds whereas the present work identifies them as alveolar sounds. He states fricative /h/ as a voiceless segment but acoustic analysis of the present study shows it as a voiced /ɦ/ sound (see Appendix, B).

Generally speaking, in manners of articulation, Hindko has eight classes namely plosives, nasals, trill, flap, fricatives, affricates, glides and laterals. Similarly, in case of places of articulation, Hindko consonants are produced at eight different places namely bilabial, labio-dental, dental, alveolar, palatal, retroflex, velar and glottal.

The phonemic inventory of Hindko verified through articulatory phonetics has also been further tested by acoustic phonetics because acoustical measurements give more valid results (see Section, 2.5). Thus, segments have been recorded and examined through Praat software which measures linguistically relevant acoustic properties of sounds in Hertz and the duration of the utterances in seconds. Subsequently, results have been verified by statistical tests ANOVA and LSD. These tests distinctly identified all the consonants of the dialect and also proved that Hindko does not allow fricative /ʒ/ sound as approved by Peshawar TBB which is actually the glide /j/ sound (see Section, 5. 1. 6). Similarly, this research assumed that an aspirated velar /g^h/ sound also exists in the Tanoli dialect but the acoustical measurement results proved it otherwise.

Like articulatory phonetics, spectrographic and VOT measurements have verified that Hindko stops have three ways of voicing in the dialect including unaspirated, voiced and aspirted sounds. Acoustical measurment results indicate that Hindko has four voiced stops and eight voiceless segments. These results also identify four places of articultion for stops, i.e. bilabial, dental, alveolar and velar. The formant transitions of the alveolar sounds shows that movements of the adjacent vowels for velar and alveolar are rarely different from previous studies. Regarding the places of articulation VOT measurements signify following hierarchy in Hindko, i.e. velar > bilabial > dental > alveolar. These results are not consistent with the various previous studies which show that VOT of bilabial, alveolar and velar stops increases respectively. The stops cue of closure duration measurements of Hindko dialect shows that dental > bilabial > velar > alveolar sounds. In this case, dental takes the place of velar and other places remain similar in terms of VOT and closure duration.

Findings also show that unlike English but like many other languages, Hindko has negative VOT for voiced sounds, less positive VOT for unaspirated segments and more VOT for aspirated sounds. It has also been found that Hindko unaspirated sounds take the longest duration time during silent gap while voiced sounds carry shortest time in the utterances of stops. On the other hand, aspirated sounds take more time than voiced but less than unaspirated sound. Overall, statistical measurements of VOT and closure duration cues reflect that alveolar takes least time as segment based on voicing features and places of articulation. In addition, comparison of VOT and closure duration measurements show that unaspirated sounds include less VOT but maximum closure duration and time of closure cue in aspirated sounds is almost double to VOT. On the other hand, VOT in voiced sounds is negative while closure duration is positive with same durational time mean values.

During the analysis of intrinsic and extrinsic properties of nasals, it has been found that Tanoli Hindko nasal bilabial gets low frequencies than other nasals. Results show that all Hindko nasals' resonances are weaker than their neighbouring segments. In the same way, most of nasal spectrograms have discontinuity of formants from adjacent sounds. Unlike the traditional concept, the nasals formants' frequency increases from front to back nasals (see Section, 2.5.2). The results of overall Hindko nasals formants show maximum frequency for retroflex whereas velar has less frequency than retroflex and alveolar (see Figure, 4.14).

Similarly, findings of individual formants average mean values of nasals; F1 and F2 of velar are shorter than retroflex nasals. However, velar F3 mean value is higher than retroflex F3. Thus, in light of the average means values, Hindko nasals have following hierarchy:

retroflex > alveolar > velar > bilabial. In addition, like majority of the languages, Hindko nasals, /m/, /n/, /ɳ/ and /ŋ/ are voiced sounds.

The acoustic analysis of Hindko fricatives reflects that /f/, /s/, /ʃ/ and /x/ are voiceless sounds and /v/, /z/, /ɣ/ and /ɦ/ are voiced phonemes. Voiceless sounds have longer duration than voiced sound. More specifically, palatal voiceless is the longest sound while front sounds uttered at labio-dental place are the shortest segments. Furthermore, there is a slight difference between the utterance time of front and back fricatives while sounds articulated at medial places of articulation have higher closure time in Tanoli Hindko.

The acoustic cue of frication noise of the fricatives show that resonances commence from lower part of spectrum for alveolar and palatal sounds than labio-dental, velar and glottal sounds. Energies for these sounds are in more compact form and cover broader area than front and back fricative sounds. Therefore, sibilant sounds, /s/, /z/ and /ʃ/ have greater interval of frication noise than other fricatives. Generally, frication resonances for voiceless sounds covers more space in spectrograms than voiced but voiced /z/ has stronger energy than its voiceless counterpart /s/ sound. Spectrographic analysis for sounds like /v/, /x/, /ɣ/ and /ɦ/ shows weak noise energies in a spread form on spectrograms. Overall, sibilant sounds have regular striations whereas non-sibilant sounds carry irregular constrictions both horizontally and vertically.

Hindko has three affricate sounds, articulated at alveolar places, i.e. unaspirated, aspirated and voiced sounds. Affricate is the by-product of fricative sound preceded by stop sound. Consequently, affricates reveal mixture of acoustic cues that are part of two sounds, stops and fricatives. Stop cue of silent gap and fricative cue of noise frication measurements depict that in combined form affricates take less utterance time than individual sound. These findings about affricates verify the previous view that individual stop and fricative sounds have longer duration than affricates. Results also show that voiceless sounds have longer duration than voiced sounds.

Hindko has four approximants including glide /j/, liquid /l/, liquid /r/ and flap /ɽ/, which are articulated without constriction like the vowels. The formants of these sounds are almost similar to vowel formants. Generally, all approximants' formants, F1, F2 and F3 remain highly energetic throughout the utterances. Nonetheless, lateral /l/ formants are a bit fainter than other approximants' formants. F1 average mean values of all approximants are nearly parallel to vowels' F1 values. Similarly, F2 mean value of /j/ remains higher than other approximants yet less than Hindko front high vowels that contradict to the previous studies. Similarly, there is difference between F2 mean values of vowels and other approximants as well. During the spectrographic analysis of /j/, it has also been observed that spectrogram of /j/ has an empty space between F1 and F2 which looks like lips in the position of utterance /e:/ (see Figure, 5.15). This indication makes /j/ spectrogram prominent in not only approximants but also consonants and vowels as well. Spectrograms of other consonant lack such strong resonances in their formants. The analysis reflects that approximants are more sonorous sounds than the consonants but less sonorous than vowels. By and large, findings of formants acoustic cue are in line with the previous theories that approximants have vowel-like qualities.

Like approximants formants, cue of duration measurements show that glide has maximum duration and liquid carries minimum utterance time. However, a small difference has been found in flap and liquid duration. The following order has been measured in articulation time of approximants: glide > lateral > flap > liquid.

8.2 Description of Vowels

Vocalic inventory of the study on articulatory basis reveals that Tanoli Hindko has nine oral vowels, six are long vowels, /a:/, /æ:/, /e:/, /i:/, /o:/, /u:/, and three are short vowels, /a/, /ʊ/, /ɪ/ (see Tables, 6.2 & 6.3). Tanoli Hindko vowels, identified in terms of articulatory phonetics, have been further examined by acoustic phonetics in light of spectral and temporal characteristics. Data was collected from illiterate people and the least sonorous sounds in the preceding and following position were used for recording the vowels, e.g. /ti:p/, /ta:p/, /tʊp/ etc. Awan (2004) also recommends that proper identification of vowels is not possible without the use of machine (see Section, 2.1).

Unlike the present study, Rashid recorded the data form literate people for acoustic analysis of vowels of AJK dialect in the environment of sonorous sounds for some sounds, either at preceding or following position, e.g. /bən/, /bʊn/, /ber/, /sɪl/, /rat/. It is proposed that factors like consonantal sonority at adjacent position of a vowel, and recording of literate people may affect on the formant frequency measurements and remain different from the least sonorous consonantal sounds to vowels and the voices of illiterate people.

The recorded data in the present study has been analyzed quantitatively through Pratt software. The results of vowels have also been verified by statistical tests ANOVA and LSD. In the course of these tests, it has been found that all vowels of the dialect are significantly different from one another. However, during the analysis, some problems encountered such as /e:/ sound was recorded in three alternative times in CVC context, because each time results tested by ANOVA, had insignificant difference between the values of /e:/ and /æ:/. Result, therefore, implies that /e:/ and /æ:/ have almost similar properties word medially in the dialect. Then, /e:/ has been recorded in VC and CV context and verified the average mean values by ANOVA, ultimately, it has been found out that /eː/ is possible sound word finally but not initially and medially. Conversely, in Peshawar and AJK Hindko, /eː/ can occupy all possible positions of a word.

Overall, ANOVA results show the significant difference among these nine vowels. Thus, on the basis of F1 and F2 measurements, Hindko vowels quadrilateral has been developed. The places of vowels show that Hindko permits centripetal system. The places of /eː/ and /æː/ sounds are somewhat far from the vowels of many languages of the world. The place of /ʊ/ is quite different in the vowel trapezium and from the indicated places of cardinal vowel as well. Therefore, it is obvious that the values of these three vowels in particular and their places are in line with the general concept that cardinal vowels are just a reference point and vowel space varies in languages.

Results of temporal characteristics of vowels, measured statistically, show that out of the nine vowels, six are long and three are short vowels. Duration of long vowels is almost double to short vowels. The findings of articulatory phonetics show that five long vowels of the dialect occupy all possible positions /iː/, /æː/, /aː/, /oː/, /uː/, and a long vowel /eː/ occurs only word finally and three short vowels /ɪ/, /a/ and /ʊ/ get positions word initially and medially.

Tanoli Hindko also allows nasal vowels as contrastive sounds. Articulatory analysis of the vocalic nasalization part of the study show five nasals and four nasalized vowels whereas Awan's (2004) study show six long and three short nasal vowels in Peshawari Hindko. On the contrary, Rashid (2011) identified five nasal vowels in Kashmiri Hindko. The comparison of the formant values of Tanoli Hindko nasal and oral vowels show that in most of the cases, F1 value of nasals is higher than that of oral vowels. The results of the acoustic study of nasal sounds are not consistent with the general concept that F1 of oral vowel is higher than nasal vowels, thus, suggested that this phenomenon should be investigated in a separate study to find out more comprehensive result. Moreover, it has also been identified two diphthongs in Tanoli Hindko, /ai/, /ei/, which were also verified by acoustic phonetic. Rashid (2011) investigated three diphthongs in Kashmiri Hindko while Awan's study lacks this phenomenon.

8.3 Description of syllables and syllabification

The findings of the suprasegmental feature of the study show that Tanoli Hindko allows maximum three syllables in its root words. It also shows that liquid /l/, nasals /m/ and /ɳ/ function as syllabic consonants in the dialect.

Tanoli Hindko allows both open and closed syllables. It has two categories in its basic syllable structure including simple syllables and complex syllables. Complex syllables refer to maximum bipartite consonant clusters which are possible in both open and closed syllables in the dialect. Short vowels cannot stand alone as syllable whereas long vowels and diphthongs can make simple rhyme in Tanoli Hindko. The findings reveal that all long vowels can occur in open syllable while short vowels cannot do so. In case of consonants, except /j/ sound, all consonants can occur at coda position whereas apart form /ŋ/, all Hindko consonants are permissible sounds at syllable initially position. In simple syllables, the templates of VV, CVV, VCC, VVC, CVCC and CVVC are possible in Tanoli Hindko. On the other hand, in bipartite consonant clusters, templates of CCVV, CCVCC / CCVVC, CVCC / CVVCC, and CCVCC /CCVVCC are permissible. Overall, the results show that Hindko has 13 syllabic templates.

Tanoli Hindko allows maximum bipartite consonant clusters at three possible positions of a word. The left edge of word initial cluster shows that except /n/, /ŋ/, /ɳ/, /v/, /l/, /r/, /ɽ/ and /j/, other all consonants allow clusters, if combination is well-formed. The segments /ɳ/, /v/ and approximants /j/, /l/, /r/ and /ɽ/ are impossible sounds as first C (left edge) of a cluster string at any position of a word. Nasals /n/ and /ŋ/ are ill-formed cluster segment word/syllable initially but well-formed at coda position followed by other consonants. The findings reflect that most of the strings at coda position have /n/ while a few coda clusters allow /m/, /ŋ/. Likewise, some fricatives also occur at the left edge of coda cluster.

Therefore, only three approximants, /l/, /r/ and /ɽ/ stand as second C (right edge) of initial and medial clusters which are preceded by stops, nasals, fricatives and affricates. In case of word final cluster, stops, affricates and fricatives are preceded by nasals and fricatives. In most of the cases, medial consonant clusters are found as the onset of the second syllable in form of open syllable and a few medial consonant clusters are found in closed syllables.

In Tanoli Hindko, word initial clusters are 47, word medial bipartite clusters are 48 clusters and coda clusters are 15 in numbers. Generally, word initial clusters are also permissible word medially whereas possible coda clusters are split up intervocalically in the dialect such as /ns/ and /nt̪/ and occur as /n.s/, /n.t̪/. The above analysis of syllable structure was carried out in light of Onset Rhyme Theory.

By using the principle of maximal onset, the study defines well-formed syllabic structure of Hindko. MOP remains an effective parameter for marking the syllable boundaries of Hindko syllables. The findings show that Hindko generally follows this principle in most of its syllabic patterns, i.e. syllables having onset satisfy the constraint[20]; however, in some of the syllabic patterns (e.g. VV, VCC & VVC), it is violated. The results show that Hindko allows 13 types of syllabic patterns, out of which the above mentioned three templates are without onset. The findings show that /ŋ/ sound cannot occur word initially and also syllable initially, thus, LOI is not violated, i.e. word initial onsets and word medial onsets resemble each other. However, flap /ɽ/ and nasal /ɳ/ are not possible sounds word initially in Tanoli Hindko but possible syllable initially representing that LOI is violated. The analysis of the syllable boundaries of the data reveals that three consonants /ŋ/, /ɳ/, /ɽ/ cannot occur word initially in Tanoli Hindko; however, as mentioned above, retroflex /ɳ/ and /ɽ/ are possible sounds syllable initially in the dialect. The retroflex /ɽ/ is also impossible sound word initially in Punjabi, Paharri, Urdu and in other dialects of Hindko except Peshawari Hindko.

In Tanoli Hindko, if retroflex /ɳ/ occurs with a short vowel at word medial position, the following consonant, i.e. the onset of second syllable turns into /ɽ/. The results show that Hindko velar /ŋ/ in bi-syllabic words is always followed by /g/ and /k/ at word medial position, thus, /g/ and /k/ get the onset position of the second syllable. Moreover, when tri-consonantal cluster occur word medially, the third C at the right edge of the string is always limited to /l/, /r/ or /ɽ/. In the same way, in case of two consonant clusters word initially, the second consonant is always limited to these three approximants in the dialect.

In the root words of Tanoli Hindko, it has been found by the application of SSP that bipartite clusters, word initially and finally; follow sonority hierarchy strictly in terms of rising and progressively falling. Not a single example has been found which occurs in reverse

---

[20] Syllable must have onset (Ito, 1989; Prince and Smolensky, 1993). Onset in a syllable is unmarked situation (Jakobson, 1962). No language can entirely exclude onset even if some of its syllables lack onsets (Kager, 1999).

order of sonority of sounds in a syllable. Moreover, at the coda position, MSD has also been maintained between fricatives and stops[21]. Overall, sonority hierarchy system of Hindko is in line with English. However, some words in English includes reverse sonority as well, for examples, onset clusters in the following words *'stoat'* and *'skunk'* (see Section, 2.10) violate SSP. Contrary to Hindko, languages like Pashto, German and Polish include reverse sonority sequencing.

Hindko allows gemination at intervocalic and word final positions. Except for a few sounds, all voiced and voiceless sounds allow gemination. Glide /j/ and fricative /ɦ/ cannot geminate at any position of a word whereas /v/ and /ɣ/ are not possible sounds for gemination at word final position. As mentioned above that flap /ɽ/ is not a possible sound word initially but possible syllable initially, thus, it allows gemination at both positions of words. In the same way, nasal /ɳ/ cannot occur word initially but possible syllable initially. This sound allows gemination word finally but in case of word medially, if it is preceded by short vowels, instead of gemination, its following C turns into /ɽ/. Nasal velar /ŋ/ is not possible sound word initially and syllable initially as well. Like retroflex nasal /ɳ/, velar nasal /ŋ/ does not allow gemination word medially but allows word finally if preceded by short vowels. Generally, these two sonorous sounds are not good candidate for gemination even word finally. Medial geminated words in the dialect are nouns, adjectives and verbs while final geminated words are only nouns and verbs.

The findings show that long vowels do not allow gemination at any position of a word. In contrast, in case of disyllable, when a short vowel occurs in the first syllable, the onset of

[21] The language like Spanish maintains MSD strictly between two segments such as fricatives + fricatives or fricatives + plosives have the same value (see Harris, 1983).

the second syllable gets geminated word medially. The results also show when either consonant cluster of word final coda or ill-formed consonant cluster is found at word medial position in Tanoli Hindko, the process of gemination does not occur.

The results of syllable structure give way to describe the syllabification rules of Tanoli Hindko. On the basis of these rules, syllable constraints have been written. Such constraints facilitate the learners to decide about the representation of the syllable structure in light of theoretical representation.

Future Research Directions

From the findings and conclusions of the study, the researcher would like to suggest that to find out the accurate places of articulation, Hindko consonantal sounds should be investigated through palatography techniques. In acoustic phonetic, data of consonants should be recorded in VCV context, such as /ipi/, /u:pu:/, /o:po:/, /a:pa:/ etc, from literate native Hindko speakers to measure the feature of locus. Since it was hard for illiterate people to record each consonant for loci measurement in the above given context. Loci of consonants, therefore, should be investigated both quantitatively and qualitatively.

The identified extra five consonants of Hindko by Awan (2004), e.g. /p̆/, /t̪̆/, /t̆/, /ǩ/, /ʧ̆/, and Hussain's (n.d) proposed /^{h}/ in Urdu after some segments, e.g. /m^{h}/ and /n^{h}/, require a thorough empirical study in acoustic phonetic. Apart from the above given five phonemes, other similar sounds in Hindko such as /g^{h}/, /l^{h}/, /m^{h}/, /n^{h}/, /j^{h}/, /s^{h}/, /ʃ^{h}/ should also be explored acoustically. For Baart (n.d), these are not phonemes rather sounds getting a tonal effect. Thus, it remains to be seen whether these are separate segments or have the tonal effect. The researcher personally feels that the case of /^{h}/ happens only word initially in Tanoli

Hindko, it cannot be found in any other environment and thus /ʰ/ after many phonemes occurs due to the tones.

In vocalic part, there is need to carry out the research on the nasal vowels in acoustic phonetics. Nasal vowels should be recorded at all possible positions, and sonorant sounds with the target nasal vowels should be avoided as much as possible. It is imperative to record the sounds of both males and females in a quiet room with proper setting of microphones and sound recorder. Five repetitions for each segment would be useful for a more precise analysis. The recording should be digitized at least 10000 Hz with a 5000 Hz low-pass filter setting on Pratt.

Geminated sounds have been identified in the present study on articulatory basis. They, however, are required to be investigated acoustically to find out duration of consonants word medially and finally. It is also recommended that syllable data for Tanoli Hindko should be further analyzed in terms of Optimality Theory. Moreover, there is intense need to work on the remaining two suprasegmental features of Hindko, i.e. stress and tones. In this way, the complete phonetic and phonological picture of Hindko may come into account.

On the whole, this thesis investigated segmental features of Tanoli Hindko in both articulatory and acoustic phonetics and found 31 consonants, nine oral vowels, nine nasal vowels and two diphthongs. The analysis of supra-segmental features of the study revealed the results of root words as maximum three syllables, three syllabic consonants, 13 syllabic templates, 47 consonant clusters word initially, 48 word medially and 15 clusters word finally, successful application of MOP and SSP, and gemination occurrence word medially and finally. In the present study, Tanoli dialect of Hindko was compared with other two dialects of Hindko and some other languages as well including English. This study may provide better understanding of Hindko, data, and useful information for further research.

REFERENCES:

Abercrombie, D. (1967). *Elements of general phonetics*. Chicago: Aldine. [1903-28, Calcutta, India].

Al-Khairy, M. A. (2005). *Acoustic characteristics of Arabic fricatives.* PhD, University of Florida.

Akram, B. (n.d.) Analysis of Urdu syllabification using maximal onset principle and sonority sequence principle. Lahore, Pakistan: *Center for Research in Urdu Language Processing*. Retreived from http://www.cle.org.pk/Publication/Crulp_report/CR02_18E.pdf

Ashby, M., & Maidment, J. (2005). *Introducing phonetic science*. Cambridge: Cambridge University Press.

Awan, E. B. (1974). *The phonology of verbal phrases in Hindko.* PhD, University of London

Awan, E. B. (2004). *Hindko sautiyat.* Peshawar: Gandhara Hindko Board.

Awan, E. B. (2008). *Gandhara Hindko lughat.* Peshawar: Gandhara Hindko Board.

Awan, E. B. (2008). *Sarzamin-e-Hindko.*Peshawar: Gandhara Hindko Board.

Baart, J. L. G. (n.d). Tonal features in languages of northern Pakistan. Retrieved from http://www.fli-online.org/documents/linguistics/tone_in_np.pdf

Ball, M. J., & Müller, N. (2005). *Phonetics for communication disorders* (Vol. 1): Routledge.

Ball, M. J., Perkins, M. R., Müller, N., & Howard, S. (2008). *The handbook of clinical linguistics*: Malden, MA: Blackwell.

Ball, M., & Rahilly, J. (1999). *Phonetics: The science of speech.* London: Arnold.

Barber, C., Beal, J., & Shaw, P. (2009). *The English language: A historical introduction* (2nd ed.). Cambridge: Cambridge University Press.

Behrens, S., & Blumstein, S. E. (1988). On the role of the amplitude of the fricative noise in the perception of place of articulation in voiceless fricative consonants. *The Journal of the Acoustical Society of America, 84*(3), 861-867.

Bird, S. (1999). Dschang syllable structure. *The syllable: Views and facts, Mouton de Gruyter, Berlin, 45*, 447- 476.

Bloomer, A., Griffiths, P., & Merrison, A. (2005). *Introducing language in use: A course book*: Routledge.

Boersma, P., & Weenink, D. (2009). Pratt: doing phonetics by computer (Version 5.1. 17) /Computer program/. Retrieved September 1, 2009.

Bradlow, A. R. (1995). A comparative acoustic study of English and Spanish vowels. *Journal of the Acoustical Society of America, 97*(3), 1916-1925.

Brinton, L. J., & Brinton, D. (2010). *The linguistic structure of modern English.* Amsterdam: John Benjamins.

Burquest, D. A. (2006). *Phonological analysis: A functional approach* (3rd ed.). Dallas, Texas: SIL International.

Butskhrikidze, M. (2002). *The consonant phonotactics of Georgian.* PhD, Universiteit Leiden, /Distributed by Netherlands Graduate School of Linguistics, Utrecht./.

Callender, C. J. (2006). *Gemination in West Germanic.* PhD, University of South Carolina.

Catford, J. C. (1977). *Fundamental problems in phonetics* (Vol. 1). Edinburgh: Edinburgh University Press.

Chao, K.Y., & Chen, L. (2008). A cross-linguistic study of voice onset time in stop consonant productions. *Computational Linguistics and Chinese Language Processing, 13* (2), 215-232.

Cho, T., & Ladefoged, P. (1999). Variation and universals in VOT: Evidence from 18 languages. *Journal of Phonetics, 27*(2), 207-229.

Chomsky, N. (1957). *Syntactic structures.* The Hague: Mouton.

Chomsky, N., & Halle, M. (1968). *The sound pattern of English.* New York: Harper and Row.

Clark, J. E., & Yallop, C. (1995). *An introduction to phonetics and phonology* (2^{nd} ed.). Malden: Blackwell.

Clark, J. E., Yallop, C., & Fletcher, J. (2007). *An introduction to phonetics and phonology* (3rd ed.). Malden: Blackwell.

Clements, G. N. (1985). The geometry of phonological features. *Phonology yearbook, 2*, 225-252.

Clements, G. N. (1990). The role of the sonority cycle in core syllabification. *Papers in laboratory phonology, 1*, 283-333.

Clements, G. N., & Keyser, S.J. (1983). *A generative theory of the syllable*. Cambridge, MA: MIT Press.

Cole, R. A., & Cooper, W. E. (1975). Perception of voicing in English affricatesand fricaitves. *The Journal of Acoustical Society of America, 58*(6), 1280–1287.

Crosswhite, K. (1999). *Vowel Reduction in Optimally Theory*. PhD, UCLA.

Cruttenden, A. (2001). *Gimson's pronunciation of English* (6th ed.). London: Arnold.

Crystal, D. (2003). *A dictionary of linguistics and phonetics*. Malden, MA: Blackwell.

Davenport, M., & Hannahs, S.J. (2005). *Phonetics and phonology* (2nd ed.). London: Hodder Arnold.

Davenport, M., & Hannahs, S.J. (2010). *Phonetics and phonology* (3rd ed.). London: Hodder.

Davis, S. (1985). *Topics in syllable phonology*. PhD, University of Arizona published in 1988, New York: Garland.

Delattre, P. (1971). Consonants gemination in four languages. An acoustic, perceptual and radiographic study. *IRAL-International Review of Applied Linguistics in Language Teaching, 9*(2), 97-114.

Delattre, P. C., Liberman, A. M., & Cooper, F. S. (1955). Acoustic loci and transitional cues for consonants. *The Journal of the Acoustical Society of America, 27*, 769- 773.

Di Paolo, M., & Yaeger-Dror, M. (2011). *Sociophonetics: A student's guide*. New York: Routledge.

Dorman, M. F., Raphael, L.J. & Isenberg, D. (1980). Acoustic cues for a fricative-affricate contrast in word-final position. *Journal of phonetics, 8*, 397-407.

Duanmu, S. (1990). *A formal study of syllable, tone, stress and domain in Chinese languages.* PhD, Massachusetts Institute of Technology./Distributed by MIT working papers in linguistics/.

Duanmu, S. (2008). *Syllable Structure: The limits of variation.* New York: Oxford University Press.

Ewen, C. J., & van der Hulst, H., (2001). *The phonological structure of words.* Cambridge: Cambridge University Press.

Fant, G. (1973). *Speech sounds and features.* Cambridge MA: MIT Press.

Fant, G., & Tatham, M. A. A. (1975). *Auditory analysis and perception of speech.* London: Academic Press.

Fatima, N. & Aden, R. (n.d) Vowel Structure of Urdu. Retreived from http://crulp.org/Publication/Crulp_report/CR03_13E.pdf

Fromkin, V., Rodman, R., Hyams, N., Collins, P., & Amberber, M. (2005). *An introduction to language* (5th ed.). Nelson Australia: Thomson.

Fromkin, V., Rodman, R., & Hyams, N. M. (2011). *An introduction to language.* Boston, Mass: Wadsworth.

Fry, D. B. (1976). *Acoustic phonetics: A course of basic reading.* New York: Cambridge University press.

Fudge, E. (1969). Syllables. *Journal of linguistics, 5*(02), 253-286.

Fudge, E. (1987). Branching structure within the syllable. *Journal of linguistics, 23*(2), 359-377.

Ghazali, M. (2002). Urdu Syllable Templates. *Annual Report of Center for Research in Urdu Language Processing (CRULP).* Retrieved from http://www.crulp.org/Publication/Crulp_report/CR02_23E.pdf

Ghaznavi, K. (2003). *Urdu zaban ka makhiz Hindko.* Islamabad, Pakistan: National Language Authority.

Giegerich, H. J. (1992). *English phonology; An introduction.* London: Cambridge University Press.

Göksel, A., & Kerslake, C. (2000). *Studies on Turkish and Turkic languages: Proceedings of the ninth International conference on Turkish linguistics, Lincoln college, Oxford, August 12-14, 1998*: Otto Harrassowitz Verlag.

Gorden, M., Barthmaier, P. & Sands, K. (2002). A cross-linguistics acoustic study of voiceless fricatives. *Journal of the International Phonetic Association, 32*, 141-174.

Gordon, M. (2003). Collecting phonetic data on endangered languages. *15th International Congress of Phonetic Sciences*, 207–210.

Greenberg, S. (2004). Speech processing in the auditory system. New York: Springer.

Grierson, G. A. (1968). *Linguistic survey of India* (Vol. I-XI.). Delhi, India: Motilal Banarsidass.

Gupta, S. (2008). *Communication skills and functional grammar.* New Delhi: University Science Press.

Gussenhoven, C., & Jacobs, H. (1998). *Understanding Phonology.* London: Arnold.

Gussmann, E. (2002). *Phonology: analysis and theory.* Cambridge: Cambridge University Press.

Gut, U. (2009). *Introduction to English phonetics and phonology* (Vol. 1). Germany: Peter Lang.

Hall, C. (2003). *Modern German pronunciation: An introduction for speakers of English.* Manchester: Manchester University Press.

Hall, T. A. (1997). *The phonology of coronals* (Vol. 149). Amsterdam: John Benjamins.

Halle, M. & Clements , G. N. (1983). *Problem book in phonology.* Cambridge, Mass: MIT Press.

Halle, M. (1962). Phonology in generative grammar. *Word 18*, 54–72.

Halle, M., & Vergnaud, J. R. (1987). *An essay on stress.* Cambridge, Mass: MIT, Press.

Hammond, M. (1999). *The phonology of English: A prosodic optimality theoretic approach.* Oxford: Oxford University Press.

Hardcastle, W. J., Laver, J. & Gibbon, F.E. (2010). *The handbook of phonetic sciences*. Oxford /u.a./: Blackwell.

Harrington, S. & Cassidy, J. (1999).*Techniques in speech acoustics*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Harris, J. (1994). *English sound structure*. Oxford and Cambridge, Mass: Blackwell.

Harris, J. W. (1983). Syllable Structure and Stress in Spanish. A Nonlinear Analysis. *Linguistic Inquiry Monographs Cambridge, Mass.*(8), 1-158.

Haugen, E. (1956). The syllable in linguistic description. *For Roman Jakobson*, 213-221.

Hayes, B. (1986). Inalterability in CV phonology. *Language, 62*, 321-351.

Hayes, B. (1987). Compensatory lengthening in moraic phonology. *MS UCLA*.

Hayes, B. (1989). Compensatory lengthening in moraic phonology. *Linguistic inquiry, 20*(2), 253-306.

Hayes, B., Kirchner, R., & Steriade, D. (2004). *Phonetically based phonology*. Cambridge: Cambridge University Press.

Hayes, B. (2009). *Introductory phonology*. Malden, MA: Wiley-Blackwell.

Hayes, B., Kirchner, R., & Steriade, D. (2004). *Phonetically based phonology*. Cambridge: Cambridge University Press.

Hayward, K. (2000). *Experimental phonetics*. London: Longman.

Hewlett, N., & Beck, J. M. (2006). *An introduction to the science of phonetics*. New Jersey: Lawrence Erlbaum Associates.

Hoard. (1971). Aspiration, tenseness, syllabification in English. *Language 47*, 133-140.

Hogg, R. M., & McCully, C. B. (1987). *Metrical phonology: A course book*. Cambridge: Cambridge University Press.

Hooper, J. B. (1972). The syllable in phonological theory. *Language 48*, 525-540.

Hooper, J. B. (1976). *An introduction to natural generative phonology.* New York: Academic Press.

Hughes, G. W., & Halle, M. (1956). Spectral properties of fricative consonants. *The Journal of the Acoustical Society of America, 28,* 303-310.

Hussain , S. (1997). Phonetic correlates of lexical stress in Urdu. PhD. North Western University IL, USA.

Hussain, S. (2009) Phonological Processing for Urdu Text to Speech System. Lahore, Pakistan: *National University of Computer and Engineering Science.* Page 5.

Hussain, S. (n.d). Letter-to-sound conversion for Urdu text-to-speech system. Lahore, Pakistan:*Center for Research in Urdu Language Processing.* http://delivery.acm.org/10.1145/1630000/1621823/p74-hussain.pdf

Hyman, L. M. (1985). *A theory of phonological weight* (Vol. 19). Dordrecht: Foris Publications

Hyman, L. M., & Katamba, F. X. (1999). The syllable in Luganda phonology and morphology. *The syllable: Views and facts, Mouton de Gruyter, Berlin, 45,* 349-416.

Jakobson, R. & Halle, M. (1956). *Fundamentals of language.* The Hague: Mouton.

Johnson, K. (2003). *Acoustics and auditory phonetics* (2^{nd} ed.). Oxford: Blackwell.

Jone, C. (1976). Some constraints on medial consonant clusters. *Language,* 121-130.

Jongman, A. (1989). Duration of fricative noise required for identification of English fricatives. *The Journal of the Acoustical Society of America, 85,* 1718–1725.

Jurafsky, D. & Martin, J. H. (2009). *Speech and language processing: an introduction to natural language processing, computational linguistics, and speech recognition.* Upper Saddle River, NJ: Prentice Hall.

Kahn, D. (1976). *Syllable based generalization in English phonology.* New York: Garland.

Karamat, N. (2001). Phonemic inventory of Punjabi. *Center for Research in Urdu Language Processing* , 179-183.
Retrieved from http://www.crulp.org/Publication/Crulp_report/CR02_21E.pdf

Karnahi, M. K. (2007). *Pahari aur Urdu, aik taqabli jaaezah.* Isalamabad, Pakistan: National Language Authority.

Katamba, F. (1989). *An introduction to phonology*. New York: Longman.

Kaye, J. D., & Lowenstam, J. (1982). Syllable structure and Markedness theory. *in Belletti, Brandi and Rizzi, eds., Theory of Markedness in Generative grammar proceedings of the 1979 Glow conference, Scuola normale superior, pisa.*

Kaye, J. D., Lowenstamm and Vergnaud, J.R. (1987). *Constituent structure and government in phonology.* ms, University du Quebec a Montreal.

Kenstowicz, M. (1994). *Phonology in generative grammar* (Vol. 7): Blackwell.

Khan, A. Q. & Bukhari, N. H. (2011). Voice Onset Time (VOT) in Pahari stops. *Kashmir journal of language research,* 14, 111-128.

Khan, A. Q. (2012). *Phonology of Pahari.* PhD, University of Azad Jammu and Kashmir, Muzaffarabad, Pakistan.

Khan, M. K. (2012). Pashto *Phonology:* The relationship between syllable structure and word oreder. PhD, University of Azad Jammu and Kashmir, Muzaffarabad, Pakistan.

Kim, J. M. (1986). Phonology and syntax of Korean morphology. PhD. University of Southern California.

Kim, M. R. & Lotto, A. J. (2004). Acoustic measurements of Korean approximants. In H.-Y, Kim (Ed.) The Korean Language in America 9 (pp.70-77). American Association of Teachers of Korean.

Kingston, J. & Diehl, R. (1994). Phonetic knowledge. *Language, 70:*419–454

Kiparsky, P. (1979). Metrical structure assignment is cyclic. *Linguistic inquiry, 10*(3), 421-441.

Klatt, D. H. (1975). Voice onset time, frication and aspiration in world- initial consonant clusters. Journal of speech and hearing research, 18: 686-706.

Knight, R. A. (2011). *Phonetics: A course book.* Cambridge: Cambridge University Press.

Kong, E. J. (2009). *The development of phonation-type contrasts in plosives: Cross-linguistic perspectives.* PhD, The Ohio State University.

Ladefoged, P. (1975). *A course in phonetics.* New York: Harcourt Brace Jovanovich.

Ladefoged, P. (2001). *Vowels and consonants: An introduction to sounds of languages. Malden, MA: Blackwell.*

Ladefoged, P. (2003). *Phonetic data analysis: An introduction to fieldwork and instrumental techniques.* Malden, MA: Blackwell.

Ladefoged, P. (2005). *Vowels and consonants: An introduction to the sounds of languages* (2nd ed.). Malden, Mass. ; Oxford: Blackwell.

Ladefoged, P. (2006). *A course in phonetics* (5th ed.). Boston, MA: Thomson Wadsworth.

Ladefoged, P., & Disner, S. F. (2012). *Vowels and consonants* (3rd ed.). Malden, MA: Wiley-Blackwell.

Ladefoged, P., & Maddieson, I. (1996). *The sounds of the world's languages.* Oxford: Blackwell.

Lehiste, I. (1964). Acoustical characteristics of selected English consonants. *International Journal of American Linguistics, 30* (3), 181-223.

Lehmann, C. (1999). Documentation of endangered languages. A priority task for linguistics. *ASSIDUE, Arbeitspapiere des Seminars für Sprachwissenschaft der Universität Erfurt* Nr. 1.Erfurt: Seminar für Sprachwissenschaft, Philosophische Fakultät, Universität Erfurt.

Leslau, W. (2000). *Introductory grammar of Amharic.* Weisbaden: Harrassowitz.

Levin, J. (1985). *A metrical theory of syllabicity.* PhD, MIT, Massachussets.

Lindau, M. K., N. & Jan-Olof, S. (1985). Cross-Linguistic differences in diphthongs. *UCLA Working Papers in Phonetics.....(Also Journal of the International Phonetic Association 20: 10-14), 61*, 40-44.

Lisker, L., & Abramson, A. S. (1964). A cross-language study of voicing in initial stops: Acoustical measurements. *Word, 20*(3), 384-422.

Lodge, K. (2009). *A critical introduction to phonetics*. New York: Continuum.

Lothers, M. & Lothers, L. (2010). Pahari and Pothwari: A sociolinguistic survey. [SIL Electronic Survey Report 2010-012] Retrieved from http://www-01.sil.org/silesr/2010/silesr2010-012.pdf

Lyons, J. (1968). *Introduction to theoretical linguistics*. Cambridge: Cambridge University Press.

Macleod, A.A.N., Stoel-Gammon, C., 2005. Are bilinguals different? What VOT tells us about simultaneous bilinguals. *Journal of Multilingual Communication Disorders 3* (2),118–127.

Maddieson, I., & Disner, S. F. (1984). *Patterns of sounds*. Cambridge: Cambridge University Press.

McCarthy, J. J. (1979). *Formal problems in Semitic phonology and morphology*. PhD, Cambridge, Mass: MIT.

McCarthy, J. J., & Prince, A. (1986). *Prosodic morphology and templatic morphology*. ms, University of Massachusetts and Brandeis University.

McCarthy. (1986). "OCP Effect: Gemination and antigemination" *Linguistic inquiry 17*, 207-263.

McCawley, J. D. (1968). *The phonological component of a grammar of Japanese*. Mouton: The Hague.

Mees, M. I., & Collins, B. (2003). *Practical phonetics and phonology: A resource book for students*. London: Routledge.

Miller, D. G. (2010). *Language change and linguistic theory* (Vol. 1): Oxford University Press.

Morris, R., McCrea, C., and Herring, K. (2008). Voice onset time differences between adult males and females: Isolated syllables. *Journal of Phonetics, 36*: 308–317.

Munglory, M. (2010). *Hindko, mukhtaser tareekh, zaban-o-adeb*. Islamabad, Pakistan: National language authority.

Nolan, F. (1983). *The phonetic bases of speaker recognition* (Vol. 131). Cambridge: Cambridge University Press.

Ohala, M. (1983). *Aspects of Hindi phonology*. Delhi: Motilal Banarsidass.

Olive, J. P., Greenwood, A., & Coleman, J. (1993). *Acoustics of American English speech: A dynamic approach*. New York: Springer.

Paradis, J. C. (1988). *The syllable structure of Japanes.* Master of Arts, The University of British Columbia.

Paul Ken, A. (1981). *Gemination in Japanese*. PhD. University of Washington.

Peterson, G.E. & Lehiste, I. (1960). Duration of syllable nuclei in English. *JASA, 32*:693-703.

Petyt, K. M. (1980). *The study of dialect: An introduction to dialectology*: Blackwell.

Pike, K. L. (1967). *Language in relation to a unified theory of the structure of human behaviour.* The Hauge, The Netherland: Mouton.

Pike, K. L., & Pike, E. V. (1947). Immediate constituents of Mazateco syllables. *International Journal of American Linguistics, 13*(2), 78-91.

Pisoni, D., & Remez, R. (2008). *The handbook of speech perception.* Malden, MA: Blackwell.

Pulgram, E. (1970). *Syllable, word, nexus, cursus.* The Hauge: Mouton.

Pullum, G. K., & Ladusas, W. A. (1996). *Phonetic symbol guide (2nd ed.).* Chicago: The University of Chicago Press.

Rahman, T. (2002). *Language teaching and power in Pakistan.* Paper presented at the world congress on language policies. 16-20, April. Barcelona.

Raphael, L. J., Borden, G. J., & Harris, K. S. (2007). *Speech science primer: Physiology, acoustics, and perception of speech.* Baltimore: Lippincott Williams & Wilkins.

Rashid, H. (2011). *The phonology of English loanwords in Hindko: Vehicle register.* MPhil, University of Azad Jammu & Kashmir, Pakistan.

Reetz, H. & Jongman, A. (2009). Phonetics: Transcription, production, acoustics, and perception. Wiley-Blackwell.

Rensch, C. R., Hallberg, C.E., & O' Leary, C. F. (1992). *Sociolinguistic survey of northern Pakistan: Hindko and Gojri.* (Vol. 3). Islamabad: National Institute of Pakistan Studies & Summer Institute of Linguistics.

Roach, P. (1983). *English phonetics and phonology.* Cambridge: Cambridge University Press.

Roach, P. (2000). *English phonetics and phonology: A practical course* (3rd ed.). Cambridge: Cambridge University Press.

Roach, P. (2009). *English phonetics and phonology: A practical course* (4th ed.). Cambridge: Cambridge University Press.

Roca, I. M. (1994). *Generative phonology.* London: Routledge.

Rogers, H. (2000). *The sounds of language: An introduction to phonetics.* Harlow /u.a./ Longman.

Rowicka, G. J. (1999). *On ghost vowels: A strict CV approach.* Ph.D, University of Leiden.

Saadah, E. (2011). The production of Arabic vowels by English L2 learners and heritage speakers of Arabic. PhD thesis, University of Illinois at urbana-champaign. School of Oriental and African Studies.

Sakoon, S. (2002). *Hindko urdu lughat.* Peshawar, Pakistan: Gandhara Hindko Board.

Selkirk, E. (1982). The syllable. In Harry van der Hulst and Norval Smith (eds.), The Structure of Phonological Representations, part II, 337–83. Dordrecht: Foris.

Selkrik, E. (1991). A two-root theory of length. *University of Massachusetts, occasional papers in linguistics, 14,* 123-171.

Sethi, J., & Dhamija, P. V. (2004). *A course in phonetics and spoken English.* New Delhi: Prentice Hall of India.

Shackle, C. (1980). Hindko in Kohat and Peshawar. *Bulletin of the school of oriental and African studies, 43*(3), 482-510.

Silverman, D. D. (2006). *A critical introduction to phonology: of sound, mind, and body.* London: Continuum.

Sohn, H.S. (1987). Under specification in Korean phonology. PhD. University of Illinois at Urbana-Champaign.

Stevens, K. N. (2000). Acoustic phonetics. Cambridge, Mass. [u.a.]: MIT Press.

Styles, E. A. (2005). *Attention, perception and memory: An integrated introduction*: Psychology Press.

Trommelen. M. (1983). The syllable in Dutch, with special reference to diminuitive formation. Dordrecht: Foris.

Trubetzkoy, N. (1969). Principles of phonology.(English translation of Grundzüge der Phonologie, 1939): Berkeley: University of California Press.

van der Hulst, H., (1984). *Syllable structure and stress in Dutch*. Dordrecht: Foris Publication.

van der Hulst, H., & Ritter, N. A. (Ed.). (1999). *The syllable: View and facts*. Berlin: Walter de gruyter gmbh.

van de Weijer, J. M., & Van Der Torre, E. J. (2007). *Voicing in Dutch:* (De) voicing phonology, phonetics, and psycholinguistics (Vol. 286): John Benjamins Publishing Company.

van Santen, J. P. H. (1997). *Progress in speech synthesis* (Vol. 1). New York: Springer.

Vance, T. J. (2008). *The sounds of Japanese*. Cambridge: Cambridge University Press.

Vennemann, T. (1972). On the theory of syllabic phonolgy. *Linguistische berichte 18*, 1-18.

Waqar, A. & Waqar, S. (2003). Identification of diphthongs in Urdu and their acoustic properties. Lahore, Pakistan: *Center for Research in Urdu Language Processing.*

Watkins, J. W. (1998). *The Phonetics of Wa.* PhD, SOAS, University of London.

Watson, J. (1999). The Syllable and Syllabification in Modern Spoken Arabic (Sancani and Cairene). *The Syllable: Views and Facts, Mouton de Gruyter, Berlin, 45,* 501-525.

Wölfel, M., & McDonough, J. (2009). *Distant speech recognition*. Chichester: Wiley.

Yavas, M. (2006). *Applied English phonology.* Oxford: Blackwell.

Yavas, M. (2011). *Applied English phonology.* (2nd ed.): Wiley-Blackwell.

Zue, V. W. (1976). Acoustic characteristics of stop consonants: A controlled study. Technical Report 523, Lincoln Laboratory, M. I. T (Lexington, MA).

ہندکو مصمتوں کی جدول*

	دولبی	لب دندانی	لثوی	کوزی	حنکی	غشائی	حنجری
انجاریہ	پ پ پھ ب	ت ٹ تھ د	ٹ ٹ ٹھ ڈ		ک ک کھ گ		
احتکاکیہ			چ چ چھ ج				
انفیہ	م	ن		ڑ			
صفیریہ	ف و	س ز			ش	خ غ	ہ
منحرفہ		ل					
دھکیہ		ر		ڑ			
متماد					ی		

* یہ جدول میری اپنی تلفظ زبان کے مطابق تیار کی گئی ہے چونکہ ہر شخص کے بولنے اور ادائیگی کا انداز مختلف ہوتا ہے اسلئے عین ممکن ہے کہ بعض افراد کی زبان کے تجزیے کے نتائج کسی حد تک اس سے قدرے مختلف ہوں۔

نمبر شمار	ہوا کا راستہ	زبان کی حالت	صوتی اوتار کی حالت	تالو کی حالت	ہونٹوں کی صورت	دورانیہ
1	حد معیاری مصوتے [æ] سے کچھ زیادہ کھلا ہوتا ہے	منہ کے نچلے حصے کی ہوئی ہے پچھلا حصہ نسبتاً بلند ہے	لرزش	بند	گول نہیں	طویل
2	"	"	"	بند نہیں	"	طویل
3	"	"	"	بند	"	مختصر
4	"	"	"	بند نہیں	"	مختصر
5	حد معیاری مصوتے [E] جتنا کھلا ہے یعنی نیم وا ہے	زبان کا وسطی حصہ ابھار کی صورت میں	"	بند	"	طویل
6	حد معیاری مصوتے [E] جتنا کھلا ہے یعنی نیم وا ہے	"	"	بند نہیں	"	طویل
7	حد معیاری مصوتے [o] جتنا کھلا ہے یعنی نیم بند ہے	ابھار وسط زبان اور زبان کے پچھل کے تقریباً درمیان میں ہے	"	بند	"	طویل
8	"	"	"	بند نہیں	"	طویل
9	حد معیاری مصوتے [ɐ:] جتنا کھلا ہے یعنی سب سے کم بند ہے	زبان کا پچھلا حصہ [illegible] کے اگلے حصے اور سوڑوں کے درمیان ابھار کی صورت میں ہے	"	بند	"	طویل

10	"	"	"	بند نہیں	"	طویل
11	"	"	"	بند	"	مختصر
12	"	"	"	بند نہیں	"	مختصر
13	نیم معیاری مصوتہ [ɛ] جتنا کھلا ہے	ابھار سازبان اور زبان کے پچھلے کے تقریبا درمیان میں ہے	"	بند	نیم ہموار	طویل
14	"	"	"	بند نہیں	ہموار	طویل
15	نیم معیاری مصوتہ [ʌ] جتنا کھلا ہے	زبان کا پچھلا اور اگلے حصے کے سطحوں کے درمیان پچھلی سمت میں ہے	"	بند	ہموار	طویل
16	"	"	"	بند نہیں	ہموار	طویل
17	"	"	"	بند	ہموار	مختصر
18	"	"	"	بند نہیں	ہموار	مختصر

نوٹ: جیسا کہ پہلے کہا گیا ہے کہ کسی بھی زبان کا بولنے والا مصوتوں کو بعینہ دوسرے اہل زبان کی طرح ادا نہیں کرتا اس لئے مصوتوں کو مشینی آلات کے بغیر تجزیہ کئے بغیر قطعیت کے ساتھ بیان نہیں کیا جا سکتا۔ اسی لئے جدول کے دوسرے کالم میں معیاری مصوتوں کے حوالے پر اکتفا کیا گیا ہے۔ یہ طلباء کی ابتدائی مشق کے لئے کافی ہے۔

نمبر شمار	مصوتہ	علامت			تسمیہ		
1	آ	[a:]	فراخ	عقبی	غیر انفی	غیر مدور	طویل
2	آں	[a:]	"	"	انفی	"	"
3	ـَ	[a]	فراخ	عقبی	غیر انفی	غیر مدور	مختصر
4	ـَ	[a]	فراخ	عقبی	انفی	غیر مدور	مختصر
5	اَے	[E]	نیم فراخ	وسطی	غیر انفی	"	"
6	اَیں	[E]	"	"	انفی	"	"
7	اے	[e]	نیم تنگ	"	غیر انفی	"	"
8	ایں	[e]	"	"	انفی	"	"
9	ای	[i:]	تنگ	متقابل	غیر انفی	"	"
10	ایں	[i:]	"	"	انفی	"	"
11	ـِ	[i]	"	"	غیر انفی	"	مختصر
12	ـِں	[i]	"	"	انفی	"	"
13	او	[o:]	نیم تنگ	"	غیر انفی	مدور	طویل
14	اوں	[o:]	نیم تنگ	"	انفی	مدور	طویل
15	اُو	[u:]	تنگ	متقابل	غیر انفی	مدور	طویل
16	اُوں	[u:]	تنگ	"	انفی	مدور	طویل
17	ـُ	[u]	تنگ	"	غیر انفی	مدور	مختصر
18	ـُں	[u]	تنگ	"	انفی	مدور	مختصر

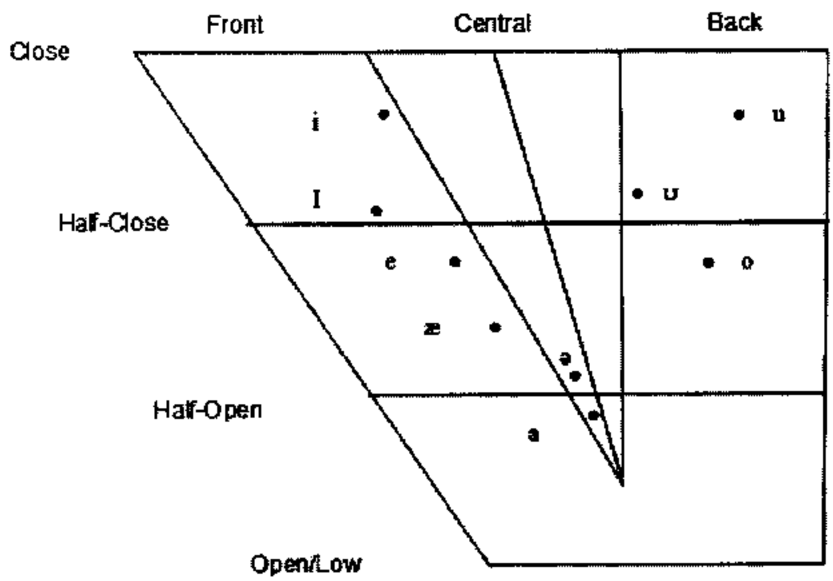
6/7/2011

ا ب پ ت ٹ ث ج چ ح خ
د ڈ ذ ر ڑ ز ژ س ش ص ض ط
ظ ع غ ف ق ک گ ل م ن ں
و ہ ھ ء ی ے۔ (انتالیس حروف 39)

تمام شرکاء ورکشاپ نے متفقہ طور پر مذکورہ بالا حروف تہجی برائے ہندکو کو منظور کر لیا ہے۔

1. محمد علی، پرنسپل گورنمنٹ [illegible]
2. ساجد صاحب
3. امتیاز الحق امتیاز
4. عبدالواحد تبسم
5. محمد نواز
6. عبدالوحید بسمل
7. شکیل احمد [illegible]
8. اورنگزیب جام [illegible]
9. فاروق صاحب
10. نسیم صاحب
11. رستم صاحب
12. عبدالرزاق صابر
13. فرزانہ عروج
14. صابر حسین عباد
15. محمد ضیا [illegible]
16. شبینہ [illegible]
17. [illegible]

Prof. [illegible]
Dr. Mohammad [illegible]
Chairman of the Committee



Vowels quadrilateral of a Hindko dialect spoken in AJK adapted from (Rashid, 2011, p.49)

Appendix-B

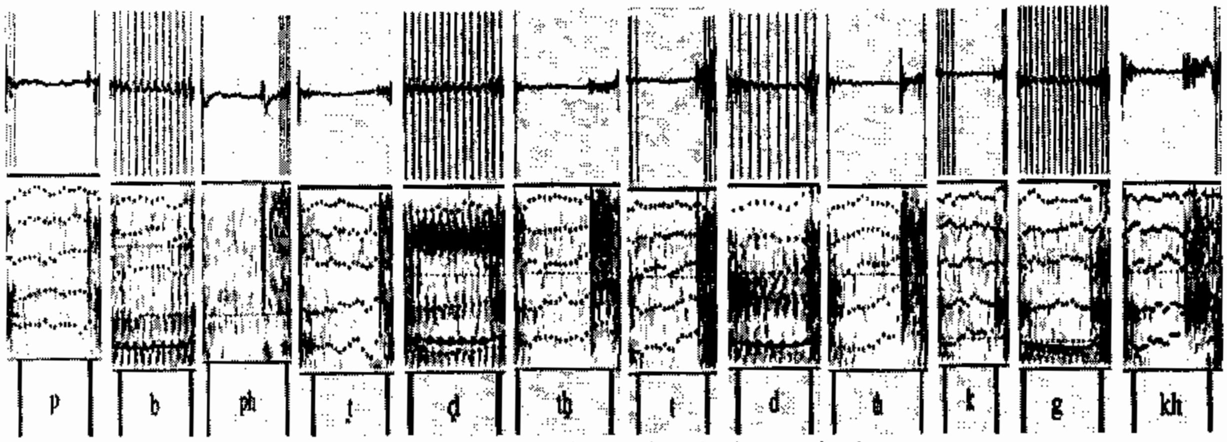


Figure.1 Hindko stops with voicing feature. Blue horizontal bars indicate voiced stops

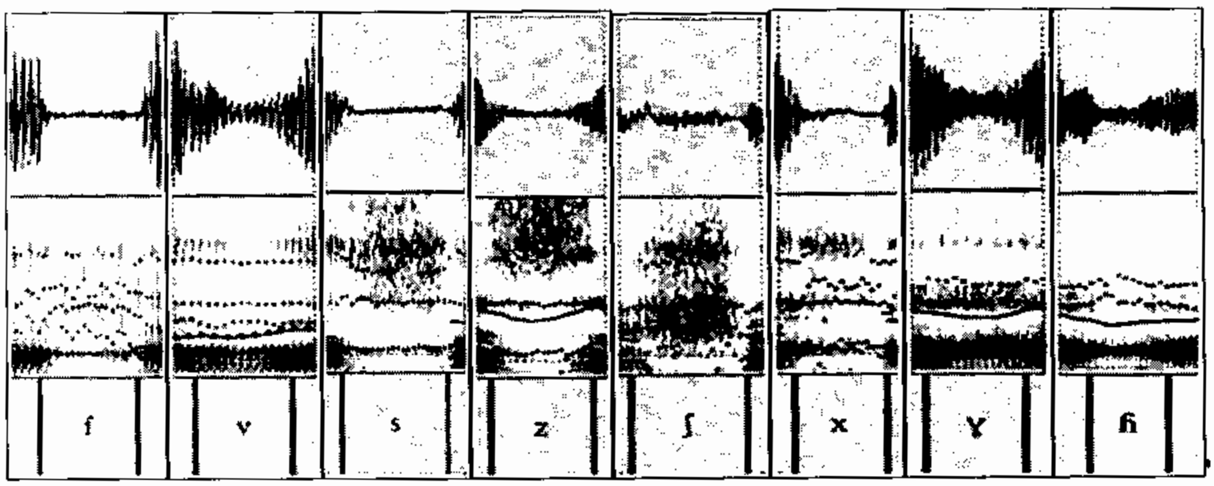
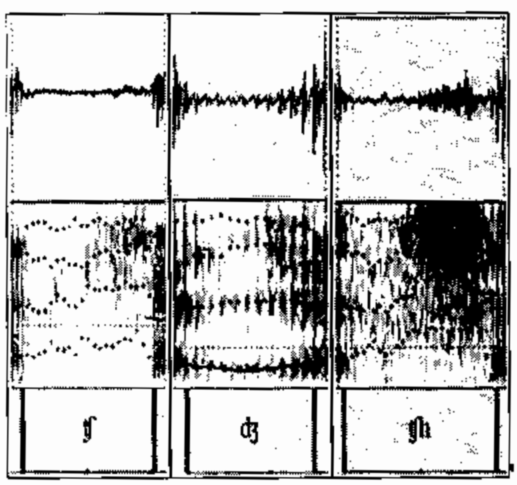


Figure.2 Hindko fricatives with voicing feature



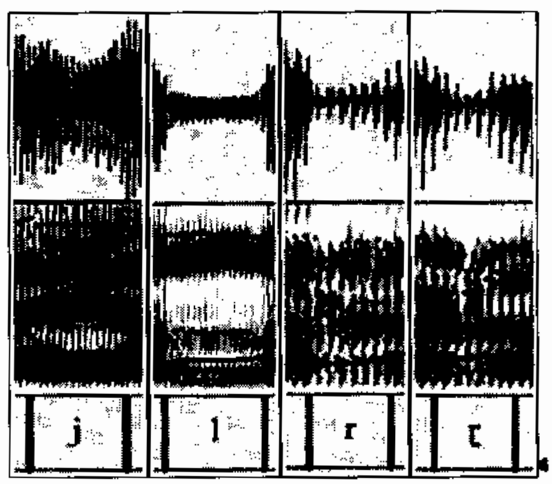


Figure.3 Pitch contours of Hindko affricates

Figure. 4 Hindko approximants

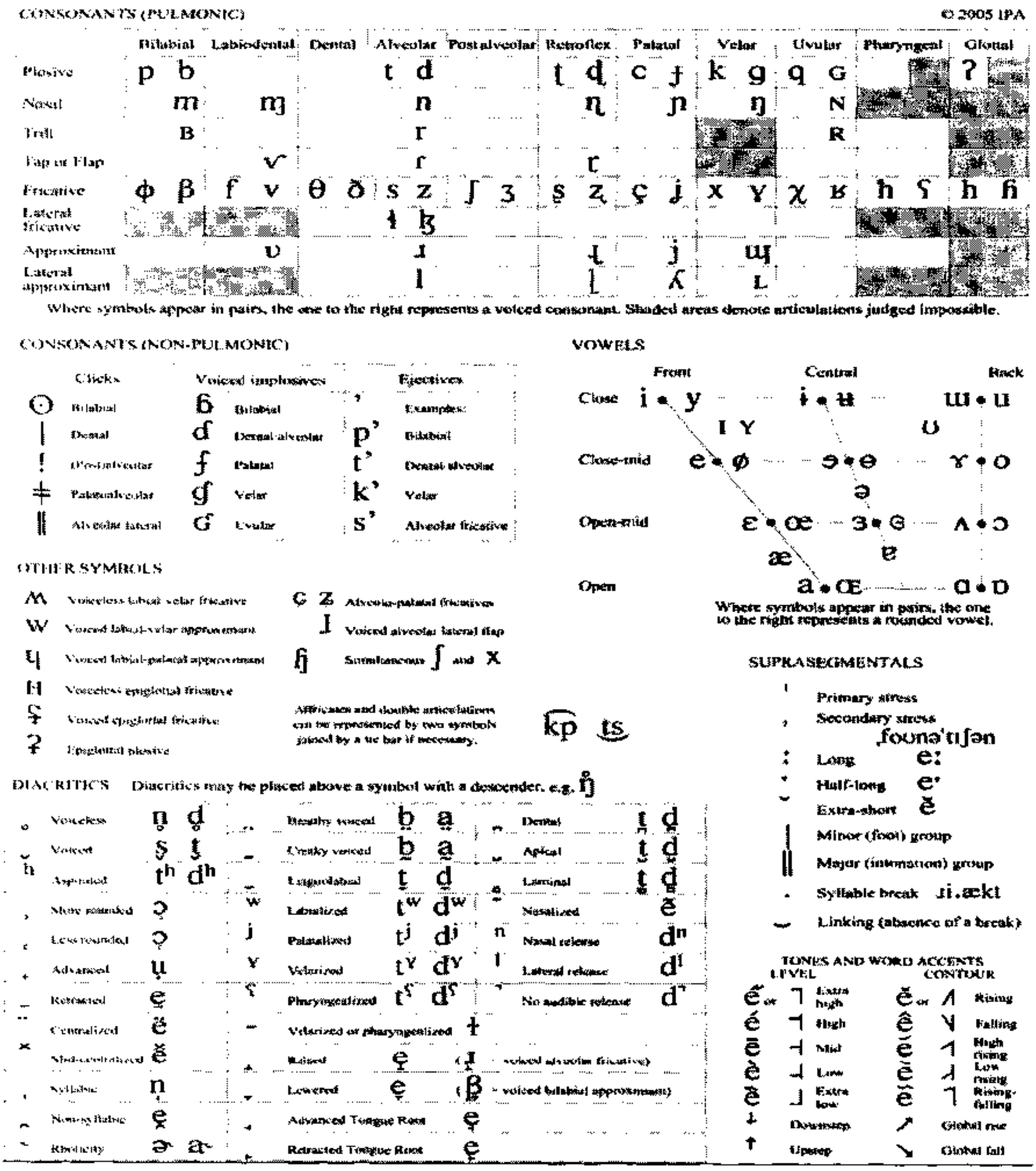
Appendix: C

List of the Informants			
Participant No	Gender	Age	Identification
1	Male	53	Ash...
2	Male	65	Faz...
3	Male	54	Zaf...
4	Male	56	Kha...
5	Male	57	Ayu..
6	Male	52	Ali...
7	Female	57	Mun...
8	Female	62	Hus...
9	Female	55	Zee...
10	Female	70	Rah...
11	Female	52	Mar...
12	Female	56	Kha...

Appendix, D

The IPA

THE INTERNATIONAL PHONETIC ALPHABET (revised to 2005)

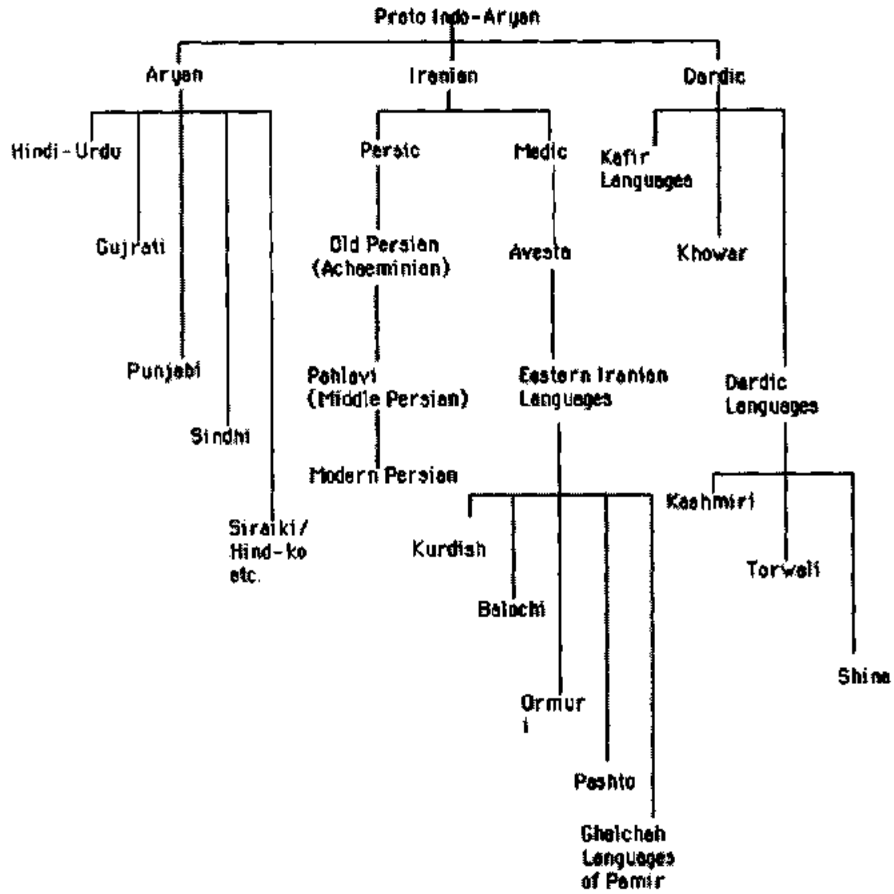


Appendix - E

Indo Aryan Family Tree

CLASSIFICATION

Figure No. 1



Source: Grierson, G. Linguistic Survey of India Vol.1, Part. 1: Introductory Ist ed. 1927 (Delhi: Motilal Banarsidas, 1967)

Language classification of some of the Indo-Aryan languages adapted from (Lothers & Lothers, 2010, p.6).

(These languages are called "Lahnda" by Masica (1991) and Lahndi by Lothers and Lothers (2010) which refers to the cluster of languages that includes Pahari, Pothwari, and closely related languages) .

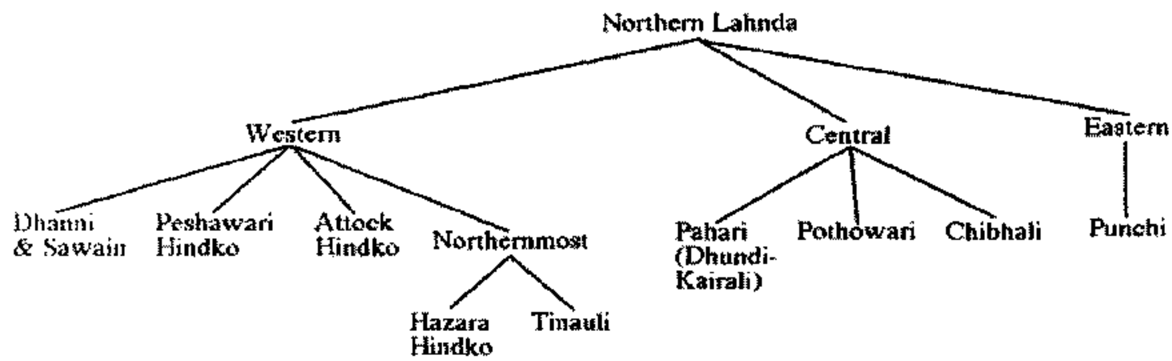


Figure 2: Modified classification of Northern Lahndi*

*This classification tree of Northern "Lahnda" was derived from Masica's (1991) discussion of "Lahnda" on pages 17–19 and through the classification of each language found in Appendix I: Inventory of NIA languages and dialects. The one difference is that we group Dhundi-Kairali with Pothwari and Chibhali rather than with Hazara Hindko and Tinauli.

Hindko spoken in Tanawal, Hazara is grouped in Northern languages as Tinauli (Tanoli) Hindko, adapted from (Lothers & Lothers, 2010, p.8):

Table 1: Northern "Lahndi" languages and groupings

Language Name	*Group*	*Alternate Name(s)*	*Location*
Chibhali	NC	Pahari	Jammu NW border to Murree and Muzaffarabad
Dhanni	NW	—	Western Jhelum District
Dhundi-Kairali	(NW) NC[a]	Pahari (variety spoken in Murree *tehsil* of Rawalpindi District)	Murree Hills, Rawalpindi District
Hindko, Attock[b]	NW	Hindko,[c] Hindko Proper (Shackle 1979)	Attock District
Hindko, Hazara	NW	Hindki (Grierson 1927), Kagani (Bailey 1938)	Hazara and Kaghan Valley
Hindko, Peshawari	NW	Hindko	Peshawar City
Pothwari	NC	Pothwari (Grierson 1927), Pothohari, Potohari	Rawalpindi and Jhelum districts
Punchi[d]	NE	Punchhi, Poonchi	Punch District
Sawain[e]	NW	Sohain	Sohan River Valley
Tinauli	NW	—	Hazara

Source: Masica (1991) and others.

[a]We would categorize Dhundi-Kairali (Murree Pahari) as NC instead of NW.
[b]There are four dialects of Attock Hindko: Awankari, Ghebi, Chachhi, Kohati (Masica 1991).
[c]Hindki is considered to be pejorative (Shackle 1980).
[d]Kashmiri has had a large influence on Punchi.
[e]Sawain is considered to be closely related to Dhanni (Masica 1991).

Appendix, F

Hindko Syllables Data

Syllables	Templates	Gloss	Syllables	Templates	Gloss
/p/			**/b/**		
pãm.bi:.ri:	CVC.CVV.CVV	Butterfly	bu:z.nã:	CVVC.CVV	Monkey
pã:. ɳĩ:	CVV. CVV	Water	bãn.nã:	CVC.CVV	Retaining part of a field
pat̪. t̪a:	CVC.CVV	Information	bax.xra:	CVC.CCVV	Part
prat̪t̪	CCVCC	Turn	bad̪.ma:ʃ	CVC.CVVC	Wicked
pu:ɽ. l̩	CVVC. C̩	Useless talking	bax.xro:.ta:	CVC.CCVV.CVV	Young goat
pas.sa:r	CVC.CVVC	Veranda	baɽɽ	CVCC	Inter
pa:.bãnd̪	CVV.CVCC	Regular	bã:n.sri:	CVVC.CCVV	Trumpet
pat.ta:s	CVC.CVVC	Outcry	bʊkk	CVCC	Jumping
pɽakk	CCVCC	Instant	baʤʤ	CVCC	Beat
pɽɪʧʰʧʰ	CCVCC	Catch	bad̪.ɦa:r	CVC.CVVC	Wednesday
paɽ.ɦass	CVC.CVCC	Steam	bõɳɳ	CVCC	Weave
prõ:ɳ	CCVVC	Strainer	bãŋg	CVCC	Bangles
pro:	CCVV	Beading	bu:.a:	CVV.VV	Door
po:r.xa:	CVVC.CVV	Cover	bo:. li:	CVV.CVV	A kind of milk
plæ:. t̪ʰãɳɳ	CCVV.CVCC	Dry flour	bʊʤʤ	CVCC	Understand
pat̪. t̪arr	CVC.CVCC	Leaf	bĩŋg	CVCC	Bend
pʊt̪. t̪arr	CVC.CVCC	Son	bãm.ball	CVC.CVCC	Flower of maize
pro:. ɽa:	CCVV.CVV	A tool used to pick luggage	bʊr.bʊll	CVC.CVCC	Nightingale
pæ:t̪. li:	CVVC.CVV	Depth of pond etc	blæ:.t̪ra:	CCVV.CCVV	A tool used in ploughing
pã:m.baɽɽ	CVVC.CVCC	Root	bad̪. ɦa:	CVC.CVV	Increase
pas.sa:.ɽa:	CVC.CVV.CVV	Heap of paddy	baʧʰ.ʧʰa:ɽ	CVC.CVVC	Thick forest

põ:ŋk	CVVCC	Barking	baɣ.ɣãmm	CVC.CVCC	Fearless
plo:.ʧʰaʈʈ	CCVV.CVCC	Bunch	bat̪ʰ. t̪ʰa:ɽ	CVC.CVVC	Mouth
pu:k	CVVC	Onion branch	baʧ. ʧɽa:	CVC.CCVV	Child
par.nã:	CVC.CVV	Muffler	bax. xi:l	CVC.CVVC	Jealous
plæ:r	CCVVC	Fence of thorn	bla:	CCVV	Giant
pɪʧʰ.ʧʰaɽɽ	CVC.CVCC	Back belt of shoes	bad̪d̪	CVCC	Bad
pi:. ũ:	CVV.VV	Bug	bar. t̪a:	CVC.CVV	Pass
/pʰ/					
pʰra:	CCVV	Spread	baʧʰ. ʧʰa:l	CVC.CVVC	Weeping mood
pʰʊf.fɽa:	CVC.CCVV	Uncle	bas. sat̪t̪	CVC.CVCC	Home
pʰæ:	CVV	A tool like a mattock	bĩn.d̪lo:	CVC.CCVV	Firefly
pʰatt	CVCC	Tear	blĩŋ.gɽa:	CCVC.CCVV	A rough line
pʰat.kɽi:	CVC.CCVV	Alum	bæ:ɽ	CVVC	A kind of tree
pʰaɽ. ka:	CVC.CVV	A piece of paper	blɪtt	CCVVCC	Rolling
pʰɪpʰ.pʰarr	CVC.CVCC	Lungs	bas.sa:r	CVC.CVVC	Forget
pʰãnd	CVCC	A bag of luggage	bas.sa:ɦ	CVC.CVVC	Reside
pʰaɽɽ	CVCC	A piece of wood	bag.ga:r	CVC.CVVC	Providing free service
pʰãŋg	CVCC	Feather	bag.gæ:ɽ	CVC.CVVC	Detrack
pʰĩ:ŋ.garr	CVVC.CVC	A small piece of stone/wood	bat.ta:	CVC.CVV	Exchange
pʰĩnʤ	CVVCC	Frowning	bat.ti:l	CVC.CVVC	Collect
pʰʊk.ka:.ɲĩ:	CVC.CVV.CVV	Balloon	bad.dæ:.ra:	CVC.CVV.CVV	Old
pʰo:. ɽi:	CVV. CVV	Fox	bakʰ.kʰra:	CVC.CCVV	Separate
/t̪/			bãɳɳ	CVCC	Agree
t̪az.kra:	CVC.CCVV	Mentioning	bat̪. t̪ra:ɽ	CVC.CCVVC	Muddle
t̪ræ:	CCVC	Thirsty	bat.tãŋg	CVC. CVCC	Pear

t̪app	CVCC	Warm	bã:ŋ	CVVC	Prayer call
t̪ɪt̪. t̪arr	CVC. CVCC	Partridge	/t/		
t̪rĩ:ŋ.gall	CCVVC.CVC	A wood fork, used in wheat thrashing	tass	CVCC	Breaking
t̪ræ:ɽ	CCVVC	Dew	tat.tu:	CVC.CVV	Pony
t̪ak.kɽa:	CVC.CCVV	Fatty	tãŋg	CVCC	Hang
t̪al.ka:	CVC.CVV	Slip	tɪʧ.karr	CVC.CVCC	Make fun of
t̪ãm.mã:	CVC.CVV	Hope	to:	CVV	Touch
t̪a:ɽ	CVVC	See/Stare	ta:l	CVVC	Heap
t̪lai	CCVV	Mattress	tat.to:l	CVC.CVVC	Grope
t̪ræ:.kall	CCVV.CVCC	Stranger	tɪkk	CVCC	Hold/stop
t̪ãm.bu:r	CVC.CVVC	Drum	tã:n. da:	CVV.CVV	Trunk of maze
t̪a:	CVV	Force	tʊpp	CVCC	A big cap
t̪ã:	CVV	That's why	tãn. do:. ra:	CVC.CVV.CVV	Spread news
t̪ra:m.bɽa:	CCVVC. CCVV	Lid	tʊrr	CVCC	Walk
t̪ro:.ɽa:	CCVVC.VV	A big bag	tʊkk	CVCC	Cut
t̪ræ:ɽ	CCVVC	Crack	tab.barr	CVC.CVCC	Family
t̪ãn. d̪u:r	CVCC.CVVC	Fireplace for cooking loaves	/tʰ/		
t̪av.vi:	CVC.CVV	Soil pane	tʰap.pɽã:	CVC.CCVV	A tool used to compress soil
t̪av.va:	CVC.CVV	Iron pane	tʰak.ko:r	CVC.CVVC	Hit gently
t̪ãm.mã:ɳ	CVC.CVVC	Dust of chimney	tʰall	CVCC	Severe Beating
t̪av.vi:z	CVC.CVVC	Amulet/charm	tʰapp	CVCC	Beat
t̪arr	CVCC	Get through	tʰakk	CVCC	Direct
t̪a:.vall	CVV.CVCC	Haste	tʰatʰ.tʰarr	CVC.CVCC	Joke in negative sense
t̪rãm.mãkk	CCVC.CVCC	Spray water gently	tʰo:k	CVVC	Hammering

t̪rãŋ.gɽi:	CCVC.CCVV	A kind of net used for grass	tʱarr	CVCC	Feeling cold
t̪ãn.ɦæ:l	CVC.CVVC	Coriander	tʱu:. tʱa:	CVV. CVV	Big bowl
t̪ab.sra:	CVC.CCVV	Comment	**/d/**		
t̪rɪd.da:	CCVC.CVV	Grass Hooper	darr	CVCC	Fear
t̪rɪb.bɽi:	CCVC.CCVV	Cucumber	dro:.kall	CCVV.CVCC	Fearful
t̪ɪt̪.t̪arr	CVC.CVCC	Partridge	dãmm	CVCC	To kill germs through use of fire
t̪rak.kɽi:	CCVC.CCVV	Weight Scale	dʊbb	CVCC	Sink
t̪ax.t̪a:	CVC.CVV	Flat wood	do:ɽ.la:	CVVC.CVV	A kind of pot
t̪ũ:	CVV	You	da:l	CVVC	Branch
/t̪ʱ/			do:. gi:	CVV.CVV	Field
t̪ʱe:	CVV	Available	dũ:ŋ	CVVC	Pertaining to snake's poison
t̪ʱo:. ɽa:	CVVC.VV	Less	dak. ka:r	CVC.CVVC	Belch
t̪ʱa:l	CVVC	Big plate	dadd	CVCC	Frog
t̪ʱapp	CVCC	Fold	da:. da:	CVV.CVV	Dominant
t̪ʱʊkk	CVCC	Spitting	dã:ŋ	CVVCC	Big stick
t̪ʱæ:. la:	CVV.CVV	Big shopper	dra:	CCVV	To fear
t̪ʱãmm	CVCC	Pillar	dʊbb	CVCC	Sinking
t̪ʱãɳɳ	CVCC	Teat/Udder	dro:.kall	CCVV.CVCC	Coward
/d̪/			**/k/**		
d̪ʊd̪d̪	CVCC	Milk	klo:. ti:	CCVV.CVV	A place made for storage of wheat
d̪ra:z	CCVVC	Drawer	kãm:. ma:d̪	CVC.CVVC	Sugarcane
d̪aɽɽ	CVCC	Jam	kʊk.kʊɽɽ	CVC.CVCC	Cock
d̪at̪ʱ.t̪ʱa:	CVC. CVV	A small pack of grass	kad̪d̪	CVCC	Stature
d̪ar.xa:s	CVC.CVVC	Application	ka:.nass	CVV.CVCC	Long shelf

					with a wall
d̪ʊr.ʃa:.t̪ãnn	CVC.CVV.CVCC	Door frame	kat.tall	CVC.CVCC	A kind of dry gross
d̪ræ:ɽ	CCVVC	Untie	kar.ʃõn.di:	CVC.CVC.CVV	Toe of animal
d̪ʊk.kɽa:	CVC.CCVV	A kind of drum	kʊʃ.t̪ã:n	CVC.CVVC	Time after evening
d̪æ:g.ʧi:	CVVC.CVV	Casserole	kri:. ɽi:	CCVV. CVV	Hail
d̪ãn.d̪ri:	CVC.CCVV	Corner of loaf	kõ:n. t̪arr	CVVC.CVCC	Pigeon
d̪u:.ɦa:r	CVV.CVVC	Loan	kɽa:.ga:	CCVV.CVV	A tool used in churning
d̪ar.bu:k	CVC.CVVC	Wasp	kãnd	CVCC	Waist
d̪ra:t	CCVVC	Sickle	kab. ra:ɦ	CVC.CVV	Fear
d̪u:.ɦã:. ɳã:	CVV.CVVC.VV	Watermelon	kõ:ŋ.gɽĩ:	CVVC.CCVV	Boiled corn
d̪a:ɦ	CVVC	Ten	kãm.ball	CVC.CVCC	Blanket
/g/			kʊl.ʧa:	CVC.CVV	A small loaf
gam.mo:t	CVC.CVVC	Mound	ku:. ɽa:	CVVC.VV	Liar
graʧʰ.ʧʰa:	CCVC.CVV	A kind of plant	kɽʊk.ki:	CCVC.CVV	Trap
gɪnt̪.t̪i:	CVCC.CVV	Counting	kɽai	CCVV	A flat type pot
gʊl.fa:	CVC.CVV	Wrist	kaɽ. ʧʰi:	CVC.CVV	Ladle
gad.vadd	CVC.CVC	Mix	krõnd	CCVCC	Working slowly
go:.gi:	CVV.CVV	Bee house	kadd	CVCC	Take out
gʊʃ.t̪i:	CVC.CVV	Butchering	kad̪.d̪ɽa:	CVC.CCVV	A kind of vegetable
gʊŋ.ga:	CVC.CVV	Dumb	kra:ɦ	CCVVC	Boiling of water extremely
gatʰ.tʰi:.rĩ:	CVC.CVV.CVV	Pieces of sugarcane	kaʧ.ʧa:.lũ:	CVC.CVV.CVV	A kind of plant
gõndʒ.dʒi:	CVCC.CVV	A bundle of thread	kat̪t̪	CVCC	Weaving of a rope

glɪt.ti:	CCVC.CVV	Hard swelling	kã:ŋ.gɽi:	CVVC.CCVV	Skinny
gall	CVCC	Talk	ka:.ri:	CVV.CVV	Need
gaʤʤ	CVCC	Decorate	ka:r.t̪u:s	CVVC.CVVC	Cartridges
got.ka:	CVC.CVV	A small stick	kãŋ.gla:	CVC.CCVV	Without money
gab.bru:	CVC.CCVV	Young	kas.su:r	CVC.CVVC	Fault
gãnd	CVCC	Sew	mak.sad̪d̪	CVC.CVCC	Aim
gæ̃:n. t̪i:	CVVC.CVV	A toll used for digging	kas.bi:	CVC.CVV	Cobbler etc
gɪd̪.d̪aɽɽ	CVC.CVCC	Jackal	kɪs.mat̪t̪	CVC.CVCC	Fortune
gat̪t̪	CVCC	Method	kas.sai	CVC.CVV	Butcher
/m/			kãm.ɳ̩	CVC.C̩	Blacksmith etc
ma:s	CVVC	Meat	**/k^h/**		
mas.sæ:.ra:	CVC.CVV.CVV	Cousin	k^{h}ʊʧ.ʧʊɽɽ	CVC.CVCC	Part under knee joint
ma:	CVV	Mother	k^{h}rʊp.pa:	CCVC.CVV	Scythe
mʊʃ.ʃʊkk	CVC.CVC	Smell	k^{h}ãŋg	CVCC	Coughing
mʊʧ^{h}ʧ^h	CVCC	Moustache	k^{h}o:. t̪a:	CVV. CVV	Alloyed
mu:.rat̪t̪	CVV.CVC	Beautiful	k^{h}ʊr.bʊll	CVC.CVC	Scraping by hen/bird
mu:.ri:	CVV.CVV	Front	k^{h}ʊr.li:	CVC.CVV	Mortar/pond
maʤ.ʤi:.la	CVC.CVV.CVV	A gathered piece of cloth to hold luggage	k^{h}rɪt.ta:	CCVC.CVV	Foot (negative use)
mo:.ta:	CVV.CVV	Fatty	k^{h}læ:r	CCVVC	Spreading of clothes
maʧ^h.ʧ^{h}i:	CVC.CVV	Fish	k^{h}õnd.da:	CVCC.CVV	Blunt
maʧ^h.ʧ^{h}arr	CVC.CVC	Mosquito	k^{h}aʧ.ka:ɽ	CVC.CVVC	Laughing
mõnʤ.ʤa:	CVC.CVV	Without nose	k^{h}ak^h.k^{h}arr	CVC.CVCC	Ripened cucumber
maʧʧ	CVCC	Decorate	k^{h}ɽa:	CCVV	Miss

moʧʧ	CVCC	Much	kʰakʰkʰ	CVCC	Cave
mass	CVCC	Muddle	kʰakʰ.kʰaɽɽ	CVC. CVCC	Cucumber
mas.sla:	CVC. CCVV	Problem	/n/		
mas.si:ʈ	CVC.CVVC	Mosque	na:	CVV	Do not come
maʧ. ʧo:ɽa:	CVC.CVVC.VV	Wiper	nã:	CVV	No
mlã:.ɳã:	CCVV. CVV	Religious scholar	nass	CVCC	Run away
mla:	CCVV	Connect	naʧ.ʧo:ɽ	CVC.CVVC	Squeeze
mla:p	CCVVC	Meet	nar.va:ɦ	CVC.CVVC	Abuse
mʊx.ʈa:ʤ	CVC. CVVC	Helpless	naf.fraʈʈ	CVC.CCVCC	Hatred
mro:ɽ	CCVVC	Bend	nʊx.sa:n	CVC.CVVC	Loss
maʤ.mã:	CVC.CVV	Tray	naʃ.ʃa:n	CVC.CVVC	Sign
mãnd	CVCC	Muddle	naɖ.ɖi:.ɖa:	CVC.CVV.CVV	Uncivilized
mãnɖ. ɖra:	CVCC. CCVV	Low stature	naʤ.ʤo:ɽ	CVC.CVVC	Sick
mo:. kʰarr	CVV.CVCC	A kind of animal disease	nar.ra:z	CVC.CVVC	Angry
mo:.ɦa:tʰ	CVV.CVVC	Grate	na:.va:	CVV.CVV	Drain-pipe
maʧʰ.ʧʰi:	CVC. CVV	Fish	nãm.ma:.ʃã:	CVC.CVV.CVV	Evening
mõɳ. ɽass	CVC.CVCC	Husband (negative use)	nĩm.ball	CVC.CVCC	Clear sky
mʊs.sʊkk	CVC.CVCC	Smile	nɪkʰ.kʰaɽ	CVC.CVC	Separate
mĩ:nʤ	CVVCC	Leather	nɪʧ. ʧaɽɽ	CVC.CVCC	sip
mõnd.da:	CVCC.CVV	Beginning	natʰ.tʰaɽɽ	CVC.CVC	Escapee
mi:ʈ	CVVC	100 Kanal land	natʰtʰ	CVCC	Escape
/f/			naʧ:ʧo:ɽ	CVC.CVVC	Squeez
fas.sall	CVC.CVCC	Crops	naz.zarr	CVC.CVCC	Eye sight
fa:l. tu:	CVVC.CVV	Spare	/s/		
fiʈ.nã:	CVC.CVV	Mischief/revolt	slu:k	CCVVC	Treatment
far.mæ:ʃ	CVVC.CVVC	Demand	sab.bũ:ɳ	CVC.CVVC	Soap
flã:	CCVV	Someone	saɖ. mã:	CVC.CVV	Shock

fæ:.sla:	CVV.CCVV	Decision	sla:	CCVV	Suggestion
/v/			sãn.d̪u:k	CVC.CVVC	Box
vax.xat̪t̪	CVC.CVCC	Fortune	sãm.mã:n	CVC. CVVC	Luggage
vak.kat̪t̪	CVC.CVCC	Time	sã:n.ʤa:	CVVC. CVV	Partnership
vakⁿ. kⁿra:	CVC.CCVV	Separate	sã:n.ʧa:	CVVC. CVV	Tool
vab.ba:l	CVC.CVVC	Tension	sã:m.la:	CVVC. CVV	A bit black
vaf.fa:	CVC.CVV	Loyal	sai	CVV	Assist
vall	CVCC	Twisted	sab.bu:ʈ	CVC.CVVC	Proof
/ʃ/			sĩ:	CVV	Lion
ʃĩŋ.garr	CVC.CVC	Frowning for attack	sæ̃:ɳ	CVVC	Recognize
ʃʊl.lʊkk	CVC.CVCC	Move	sat̪t̪	CVCC	Invite
ʃaʤ. ʤra:	CVC.CCVV	History	sʊt̪.t̪ri:	CVC.CCVV	Clean
ʃarr	CVCC	Dispute	saʤ.ʤra:	CVC.CCVV	Fresh
ʃra:.fat̪t̪	CCVV.CVC	Gentleness	sɪl.ta:	CVC.CVV	Maize corn
ʃru:	CCVV	Begin	sar.gi:	CVC.CVV	Before morning time
ʃra:.rat̪t̪	CCVV.CVC	Mischief	sax.xat̪t̪	CVC.CVC	Hard
ʃɽãŋg	CCVCC	Jiggle	sar.nã:	CVC.CVV	A wood use for churner
ʃɪʃʈ	CVCC	Target	sradd	CCVCC	Hay
ʃakk	CVCC	Doubt	sram.ʧu:	CCVC.CVV	Needle used in antimony
paʃʈ	CVCC	Beaten extremely	sla:b	CCVVC	Flood
ʃɪŋ.gaɽɽ	CVC.CVCC	Skin of Trees	slu:. ɳã:	CCVV. CVV	Salty
ʃũ:n.t̪all	CVC.CVCC	A kind of grass	sɪl.sla:	CVC. CCVV	Connection
ʃɪk.kra:	CVC.CCVV	Hawk/falcon	sõmb.ba:	CVCC. CVV	A tool used by blacksmith
ʃlɪb.bɽa:	CCVC.CCVV	Useless piece of meat	sãm.maʤʤ	CVC. CVCC	Understand

ʃna:.xatt	CCVV.CVC	Identity	sõm. ball	CVC. CVC	Hyacinth
ʃæ̃:n.ta:	CVVC.CVV	Cone of pine	sãn. ʈa:.li:	CVC. CVV.CVV	Forty seven
ʃu:.ɦa:r	CVV.CVVC	Active	baʃ.ka:r	CVC. CVVC	Centre
ʃax.xass	CVC.CVCC	Person	sãm.mæ:t̪	CVC.CVV.C	Including
ʃæ:r	CVVC	City	so:ʧ	CVVC	Think
ʃɽõn.nĩ:	CCVC.CVV	Defeated through discussion	sræ:.la:	CVV. CVV	A prickle of hay
/ɣ/			sɪd̪.d̪a:	CVC. CVV	Straight
ɣæ:.ɽa:	CVV.CVV	Suffocation	sa:.va:	CVV. CVV	Green
ɣo:l	CVVC	Circular	sa:.batt	CVV.CVC	Complete
ɣal.bæ:l	CVC.CVVC	A tool used for flour	sʊr.mã:	CVC. CVV	Black
ɣõn.da:	CVC.CVV	Wicked	slo:.ʈri:	CCVV.CCVV	Animals' doctor
ɣla:m	CCVVC	Slave	sã:n.tʰa:	CVVC.CVV	A branch of pine tree
ɣo:. ʈa:	CVV.CVV	Dive	sʊrr	CVCC	Situation
ɣaɽɽ	CVCC	A small cave	sall	CVCC	Hole
ɣal.ɣo:.za:	CVC.CVV.CVV	Pine-nut	/z/		
/ɦ/			zãm.bu:r	CVC.CVVC	Plier
ɦla:	CCVV	Sway	zʊl.fã:	CVC.CVV	Long hair
ɦra:	CCVV	Defeat	zãn. zi:r	CVC.CVVC	Zip
ɦass	CVCC	Laugh	zæ:. d̪a:	CVV.CVV	Much
ɦab. bɽa:	CVC.CCVV	Uncivilized	zæ:.varr	CVV.CVCC	Jewellery
haʃ.ʃarr	CVC.CVCC	Get-together	zo:r	CVVC	Force
hat̪ʰt̪ʰ	CVCC	hand	ze:	CVV	Peep
ɦaz.zamm	CVC.CVCC	Digest	zɪd̪d̪	CVCC	Obstinate
ɦam.zo:.la:	CVC.CVV.CVV	Of the same age	/x/		
ɦõ:n. darr	CVC.CVCC	Technical work	xra:t̪	CCVVC	Charity

/ʧ/			xab.barr	CVC.CVC	News
ʧa:r	CVVC	To graze	xɪz.maʈʈ	CVC.CVCC	Help
ʧaʃʃ	CVVCC	Ecstasy	xra:b	CCVVC	Out of order
ʧaf.fæ:.ria	CVC.CVV.CVV	Round about	xãm.bi:.ra:	CVC.CVV.CVV	Leaven/yeast/ ferment
ʧɪʈʰʈʰ	CVCC	Press	xãm. xa:	CVC.CVV	Useless
ʧʰap.parr	CVC.CVCC	Thatch	xu:r. d̪a:	CVVC. CVV	Edible things from a sacred place
ʧla:k	CCVVC	Clever	xæ:r	CVVC	All right
ʧapʰ.pʰaɽɽ	CVC. CVC	Stagnate water	xaʤ.ʤa:.laʈʈ	CVC.CVV.CVC	Teasing
ʧaʤʤ	CVCC	Manner	xaʈʈ	CVC.CVV.CVCC	Letter
ʧɪʧ. ʧaɽɽ	CVC. CVCC	A kind of bug	xãm.ba:	CVC.CVV	Fresh straight branch of a tree
ʧo:.rass	CVV.CVCC	Square	xlã:m	CCVVC	Small cave
ʧu:.rã:n.vẽ:	CVV.CVVC.CVC	Ninety four	xõ:ŋk	CVVCC	Partridge
ʧo:.ɦa:ɽ	CVV.CVVC	Sharp part of an axe	/ʤ/		
ʧɪl.lãmm	CVC.CVCC	Hookah bowl	ʤʊtt	CVCC	Fight
ʧãm.ba:	CVC.CVV	Black and white colour	ʤra:b	CCVVC	Socks
ʧãm.ʧɪɽ.li:	CCVC.CVC.CVV	Bat	ʤãmm	CVCC	Birth
ʧãm.maɽɽ	CVC.CVCC	Touch	ʤĩnd̪	CVCC	Body
ʧæ̃:ŋ.gãɳ	CVVC.CVC	Tomato	ʤãŋ.gla:	CVC.CCVV	Fence
ʧa:ʃ.ka:	CVVC.CVV	Before noon	ʤab.ba:	CVC.CVV	Meadow
ʧro:k	CCVVC	Time ago	ʤɪgɳ	CVCC	Liquid of pine tree
ʧro:.ɽa:	CCVV.CVV	Unriped fruit	ʤo:gɳ	CVVCC	Giant
ʧrũ:nd	CCVVCC	Bite savagely	ʤʊɽɽ	CVCC	Attach
/ʧʰ/			ʤlat.ta:	CCVC.CVV	Strict

ʧʰab.bɽi:	CVC.CCVV	A pot used for loaves	ʤãnʤ	CVCC	A group of people
ʧʰã:ɳ	CVVC	Filter	ʤãn.nakk	CVC.CVC	Children
ʧʰapp	CVCC	Hide	ʤa:g	CVVC	Awake
ʧʰɪʧʰ.ʧʰɽa:	CVC. CCVV	Useless piece of meat	ʤũ:nt	CVVCC	A tool used to join oxen
ʧʰaʤʤ	CVCC	Winnower	/j/		
ʧʰĩɳ.akk	CVC.VCC	Affect of eye-sight	jal.lãmm	CVC.CVCC	A kind of Leach
ʧʰĩɳ.ɽĩ:	CVC.CVV	Chisel	jæ:.la:	CVV.CVV	Water-logging
ʧʰɪkk	CVCC	Press	jo:k	CVVC	Leach
ʧʰʊk. ko:r	CVC.CVVC	Handmade pot for loaves	jõŋ.ga:	CVC.CVV	A person who talks in nostrils
ʧʰʊʧʰ. ʧʰla:	CVC.CCVV	Over confidence	jax.xi:	CVC.CVV	Chill
ʧʰo:.la:	CVVC. CVV	Active/ quick	jʊll	CVCC	Cockroach
ʧʰã:m	CVVC	Shadow	ja:r	CVVC	Friend
ʧʰapp	CVCC	Hide	/r/		
Vowels			ra:b.t̪a:	CVVC.CVV	Contact
a:	VV	Come	rat̪.t̪ann	CVC.CVCC	A red bird
a:.pe:	VV.CVV	Self	rãn.d̪a:	CVC.CVV	Jack plane
a:. pass	VV.CVCC	Jointly	raɽɽ	CVCC	Barren place having stones
a:. la:	VV.CVV	Hole	rakʰkʰ	CVCC	A kind of land
a:s.t̪a:	VVC.CVV	Slow	ra:m	CVVC	Rest
ã:ɳ	VVC	Bring	ra:t̪	CVVC	Night
a:.sra:	VV. CCVV	Hold	ra:g	CVVC	Musical mode
a:.xarr	VV. CVCC	Last	rĩ:	CVV	A kind of tree
al.nã:	VC.CVV	Nest	ri:s	CVVC	Compete
aʃ. na:	VC. CVV	Acquaintance	ro:	CVV	Weep

at.kall	VC. CVCC	Method	ræ:.t^{h}a:	CVV. CVV	A kind of tree
at^{h}t^h	VCC	Eight	ro:. la:	CVV. CVV	Dispute
adʒ.dʒaɽɽ	VC.CVCC	Herd	ram.bi:	CVCC. CVV	Clipper of cobbler
ad̪d̪	VCC	Half	ro:b	CVVC	Personality
ar.za:	VC.CVV	Cash	rʊz.ga:r	CVC. CVVC	Job
ar.mã:	VC.CVV	A kind of pulse	rãndʒ	CVCC	A kind of disease
as.t̪a:	VC.CVV	Ours	rat̪t̪	CVCC	Jealous
a:. darr	VV. CVCC	Order	rap.paɽɽ	CVC. CVCC	Field
ãmm	VCC	Mango	radʒ. dʒo:ɽ	CVC. CVVC	Fine
ãn. d̪arr	VCC. CVC	Inside	radʒdʒ	CVCC	Fulfil
at.tɽa:	VC. CCVV	Egg	ra:ɦ	CVC	Plough
aɽɽ	VCC	Hurdle	/l/		
az. ma:	VC. CVV	Test	lãŋg	CVCC	Cross
at. kã:	VC.CVV	Month of Feb.	la:dʒdʒ	CVVCC	Treatment
aɽ. ɽa:	VC.VV	A big stick	la:d	CVVC	Love
ar. zã:n	VC.CVVC	Much	la:. ra:	CVV. CVV	Hang/sling
ãm. mall	VC.CVCC	Act	lɪp^{h}p^h	CVCC	Bend
as. ma:n	VC. CVVC	Sky	la:l	CVVC	Pink
at̪. t̪arr	VC. CVC	Scent	lã:n. dʒa:	CVVC. CVV	Family
ɪd̪. d̪arr	VC.CVCC	This side	lʊʧ. ʧa:	CVC. CVV	Cunning
ɪt. ti:	VC.CVV	Tip-cat	lʊt̪. t̪arr	CVC. CVC	Tired
ɪk. ki:	VC.CVV	Twenty one	lʊs. si:	CVC. CVV	Lazy
ʊl. li:	VC.CVV	Fungi	lʊk. kaɽɽ	CVC. CVCC	Wood
ʊdʒ.dʒa:ɽ	VC.CVVC	Desolate	lo:. t̪arr	CVV. CVCC	Curry
ʊs. t̪a:z	VC. CVVC	Teacher	laɽ.ɽa:	CVC. CVV	Log
ʊt̪. t̪ã:	VC. CVV	Up	lakk	CVCC	Waist
ʊg. gaɽɽ	VC. CVCC	Open	li:k	CVVC	Line

Appendix- G

Tanoli Hindko Phonetic symbols (Consonants and Vowels). Description of IPA phonetic name adapted from Phonetic Symbol Guide by (Pullum & Ladusas, 1996).

Symbols	IPA phonetic name	Symbols	IPA phonetic name
/p/	Lower-case P	/ʧ/	T-Esh Ligature unaspirated
/b/	Lower-case B	/ʤ/	D-Yogh Ligature
/pʰ/	Lower-case P Aspirated	/ʧʰ/	T-Esh Ligature aspirated
/t̪/	Lower-case T Unaspirated dental	/f/	Lower-case F
/d̪/	Lower-case D Voiced dental	/v/	Lower-case V
/t̪ʰ/	Lower-case T aspirated dental	/s/	Lower-case S
/t/	Lower-case T Unaspirated Alveolar	/z/	Lower-case Z
/d/	Lower-case D Voiced alveolar	/ʃ/	Esh
/tʰ/	Lower-case T aspirated Alveolar	/x/	Lower-case X
/k/	Lower-case K unaspirated	/ɣ/	Gamma
/g/	Lower-case G	/ɦ/	Hooktop H
/kʰ/	Lower-case K aspirated	/r/	Lower-case R (trill)
/m/	Lower-case M	/ɽ/	Right-tail R (flap)
/n/	Lower-case N	/j/	Lower-case J
/ɳ/	Right-tail N	/l/	Lower-case L
/ŋ/	Eng		

Tanoli Hindko Vowels

Symbol	Phonetic name	Symbols	Phonetic name
i:	Lower-case I	a	Lower-case A (short a)
ɪ	Small capital I	o:	Lower-case O
e:	Lower- case E	ʊ	Upsilon
æ:	ash	u:	Lower-case U
a:	Lower-case A (Long a:)		