

A Phonetic Analysis of Hindko Affricate Sounds

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Abstract

The paper aims to analyze the affricate sounds of Hindko dialect spoken in Tanawal, Mansehra, Pakistan. The data were taken from the 12 native speakers, and measured in light of articulatory and acoustic phonetics. The articulatory analysis was taken into account to find out the places of articulation and word distributional occurrences. However, for the acoustic analysis, a list of the affricates was developed in vowel-consonant-vowel (VCV) context, e.g. /aʃa/, /adʒa/, /aʃʰa/, and recorded from the native speakers. The data were examined both spectrographically and statistically in the computer software, 'PRAAT'. The spectrographic analysis was carried out to examine extrinsic properties of the affricates and the statistical measurement was taken into account to find out the silent gap duration, noise friction duration and overall duration of the three consonants. It was found that Hindko has three affricate sounds, unapirated, voiced and aspirated. They are articulated from the palatal place of articulation and these sounds freely occur word initially, medially and finally. Since the affricates are the combination of stops /t, d/ and fricatives /ʃ, ʒ/, and like the previous studies on affricates, the present study also shows that individual stop and fricative sounds have longer duration than affricates.

Keywords: *Affricates, Tanawal Hindko, acoustic measurement, silent gap, noise friction, duration*

1. Introduction

Hindko is mainly spoken in Khyber Pakhtunkhwa province of Pakistan. It is the second biggest language of the province containing various dialects. The dialect spoken in the region of Tanawal is known as Tanoli Hindko. This region has around 0.8 million population and almost 90% speakers speak the same dialect. This paper is the first phonetic study of Tanoli Hindko affricate sounds. Generally speaking, the trend of experimental studies started in forties in the last century and most of languages of the world have gone through such experiments. This study is also carried out to be part of the well described and well documented languages of the world both phonetically and acoustically. The affricate sounds of Tanoli Hindko were identified through minimal pairs and then analyzed in terms of articulatory phonetics such as place of articulation and word distributional occurrence. Then the sounds were verified through acoustic phonetics including spectrographic and statistical analyses in light of silent gap duration; noise friction duration and overall duration of consonants.

However, Awan (2004) conducted an articulatory analysis of Peshawari Hindko and described four affricates such as /tʃ/, /tʃʰ/, /dʒ/ and /dʒʰ/; and Haroon ur Rashid (2015) identified three affricates, /tʃ/, /tʃʰ/ and /dʒ/, of Hindko spoken in Abbottabad (see Section, 6). Awan states that he has developed the phonemic inventory of Hindko according to his own perspective, and he further wrote; however, every speaker has its own way of articulation and it is possible that the findings of some other Hindko speakers remain different from his results. Awan's study was carried out in terms of articulatory phonetics and the data were based on a single speaker's experience. On the

other hand, Haroon ur Rashid (2015) measured the affricates acoustically and the data were taken from the young University students. But the present study was carried out both in articulatory phonetics and acoustic phonetics, and the data were taken from the people of above 50 years of age and who knew only Tanoli Hindko. They were illiterate and had not any schooling. The reason for selecting such a sample is that the participants will have minimum possible contact with other languages and uninfluenced data may be gathered for identification of the sounds. Thus, the pure measurement of the sounds may be the result of this effort. The investigation of the sounds has been confirmed in multiple ways; first, in articulatory phonetics in terms of places, voicing and distributional occurrence; and secondly, in acoustic phonetics in light of silent gap, noise frication and overall duration; and then compared the results with the previous studies, specifically which were carried out on the other dialects of Hindko (see Section, 6).

2. Literature Review

The term affricate is defined by Cruttenden (2001), "Any plosive whose release stage is performed in such a way that considerable frication occurs approximately at the point where the plosive stop is made...sounds may be considered either as single phonemic entities or as sequences of two phonemes" (p.171). It implies that phonetically, affricates are similar to plosives and fricatives due to their behaviour of sequential utterance.

Affricates are found in many languages of the world. Ladefoged and Maddieson (1996) state that affricate /tʃ/ is used in 45 of the languages in their sample. The combination of the stops /t,d/ and fricatives /ʃ,z/ make affricate sounds as /tʃ/, /dʒ/. Dorman et al. (1980) refer to the difference of the two groups of sounds that short durations in the articulation of fricatives and rapid rise times lead to the perception of affricates while longer fricative noise durations and slow rise time lead to the perception of fricatives.

Phonologically, unlike long vowels and geminate consonants, affricates get reverse order in terms of lengthening that they represent combination of two segments, i.e. a stop part and a fricative part, but their articulatory timing slots remain single that termed as /tʃ/, /dʒ/ (Ewen & van der Hulst, 2001). Therefore, affricates at segmental level have double features of stops /t & d/ and fricatives /ʃ & z/, and at timing level, they are single segments as /tʃ/ and /dʒ/.

According to Raphael et al. (2007) and Ball et al. (2008), acoustic features of affricates are much similar to stops and fricatives that affricates include silent gap of stop closure, i.e. obstruction of vocal tract and the burst of noise which refers to the release of stop sounds. Affricate sounds also consist of duration of frication which are the cues of the fricatives. It implies that affricates are somehow amalgamation of stops and fricatives. However, being phonemic entity, affricate sounds have their own acoustic characteristics.

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

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

3. Methodology

This study was limited to the affricate sounds of Tanoli Hindko dialect. These sounds were first investigated in articulatory phonetics and then verified by acoustical measurement. The data were collected from 12 native speakers (male and female). According to Gordon (2003), six male and six female speakers are an ideal pool to collect data for a quantitative study. All informants were above 50 years of the age and had a minimum possible contact with other languages. All the informants had normal hearing and speaking ability. A list of affricates in VCV context was given to them, preceded and followed by vowel /a/ sound and data were recorded directly in Pratt software. The informants were asked to keep a constant speech rate and were made to articulate each word three times to ensure minimum error.

A total of 18 tokens (3 affricates x 3 repetitions x 12 informants) were recorded on Pratt software to find the characteristics of Tanoli Hindko affricates. First, the visual analysis of affricate spectrograms was carried out to know both intrinsic and extrinsic properties. For this purpose, spectrogram of each utterance was studied and the most common trends in sounds were described. Secondly, sounds were statistically measured in terms of Hertz (Hz) including silent gap duration; noise frication duration and overall duration of consonants. Thus, on the basis of average calculation of sounds, their standard deviation (Std. Dev.) and coefficient of variation (Co.Var.) were taken into account.

In addition, the measured values were further tested by ANOVA to verify differences within segments. The level of significance was set as 0.01 and 0.05. Moreover, Least Significant Difference (LSD) test was also applied for further analysis (where required) to detect which pair is actually different. In addition to this general description for analysis of consonants, specific detail for the analysis of each group of sound, i.e. stops, nasals, fricatives, affricates and approximants is given in the following section:

4. Articulatory phonetic analysis of Hindko affricates

Hindko has three affricate sounds including unaspirated /tʃ/, voiced /dʒ/ and aspirated /tʃʰ/. First, these sounds are distinguished by voicing:

Table 1: Contrast in places and voicing of Hindko affricates

Position of sounds	Palatal unaspirated	Gloss	Palatal voiced	Gloss	Palatal aspirated	Gloss
Initial	tʃa:l	Gait	dʒa:l	Mesh	tʃʰa:l	Big jump
Medial	tʃa:tʃa:	Uncle	kæ:dʒa:	How	ka:tʃʰi:	Ladle
Final	bæ:tʃ	Sale out	sa:dʒ	Tool	ba:tʃʰ	Contribution

The data in the table 1 shows three Hindko affricate sounds, /tʃ/, /dʒ/ and /tʃʰ/. These sounds can freely contrast with one another. The phoneme /tʃ/ contrasts with /dʒ/ as in the words /tʃa:l/ and /dʒa:l/. It signifies that /tʃ/ is unaspirated affricate while /dʒ/ is a voiced affricate. The Table also reveals contrast of these two segments with /tʃʰ/ at three possible positions as well. Hindko also allows aspirated affricate sound /tʃʰ/ which is produced with an audible puff of air at the release stage. All the three Hindko affricates are produced at palatal part of articulation. The data show that each affricate sound is found in commutation test. Affricates are also analyzed in terms of different possible occurrence in the following table:

Table 2: **Distribution of Hindko affricates**

Sounds	Initial	Gloss	Medial	Gloss	Final	Gloss
/dʒ/	dʒott	Fight	sa:ndʒa:	Together	la:dʒ	Treatment
/tʃ/	tʃabb	Bite	mo:tʃi:	Cobbler	ku:tʃ	Clean up
/tʃʰ/	tʃʰaʈt	Roof	ka:tʃʰa:	Nicker	ba:tʃʰ	Contribution

The data in the table 2 show that Hindko affricates /dʒ/, /tʃ/ and /tʃʰ/ can freely occur word initially, medially and finally. All the occurrence of affricates at different positions in Hindko is not strange because many other languages of subcontinent, like Punjabi, Urdu, Hindi and Pahari etc also allow the occurrence of such sounds at three positions of a word.

5. Acoustic analysis of Hindko affricate sounds

Hindko affricates are acoustically analyzed in the following sections:

5.1 Spectrographic analysis of Hindko affricates

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

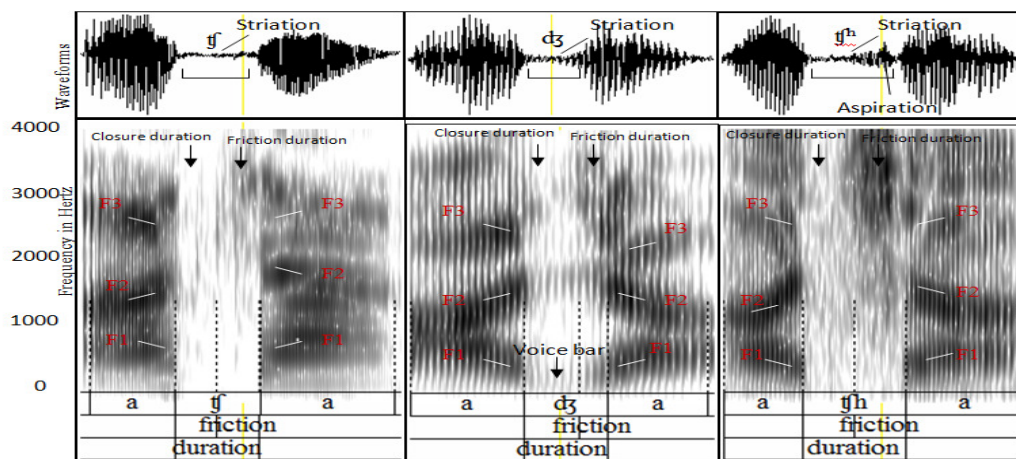


Figure 1: Waveforms and spectrograms of Hindko affricates

The figure 1 shows waveforms and spectrograms of /tʃ/, /dʒ/ and /tʃʰ/. The marked boundaries clearly indicate the parts of affricate sounds. The overall duration of sounds have two parts, i.e. complete closure before the release of sound and the friction of sounds respectively. Since the silent gap is the feature of stop sounds while the friction is the feature of fricative sound. Thus, the combination of these two cues makes them affricates.

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

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

5.2 Statistical measurements of Hindko affricates

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

Table 3: Frication duration values of Hindko affricates; Means, Std. Dev. & Co. Var.

Affricates	No. of Tokens	Means (sec)	Std. Dev.	Co.Var.
tʃ	36	0.0597	0.0136	22.8216
dʒ	36	0.0423	0.0058	13.8027
tʃʰ	36	0.0798	0.0117	14.7081

The table 3 shows the average mean values of frication duration in affricates with standard deviation and coefficient variation. Average mean values are further determined by ANOVA.

Table 4: ANOVA for frication duration of affricates

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

The ANOVA Table shows significant statistics as p-value is less than 0.01. Moreover, the Least Significant Difference (LSD) test is employed to measure the discrepancies within affricate pairs.

LSD=0.009814

Segments	ɖʒ	tʃ	tʃ ^h
Frication duration Means	0.042302	0.059755	0.079808

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

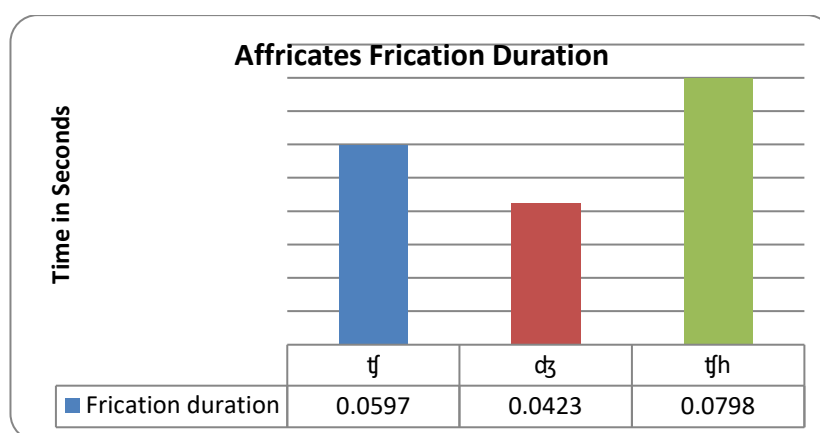


Figure 2: Hindko affricate sounds in terms of frication

The figure 2 reveals frication duration that the aspirated /tʃ^h/ has maximum frication duration almost double to the voiced /ɖʒ/ sound whereas the unaspirated /tʃ/ carries frication time in the mid of both sounds. Consequently, like the general concept, Hindko voiced affricate has less frication duration than the unaspirated and the aspirated sound get more time than the unaspirated.

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

Affricates	No. of Tokens	Means (sec)	Std. Dev.	Co.Var.
tʃ	36	0.0815	0.0133	16.3500
ɖʒ	36	0.0564	0.0069	12.3085
tʃ ^h	36	0.0763	0.0116	15.2533

The table 5 reveals that average mean values of affricates closure duration with standard deviations and coefficient variation. The average mean values are further analyzed by ANOVA.

Table 6: ANOVA for closure duration of affricates

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

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

LSD=0.009865

Segments	ɟʒ	tʃ ^h	tʃ
Means of closure duration	0.056449	0.076298	0.081564

The average mean values carried out by Praat software and then confirmed by ANOVA are drawn in the bar graphs in the following:

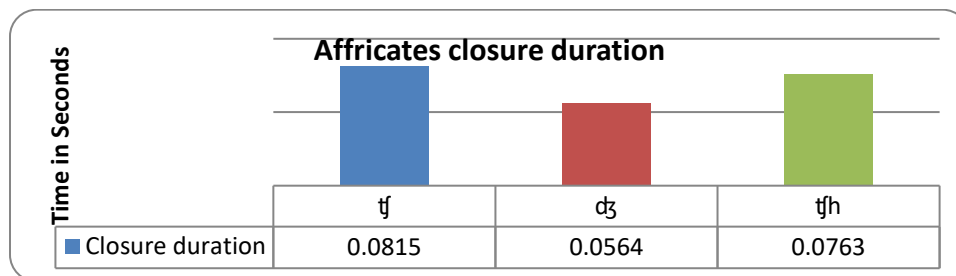


Figure 3: Hindko affricate sounds in terms of closure duration

The figure 3 shows maximum closure duration for the unaspirated /tʃ/ sound, the aspirated /tʃ^h/ takes less closure time than the unaspirated sound but more than the voiced sound. Thus, /ɟʒ/ has minimum closure than the other affricates. In the following part, affricates were investigated by considering the overall duration.

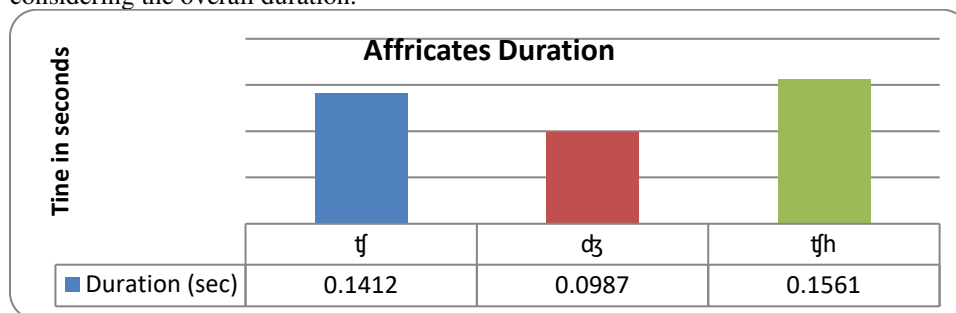


Figure 4: Hindko affricate sounds in terms of duration

The figure 4 displays overall duration of Hindko affricates. The aspirated sound carries a longer duration than the unaspirated sound. However, the unaspirated voiced sound shows the shortest duration.

6. Discussion

The articulatory analysis shows that Tanoli Hindko has three affricates, unaspirated palatal /tʃ/, its counterpart the voiced /dʒ/ and the aspirated /tʃʰ/ sound. All the segments can freely make a contrast of phonemes, contrasting in voicing and distribution at three possible positions with different lexical items. Awan (2004) identified four affricate sounds, /tʃ/, /tʃʰ/, /tʃʰ/ and /dʒ/.

However, the present study investigates that the /tʃʰ/ is not a sound in Hindko because it does not represent a variant of the sound and the vowels following the above mentioned consonant carry a low tone which makes it a different word. Like the present study, Haroon ur Rashid (2015) also identified three affricates in Abbottabad Hindko.

Many local languages of subcontinent allow three affricate sounds including Urdu, the national language of Pakistan, and these sounds freely occur at three positions of a word. In case of English, there are two affricate sounds unaspirated and voiced and both sounds can occur word initially, medially and finally. Davenport and Hannahs (2010) refer to other languages that affricates are found in many languages with different places of articulation. Such as, “German has voiceless labio- dental /pʰ/ in *pferd* ‘horse’ and voiceless alveolar /tʰ/ in *zug* ‘train’; Italian has a voiced alveolar /dz/ in *zona* ‘zone’” (p.27). Reetz and Jongman (2009) denote that /tʰ/ in German freely occurs word initially, medially and finally. They state that IPA has no separate symbols for affricates but combines plosive and fricative and this procedure reduces the number of symbols that have to be remembered.

The acoustic measurement verified the analysis of the articulatory phonetics that /tʃ/ in Tanoli Hindko is an unaspirated sound, /dʒ/ is a voiced and /tʃʰ/ is an aspirated segment. These are articulated from the palatal place of articulation. The results show that Hindko affricates have shorter duration than that of stop and fricative. That silent gap duration for the unaspirated /tʃ/ is 0.0815 (sec) while stop /t/ shows 0.102 (sec), voiced /dʒ/ has 0.0564 (sec) and stop /d/ shows 0.0683 (sec), aspirated /tʃʰ/ has 0.0763 (sec) while stop aspirated /tʰ/ shows 0.0902 (sec). Similarly, Hindko fricative /ʃ/ has 0.115 (sec) frication duration while Hindko affricate noise period duration is 0.0597 (sec) and Hindko has no /ʒ/ fricative, thus, not been given its measurement to match with affricate. Likewise, Hayward (2000) states that the silence period of affricates remains less than stops, and the noise period of affricates takes shorter time than fricatives. He gave an example of English /tʃ/ and /ʃ/ with the duration of (236 ms) and (212ms) respectively which reveal that total duration affricate /tʃ/ is slightly longer than single fricative /ʃ/.

Haroon ur Rashid (2015) analyzed affricates sounds of Hindko spoken in Abbottabad region with more frequency of around 0.020 (sec) than the present study results for each case like the closure duration for /tʃ/, 0.101 (sec.), for /dʒ/, 0.093 (sec.) and /tʃʰ/ 0.113 (sec.), and frication duration for /tʃ/, 0.076 (sec.), for /dʒ/, 0.063 (ms) and /tʃʰ/ 0.093 (ms). It seems that the boundary of the sounds have been marked more flexibly; thus, the results show higher frequency than the generally

described length. Overall, it can be concluded that the affricates silent gap period take less time than stops. Similarly, noise part of affricates is shorter than fricatives.

7. Conclusion

The results show that Hindko affricate sounds are the by-product of fricative sound preceded by stop sound which reveal the mixture of acoustic cues that are the part of two sounds, stops and fricatives. The stop cue of silent gap and fricative cue of noise frication measurements depict that in the combined form, Hindko affricates take less utterance time than the individual sound. The findings show that the voiceless sounds have longer duration than the voiced sound. Generally, the findings about affricates verify the previous view that individual stop and fricative sounds have longer duration than affricates.

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