

*Muhammad Nadeem Chohan

** Muhammad Asad Habib

*** Zafar Iqbal Bhatti

AN ACOUSTIC ANALYSIS OF PUNJABI (MAJHI) STOPS CONSONANTS

Abstract

This paper examines the acoustics properties (VOT, closing duration) of Punjabi plosives spoken by the Punjabi speakers in Lahore. The 13 Punjabi plosives (bilabial, dental, retroflex, velar, and uvular) were recorded by five Punjabi speakers in a silent context. The results show that the velar plosive /k/ has the longest VOT while that of the bilabial has the shortest. As for the closure duration, the phoneme /t/ has the longest closure duration while that of the alveolar voiced /d/ has the shortest. Furthermore, like English stop, the VOT slightly increases as we go further back regarding the place of articulation. The VOT of the aspirated stops is longer than that of the unaspirated stops. It further suggests that longer the contact between the articulators, longer is the VOT of the phoneme.

Keywords: *Acoustic properties, Closure duration, Voice onset time (VOT), Aspirated Stops.*

1. Introduction

This study gives the acoustic analysis of the stops present in the Punjabi accent spoken in Lahore. Punjabi is a transnational language, spoken and understood in many countries. A large majority of its speakers lives in Province Punjab, both in Pakistan and India. Many researchers have discussed the phonemic inventory of Punjabi but the

majority of work is done on the Indian side of Punjabi. On the Pakistani side of Punjab, the Punjabi spoken is different due to religious and corresponding social setups. Thus, the phonemic inventories of Punjabi are also different. This study is conducted in Lahore and its neighbouring areas where the Punjabi is effected by the Arabic due to the religious affiliation. It is also affected by Persian, Urdu, English and other indigenous languages. For this purpose, this work intends to provide a description of stops in Punjabi spoken in the Lahore district.

Among all the languages spoken in Pakistan, Punjabi is spoken and understood by the majority of the people. The Punjabi language is graded among the top twenty most spoken languages of the world (Daniels, 2005). Punjabi is an international language and its speakers are found in almost all parts of the world. It is extensively spoken in India and Pakistan. In Pakistan, more than 54% population speaks Punjabi as their native language (Census, 2001). There are 92,721,700 speakers, majority of which lives in the area of province Punjab (Baart & Baart-Bremer, 2001), however, in India, 29,258,970 people use Punjabi as their first language. The scripts used by speakers of Punjabi in India and Pakistan are different. In Indian side of Punjab, the script used by the Punjabi speakers is called Gurmukhi while in Pakistani Punjab Shahmukhi is used.

Although, Punjabi is spoken widely yet it lacks prestige and status in Pakistan. Punjabi is not the medium of instruction and it is not taught or encouraged. The situation in the Indian side of Punjab is different where Punjabi is given the status of one of the official languages by the state. Punjabi is taught and encouraged. In the Pakistani side, the status and prestige are lying with English and Urdu. Urdu is National language and English enjoys the status of the official language (Rahman, 2002). Due to this situation research on a different aspect of Punjabi is deficient. This study is an effort to fulfill this gap. It explores the stops present in Punjabi and the acoustic properties of Punjabi stops, spoken by the people of Lahore. This variety of Punjabi is called Majhi. The purpose of this study is to explore the acoustic properties of stops. The main

contribution of this study is that it provides the fundamental acoustic features of the Punjabi stops for the larger community worldwide for further research. It is hoped that this study fills an enormous gap for Punjabi. It will also work as a precursor of an automatic speech recognition system and other large variety of applications for developing accurate speech production system to model a robust speaker-independent speech recognition system (Ansarin, 2004). This research will try to find out these objectives.

1. To find out the stops in the Punjabi language.
2. To find out the VOT of Punjabi stops
3. To explore the closure duration of Punjabi stops.

2. Literature Review

This section reviews the existing literature in the field of Acoustic Phonetics. The focus of this review is on the understanding of the Acoustic Phonetic approach towards the plosives. It will cater to the features involved in the analysis of plosives. Further, it will discuss the main terminologies involved in the study: voice onset time and closure duration. The review is handy in understanding different work done on the VOT and closure duration and how these works are related to this study.

2.1 Acoustic Phonetics

Acoustic phonetic determines the functional and formative properties of speech sounds. Acoustic Phonetics is an empirical study of speech sounds which involves the spectrographs, amplitude, fundamental frequency, and durational measurement, etc. The acoustic-phonetic properties work as a toll in determining and classifying the phonetic features of a particular language. These are referred to as meaningful phonemes of a language. The word utterance in any language is the result of the combination of the sequence of these features(Keerio, 2011).

This research aims to describe the acoustic-phonetic features of the plosive sounds present in the Punjabi language which is a branch of

Indo- Aryan language. This is an effort to add to the available articulatory-phonetic knowledge; acoustic-phonetic knowledge has been classified for the identification and classification of Punjabi language sounds. Determining the acoustic features of the language sounds helps to bring together the sounds with similar acoustic characteristics under the name of one natural class of meaningful phonemes. The analysis of the acoustic features and the results obtained for a certain natural class of features can be handy in a vivid understanding of the Punjabi speech sounds.

Articulation of stops is considered from two points of views, manner, and place. Manner of articulation can be studied in vertical relation to the articulators. It considers the distance between the two articulators (closure). Place of articulation shows the horizontal relationship between the articulators(Habib & Saeed, 2016). Keeping in view the two-place and manner, Punjabi stops can be categorized into bilabial, dental, postalveolar (retroflex) and velar. In the articulation of bilabial stops, the two lips come close to make a stricture which builds pressure behind the lips. As the stricture is opened the air rushes out. Dental stops are produced by bringing the tip of the tongue in close contact with the teeth and making a complete closure of the air. This closure than parts and creates the sound. Similarly, alveolar stops are articulated by bringing the tip of the tongue in contact with the alveolar ridge. Retroflex stops are different in their articulation. For retroflexion, the tongue curls back and makes a closure by coming in contact with the place behind the alveolar ridge. After the stricture is removed the tongues come back to its normal position and the sound is produced. For the articulation of velar stops, the back of the tongue is raised and it touches the vellum to create a stricture.

2.2 Acoustic Properties of Stop

Stops varies in different ways: voice onset time (VOT), closure duration, spectral characteristics of formant transition of adjacent phonemes, burst and release (Ladefoged & Disner, 2012). Closure, VOT

and release burst are intrinsic cues, while neighbouring vowel transitions are extrinsic cues of stops (Khan & Bukhari, 2011). Punjabi has four contrasting stop series: voiced, voiced aspirated, voiceless unaspirated and voiceless aspirated, and with respect to the place of articulation, it has four contrasting places: bilabial, dental, postalveolar and velar.

2.2 Voice Onset Time

Voice onset time (VOT) is the interval between the release of a stop consonant occlusion and the onset of the vocal fold vibration and is measured from acoustic displays as the time between the release burst and the first quasi periodicity in the acoustic signal (Lisker & Abramson, 1964). VOT can be studied from three different dimensions: Positive VOT, negative VOT, and zero VOT. There are three different types of VOT i.e., zero VOT, positive VOT, and Negative VOT. In zero VOT, the onset of vocal fold vibration coincides (approximately) with the stop release. In positive VOT, there is a delay in the onset of vocal fold after the stop release (also called Lag VOT), while in negative VOT, the onset of vocal fold vibration precedes the stop release (also known as Lead VOT). Positive VOT is further divided into short lag VOT and long lag VOT.

The study of VOT provides a solid cue to voicing contrasts. Place of articulation is responsible for the variation in the VOT. It entails the claim that length of VOT is related to frontness and backness of closure. If the closure is in the front part of the cavity the VOT will be shorter on the contrary VOT will longer if the constriction is back (Peterson & Lehiste, 1960). Stevens, Keyser, and Kawasaki (1986) analyzed VOT on the basis of contact in the oral cavity. Longer duration of contact creates a longer VOT. VOT for the aspirated stops are higher than the unaspirated stops which are due to the contact. Another plausible explanation for the variation in VOT is provided by Hardcastle (1973). According to him, VOT is dependent on the movement of the tongue. Since the tip of the tongue is faster along with the movement of

the lips in comparison with the back part of the tongue which is bulkier and thus, slower to respond.

The recent work is an effort to evaluate the acoustic-phonetic aspects of Punjabi plosives. It will consider voice onset time along with closure duration. This work not only adds to the previous knowledge but it also to check the existing theories on VOT.

3. Methodology

3.1 Participants

The data was taken from the data collected for the Ph.D. dissertation. The topic of the study was ‘Phonological and morphological integration: A corpus-based study of English loan words in the Punjabi Language’. From the data set, Punjabi stops were identified. For the utterance of these words, 10 Punjabi native speakers (five male and five female) participated in the study. The participants were born in the Lahore and speak Majhi dialect of Punjabi. They use Punjabi in their daily routine and have no language impairment issues. All the subjects were guided by the researcher and it was taken care that none of them had received any kind of phonetic training and possesses any knowledge for this kind of experiments.

3.2 Punjabi Stops

A stop is produced by a brief obstruction of air in the vocal tract which forms a momentary constriction at different articulatory places and a sudden release of the blocked air. The Punjabi possesses thirteen oral stops. In the table given below gives the detail of the Punjabi oral stops which are articulated from four different places of articulation. The phoneme b^h was not a feature of Punjabi spoken in Lahore previously, but due to the impact of other Punjabi dialects spoken by the different people residing in Lahore and effect of Urdu on Punjabi, the phoneme t^h is now becoming a regular feature of Punjabi. For the identification of Punjabi stops, minimal pairs were made from the available corpus. After

the analysis of minimal pairs, thirteen Punjabi stops are identified which are given below.

Table 1. List of Punjabi stops

Phoneme	Punjabi word	Translation
P	p a:l nã:	To grow
p ^h	p ^h u:k nã:	To blow air from the mouth
B	ba:l	Hair/child
t̪	t̪a:li:	Clapping
t̪ ^h	t̪ ^h a:li:	A large plate
ɖ	ɖ a: ɖa:	Grandfather
T	t a:l nã:	To postpone
t ^h	t ^h ɔknã:	To get hit
D	dɔknã:	To capture
K	ka:la:	Black
k ^h	k ^h ət a:	Sour
g	ga:nã:	To sing
b ^h	b ^h əl	Loam

3.3 Stimuli

The stimuli list consist of Punjabi words and non-words has been developed. All the target consonants are placed in VCV sequence, in which C is one of the target plosives. In order to avoid variation from the vowel consonant’s co-articulation effect, vowel /a/ is used for both V1 and V2 positions for all stimuli. According to Stevens (1993) in any utterance, the vowels surrounding the stop (as VCV pattern), enables the stops to create a complete closure in the vocal tract. This will be helpful in obtaining accurate results and thus, it will suit this study. These words were placed in carrier phrases. These phrases are uttered thrice by every participant. Total of thirty tokens for every stop was analyzed and the average length of closure and voice onset time was taken. The phrases were presented in random order and made recordings at 8000 Hz. Maximum attention was paid to make the environment noise-free. The recordings were done directly on a laptop with a hi-fi microphone. These

words are then analyzed by using the software PRAAT. The data was analyzed for closure duration, voice onset time duration, and voicing.

4. Results

The measurement of VOT, closure duration was done visually inspecting the spectrographs created through the PRAAT software. For the measurement of closure and VOT, a time marker was placed at the starting of onset and the second at the onset of the coming vowel. For the measurement of negative VOT, the markers were at the part of the starting of the closure to the release of the stop. Closure duration was also separated. The spectrogram displayed in PRAAT measured time in milliseconds at the horizontal axis. All the stops are measured in a similar way. Average VOT is calculated which is shown in the table below.

Table 2. Mean values of all Punjabi plosives

S.No	Stops	Avg VOT	Avg Closure	Phoneme duration
1	P	12	120	132
2	p ^h	44	106	150
3	B	-11	87	98
4	b ^h	28	98	126
5	t̪	14	106	120
6	t̪ ^h	74	112	186
7	T	09	122	121
8	t ^h	63	107	170
9	D	-9	81	90
10	K	20	92	112
11	k ^h	61	105	166
12	G	-18	97	115
13	g	-11	86	97

The results of the study are classified according to the duration of the phoneme, voice onset time and closure duration. These results are shown in the form of graphs below.

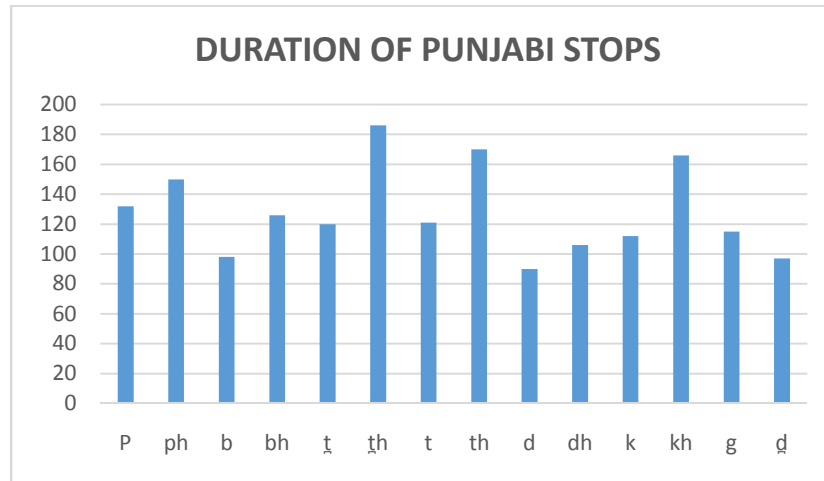


Figure 1. The average duration of Punjabi stops.

The figure above shows the mean values of the duration of Punjabi plosives. The result shows that the phone with the longest duration is /ṭ^h/ while the phoneme with the shortest duration is /d/.

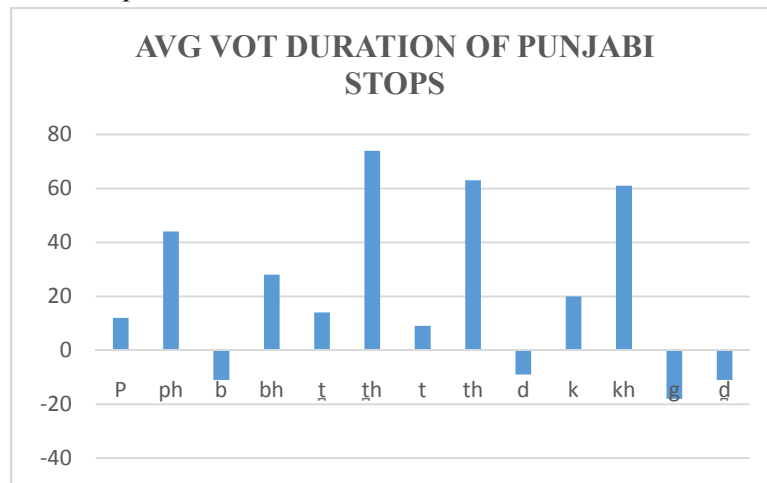


Figure2. Average VOT duration of Punjabi stops.

The graph represents the mean values of VOT of Punjabi plosives. The longest VOT is occupied by the phoneme /t̪ʰ/ and the shortest VOT is shared by two Phonemes: /t/ and /d/. Although phonemes /b/, /d/, /g/ and /ɖ/ showed negative VOT.

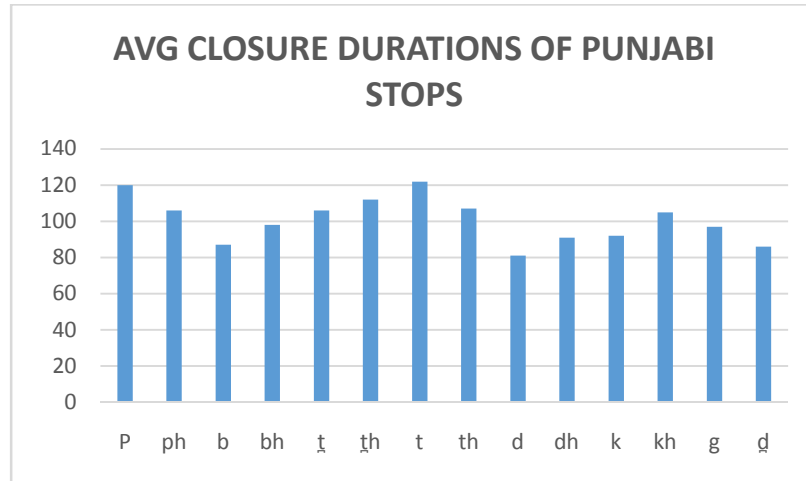


Figure 3. Average closure duration of Punjabi stops

The graph above shows the mean values of closure durations of Punjabi Stops. Phoneme /t/ has the maximum closure duration while the Phoneme /d/ has the shortest closure duration.

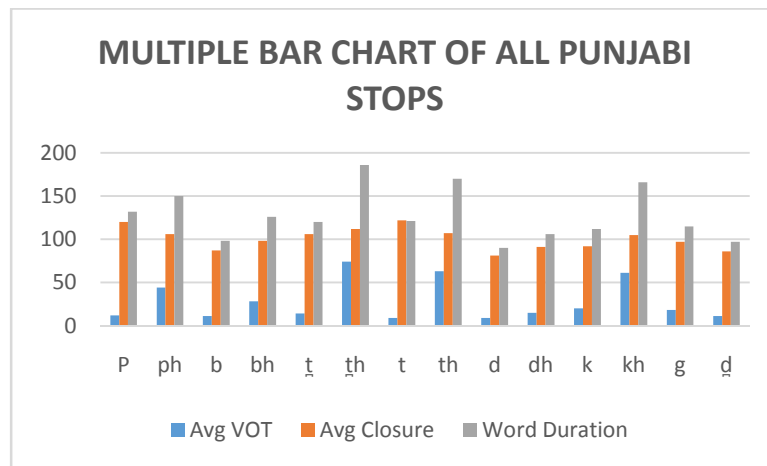


Figure 4. Multiple Bar Chart of All Punjabi Stops.

The above graph represents the average VOT, average closure and average length of a complete plosive sound.

5. Conclusion

The study is the acoustic analysis of Punjabi plosives spoken by ten speakers of Majhi dialect residing in Lahore. The results showed that unvoiced plosives along with aspirated voiced and unvoiced plosives showed positive VOT while voiced plosives showed the negative VOT. The negative and positive VOT are shown on the same dimensions. Among all the plosives /t^h/ showed the longest VOT and /t/ and /d/ showed the shortest VOT. The longest closure duration of /t/ is the longest while /d/ has the shortest closure duration. The /t^h/ has the longest duration and /d/ has the shortest duration. Measurement of VOT in Punjabi plosives indicates that average VOT for unaspirated stops are shorter than the aspirated stops. The study reinforces the claim made by Stevens, Keyser & Kawasaki (1986) which exerts that longer the contact area between the articulator, the longer will be VOT. The contact during the production of /t^h/ sound is maximum which is evident with the longest VOT present in the list of all the stops and /d/ has the shortest VOT due to minimum contact. The study is also in line with the study made by Fischer-Jørgensen (1954) which states that VOT is longer if the closure is towards the backside of the oral cavity. It implies that bilabial stops have shorter VOT than alveolar stops. It further shows that aspirated stops have longer VOT than unaspirated stops.

References

*PhD Scholar (Applied Linguistics)

University of management and technology, Lahore

**PhD Scholar (Applied Linguistics)

University of management and technology, Lahore

***Assistant Professor

University of management and technology, Lahore

Ansarin, A. A. (2004). *An acoustic analysis of modern persian vowels*.

Paper presented at the 9th Conference Speech and Computer.

- Baart, J. L., & Baart-Bremer, E. L. (2001). *Bibliography of Languages of Northern Pakistan*: National Institute of Pakistan Studies, Quaid-i-Azam University Islamabad.
- Daniels, P. T. (2005). The atlas of languages: The origin and development of languages throughout the world. *Language*, 81(2), 517-517.
- Fischer-Jørgensen, E. (1954). Acoustic analysis of stop consonants. *Misc. Phonet*, 2, 42-59.
- Habib, A., & Saeed, A. (2016). ACOUSTICS ANALYSIS OF PASHTO PLOSIVES.
- Hardcastle, W. J. (1973). Some generalizations on the tense-lax distinction in initial stops in Korean. *J. Phonetics*, 1, 263-272.
- Keerio, A. (2011). *Acoustic analysis of Sindhi speech-a pre-cursor for an ASR system*. University of Sussex.
- Khan, A. Q., & Bukhari, N. H. (2011). An Acoustic Study of VOT in Pahari Stops. *Kashmir Journal of Language Research*, 14(1).
- Ladefoged, P., & Disner, S. F. (2012). *Vowels and consonants*: John Wiley & Sons.
- Lisker, L., & Abramson, A. S. (1964). A cross-language study of voicing in initial stops: Acoustical measurements. *Word*, 20(3), 384-422.
- Peterson, G. E., & Lehiste, I. (1960). Duration of syllable nuclei in English. *The Journal of the Acoustical Society of America*, 32(6), 693-703.
- Rahman, T. (2002). Language, power and ideology. *Economic and Political Weekly*, 4556-4560.
- Stevens, K. N. (1993). Models for the production and acoustics of stop consonants. *Speech communication*, 13(3), 367-375.
- Stevens, K. N., Keyser, S. J., & Kawasaki, H. (1986). Toward a phonetic and phonological theory of redundant features. *Invariance and variability in speech processes*, 426-449.