Investigating Gender, L1 and Voice Onset Time based variations in Urdu aspirated voiceless and voiced plosives: An Acoustic analysis

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Abstract

This article explores the feature of aspiration in Urdu voiceless and voiced plosives /ph, bh, th, dh, kh, gh/ from the perspective of three variables i.e., gender, L1 and VOT. It attempts to investigate which of these variables has a significant impact in the production of bilabial, alveolar and velar Urdu plosives. A wordlist of 60 tokens was used as stimuli which carried 10 instances from each category of plosives. 30 post-graduate male and female students, from Punjabi, Seraiki and Urdu L1 aged between 20 and 25, were selected as participants of the study. The recordings were analyzed to measure VOT of hold phase of plosives using PRAAT. The independent t-test and ANOVA were applied to probe into significance of each variable. Findings revealed that belonging to different L1 backgrounds did not have significant differences as the mean values were almost the similar and $p>.05$ for each category except for Punjabi speakers in /bh/. For gender variable, significant variation was found in /ph, bh, dh, kh, gh./. The most significant variable was VOT where $p<.01$ in each plosive category with huge differences in the high mean VOTs for voiceless plosives /ph, th, kh/ and very low mean VOTs for voiced plosives / bh, dh, gh/. It also implied that voicing impeded the hold phase of aspirated voiced plosives resulting in huge VOT differences; although a tendency of rising VOT from alveolar to bilabial and then to velar was found between voiceless and voiced plosives.

Keywords*:* Gender variation; L1 variation; VOT; Urdu plosives; Aspiration

1. Introduction

Pakistan's national language Urdu, along with English, is also the official language (Constitution of Pakistan, 1956, Article 6; 1973, Article 251). In 2015, the government of Pakistan announced plans to make Urdu the sole official language and abolish English as the second official language (Mansoor, 2015) but practically, this has not yet been implemented fully. The country is also home to 73 regional languages (OLAC: Open Language Archives Community, 2017) including Punjabi, Seraiki, Pashto, Sindhi, Balochi, Kashmiri, Hindko, Brahui, Shina, Balti, Khowar, Dhatki, Marwari, Wakhi and Burushaski. From among these, four (Punjabi, Pashto, Sindhi, and Balochi) are provincial languages. The difference in the number of spoken languages occurs because of the confusion of languages as dialects or independent languages (Rehman, 2002) whereas according to Ethnologue (Simons & Charles, 2017), there are 73 spoken languages and most of these languages belong to Indo-Aryan, Indo-Iranian, Indo-European, and Turkic language families (Gordon, 2005). Following are the major languages spoken in Pakistan, by number of people that speak them as their first language (Rehman, 2006).

Table 1.1. Major languages spoken in Pakistan as L1 by percentage of population

	Language		1998 census
1	Punjabi		44.17%
2	Pashto		15.44%
3	Sindhi		14.12%
4	Saraiki		10.42%
5	Urdu		7.59%
6	Balochi		3.59%
7	Others		4.66%

Recently, census 2017 is in process, so the current estimation of languages spoken in Pakistan would become clear in near future. Although, the number of Urdu speakers as L1 is significantly lesser than (almost 8%) that of other regional languages; yet, it is widely spoken and understood as a second language by the vast majority of Pakistanis and is being adopted increasingly as a first language by urbanized Pakistanis due to the language policies adopted to promote English and Urdu language at the cost of other regional languages (Rehman, 2006). Its status as the national language and one of two official languages of Pakistan (the other currently being English) makes it lingua franca. Urdu is the second or third language for almost all Pakistani speakers therefore, it has acquired Pakistani flavour by absorbing Punjabi, Sindhi, Balochi, Pashto and Saraiki languages in terms of accents and vocabulary so there are six major accents of Urdu in Pakistan (Rehman, 2002).

In the context of Punjab, Urdu is spoken and understood by many of the Punjabi and Seraiki speakers. One of the shared phonological features among these three languages is the usage of aspiration in voiceless and voiced plosives. The plosives in phonemic inventories of Seraiki (Awan et al., 2011), Punjabi (Lata, 2011) and Urdu (Oxford Urdu English Dictionary, 2013; Saleem et al., 2002) are listed below:

Table 1.2. Plosives in Punjabi, Seraiki and Urdu phonemic inventories

	Bilabial	Dental/ Alveolar	Retroflex	Velar
Punjabi	p pʰ b	t̪ t̪ʰ d̪	ʈ ʈʰ ɖ	k kʰ g
Seraiki	p b pʰ bʰ	t̪ d̪ t̪ʰ d̪ʰ	ʈ ɖ ʈʰ ɖʰ	k g kʰ gʰ
Urdu	p pʰ b bʱ	t̪ d̪ t̪ʰ d̪ʱ	ʈ ɖ ʈʰ ɖʱ	k kʰ g gʱ

This table makes the situation clear that aspiration is a shared feature of all the three phonologies with one variation in Punjabi phonemic inventory where bilabial, alveolar and velar voiced aspirated plosives are not used. The question arises that do speakers of one L1, belonging to different genders as well, pronounce the same shared feature of L2 in the similar way or if there is a variation in their production. In this wake, this article deals with the three-fold perspectives stated as research questions:

1. Whether variation exists in aspirated voiceless and voiced plosives of Urdu as pronounced by Seraiki, Punjabi and Urdu speakers?

2. Whether male and female speakers of Seraiki, Punjabi and Urdu vary in their pronunciation in these two sets of plosives phonemes or not? /
3. What is the nature of aspiration in voiceless and voiced sounds in Urdu language in different vowel contexts measured through the acoustic co-relate i.e., VOT?

1.1. Nature of voiceless and voiced plosives

Plosives or stops for which the air is completely blocked by the articulators e.g., both the lips /p,b/; alveolar ridge and blade of the tongue /t, d/; and velum and back of tongue /k, g/ etc (Roach, 2009, p. 26; Trask, 1996, p. 281). They are also categorized as obstruents according to their noise component; those in whose production the constriction impeding the airflow through the vocal tract is sufficient to cause noise. At any place of articulation, a consonantal articulation may involve the vibration of the vocal cords, i.e. may be voiceless or voiced (Cruttenden & Gimson, 2014). Those English consonants which are usually voiced tend to be articulated with relatively weak energy (Lenis e.g., /b, d, g/), whereas those which are always voiceless are relatively strong (Fortis e.g., /p, t, k/) (Roach, 2009, p.29).

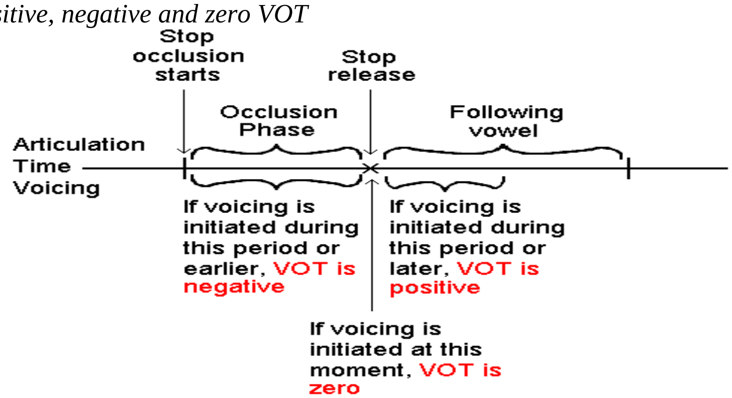
In terms of plosive sounds, many Indian languages have a four-term distinction (voiceless vs. aspirated voiceless vs. voiced vs. aspirated voiced). Non-aspiration languages tend to have firmer closures for voiceless plosives; the articulators form a tight, efficient valve, with a brisk release of the compressed air. Aspirated articulations have looser closures which act like an inefficient 'leaky' valve from which the air is released somewhat more slowly (Collins &Mees, 2013).
In the similar way, the voiceless and voiced plosive sounds in Urdu phonology are classified into two types i.e., aspirated and unaspirated. Unlike English plosives where aspiration denotes the allophonic variation of plosive sounds (Davenport &Hannahs, 2010), the use of aspiration brings a semantic change in Urdu language granting the status of distinctiveness to each phoneme in a minimal pair e.g., /p^h, b^h/, /t^h, d^h/, /k^h, g^h/.
/phal/ 'fruit', /phūl/ 'flower' /bhāi/ 'brother', /bhūl/ 'a small mistake'
thāli/ 'plate', /thakān/ 'tiredness' /dhabbā/ 'spot', /dho:l/ drum
/kheel/ 'play', /khānā/ 'food' /ghar/ 'house', /ghooRā/ 'horse'

The use of aspiration is equally valid for voiced sounds in the creation of a new phoneme instead of a variant for Urdu Language although voiced aspirated sounds are rarely found in world phonologies. Discussing the laryngeal features of obstruents, Hall and Steven (1971) propose two dichotomies of features i.e., stiff and slack vocal cords; and constricted and spread vocal cords. They conclude the division of the obstruents into plain [—spread glottis, —constricted glottis], aspirated [+spread glottis, —constricted glottis]. When the vocal cords are [+stiff, —slack], they will not vibrate when the pressure across the glottis is reduced. This observation suggests that [+stiff, —slack] is the appropriate feature assignment for the traditionally voiceless consonants. A voiced stop that contrasts with [b] in some languages is the aspirated consonant [bh]. The features are the same as those for [b] except that the glottis is [+spread] rather than [-spread]. Ladefoged and Johnson (2006) classify aspirated voiced stops as murmured voiced sounds quoting the evidence from Sindhi language. The difference between voiceless unaspirated, aspirated, and murmured stops is largely a matter of the size and timing of the opening of the vocal folds. In voiceless unaspirated stops, the maximum opening of the glottis (which is not very great) occurs during the stop closure. In (voiceless) aspirated stops, the glottal opening is larger and occurs later, near the moment of release of the stop closure. In murmured stops, the glottal opening is similar in size to that in voiceless unaspirated stops, but it occurs later, during the release of the closure. Because there is a rapid flow of air through the vocal folds at this time, the vocal folds vibrate while remaining slightly apart, thus producing breathy voice.

1.2. Aspiration

Aspiration (Davenport and Hannahs, 2010; Wells, 2016) is measured through acoustic co-relate, Voice Onset Time (VOT, henceforth) to determine the timing of hold phase before release of burst or voicing. This timing realizes three situations of plosives: positive high lag VOT realizing aspirated sounds, zero or near zero VOT realizing unaspirated sounds and negative VOT where voicing starts before release as illustrated through the diagram below (Mannell, 2009).

Figure 1.1. *Positive, negative and zero VOT*



1.3. VOT and gender difference

Gender differences in voice onset time have received relatively little attention in the literature. This is surprising considering the differences in the articulators between male and female speakers that have been established in previous research. The data summarised by Titze (1994) shows that the average vocal fold membranous length is 6 mm shorter in female adults compared to male adults. The shorter membranous length in turn increases the possibility of a more rapid closure gesture, which is shown by the higher average f0 value in female speech compared to male speech. Accordingly, if voice onset time is influenced by the abduction speed of the vocal folds (Kewley-Port and Preston, 1974), male and female plosives would be unequally affected by this factor, creating a gender bias. This hypothesised effect of gender on VOT was investigated by Swartz (1992). Using VOT measurements obtained from the waveform of productions made by adult male and female native speakers of American English, Swartz showed a significant difference in VOT due to gender and also that this difference did not correlate with the higher speaking rate of men compared to women.

2. Literature Review

An extended literature review realizes different dimensions of research on Urdu Language, VOT in plosive sounds and gender and L1 based variations in the pronunciation of aspirated and unaspirated sounds.

In this regard, Farooq (2014) compared the six accents of Urdu based on the top six languages listed in census through acoustic analysis of each by phonemic inventories of these six languages and its impact on the accent of non-native speakers of Urdu focussing only on the analysis of vowel sounds. Afsheen et. al. (2014) probed into accent classification among Punjabi, Urdu, Pashto, Saraiki and Sindhi Accents of Urdu Language using mel frequency cepstral coefficient (MFCCs) and feature formants. Based on two different acoustic features, two experiments had been conducted to classify above mentioned five accents. The results of the two experiments showed that two-dimensional formant features F1 and F2 are not sufficient to classify Punjabi, Urdu, Pashto, Saraiki and Sindhi accents of Urdu language spoken in different geographical regions of Pakistan. Batti and Mumtaz (2016) carried out a research to finalize the list of diphthongs for the development of Urdu Phonetic Inventory. They identified diphthongs in Urdu using i.e. perceptual approach and acoustic approach respectively. Speech of six native speakers was analyzed using durational and formant cues both at stressed and unstressed forms on PRAAT. The combined analysis of perceptual and acoustic approaches indicated that Urdu has fifteen diphthongs. Rauf et al (2016) have conducted an acoustic investigation of /l, j, v/ as approximants in Urdu and their aspirated allophonic variation using PRAAT for spectrographic analysis of these sounds at syllable initial, medial and final position. They concluded that Urdu approximants also behave like fricatives and only two aspirated approximants exist in Urdu i.e. / l^h , v^h /.

Hussain, Mahmood and Mahmood (2012) investigated the phonological make-up of English loanwords incorporated into Punjabi via Urdu. Differences and similarities between bilingual and monolingual speakers were highlighted to determine the route of borrowing. Based on two corpora, a corpus of 292 English loanwords in Punjabi; and a corpus of 421 English loans in Punjabi and Urdu, metathesis, aphaeresis, and substitution of consonants had been found as some of the adaptation strategies on the basis of which they differentiated between the output forms of monolingual and bilingual speakers. Ejaz (2004) explored the rules and explanation of the phonological behaviour of aspirated consonants occurring at two or more than two places in Urdu words. Regarding, phonological rules, deletion and dissimilation were reported very common. Metathesis was quite rare while assimilation; epenthesis and compensatory lengthening were absent in her data. Shah (2002) has investigated Urdu nasal consonants and their phonological behaviour through spectrograms. He identified the nasal phonemes and their allophones alongside the rules for nasal and place assimilation. Sheikh (2002) studied aspirated continuants in Urdu disguised in carrier sentences at every possible position. The results showed that the aspiration of continuants in Urdu has almost vanished and in some cases broken into a separate |h|. Shahid (2002) studied Glottal Stops in Urdu to investigate and identify the rules. He found that the occurrence and the probability of glottal stops are dependent on the speaker's way of pronouncing.

Syed (2012) has investigated the voice onset time for plosives in Seraiki and its implications for acquisition of English aspiration contrast in this respect. Ten local speakers of Seraiki read sixteen Saraiki words beginning with stops took after by a front vowel. Each word had six redundancies, 3 in a bearer sentence and 3 in separation. The acoustic investigations utilizing Praat demonstrated that the place of articulation of stops significantly affects the VOT with the bearing of increment of VOT from labial to velar stops with coronals in the middle.

After investigating into VOTs of English voiceless plosives, Malik & Saeed (2015) demonstrated that Pakistani English speakers' range of production, with Punjabi, Seraiki and Urdu as their L1, starts from 0.005ms and ends at 0.045ms for /p, t, k/ irrespective of stressed and unstressed syllable initial position whereas RP speakers' range of production is from 0.015ms to 0.045 for unstressed syllable initial position and goes beyond 0.081ms for stressed syllable initial position on average especially in long vowel contexts.

In order to study inter-relation between gender and VOT, Karlsson, Zetterholm & Sullivan (2004) investigated the effect of gender on voice onset time distribution at three stages of speech development. Two subject groups consisting of children, aged approximately 3 and 9 years, were compared to adult speakers regarding voice onset time of initial plosives. The results showed significant gender effects in the aspirated plosives in the young subjects that were not present in the plosives produced by adults. It is hypothesised that the effect of gender at the earlier stages of development may be due to the differences in airflow intensity and variability. In another study, Whitehead et. al. (2004) probed into VOT data for the plosives /p b t d k g/ in two vowel contexts (/i a/) for 5 groups of 46 boys and girls aged 5;8 to 13;2 years to examine patterns of sex differences. Results indicated that there was some evidence of females displaying longer VOT values than the males. In addition, these were found to be most marked for the data of the 13;2-year olds. Furthermore, the sex differences in the VOT values displayed phonetic context effects. For example, the greatest sex differences were observed for the voiceless plosives, and within the context of the vowel /i/.

3. Research Methodology

The data for the present research was obtained from 30 male and female participants belonging to three different L1 i.e., 10 from Punjabi (5 male and 5 female), 10 from Seraiki (5 male and 5 female) and 10 from Urdu (5 male and 5 female). All of them were post-graduate students at the department of English aged between 20 and 25 and they used to speak their L1s at their homes. In order to compare, 6 categories of Urdu voiced /b, d, g/ and voiceless /p, t, k/ aspirated plosives at syllable initial position in different vowel contexts, a wordlist of 60 was used as stimuli (See Appendix-A) i.e.,10 words from each category in short and long vowel context. The participants were asked to pronounce the words one by one with the pause of 5 sec after each word; so, the total no of recorded token words were 1800. The recordings were analyzed using PRAAT to measure the VOTs of each plosive in milliseconds. The independent t- test and Anova were applied to find out the mean and significance of each category from each group of participants at the levels of $p<.01$, $p<0.05$ and $p<.001$. The statistical data analysis was reported using graphs and tables from the perspective of gender, L1 and VOT values of aspiration variables.

4. Findings

The findings of analysis are reported according to three different variables tested in this article as stated below:

4.1 Gender

The results of independent t-test on gender variable are summarized in Table 4.1 below. In the present data set, significant differences in the p-values were found in four aspirated phonemic categories i.e., for /p^h/highly significant p-value was .005 with the mean value for m=.071ms and f=.063ms; for /b^h/ non-significant results were found as p=.0125 with the mean value for m=.011ms and f=.014ms; f= .064; for /t^h/ non-significant results were found as p=.187 with mean values for m=.059ms and f=.055ms; for /d^h/p=.026 was significant at 5% with mean values for m=

0.012ms and f= 0.019ms; for /k^h/ p= .073 was significant at 10% with mean VOTs for m=0.009ms and f= 0.006ms; and for /g^h/ significance was .081 at 10% with mean VOTs for m=.031ms and f=.041ms. Aspirated bilabial plosive/p^h/ was the only category where highly significant differences were found between male and female speakers with moderately significant results for /bh/, /kh/ and /gh/illustrating that gender can be called a moderately strong variable in the measurement of variation in aspirated voiceless and voiced phonemes and males and females vary in their VOTs.

Table 4.1. *Summary of independent t-test on gender variable*

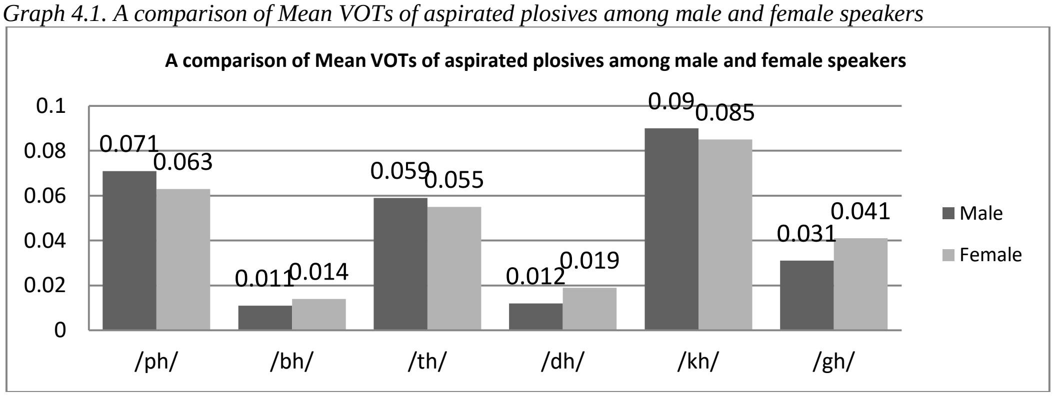
	Gender	N	M	SD	t	Df	p-value	95% CI Mean Diff	
								Lower	Upper
/ph/	Male	15	.07169	.008623	3.038	28	0.005***	.002575	.013238
	Female	15	.06378	.005220				.002523	.013290
/bh/	Male	15	.01181	.003651	-1.580	28	.125	-.007088	.000915
	Female	15	.01489	.006627				-.007140	.000967
/th/	Male	15	.05977	.008492	1.353	28	.187	-.001953	.009553
	Female	15	.05597	.006799				-.001966	.009566
/dh/	Male	15	.01257	.006103	-2.351	28	.026**	-.012687	-.000873
	Female	15	.01935	.009355				-.012731	-.000829
/kh/	Male	15	.09082	.009683	1.865	28	.073*	-.000562	.011989
	Female	15	.08511	.006857				-.000594	.012020
/gh/	Male	15	.03117	.015074	-1.809	28	.081*	-.022559	.001399
	Female	15	.04175	.016904				-.022566	.001406

*P<0.10, **P<0.05, ***P<0.01

4.1.1 Acoustic Analysis of VOTs in gender variable

The acoustic analysis of all the recordings by male and female speakers does not realize huge variations in the usage of aspiration as represented in Graph 1 below which summarizes the mean VOTs for 6 plosives. The 6 paired columns realize almost the similar pattern of high aspiration for voiceless plosives /p^h, t^h, k^h/ and low aspiration for voiced plosives /b^h, d^h, g^h/. Male speakers have relatively high VOT for /p^h, t^h, k^h/ i.e., .071ms, .059ms and .090ms respectively as compared to female's VOTs of .063ms, .055ms and .085ms respectively.

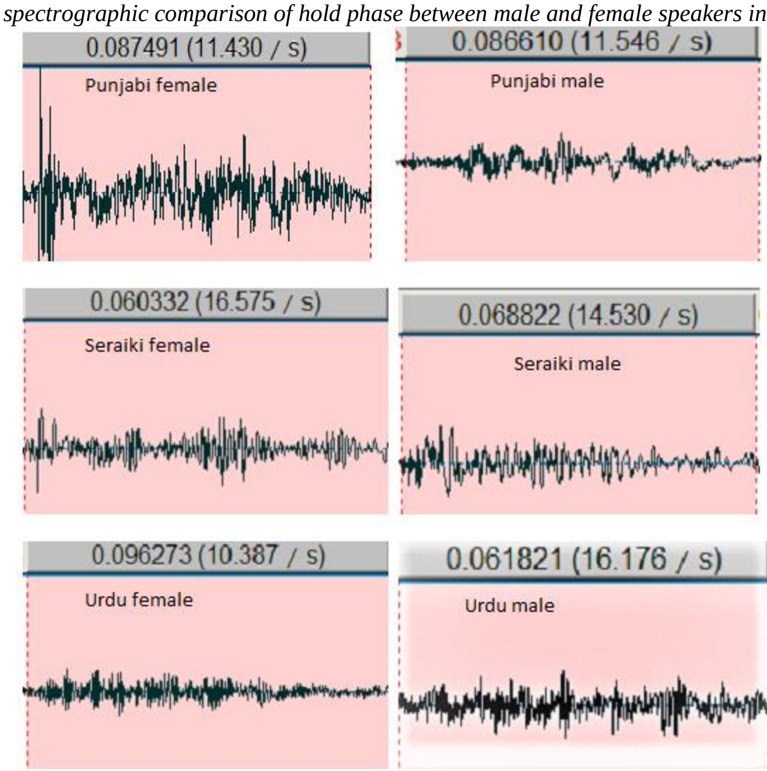
Graph 4.1. A comparison of Mean VOTs of aspirated plosives among male and female speakers



The situation is vice versa in aspirated voiced plosives where female speakers realized a relatively higher VOTs for /b^h, d^h, g^h/ i.e., .014ms, .019ms and .041ms as compared to that of .011ms, .012ms and .031ms for male speakers respectively.

The following spectrograms for the hold phase in /p^{h}u:l/ indicate similarities among Punjabi and Seraiki male and female speakers in terms of time given at the top bar of each spectrogram expect Urdu male's low VOT of .061ms and high VOT of .096ms for Urdu female speaker. The peaks of each sound wave also do not differ expect Punjabi female speaker's high to low variation.

Figure 4.1. A spectrographic comparison of hold phase between male and female speakers in /p^{h}u:l/



4.2 L1

In order to examine the variable of variation in L1, ANOVA test was applied. Like gender, in this case too, the statistical results were non-significant except bilabial voiced plosives where significance level was $p<.013$. It can be observed in Table 4.2 below that VOTs of Punjabi speakers was quite low in lower=.008ms, upper=.013ms, minimum= .004 and maximum=.019ms bounds with the standard deviation of .003ms. So, it can be inferred from data that the sound, non-existent in Punjabi phonology, is produced with greater variation by its speakers as compared to the Seraiki and Urdu speakers but it is not completely non-existent. Alveolar and velar voiced aspirated plosives /d^h, g^h/ are not present in Punjabi phonology too, yet in the present data, the Punjabi speakers had no difficulty in pronouncing these phonemes of Urdu; the reason might be the acquisition of these features due to the frequent usage of Urdu within the same regional background resulting in their non-significant variation in the VOTs of these sounds as compared to Seraiki and Urdu L1 speakers.

Table 4.2. Significant results of ANOVA among 3 different L1 speakers in aspirated voiced bilabial plosives /bh/

	N	M	SD	95% CI Mean Diff		Minimum	Maximum
				Lower Bound	Upper Bound		
Punjabi*	10*	.01080*	.003849*	.00805*	.01355***	.004*	.019*
Seraiki	10	.01195	.004167	.00897	.01493	.009	.023
Urdu	10	.01730	.006171	.01289	.02171	.007	.024
Total	30	.01335	.005486	.01130	.01540	.004	.024

***P<0.01

The complete results of ANOVA are given below in Table 5 where p-value for /ph/ was .063; /bh/ was .013***; /th/ was .607; /dh/ was .214 and /gh/ was .695. So, the variation between and within groups was found to be non-significant except /bh/.

Table 4.3. Results of ANOVA in L1 variation

Plosives	Sum of Squares	SS	df	MS	F	p-value
/ph/	Between Groups	.000	2	.000	.457	.638
	Within Groups	.002	27	.000		
	Total	.002	29			
/bh/	Between Groups	.000	2	.000	5.138	.013***
	Within Groups	.001	27	.000		
	Total	.001	29			
/th/	Between Groups	.000	2	.000	.508	.607
	Within Groups	.002	27	.000		
	Total	.002	29			
/dh/	Between Groups	.000	2	.000	.701	.505
	Within Groups	.002	27	.000		
	Total	.002	29			
/kh/	Between Groups	.000	2	.000	1.635	.214
	Within Groups	.002	27	.000		
	Total	.002	29			
/gh/	Between Groups	.000	2	.000	.369	.695
	Within Groups	.008	27	.000		
	Total	.008	29			

***P<0.01

However, insights into means of these 6 phonemes, divided into three different types of plosives, through descriptive ANOVA (see Table 6) realize the average range of VOTs which is almost similar for each L1 speaker mean value. The high VOT values for voiceless aspirated plosives /p^h, t^h, k^h/ as compared to low VOTs of voiced aspirated plosives /b^h, d^h, g^h/ is also a similar feature among Punjabi, Seraiki and Urdu speakers.

Table 4.4. Mean values of aspirated voiceless and voiced plosives among Punjabi, Seraiki and Urdu speakers through descriptive ANOVA

*total mean is highlighted

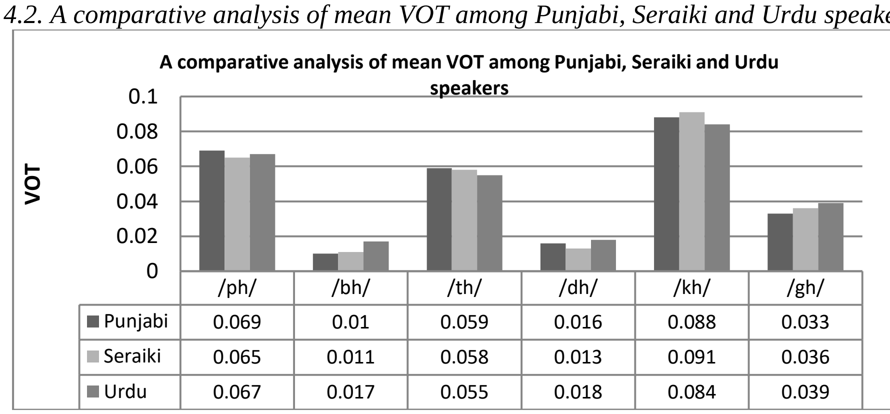
		N	M	SD	95% CI Mean Diff		Min	Max
					Lower	Upper		
/ph/	Punjabi	10	.06949	.008870	.06314	.07584	.057	.087
	Seraiki	10	.06597	.007818	.06038	.07156	.055	.080
	Urdu	10	.06774	.007966	.06204	.07344	.056	.082
	Total	30	.06773*	.008076	.06472	.07075	.055	.087
/bh/	Punjabi	10	.01080	.003849	.00805	.01355	.004	.019
	Seraiki	10	.01195	.004167	.00897	.01493	.009	.023

	Urdu	10	.01730	.006171	.01289	.02171	.007	.024
	Total	30	.01335*	.005486	.01130	.01540	.004	.024
/th/	Punjabi	10	.05934	.007930	.05367	.06501	.046	.069
	Seraiki	10	.05840	.009129	.05187	.06493	.043	.071
	Urdu	10	.05588	.006540	.05120	.06056	.046	.065
	Total	30	.05787*	.007801	.05496	.06079	.043	.071
/dh/	Punjabi	10	.01605	.008712	.00982	.02228	.003	.031
	Seraiki	10	.01364	.008089	.00785	.01943	.003	.028
	Urdu	10	.01818	.008920	.01180	.02456	.005	.034
	Total	30	.01596*	.008492	.01279	.01913	.003	.034
/kh/	Punjabi	10	.08839	.008126	.08258	.09420	.079	.105
	Seraiki	10	.09119	.008950	.08479	.09759	.072	.103
	Urdu	10	.08431	.008572	.07818	.09044	.065	.096
	Total	30	.08796*	.008741	.08470	.09123	.065	.105
/gh/	Punjabi	10	.03303	.015728	.02178	.04428	.015	.059
	Seraiki	10	.03680	.021000	.02178	.05182	.014	.078
	Urdu	10	.03954	.013383	.02997	.04911	.016	.057
	Total	30	.03646*	.016631	.03025	.04267	.014	.078

4.2.1 Acoustic Analysis of VOTs in L1 variable

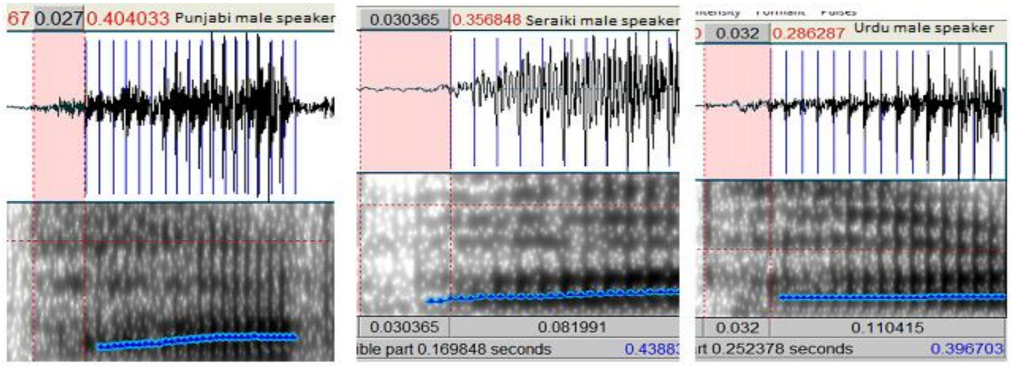
The VOTs measured from the perspectives of Punjabi, Seraiki and Urdu speakers demonstrate very similar timings for the hold phases of aspiration for the voiced and voiceless plosives as the three representative columns are almost similar in height supported by the correspondent data labels in Grpah 4.2 below.

Graph 4.2. A comparative analysis of mean VOT among Punjabi, Seraiki and Urdu speakers



The following spectrograph of /b^{h}ɜ:na:/ by Punjabi, Seraiki and Urdu male speakers respectively illustrates the similar VOTs at the top bar for the highlighted hold phases of plosives making it clear that variation does not exist in the central long vowel context among these speakers. Almost similar is the case for all the other aspirated voiceless and voiced plosives.

Figure 4.2. A spectrographic comparison of hold phases among Punjabi, Seraiki and Urdu male speakers in /b^{h}ɜ:na:/



4.3 Statistical analysis of aspiration between voiceless and voiced plosives

This was the only variable where highly significant results $p<0.01$ were obtained in all the 6 aspirated phonemes divided into three categories of bilabial, alveolar and velar sounds as realized in Table 4.5.

Table 4.5. t-test on variation in VOTs between aspirated voiceless and voiced plosives

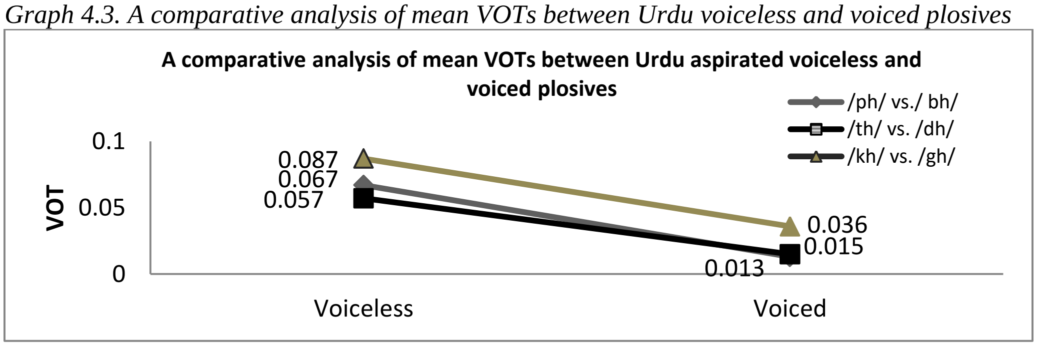
Aspirated plosives	N	M	SD	p-value	95% CI Mean Diff	
					Lower	Upper
/ph/	30	.06773	.008076	.000***	.050815	.057951
/bh/	30	.01335	.005486		.050805	.057962
/th/	30	.05787	.007801	.000***	.037702	.046131
/dh/	30	.01596	.008492		.037702	.046132
/kh/	30	.08796	.008741	.000***	.044640	.058373
/gh/	30	.03646	.016631		.044593	.058420

***P<0.01* Significant results are highlighted ***p < .01

4.3.1 An acoustic analysis of VOTs between Urdu voiceless and voiced plosives

The mean VOT values for /p^h/ and /b^h/ are .067ms and .013ms; for /t^h/ and /d^h/ are .057ms and .015ms; and for /k^h/ and /g^h/ are .087ms and .016ms respectively implying significantly that aspiration functions differently in voiceless and voiced plosives in Urdu as illustrated in Graph 4.3 below.

Graph 4.3. A comparative analysis of mean VOTs between Urdu voiceless and voiced plosives

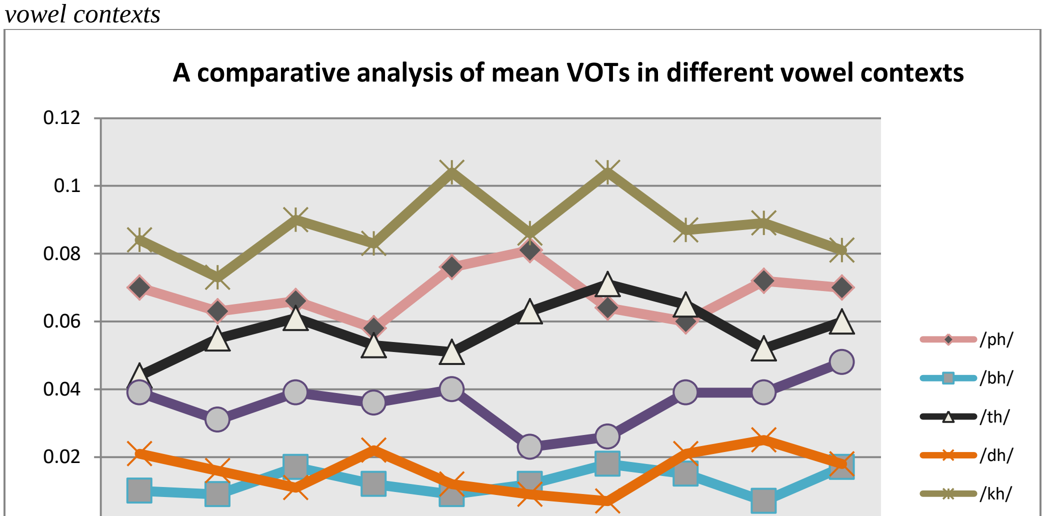


A stark difference can be observed in the dropping of line for /b^h, d^h, k^h/ as compared to rising line for /p^h, t^h, k^h/. The order of high to low VOTs puts velar plosives, whether voiceless or voiced, at the top followed by the bilabial and then alveolar plosives. The situation varies from English plosives where rise has been observed from bilabial to alveolar to velar plosives (Ladefoged, 2001).

The acoustic analysis of all the six plosives realizes huge differences between voiceless and voiced plosives in the similar vowel contexts. Very high negative VOTs were observed in long vowel contexts of /bh/ and /gh/ as illustrated in Graph 4 and Figure 4 below. Surprisingly, no such observation came across for /dh/ and relatively, the VOTs were low in short and long vowel context as compared to other voiced plosives.

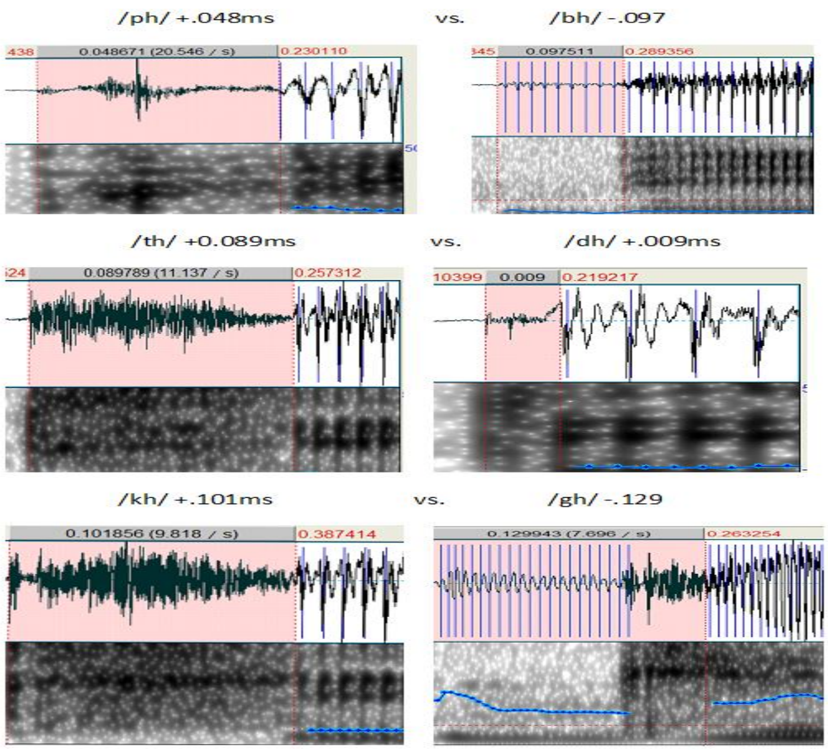
Graph 4.4 explains the in longer vowel context, the VOTs were comparatively high as compared to relatively low VOTs in short vowel context. The velar voiceless and voiced plosives had higher VOTs in all the vowel contexts as compared to bilabial and alveolar plosives.

Graph 4.4. A comparative analysis of mean VOTs of voiceless and voiced plosives in different vowel contexts



	/i/	/V/	/o/	/U/	/E/	/u:/	/i:/	/a:/	/ɜ:/	/ai/
/ph/	0.07	0.063	0.066	0.058	0.076	0.081	0.064	0.06	0.072	0.07
/bh/	0.01	0.009	0.017	0.012	0.009	0.012	0.018	0.015	0.007	0.017
/th/	0.044	0.055	0.061	0.053	0.051	0.063	0.071	0.065	0.052	0.06
/dh/	0.021	0.016	0.011	0.022	0.012	0.009	0.007	0.021	0.025	0.018
/kh/	0.084	0.073	0.09	0.083	0.104	0.086	0.104	0.087	0.089	0.081
/gh/	0.039	0.031	0.039	0.036	0.04	0.023	0.026	0.039	0.039	0.048

Figure 4.3. An acoustic comparison of aspirated voiceless and voiced plosives of Urdu in the context of /i:/



5. Conclusion

To sum up the findings, it can be reported that L1 has not been a strong variable as Punjabi, Seraiki and Urdu speakers produced the aspirated voiceless and voiced plosives almost within the similar range except /bh/ for Punjabi speakers. The non-existent sounds in Punjabi phonology /b^h, d^h, g^h/ were produced with similar proficiency with slight variation in /b^h/ by Punjabi speakers as uttered by Seraiki and Urdu speakers, realizing the acquisition of Urdu as Lingua franca or L2/3 (Rehman, 2002; 2006) for Punjabi and Seraiki speakers.

The gender differences were moderately significant as VOTs for /p^h/ were significantly different as compared to /b^h, d^h, g^h/ were slightly different. A consistent variation was observed in terms of male speakers' realizations of higher VOTs in voiceless plosives as compared to female speakers whereas the situation was vice versa in voiced plosives. The factor of shorter vocal fold membranous length of females as compared to males (Titze, 1994) and its effect on abduction speed of vocal folds (Kewley-Port and Preston, 1974) seems to be working out as for aspirated voiceless plosives, males' longer vocal folds prolonged the hold/occlusion phase of the plosive release whereas females' VOTs was comparatively short. For the aspirated voiced plosives, female speakers were able to hold the air in vocal folds for comparatively longer time as compared to male speakers whose negative VOTs in /b^h/ and /g^h/ realize the pre-voicing than the plosive release; it can be inferred that longer vocal fold size could not remain stiff enough in aspirated voiced plosive so resulted in -VOTs. Although, it implies that biological gender differences work out differently in voiceless and voiced plosives' hold phases; yet, more data would be required to support this viewpoint.

Through the measurement of VOTs to determine the nature of aspiration in voiceless and voiced sounds, Hall and Steven's (1971) features of stiff & slack, and constricted & spread vocal cords along with Ladefoged & Johnson's (2006) classification of voiceless aspirated and murmured (breathy) stops can be discussed in Urdu aspirated voiceless and voiced plosives as the timing and size of opening of vocal folds was varyingly distinct in spectrographic analysis of both kinds of plosives. In voiceless aspirated plosives, the +spread and +stiff vocal folds made the glottal opening larger and occurred later, near the moment of release of the stop closure. For voiced plosives, the vocal folds were +spread, -constricted to hold the air into vocal folds but –stiff, +slack to release the air even before the release of burst of plosive; thus realization of high negative VOTs in/b^h, g^h/ and low positive VOTs in /d^h/ make them more breathy or murmured sounds as compared to completely aspirated sounds justifying the variation of aspiration in voiced and voiceless plosives in Urdu.

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Appendix-A

Wordlist as Stimuli for recording

/p^h/	/t^h/	/k^h/	/b^h/	/d^h/	/g^h/
Phir	**Thikana**	**Khaat**	**Bhir**	**Dheel**	**Ghirna**
Pheil	Thehar	Kheer	Bheir	Dhoond	Gheir
Phurteela	Theek	Kheil	Bhoot	Dhang	Ghee
Phool	Thela	Khat	Bhaap	Dheir	Ghot
Phohar	Thug	Khoosat	Bhonda	Dhong	Ghoor
Pheeka	Thos	Khol	Bheek	Dhaal	Ghatna
Phaansi	Thoongna	Khul	Bhang	Dhitai	Ghul
Phora	Thaan	Kholna	Bhus	Dhundya	Ghaati
Phal	Thanda	Khai	Bharna	Dhai	Ghao
Pheir	Tharki	Khil	Bhonk	Dhela	Ghar