Tone Analysis in Punjabi Dialect of Lahore

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Abstract

Punjabi is a widely spoken Indo-Aryan language. The standard phonetics of Punjabi has 5 tonal segments and three tones. Tone is a segmental unit in a tonal language and is used for differentiating two identical words having similar sequence of vowels and consonants. Punjabi is a contour tone language and the motivation of this research is to find out the actual use of tones among educated Punjabi speakers of Lahore. It is being observed that spoken Punjabi of educated speakers is influenced with the multilingualism and educational factors in the premises of Lahore that's why pitch contours become leveled. Therefore, the semantic differentiation of two identical words is being done on the basis of context not because of pitch patterns of tone. This is a phonetic research, therefore, PRAAT software is used for recordings and analysis. Consequently, the minimal pairs were recorded initially in carrier phrases then in different contexts. Speech annotation was done at segmental and supra-segmental levels. This research will prove beneficial for the identification of language endangerment of Punjabi in Pakistan. Therefore, its revival is considered very essential for new generations, otherwise, it will become extinct.

Keywords: acoustic analysis, tonal languages, tone, language endangerment and revival

1. Introduction

This study offers a comprehensive examination of tones in Punjabi dialect of Lahore. Punjabi is a largely spoken Indo-Aryan language but has no official status in Pakistan. Regardless of this, it is enjoying official, religious, and even constitutional status in India. Therefore, it has two written scripts, i.e., Shahmukhi in Pakistan and Ghurmukhi India. It is a tonal language with 5 tonal segments (i.e., p, k, ʈ, ʈ, ʧ) and three tones (i.e., high, low or level). These tones are working at morphological as well as syntactic levels. Presently, this research is done in order to know the

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acoustic behavior of Punjabi speakers in Lahore whether they are still following this tonal system or not. The reason is; Pakistan is a multilingual country and people are speaking different native and official languages (Farooq, 2015). Consequently, socio-cultural and educational background of different languages exist and show inter-language changes. Therefore, this research is done to know the language change by dividing the methodology in two parts. First part deals with the acoustic analysis of tonal segments and second part is about the acoustic behavior of three tones. Therefore, the verification of hypothesis is done by selecting the educated young speakers of Lahore dialect. Their speech was recorded, annotated, and analyzed in PRAAT software.

1.1 Problem
The spoken Punjabi language of educated speakers is influenced by the multilingualism, socio-cultural, and educational factors in Lahore but current study has investigated the multilingual effect on Punjabi. Consequently, tonal variations do not cause any change but the contextual differences become the reasons for semantic differentiation of minimal pairs.

1.2 Objectives
A number of factors affect Punjabi language, but this study has explored the multilingual effect only. The objective of this research is to investigate the effect of Urdu and English languages on Punjabi dialect of Lahore, Pakistan.

1.3 Significance of the Study
This work is beneficial for understanding the endangerment or even death of Punjabi language due to the multilingual and educational factors.

1.4 Research Questions
This study has answered the following questions:
1. Whether the multilingual effect of Urdu and English language affect tonal system of Punjabi dialect in Lahore or not?
   a. Are Punjabi speakers of Lahore articulating five tonal segments?
   b. Are Punjabi speakers of Lahore articulating 3 different tones?
   c. Is there any gender difference in Punjabi speakers of Lahore?

1.5 Limitations
Due to the limited resources and time, this research deals with the speech of only six speakers and limited speech corpus. Therefore, it is not enough to generalize the results for all native Pakistani speakers.

1.6 Delimitations
This research only has dealt only with the five tonal segments and three tones of Punjabi dialect of Lahore, Pakistan. All the segmental and supra-segmental features of Punjabi phonetic inventory are not completely covered yet.

2. Literature Review
Punjabi is the widely spoken Indo-Aryan language of sub-continent. Indo-Aryan languages have both supra-segmental features, i.e., stress and tone. Currently, the role of stress and tone are discussed in order to understand their collaboration in different languages. The idea of a pitch accent system is rejected in favor of classifying these languages as stress and tone systems (Hyman, 2007).

2.1 Stress
Stress is an important element of prosody along with the intonation, rhythm, phrasal stress and contrastive stress. Linguistically, it is a comparative emphasis given to a syllable, word, or phrase in a sentence. It is naturally perceived with the increased loudness, vowel lengthening, and pitch variations. It has two types; lexical stress and prosodic stress. The placement of stress on different syllables within a word is called lexical stress. In a sentence, different words may carry stress which would be known as prosodic stress (Roach, 2009). Stress is fixed phenomenon in some languages but variant and unpredictable among other languages, e.g., Mandarin (Ladefoged, 1975).

2.2 Tone
Native speakers of a language can easily identify the tonal variations (Singh, 2010). As, tone plays important role at morphological and syntactic levels. When the meaning of the word is marked by using a tone, then, it represents a morphological role. If a tone marks a specific phrase or a clause in a sentence then identifies a syntactic role (Gussenhoven, 2004). Tone is also described as pitch pattern (Clark, Yallop, & Fletcher, 2007).

Phonetically, a change in pitch values of the syllables are used to measure tone from maximum to minimum pitch contours in a unit time (Singh, 2010) and the fundamental frequency (F0) is responsible for the tone. Major languages of the world are tonal (Lehiste, 1970), therefore, the pitch is an essential element for making contrast between two words or lexical items (Gandour & Harshman, 1978). When pitch is changing its position from maximum to minimum point it is be called falling or low tone. If pitch changes without showing any change then such type of tone is known as neutral or level tone. When pitch is changing its position from minimum to maximum point it is called rising or high tone (Singh, 2010).

2.3 Geographical Classification of Indo-Aryan Languages

Tone is the prominent supra-segmental feature but less acknowledged in Indo-Aryan languages. The reason for the negligence is the unexplored tonal typology. But in prior studies, grammatical information is used for the tonal identification. Among all Indo-Aryan languages, almost 15-20 languages are tonal (as cited in Dhillon, 2010; Masica, 1991). The occurrence of stress and its positions may not be fixed in a word. Therefore, different researchers have multiple phenomenon. For example, Penultimate stress is developed in those languages (i.e. Punjabi, Hindi, Gujarati, Rajasthani, Bengali and Shinghales, etc.) which have been descended from Prakrit. All words receive stress on their initial syllable but stress shifts its position in all those words which have long vowel in their penultimate syllable. The reason is; long vowel receives stress in the word and this would lead to a compensatory short vowel lengthening in the word. All these languages have fixed stress as they are the descendants of Prakrit language (Dhillon, 2010). Among all Indo-Aryan languages, tone is encountered in four stages but only Punjabi shows more clear depiction than any other language. The development of tone in Punjabi would follow the subsequent stages (Bhatia, 1975);

1. In multisyllabic words when aspirated stops and voiced segment come together than high stress comes on the vowel of initial position and low stress comes on later vowels.

2. When aspirated stops and unvoiced /h/ comes together at word initial position then low tone follows initial voiced aspirates and /h/ becomes unpredictable.

3. Aspirated stops and voiced /h/ disappear at word medial or word final position.

4. An aspirated voiceless lax stop becomes un-aspirated via deaspiration process.

2.4 Punjabi as a Tonal Language

Punjabi is a tonal Indo-Aryan language and widely spoken in subcontinent. It is 10th largely spoken language of the world and considered a first language of 76 million speakers in Pakistan but with no official status. In Pakistan spoken Punjabi is influenced by Persian and Arabic sources. Punjabi has different dialects, i.e., Lehandi, Multani and Pothohari, etc. which are different at segmental and supra segmental levels (Farooq, 2015). In Pakistan, it uses Arabic (Urdu) script and is called Shahmukhi but in India it uses Devangari script and called Gurumukhi. It is also called Less Resource Language (LRL) due to insufficient electronic resources (Lata, 2011). Tone is the important element in the Punjabi language and functions at segmental level; tonal variation causes semantic variation of a word with same consonant vowel template (Karamat, 2012). In the production of the tonal segment there is no air stoppage and air frication in the oral cavity. This phonologically contrastive element makes Punjabi a more unique language among other Indo-Aryan languages (Qandeel et al., 2012). According to Lata and Arora (2011), it has three segmental tones high /oˊ/, low /oˋ/ and mid tone /ō/ and 5 tonal phonemes; /p/, /ʈ/, /t̪/, /k/ and /ʧ/. These voiceless unaspirated stops replaced the voiced aspirated stops in Punjabi accordingly (bʰ) /p/, (d̪ʰ) /t̪/, (d̪ʰ) /t̪/, (gʰ) /k/ and (dʒʰ) /ʧ/.

Complex stress status of Punjabi gives it a more prominent status among all other tonal languages. Majhi dialect is spoken in Lahore, Pakistan. It has a three-way syllable weight distinction, i.e., monomoraic light syllables [(C)V], bimoraic heavy syllable [(C)VV, (C)VC)], and trimoraic super heavy syllables [(C)VV, (C)VC]. Primary stress is left-dominant in Punjabi language which needs moraic trochees. Foot construction and degeneration are right to left but secondary stress has not been reported yet. Turnery feet is another important feature which means stress falls on super heavy syllable of the word (Dhillon, 2010). Bhatia (1993) also claims that in Punjabi language, stress is contrastive in its nature but Dhillon (2010) challenges the contrastive effect and claims that even suffix addition with the verbs will never alter stress pattern of a word. In Punjabi language, stress, and tone always occur together and dealt collectively (Arorar & Singh, 2014). Different researchers analyzed tone and stress effect in Punjabi language by using Optimality Theory in 1990 (McCarthy, 2008), (Dekkers, Leeuw, & Weijer, 2000), (Karttunen, 1998) (Oostendorp, 2006) and the Stringent Markedness theory (Lacy, 2007).

2.5 A Multi-hierarchical Theory of Stress and Tone Interaction

According to Dillon (2010), stress and tone are the necessary aspects of the Stringent Markedness approach across linguistically. The ability to conflate elements is crucially important and ought to have a role in all discussed theories. The Stringent Markedness approach (as set forth by Lacy in 2007) proves highly insufficient on account for the interaction between tone and stress due to the use of a restrictive tonal scale. The scale is implemented to represent the 'universal' behavior of tone, therefore, the scale falters in this respect. This scale has the unwanted side-effect of either preventing the conflation of elements or conflating the incorrect elements. Therefore, any theory may appear with the interaction of stress and tone inferred within the Optimality Theory by following three key components: (1) the ability to conflate categories, (2) the appropriate tonal scale to employ, and (3) the typological impact of new tonal scales. This approach allows the necessary freedom to collapse categories for Indo-Aryan languages as they treat low and high tones in the similar way. The conflation occurs by rendering a typology which represents the equal status of low and high tone in these languages. While avoiding conflation by forcing these tones to be referenced in a discrete manner via following constraints and it does not allow the correct characterization of these languages, therefore, leads to a different typology. Thus, the conflation is a representative of the Stringent Markedness approach which must be reserved in a theory expressing the interaction between stress and tone. The second issue is to know the type of tonal scale for constructing an appropriate theory.

Therefore, the question is; how can these two different scales be reconciled and united with each other? For developing a theory of stress-tone interaction, the possible solution is to allow an existence of multiple tonal hierarchies because all languages differ in the scales that they employ. These differences must be accounted in a comprehensive theory of the interaction between stress and tone. The advantage of having this theory is to avoid the restrictions contained within the Stringent Markedness approach. Being an expandable theory, it is able to accommodate a large number of stress-tone phenomena by offering more cross-linguistic support. Moreover, contour tones can also be implemented in this theory for adding more comprehensiveness. It must be considered that any hierarchy employed within this theory must display cross-linguistic appeal for justifying a particular hierarchy across languages. Furthermore, the theory must deal with the emergence of combinatorial

hierarchies which allow mix simple tones and contour tones. Because, contour tones are being considered more prominent than high tone especially HL (as cited in Dhillon, 2010; Smith, 2005). By using the multiple hierarchies, the typological predictions would be dependent on the employed hierarchy and the conflation of the elements. Thus, the use of multiple hierarchies has the ability to offer cross-linguistic account for stress-tone interaction and language-specific support. The primary advantages of this theory are its ability for expandability, comprehensive cross-linguistic and language specific support in the stress-tone interaction domain (Dhillon, 2010). Therefore, this theory is used in this study.

3. Methodology
The nature of the study is epistemological and directly related with positivism because it has acquired the results by using the scientific methodologies and descriptions. This study has followed the quantitative approach for finding out the prospective results. In Punjabi language, the tonal behavior was reviewed as default tones, tonal associations, mobility, and weight sensitivity for assigning tones. The present research is based only on the synchronic analysis of stress and tone in Punjabi dialect of Lahore. The reason is the diachronically emerged relationship between stress and tone which is beyond the scope of this work. Literature review tells that Punjabi is a tonal language, having 3 tones and 5 tonal segments (2.6). In past, a number of different methods (i.e., Optimality Theory, Stringent Markedness, Edge Preferences, and Directionality) have been adopted to analyze the tonal behavior of Punjabi language by different researchers. But none of them worked better than the "Multi- hierarchical Theory of Stress and Tone Interaction" introduced by Dhillon in 2010. Therefore, it was currently selected for the acoustic analysis of Punjabi dialect of Lahori speakers with a number of experimental methods such as fundamental frequency, pitch, intensity, phonemic duration or stress, etc.

6 native (i.e., 3 male and 3 female) Punjabi speakers of Lahore (Punjab, Pakistan) were selected for recordings. All of them were graduates and use Punjabi at their homes as a native language but Urdu and English as their official languages. Educated population was selected purposively in order to know whether their multilingual effect. Means that, their second language, Urdu and third language, English are affecting their native language Punjabi or not. The age of this sample group rages between 25 to 30 years old. After selecting the sample, the recording was done for the collection of research data.

The speech recording was done in PRAAT (Boersma & Weenink, 2018) by selecting mono-sound at the frequency rate of 48 KHz. PRAAT is a flexible package for speech synthesis. It is an open-source used for the acoustic analysis of speech (Wilson, 2015). The selected words were recorded in a carrier phrase in a connected speech at neutral tone for avoiding extra stress and phrase final lengthening effect. Later, that recorded speech was used as a speech corpus. Every word was asked to record three times by each speaker for taking average values of tonal segments and 3 tones (5 segmental tone words and 6 minimal pairs of tonal words and 3 repetitions of each lexical item by all speakers = 5 + 12 x 6 x 3 = 306 utterances). The whole process is divided in two steps, i.e., firstly, Punjabi tonal segments were acoustically analyzed and secondly, 3 tones were acoustically analyzed in minimal pairs of Punjabi tonal words. Corpus is designed according to the research requirement as it is still ignorable field (Bird, 2001). Afterwards, the speech corpus was annotated at multiple levels; segment, syllable, word, stress, tone, etc. Their results were discussed in the subsequent sections.

4. Data Analysis and Findings

All the speech corpus of six native Punjabi speakers of Lahore were recorded and analyzed in the PRAAT software. Currently, "Multi-hierarchical Theory of Stress and Tone Interaction" was selected as a methodological framework. Consequently, the phonetic analysis was done with formant frequencies (F1, F2), phonemic durations, stress, pitch, and intensity. The speech annotation of the recordings was initially done in PRAAT software at different tiers, i.e., phoneme, syllable, word, stress, intensity, and tone after analyzing the spectrographic features of each segment. Tone is realized over two syllables, therefore, segment annotation of all these tiers was very essential. Afterwards, the research methodology divided in two steps, i.e., acoustic analysis of (i) five tonal segments and (ii) three tones in Punjabi dialect of Lahore. Both steps discussed stepwise in the subsequent sections

4.1 Acoustic Analysis of Five Tonal Segments in Punjabi Dialect of Lahore

4.1.1 Duration of Voice Onset Time (VOT) in Punjabi Dialect of Lahore

Tonal stop can be divided in two parts, i.e., closure period and voice onset time (VOT). It is the relative timing of the air release for a stop consonant

and the phonation of the following vowel (Wilson, 2015). Every language differs on the basis of VOT usage (Weber, 2007). VOT value is long for voiceless Punjabi stops but it is short or sometimes had negative values for voiced stops. VOT varies from person to person and there are different tendencies across languages as well. Punjabi language had no voiced aspirated stops as they were replaced by voiceless stops (Bhatia, 1975). Therefore, the speakers pronounced the list of tonal words (including 1 proper noun) for the confirmation. All suggested words were pronounced by replacing voiced aspirated stops with voiceless un-aspirated stops but 4 out of six speakers pronounced proper noun بهرت سنگھ with voiced aspirated stop /bʱ/ as shown in the figure. The negative voice onset time of the stop showed the presence of a voiced stop but without aspiration.

Table 4.1 Segmental Duration or Stress in a Stop

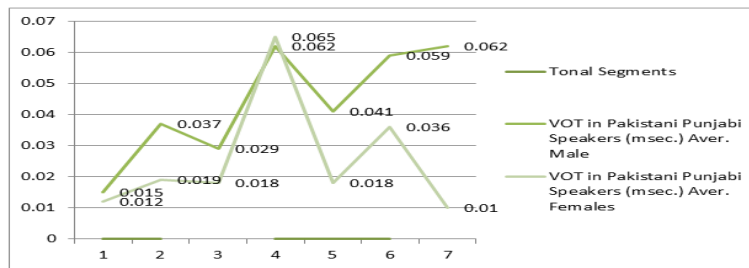| Tonal Segments	Tonal Words	Aver. VOT in Punjabi Speakers of Lahore (msec.)		
		Tonal Segment	Male	Females
(bʰ) →/bʰ/	بهرت /bʰərət̪/	/b/	0.029	0.022
(bʰ) →/p/	پرم /pərəm/	/p/	0.015	0.012
(d̪ʰ) → /t̪/	تپ /t̪ʊp/	/t̪/	0.037	0.019
		/p/	0.029	0.018
(ɖʰ) → /ʈ/	ٹول /ʈol/	/ʈ/	0.062	0.065
(gʰ) → /k/	کوڑا /koɽa:/	/k/	0.041	0.018
(dʒʰ) → /tʃ/	چونکا /tʃõka:/	/tʃ/	0.059	0.036
		/k/	0.062	0.010
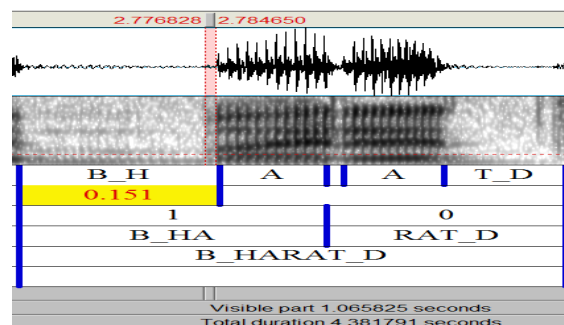
Fig. 4.1: Measurement of Tonal Stop VOT

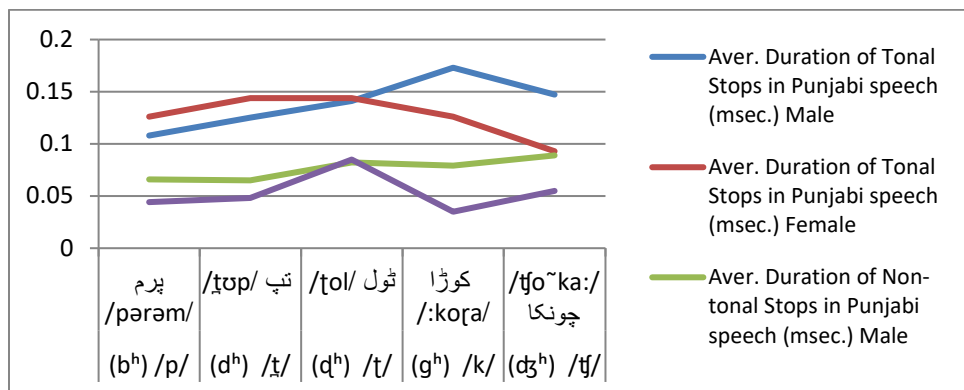**Fig. 4.2: Voice Onset Time (VOT) in Punjabi Dialect of Lahore**

Data analysis shows that voice onset time of /p/ and /ʈ/ tonal segments are almost similar to each other among all (male-female) Punjabi speakers of Lahore. On the other hand, VOT of all tonal segments (except /p/and /ʈ/) are less in female speakers than the male speakers. It has also been analyzed that VOT of /ʈ/ is larger than any other tonal stop among all (male-female) speakers. The larger value of /ʧ/ is considered normal as it is a voiceless affricate.

4.1.2 Segmental Duration or Stress in Tonal Stops in Punjabi Dialect of Lahore

PRAAT is used for the acoustic analysis of stressed and unstressed speech segments. Perceptually, a stressed segment is perceived loud and prominent among the other phonemes in an utterance while acoustically a stressed segment is differentiated on the basis of duration as a stressed segment has more duration with more number of wave cycles (Baepler, Ekegren, Marsh, & Amanda, 2006). Segment duration is directly influenced by the tone because stress and tone always come together in Punjabi spoken language. Tonal stops have more segmental duration than the non-tonal stops.

Table 4.2 Segmental Duration or Stress in a Stop

Tonal Segments	Tonal Words	Aver. Duration of Stressed Stops in Punjabi speech (msec.)		Aver. Duration of Unstressed Stops in Punjabi speech (msec.)	
		Male	**Female**	**Male**	**Female**
bʰ → /p/	پرم /pərəm/	0.108	0.126	0.066	0.044
(dʰ) → /ʈ/	تپ /ʈʊp/	0.125	0.144	0.065	0.048
(dʰ) → /ʈ/	ٹول /ʈol/	0.141	0.144	0.082	0.085
(gʰ) → /k/	کوڑا /koɽa:/	0.173	0.126	0.079	0.035
(ʤʰ) → /ʧ/	چونکا /ʧo˜ka:/	0.147	0.093	0.089	0.055

Fig. 4.3 Comparative Analysis of Tonal (Stressed) and Non-tonal (Unstressed) Stops

Data analysis shows that the segmental duration of tonal stops is larger than the non-tonal stops in Punjabi speech of Lahori speakers. It is also the matter of discussion; among female speakers, the segmental duration is 20-25 mili-seconds larger than the tonal (stressed) speech segments of male speakers. But segmental durations of /k/ and /ʧ/ are lesser than the tonal segment of male speakers' speech. The reason for this difference may be occurred to the level articulation of these tonal segments by female speakers due to the multilingual effect. Contrary to this, all non-tonal stops (unstressed) of female speakers are less in duration than tonal segments in male speakers' speech.

4.1.3   Intensity and Intensity Graph in Punjabi Dialect of Lahore
Perceptually, intensity can be felt as the amplitude or the speech loudness while acoustically intensity is the voice dynamics produced by the articulators. The voice dynamics is measured by using the vocal intensity in decibels (dB). It is also known as the sound pressure level (SPL) used to indicate the vibration of the vocal folds. The rate of normal speakers' minimum intensities varies around 50-115 (dB) intensities as the maximum intensities. In previous researches, it has also been reported that the intensity rate of male speakers is slightly higher than the female speakers (as cited in Colton & Casper, 1996; Coleman, Mabis, & Hinson, 1977). Another study reported, the sound pressure level (SPL) was between 70-80 dB (as cited in Colton & Casper, 1996; Baken, 1987). Measurement of perturbation denotes to the rapid but minor cycle-to-cycle changed in the fundamental frequency and amplitude of the voice that happened during phonation process. Such type of variation reflected the

small differences of tension, mass, and biochemical features of the vocal folds, including minor variations in their neural control. Perturbation linked with the perceived hoarseness or roughness in voice (Colton & Casper, 1996). Yellow line shows the intensity while blue line shows pitch track.
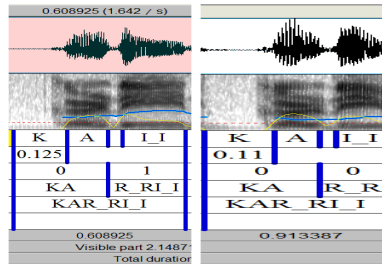

Fig. 4.3: Red highlighted selection showing Intensity and Pitch

Intensity of the vowels, those carry tones, are measured three times for each Punjabi speaker. Systematic analysis of tone has been done by using minimum and maximum intensity values in PRAAT. Detailed calculated measurements are given in the Table 4.3.

Table 4.1 Average Intensity Values of Tonal Segments in Punjabi Speech

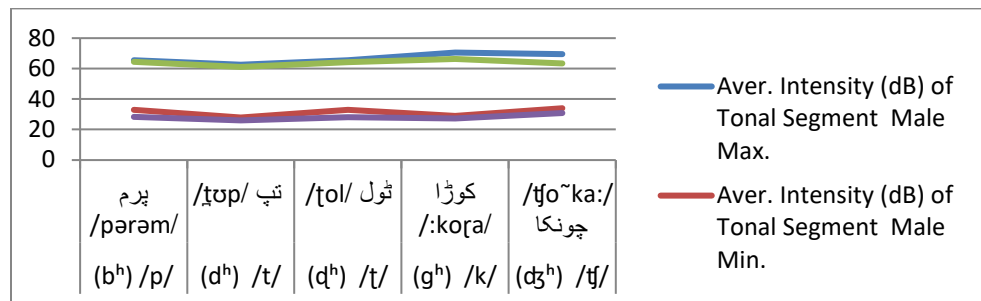| Tonal Segments	Tonal Words	Male Speakers (dB)		Female Speakers (dB)	
		Max.	Min.	Max.	Min.
/bʰ/ → /p/	پرم /pərəm/	65.32	32.87	64.25	28.18
/dʰ/ → /t/	تپ /ʈʊp/	62.49	27.86	61.1	26.05
/ɖʰ/ → /ʈ/	ٹول /ʈol/	65.3	32.85	64.1	28.1
/gʰ/ → /k/	کوڑا /koɽa:/	70.45	28.98	66.26	27.23
/ʤʰ/ → /ʧ/	چونکا /ʧõ˜ka:/	69.41	34.06	63.38	30.82

**Fig. 4.4 Average Intensity among all (Male-Female) Speakers**

Data analysis showed almost similar intensity rate of speech among male and female speakers. But the intensity rate of male speakers is slightly

higher than the females but not as much higher which can indicate any drastic difference.

4.1.4 Formant Frequencies verses Tone in Punjabi Dialect of Lahore

The vibration rate of the vocal folds is known as fundamental frequency (F0) and measured in Hertz (Hz). Average rate of fundamental frequency in male speakers ranges between 100-150 Hz while in females, it ranges around 180-250 Hz. Acoustically, the frequency range of a person decreases with the growing age (Simpson, 2004). F0 is one of the essential element and major acoustic manifestations of supra-segmental features, i.e., pitch accents, tone, and intonation. These features are important for the perceptually natural effect of speech. Pitch is the fundamentally phonetic principal of the tone. F0 is the primary acoustic correlate of tone. Perceptually, it is very difficult to separate it from tone (Lata & Arora, 2012).

Different tones with a single syllable are associated with different lexical meanings. Formants are frequency peaks of energy and are more prominent in vowels than consonants where each energy band represents a unique formant frequency (i.e., F1, F2, F3, F4, F5). In other words, formants are the 'speech filters' used to identify the sound source by strengthening and attenuating each phoneme from the other (Welker, 2006).
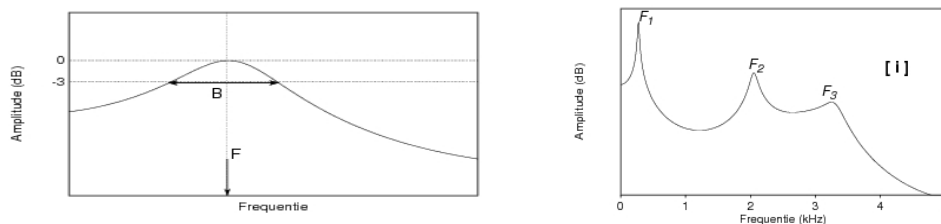

Fig. 4.6 Spectral Slice of Fundamental and other Formant Frequencies

Data analysis strangely reported that the fundamental frequency rate (F0) in females is lesser than Punjabi male members. F0 of male speakers ranges between 75-200 hertz while it ranges between 75-140 hertz for females. The reason might be the data scarcity issue due to the limited

sample size. For further confirmation of these results, formant frequencies (i.e., F1, F2, F3) have also been analyzed as reported subsequently.
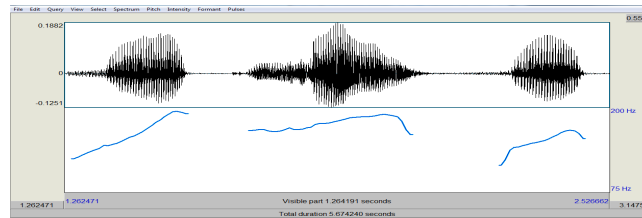
Figure 4.5: F0 of Male Speakers of Lahore
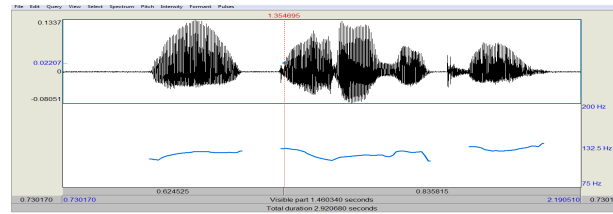
**Figure 4.6: F0 of Female Speakers of Lahore**

Moreover, during speech production, the source signals are produced by the larynx and are filtered according to the morphology of the articulators and oral tract. F1, F2, F3 are important for the voice timber of each speaker but F4, F5 are important for the singing because they are considered strong for singing but not in the normal speech. Formant frequencies are influenced by the articulators, i.e., F1 is influenced by the degree of opening and closing of the oral cavity, F2 is related with the tongue backward displacement in the mouth, and F3 is related with the rounded or relaxed articulation of the phonemic segment, e.g., /i/ verses /u/ articulation (Welker, 2006). Presently, in this research, by using PRAAT first three formant frequencies (F1, F2, F3) of vowels of tonal words have been analyzed. These frequencies are analyzed for finding out whether tonal variation caused by the vibrations and differences in the speech of Punjabi speakers of Lahore or not. Afterwards, frequencies of tonal words are cross checked with the formant frequencies of the non-tonal words' vowel.

Table 2.4: Formant Frequencies of the Tonal and Non-tonal Words

Tonal Words		Tonal Segment					
		Male			Female		
		F1	F2	F3	F1	F2	F3
پرم /pərəm/	ə	500	1492	2401	676	1661	2905
تپ /ʈʊp/	ʊ	416	996	2649	520	1298	3061
ٹول /ʈo:l/	o	777	1515	2753	818	1559	2859
برا /həra:/	a:	624	1327	2401	818	1557	2853
چونکا /ʧɔ̃ka:/	ɔ̃	507	1120	2236	515	1191	2387

Non-Tonal Words		Non-Tonal Segment					
		Male			Female		
		F1	F2	F3	F1	F2	F3
کرم /kərəm/	ə	444	1257	2330	572	1513	2750
چپ /ʧʊp/	ʊ	398	1077	2234	416	1098	2522
گول /go:l/	o	468	987	2646	572	1039	3061
میرا /mera/	a:	727	1275	2200	676	1296	2853
کپونک /ŋk ɔ̃p/	ɔ̃	365	1246	2094	420	1026	2253
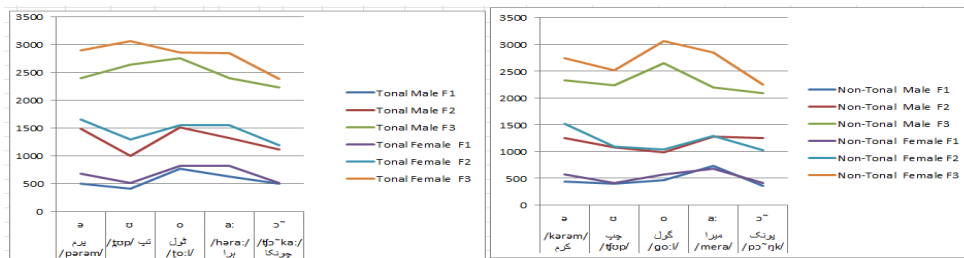
Fig. 4.7: Comparative Analysis of Tonal and Non-Tonal Formant Frequencies

Comparative analysis was done among the vowel frequencies of tonal and non-tonal words. These words were articulated by male-female Punjabi speakers of Lahore. The analysis graphs gave two results; one was the information about the tonal behavior of the speakers and the other was the difference between the format frequencies of both male and female speakers. Tonal information identified minor or actually non-significant difference between the formant frequencies of tonal and non-tonal vowels of the Punjabi words. The reasons were the multilingual effect of Urdu and English, education, and the relaxed articulation of the speakers.

4.1.5 Pitch verses Tone in Punjabi Dialect of Lahore

Pitch is the perception of relative frequency means perceptually low or high pitched while *tone* is meaningful and significant. Phonemic contrasts are signaled by the differences in pitch (Prosody 1 - Pitch, Tone and Intonation). Pitch and tone are two different components of sound but also have differences. But we can say that pitch is frequency dependent and tone has the attribute to differentiate different voices and determines the sound quality (Olivia, 2011).

Table 3: Pitch of Tonal Segments in Punjabi Dialect of Lahore

Tonal Segments	Tonal Words	Male Punjabi Speakers		Female Punjabi Speakers	
		Syllable1	Syllable2	Syllable1	Syllable2
(bʰ) /p/	پرم /pərəm/	No contour	L	No contour	L
(dʰ) /t̪/	تپ /t̪ʊp/	H*L (monosyllabic)		H*L (monosyllabic)	
(dʰ) /ʈ/	ٹول /ʈol/	HL (monosyllabic)		Level (monosyllabic)	
(gʰ) /k/	کوڑا /koɽa:/	L*	H	L-L	Level
(dʒʰ) /ʧ/	/ʧɔ̃ka:/ چونکا	L*	H	L-L	Level

(*) used for accented segment regardless of high or low

Data analysis shows that tonal articulation of male speakers is clear than females. Pitch stylization shows that the word پرم /pərəm/ is articulated with level tone while تپ /t̪ʊp/ is articulated accented by both male and female Punjabi speakers of Lahore. While the word ٹول /ʈol/ is articulated with HL pitch contours by male and female speakers. The words کوڑا /koɽa:/ and /ʧɔ̃ka:/ چونکا are disyllabic words and first syllable of both words are articulated with L* while females uttered first syllables of both words with low to low tone (L-L). Second syllables of کوڑا /koɽa:/ and /ʧɔ̃ka:/ چونکا are pronounced with high tone (H) by the male speakers but females uttered with level tone. Data analysis confirms that speakers have articulated tonal words with different levels of tone but tonal articulation of females are more relaxed than male members. The relaxed behavior has been further discussed in the second part of this research.

4.1.6 Acoustic Analysis of Three Tones in Punjabi Dialect of Lahore

5 tonal segments have been analyzed in the first part of this study while the acoustic analysis of 3 Punjabi tones is done in second part by using different experimental methods, i.e., fundamental frequency, segmental duration, pitch, intensity. Therefore, 6 graduate native Punjabi speakers of Lahore (Punjab, Pakistan) are selected for speech recordings. Later, 6 Punjabi minimal pair words are selected as a corpus and recorded in

carrier phrases at a normal speaking rate for avoiding extra stress and phrase final lengthening effect. Same Punjabi minimal pairs are also recorded in different contextual phrases. The purpose is to investigate; Punjabi speakers' speech has different tones or are relaxed. Each sentence is recorded thrice by each speaker for taking average values of tones among all speakers. Speech annotation is done after analyzing the spectrographic features of phonemes and tonemes at different tiers, i.e., phoneme, syllable, word, stress, tone, and intensity. As tone is realized over two syllables, therefore, the annotation of all these tiers is very essential element of data analysis (Wilson, 2015).

4.1.7 Speech Intensity in Minimal Pairs in Punjabi Dialect of Lahore

Intensity is the amplitude or speech loudness whereas acoustically it is the voice dynamics produced by the speech articulators and measured in decibels (dB) (as cited in Colton & Casper, 1996; Coleman, Mabis, & Hinson, 1977).

Table 4.4: Speech Intensity

| Words	Minimal Pairs	English Meaning	Average values of Male Speakers				Average values of Female Speaker			
			Syllable 1		Syllable 2		Syllable 1		Syllable 2	
			Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
کڑا	/kəɽa/	pitcher, mound	63.51	30.41	66.91	55.7	63.36	29.91	63.96	54.12
	/kəɽaˊ/	carving, cutting	64.48	27.03	64.71	54.2	63.19	27.27	60.51	52.51
کڑی	/kəɽi:/	gravy	63.66	28.92	61.76	46.55	61.34	28.6	60.15	30.9
	/kəɽi:/	clues	62.6	28.64	64.2	51.83	61.14	28.4	62.2	49.53
گلٕ/گلا	/gəla:/	Neck	65.86	40.37	68.41	58.05	64.49	39.57	65.53	56.18
	/gəlaˊ:/	cooked	62.25	39.8	67.4	57.71	61.45	38.96	67.94	53.93
چاہ	/tʃa:/	Tea	70.96	28.94			63.12	26.79		
	/tʃaˊ:/	affection	70.57	30.98			66.61	30.49		
برا	/həra/	Green Colour	64.82	48.41	69.2	59.85	62.2	30.82	65.42	53.5
	/həraˊ/	Defeat	66.87	50.63	69.46	61.5	64.21	50.31	66.11	55.66
کوڑا	/koɽa/	bitter	65.43	28.81	71.07	60.19	62.84	28.13	62.7	54
	/koɽa/	horse	64.58	29.11	70.48	58.62	63.47	28.26	66.24	57.1
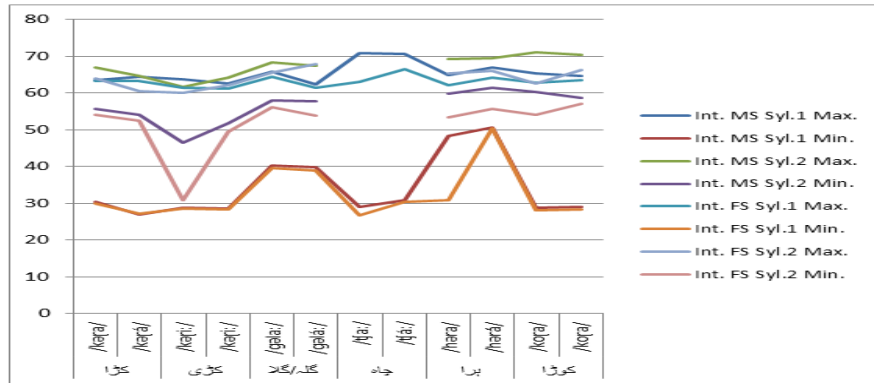
Fig. 4.8: Speech Intensity in Tone Articulation

Data analysis shows that the speech intensity of Punjabi male speakers is greater than the female Punjabi speakers of Lahore. This is not as much larger difference which causes drastic variation, therefore, could be ignored.

4.1.8 Formant Frequencies in Minimal Pairs of Punjabi Dialect of Lahore

The rate of vibration of the vocal folds is called fundamental frequency (F0) and measured in hertz (Hz). Average rate of F0 in males is between 100-150 Hz while 180-200 Hz in females. But the range decreases with the growing age (Simpson, 2004). It is basic acoustical manifestation of supra-segmental features. It is primary acoustic correlate of tone, therefore, is very difficult to separate fundamental frequency from tone (Lata & Arora, 2012). On the other hand, formants (i.e., F1, F2, F3, F4, F5) are frequency peaks of vowels as 'speech filters' which can cause strengthening and weakening of each phoneme (Welker, 2006).

Table 4.5 Analysis of Formant Frequencies of Minimal Pairs in Punjabi Dialect of Lahore

Words	Minimal Pairs	English Meaning	Male Speakers						Female Speakers					
			Vowel of Syllable 1			Vowel of Syllable 2			Vowel of Syllable 1			Vowel of Syllable 2		
			F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
کڑا	/kəɽa/	bangle, pitcher, mound	624	1505	2283	727	1661	2439	727	1765	2490	883	1819	2905
	/kəɽá/	carving, cutting	624	1565	2483	727	1505	2439	724	1557	2646	779	1761	2490
گل/گلا	/ɡəla:/	Neck	676	1505	2490	727	1454	2594	676	1765	2853	831	1454	2801

|															
	/gəláː/	Cooked	676	1557	2283	727	1350	2594	572	1816	2750	935	1505	2646
چاه	/tʃáː/	Tea	780	1557	2542				727	1454	2905			
	/tʃaː/	Affection	727	1402	2542				935	1609	2387			
برا	/həra/	Green Colour	707	1575	2483	748	1740	2442	779	1609	3009	759	1770	2609
	/hərá/	Defeat	624	1661	2542	748	1557	2542	831	1765	2905	779	1576	2550
	/koɽa/	Bitter	572	2231	2957	780	1454	2542	468	1143	2750		1505	2698
کوڑا	/koɽa/	Horse	520	831	2490	676	1505	2594	572	1143	2801	727	1557	2853
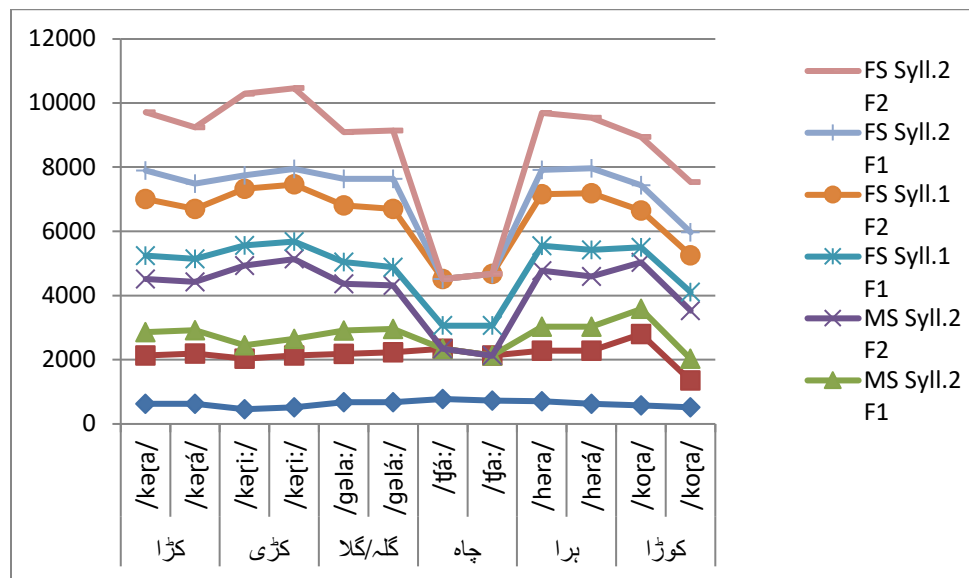
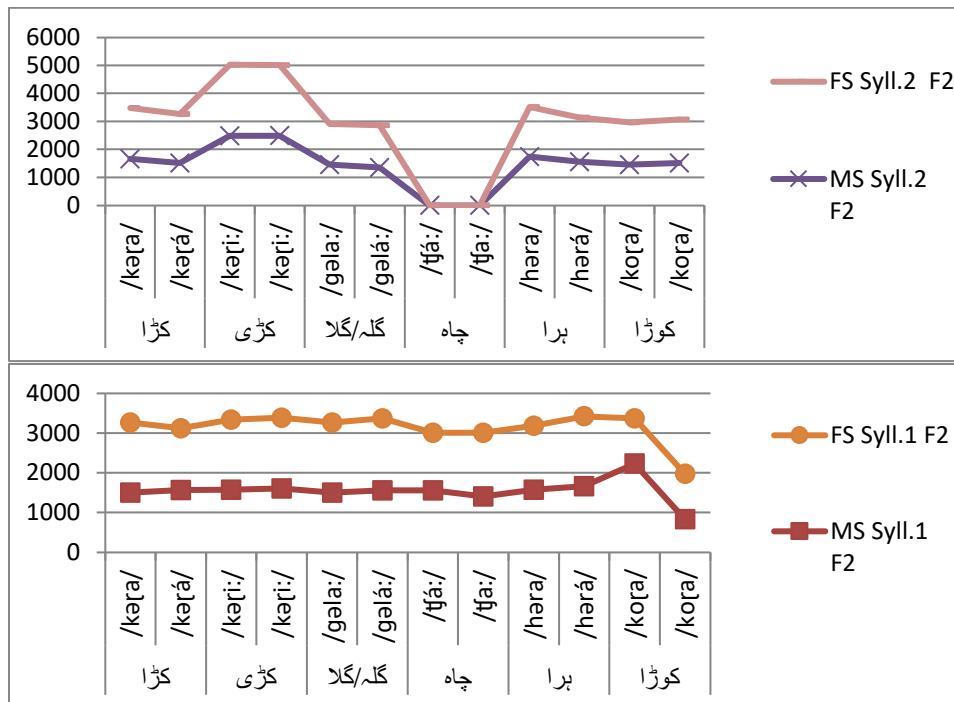**Fig. 4.9: Formant Frequencies of Punjabi Minimal Pairs**

Fig. 4.10: Formant Frequencies

Data analysis of Punjabi minimal pairs shows that the formant frequency values (F1, F2, F3) of the vowels in females are greater than formant frequencies of Punjabi male speakers.

4.1.9 Segmental Duration or Stress in Minimal Pairs of Punjabi Dialect of Lahore

A stressed segment is loud and prominent among other phonemes in a speech utterance. Acoustically, a stressed segment is different on the bases of duration or by having more number of wave cycles. PRAAT is for the acoustic analysis of stressed and unstressed speech segments. Perceptually, a stressed segment is perceived loud and prominent among the rest of phonemes in an utterance while acoustically a stressed segment is differentiated on the bases of duration because a stressed segment has more duration (Baepler, Ekegren, Marsh, & Amanda, 2006). Segment duration is directly influenced by the tone as stress and tone always come together in Punjabi spoken language. Praat is used to measure the duration of speech sounds at the level of segment, syllable, and word. The vowel

part of the word برا (/həra:/ green) verses برا (/həra´:/ defeat) as is shown in the following figures.
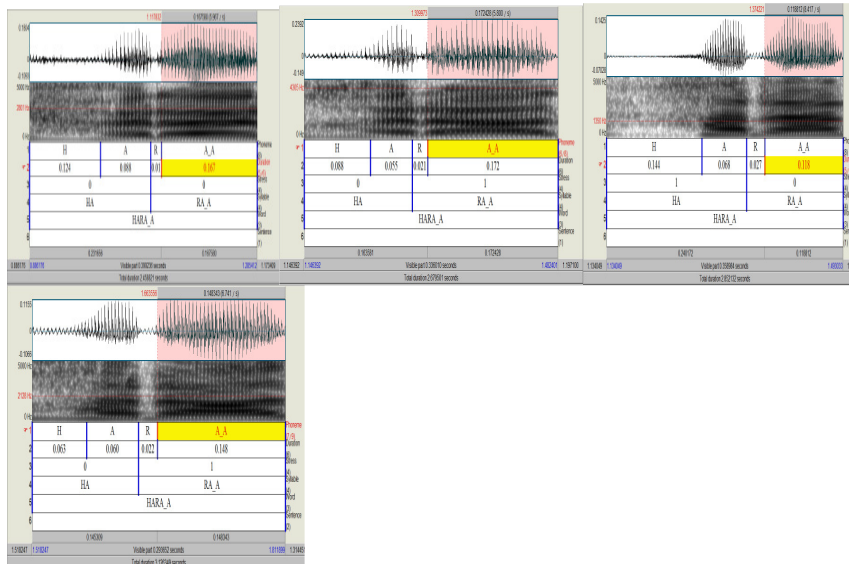
Fig. 4.11: Stress Analysis in Punjabi Minimal Pairs in Male Speaker and Female Speakers respectively

Punjabi tones are stress dependent and stress variation causes meaning variation in Punjabi minimal pairs.

Table 4.6 Segmental Duration or Stress of Tonal Segment

Punjabi Words	Minimal Pairs	English Meaning	Average Values of Male Speakers (ms.)				Average Values of Female Speakers (ms.)			
			Syllable 1		Syllable 2		Syllable 1		Syllable 2	
			Consonant	Vowel	Consonant	Vowel	Consonant	Vowel	Consonant	Vowel
کڑا	/kəɽa/	pitcher, mound	0.099	0.082	0.034	0.117	0.091	0.092	0.025	0.135
	/kəɽa/	carving, cutting	0.141	0.105	0.024	0.134	0.070	0.072	0.027	0.089
کڑی	/kəɽi:/	Gravy	0.139	0.075	0.023	0.105	0.122	0.068	0.025	0.077
	/kəɽi:/	Clues	0.125	0.097	0.034	0.149	0.107	0.095	0.020	0.095
گلہ/گلا	/gəla:/	Neck	0.136	0.078	0.059	0.168	0.066	0.075	0.057	0.088
	/gəla´:/	Cooked	0.092	0.063	0.064	0.175	0.052	0.051	0.072	0.135
چاہ	/ʧa:/	Tea	0.147	0.217			0.072	0.219		
	/ʧa´:/	Affection	0.140	0.213			0.097	0.223		
برا	/həra/	Green Colour	0.124	0.088	0.019	0.168	0.144	0.068	0.027	0.118
	/həra´/	Defeat	0.088	0.055	0.021	0.172	0.068	0.062	0.025	0.148
کوڑا	/koɽa/	Bitter	0.169	0.125	0.036	0.115	0.116	0.098	0.034	0.091
	/koɽa/	Horse	0.173	0.15	0.038	0.153	0.127	0.122	0.029	0.111

Data shows that stress variation causes the difference in the tone of the minimal pairs articulated by Punjabi speakers of Lahore. This is clear by analyzing the minimal pair of كڑا articulated with minor changes in the segmental duration which can be understood by comparing the values of each segment: كڑا (/kəɽa/ pitcher, mound) MS_C1 is 0.099, MS_V1 is 0.082, MS_C2 is 0.034, MS_V2 is 0.117, FS_C1 is 0.091, FS_V1 is 0.092, FS_C2 is 0.025 and FS_V2 is 0.135 and the segmental duration in the word كڑا (/kəɽa/ carving, cutting) MS_C1 is 0.141, MS_V1 is 0.105, MS_C2 is 0.024, MS_V2 is 0.134, FS_C1 is 0.07, FS_V1 is 0.072, FS_C2 is 0.027 and FS_V2 is 0.089. Data analysis also confirms that vowel duration of male and female speakers is very close to each other. The analysis also confirms that the segmental duration shows less increase in the stressed articulation while male speakers' speech shows at least 50-70 mili-seconds increase which is larger rate then the female speech.
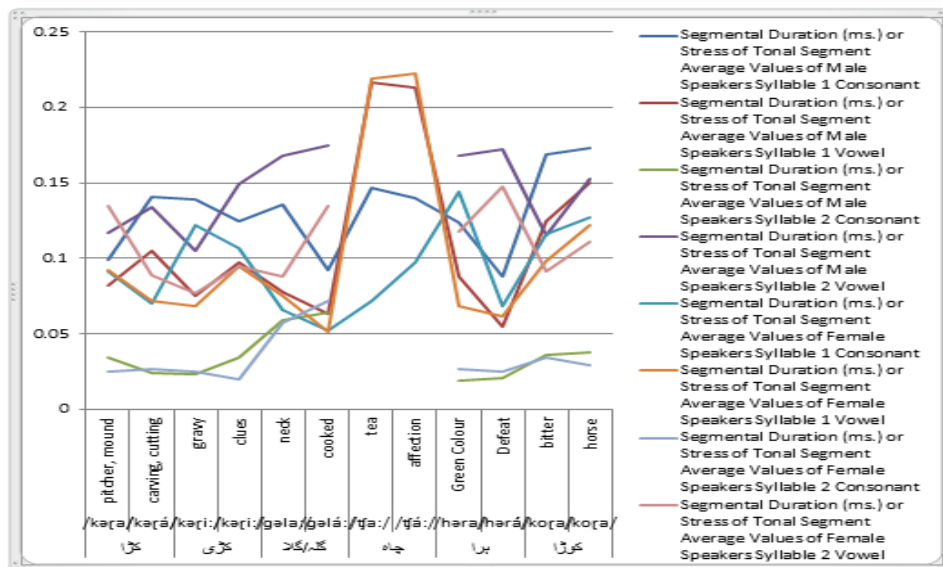

Fig.4.12: Stress Analysis of Minimal Pairs in Punjabi Dialect of Lahore

4.1.10 Pitch in Minimal Pairs of Punjabi Dialect of Lahore

Pitch is the perception of relative frequency while *tone* is significant. Phonemic contrasts among words signaled by the differences in pitch. Pitch and tone are different mechanisms of sound but are correlated with each other. Pitch is frequency dependent to the sound while tone has the quality to differentiate various voices by regulating the sound quality (Olivia, 2011).

Table 4.7 Pitch Analysis in Punjabi Minimal Pairs of Lahori Dialect

Words	Tonal Words	English Meaning	Average Values of Male Speakers		Average Values of Female Speakers	
			Syllable 1	Syllable 2	Syllable 1	Syllable 2
کڑا	/kəɽa/	Pitcher, mound	L-L	Level	Level	Level
	/kəɽá/	Carving, cutting	Level	L-H	Level	Level
گَلَ/گَلَ	/gəla:/	Neck	M-L	L-M	M-L	Level
	/gəlá:/	Cooked	Level	L-H	Level	Level
چاہ	/ʧa:/	Tea	L-H*		H-L (pau)	
	/ʧá:/	Affection	M-L		M-L	
برا	/həra/	Green Colour	M-L	L-M	M-L	Level
	/hərá/	Defeat	M-L	L-H	L-H	L-H
کوڑا	/kɔ́ɽa/	Bitter	H-L	L-L	L-L	Level
	/koɽa/	Horse	L-L	H-L	L-L	Level

Data has been collected after stylizing the pitch of sound waves in PRAAT window. Data analysis of pitch contours shows the different tonal behavior of male and female Punjabi speakers of Lahore. The results of data analysis show that tone remains at intermediate level, middle to low or low to middle levels in female Punjabi speakers. Contrary to it, the tonal variations are confirmed in the males and are up to the mark mostly. The analysis clears the idea that tonal effect is not vivid in female speakers of Lahore dialect.

5. Conclusion

Punjabi is a tonal language and tone plays morphological as well as syntactic role (2.5.). There are 5 tonal segments and three tones in Punjabi language. Therefore, this research has been done to know whether educated Punjabi speakers of Lahore are still following the tonal system or not. So, for the confirmation, the research has done in two steps. First step (4.1.) deals with the acoustic analysis of tonal segments while the second step (4.2.) deals with the acoustic analysis of the three tones (i.e., low, mid and high). This study answers the research questions that multilingual effect of Urdu and English language affects the tonal system of Punjabi dialect of Lahore and speakers are articulating five tonal segments and 3 different tones. Gender differences have also been observed in the speech of male and female educated Punjabi speakers of Lahore.

Acoustic analysis of tonal segments concluded that the voice onset time (VOT) is less in female speakers (4.1.1.). Segmental duration of tonal stops is larger than the non-tonal stops. It is concluded that the segmental duration of female speaker is at least 20-25 mili-seconds larger than male

speakers in the tonal segments. Opposite to this, segmental duration in female speakers' speech is less than the male speakers' in non-tonal words. Fundamental frequency (F0) of male female speakers also varies. Formant frequencies of tonal and non-tonal vowels show minor differences (4.1.4.). Speech intensity of male speakers is slightly high than the females speakers (4.1.3.). Punjabi speakers of Lahore have articulated tonal words with different levels of tone but the tonal articulation of females are more relaxed than male members.

Acoustic analysis of 3 tones in Punjabi speech concludes that speech intensity of Punjabi male speakers is greater than the females (4.3.1.). In the articulation of the minimal pairs, formant frequencies of females are greater than Punjabi male speakers (4.3.2.). Stress variation plays important role by causing differences in the tone of the minimal pairs articulated by Punjabi speakers of Lahori dialect. But there is limited increase in number of cycles per segment in female Punjabi speakers' speech. Male speakers show at least 50-70 mili-second increase which is larger rate then the females (4.3.3.). During the articulation of minimal pairs, female speakers' speech show minor variation in tonal patterns which could be ignorable. This would clear the idea that tonal effect is not as much prominent in females. But the male speakers' speech shows clear tonal variations which are reasonably better than females (4.3.4.). Firstly, the multilingual background of these young Punjabi speakers of Lahore. Secondly, it might be the relaxed articulation of the speakers. As Punjabi is a contour tone language; the motivation of this research is to find out the actual use of tones by Punjabi speakers of Lahore dialect. It is concluded that spoken Punjabi language of educated speakers is affected. It would not be wrong if said that their Punjabi is contaminated with the socio-cultural and educational factors in the premises of Lahore that's why pitch contours become leveled. Therefore, semantic differentiation of two identical words has been done on the basis of context but not on the basis of pitch patterns of tone.

6. Recommendations and Future Work
The present work is based only on a limited sample, therefore, is not generalized but it opens new horizons for the future research and will give directions to other researchers. Firstly, a research can be done in contrastive analysis with the native Punjabi speakers with and without educational background. Analyses of other Indo-Aryan languages can be done in future. Historical development of stress and tone can be

investigated in depth by increasing population size. Last but not least multi-hierarchical theory of the interaction of stress and tone can be used in future for the execution of more hierarchies for increasing the scales and inventory of hierarchies.

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