Laryngeal Tonal characteristics of Punjabi- An Experimental Study

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Abstract:
This paper is an attempt towards an experimental study of tonal aspects of laryngeal phoneme [ਹ] /h/ in Punjabi. Punjabi belongs to the Indo-Aryan language family but because of its tonal features it is different from other languages of the family. Every tonal aspect of [ਹ] /h/, including most exceptions, has been experimentally examined. Words containing [ਹ] /h/ in various positions have been recorded by native Punjabi (Malwai dialect) speakers. This data has been analyzed using speech analysis tools. Orthographically, [ਹ] /h/ is used in all word positions i.e. initial, medial & final but is tonal in some cases. It has been pointed out in the literature on Punjabi linguistics Harkirat Singh (1991), Dr. Atam Singh (1993); it is pronounced at initial position but is tonal at medial and final position. Phonetically it is represented by a high rising tone /ó / or low rising tone /o̗ / on top of the accompanying vowel. Also, the pronunciation of [ਹ੍] i.e. half /h/ is so weak that it is perceived as a tone which has also been experimentally verified. This analysis will aid the future speech researchers in building the Punjabi speech systems and speech data.

Keywords:
Punjabi, Tone, Pitch, Fundamental Frequency F_0, Phonology, Indo-Aryan, Indo-European, Asian languages, Laryngeal Phoneme

1. Introduction

1.1 What is Tone

Tone is the use of pitch in a language to distinguish the lexical or grammatical meaning. All verbal languages use pitch to express emotional and other paralinguistic information and to convey emphasis, contrast, and other such features resulting in intonation. However only some languages use tones to distinguish words or their inflections, analogous to consonants and vowels. Many languages in the Indo-European family exhibit tones such as Scandinavian languages (Swedish, Norwegian, Danish), the Yugo-Slavic languages (Slavic, Serbo-Croate), Ancient Greek and Lithuanian. From the diachronic point of view, the tones develop either from a syllabic contraction (as in Scandinavian languages) or from the loss of older laryngeals (as in Lithuanian and Slavic), [Haudricourt A.G., 1971]. A detailed linguistic study of tonal features of Indo-Aryan and Indo-European languages is presented in Fromkin (1978). Chinese has four contrastive tones high level (o□), high rising (ó), low-dipping (o□) and high-falling (ò). Thai has five contrastive tones, mid (o□), low (ò), falling (o□), high (ó) and rising (o□). Yoruba languages have three tones: high (ó), mid (o□), and low (ò).

1.2 Occurrence of tone in Indo-Aryan languages

The occurrence of tonal features in Indo-Aryan languages is prominent in a few languages such as Punjabi and Dogri. Punjabi has three phonemically distinct tones i.e. high-tone /Ó/, low-tone /Ò/ and mid-tone /o□/ [Gill & Gleason, 1969]. It is spoken by about 105 million people mainly in West Punjab in Pakistan and in East Punjab in India. It has descended from the Shauraseni language of medieval northern India and became a distinct language during the 11th century. It was declared as one of the official languages of India in October 1962 and it is the first official language in East Punjab. In India, Punjabi is written with the Gurumukhi (ਗੁਰਮੁਖੀ) script in India, while in Pakistan it uses Perso-Arabic script i.e. Shahmukhi (شاہ مکھی). Punjabi is the second most widely-spoken language in Pakistan but has no official status.

2. Objective

In available Punjabi literature, we find that [ਹ] /h/ is orthographically present at all the three positions in a word and [ਹ੍] i.e. half /h/, only at medial and final position. Through this paper, we have tried to experimentally verify the tonal rules associated with /h/ and half /h/ using PRAAT and MATLAB to corroborate with the literature survey.

3. Tonal Features of Punjabi

3.1 Literature Survey

In Punjabi language the tone has developed from the consonantal mutation i.e., from the loss of a series of initial consonants which merged with another series, [Haudricourt A.G, 1971]. The details are elucidated by A Singh (1993) also as under:

ਘੋੜਾ /kòra/ Horse , ਕੋੜਾ /ko□ra / Whip , ਕੋਹੜਾ /kóra/ Leper

Tone is observed only on one syllable and may co-occur with stress on it. The frequency of vibration of the vocal cords determines the type of tone produced. If the vowel (ਇ /I/, ਉ /U/, ਅ /ə/) occurs in the first syllable, tone gets extended to the second syllable. Although one word has one tone only but

phonetically its effect is observed across syllables. [Singh Joginder 2010] highlights that not more than one tone can occur in a single Punjabi word. Tone is reflected on stressed vowels and restriction in vocal cord is felt while pronouncing low tone words. There are five consonants in Punjabi which are inherently tonal i.e. ਭ /bʰ /, ਧ /dʰ /, ਢ /ɖʰ /, ਘ /gʰ/ and ਝ /ɖʒʰ /. In a paper on 'An exploratory Analysis of Punjabi Tones in relation to orthographic characters', these tonal characters have been studied [Lata Swaran, 2011].

4. Laryngeal characteristics of Punjabi

4.1 Literature survey:

[Bailey 1914], stated that The tone resulting from the middle [ਹ] /h/ occurs at the last syllable and in some cases it occurs on previous syllable and it sounds combination of velar & glottal.

[Tisdall 1953], diagnosed that 'ਕਿਹਾ /keha/, ਰਿਹਾ /reha/' the pronunciation of [ਹ] /h/ is very week and is not heard like an independent character. In essence it is heard as 'ਕਿਆ, ਰਿਆ'. In some cases i.e. 'ਵਿਹਲਾ /vehƏla/, ਬਿਹਲਾ /behƏla/' it produces elongation effect on the pronunciation of previous character and is heard as 'ਵੇਅਲਾ /veƏla/, ਬੇਅਲਾ /beƏla/'.

Sandhu (1968), studied the evolution of 3 types of tones in Punjabi in the context of *udatt* (high tone), *anudatt* (low tone) & *swaritt* (level tone), the 3 accents in Vedic Sanskrit. The aspiration effect of /h/ was separated during Middle Indo-Aryan period in Pali, Prakrit & Apbhransh which got developed into the tones system in Punjabi. He also investigated in [1986] the tone contour pattern of Punjabi and established that the syllables involving these contour patterns indicate contrasting modulation and play a functional role in the word occurrence.

[Singh H. 1991], stated words with [ਹ] /h/ in the end, [ਹ] /h/ is not pronounced as a full consonant but is pronounced with a breathy force. Similarly in medial position [ਹ] /h/ is pronounced with tonal feature which is reported as a high tone. [Gill H.S. & Gleason, 1969], Gill deeply analyzed place of articulation & manner of articulation in the context of tones and concluded that tone system in Punjabi language is well developed & established.

[Joshi 1987], established through research studies that the vibrations of the vocal cord result in change of pitch and this change of pitch is used to distinguish words. The change of tone results in distinctive word formation.

4.2 Rules associated with tonal features of [ਹ] /h/ based on literature survey

Orthographically [ਹ] /h/ is used in all word positions i.e. initial, medial & final but is tonal in some cases. [ਹ] /h/ is always pronounced at initial position and it is tonal at medial and final position. Phonetically it is represented by a high rising tone /ó/ or low rising tone /ò/ on top of the accompanying vowel.

4.2.1 General Tonal characteristics of [ਹ] /h/

The [ਹ] /h/ occurring in the end of words is not pronounced however the pronunciation ends with breathy force. Eg:

ਪੀਹ /pí/ Grind

This indicates the occurrence of tone. Other examples are:

ਚਾਹ /tʃ á/ Tea ; ਬਹਿ /bé/ Sit ; ਟੋਹ /ʈ ó/ Probe

Similarly the [ਹ] /h/ occurring in the medial position also leads to a tone. Eg:

ਸਹਿਜ /s□́dʒ/ Slowness ; ਇਹਨਾਂ /énã̃/ These

4.2.2 General Tonal characteristics of [ਹ੍] i.e. half /h/

[ਹ੍] i.e. half /h/ is a consonant without vowel and is usually spoken with a consonant making it a conjunct sound. The pronunciation of [ਹ੍] i.e. half /h/ in medial and final position is so weak that it is perceived as a tone. The [ਹ੍] i.e. half /h/ is represented in the conjunct form when used in words. Tone associated with [ਹ੍] i.e. half /h/ also resulting in phonemically different words such as:

ਸੰਨ /sə̃n/ Year , ਸੰਨ੍ਹ /sə̃nə́/ Intrude/Invade

4.3 Nature of tones:

1. Words ending with full [ਹ] /h/ or [ਹ੍] i.e. half /h/ has high tone. Eg ਰਹਿ /ré/ 'to stay' ; ਪੜ੍ਹ /pə□ə́/ 'to study'
2. Words with [ਹ੍] i.e. half /h/ in the middle can bear low or high tone depending on the associated syllable with which it is pronounced. Eg

   High tone - ਪੜ੍ਹਿਆ /pə́ɖ ea/ 'Read /Studied'

   Low tone – ਪੜ੍ਹਾਉਣਾ /pəɖ àUɳ a / 'to teach'

5. Similar Experimental Work

5.1 International work

Glottal consonants are known for influencing F_0, both synchronically [DiCanio, 2009; Garrellek and Keating, 2011;

Mazaudon and Michaud, 2008; Silverman, 1997b; Lee, 2008; Watkins, 2002], and diachronically via processes of tonogenesis and tonal mutation [Dürr, 1987; Haudricourt, 1954; Hombert, 1979; Kingston, 2005; Mazaudon and Michaud, 2008; Svantesson and House, 2006; Thurgood, 2002]. Within the literature on tonogenesis, languages with glottal consonants evolve into systems with contrastive tone. The testing method for plotting F_0 (fundamental frequency) defined by Aniruddh D. Patel, Yi Xu, and Bei Wang, (2010) "The role of F_0 variation in the intelligibility of Mandarin sentences" examined the intelligibility of Mandarin sentences with natural vs. flat- F_0 contours.

5.2 National work

According to Singh (2001), Punjabi has a lexically significant contrastive pitch accent (tone) which it makes use of to distinguish words which otherwise have identical phonetic form. The use of pitch by Punjabi to differentiate the meaning of various lexical items, i.e. words, establishes it as a tone language beyond any doubt. The author has studied the prosodic features in Paninian linguistics and has evolved the Moraic-Model for representing the prosodic features. Especially study on tones in Punjabi has been carried out in which he has identified presence of three tones in Punjabi. He has also defined rules with respect to various types of tone occurring in Punjabi words. About tonal [ਹ] /h/ he has proposed a rule which says that high tone in Punjabi is generated in the leftward nucleus of the segment in the following syllable, which reveals the occurrence of [ਹ] /h/ sound in the onset. Eg:

ਲੋਹਾ /lóa / Iron ; ਚੂਹਾ /tʃ úa/ Mouse

6. Methodology

Sample data of recorded words containing [ਹ] /h/ will be used for this experimental analysis. Annotation of the data will be based on auditory perception. Scientific tools will be used to analyze the data and tonal behavior will be reported using observation method.

6.1 Collection of data

A list of most frequently used words having [ਹ] /h/ at all three positions i.e. initial, medial and final and [ਹ੍] i.e. half /h/ at middle and final position has been compiled (Annexure I & II). Phonetically rich words were selected to ensure the coverage of major phonetic nuances related to [ਹ] /h/. The word lists were prepared using available published dictionary from authentic sources such as Punjabi-English Dictionary, Punjabi University [2011].

6.2 Informants

The informants were selected from region of Punjab i.e. Patiala where Malwai dialect is spoken. The numbers of informants used for the speech data for the present analysis are male between 25-30 age groups. The orthographic representations of words involving /h/ consonant in initial, medial & final position and half /h/ in medial and final position are recorded by these informants. Punjabi native speakers were selected and the sample size taken was five in each category.

6.3 Recording specification

For the recording of the Punjabi speech data, standardized procedure for speech corpora development based on the ITU recommendations has been adopted. The recording of the annexed word list has been done in standard recording environment having SNR>=45dB. The recording format is 16 bit, PCM, Mono and sampling rate is 48 KHz and the speech rate is medium with neutral emotion. Each word was recorded thrice and the middle sample was selected for analysis for capturing the exact pronunciation.

6.4 Speech analysis Tools

Two speech analysis tools were used to corroborate the analyzed results against the findings orthographically reported as per above literature survey.

6.4.1 PRAAT

The annotation of the recorded speech data has been carried out using the PRAAT software package since it is a very flexible tool to do speech analysis.

6.4.2 MATLAB

It stands for MATrix LABoratory. It is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. The basic of the Matlab programming language is introduced in the form of time & frequency domain characterizations of speech signals.

7. Analysis

7.1 PRAAT

The annotation of the recorded speech data has been carried out using the PRAAT software package. The spectrographic analysis of the samples was carried out and phoneme level annotation was done. The PRAAT tool has also been used for analysis of the F_0 contour and the slope of the contour over the pitch area of the vowel accompanying that syllable. The ESPS (epochs program) was used to mark every vocal cycle in the sentences. This signal processing software has been used for the F_0 analysis.

7.2 MATLAB

Fundamental Frequency (F_0) contour algorithm was used and a program was developed to Plot F_0 graphs of wave files recorded through the informants.

The sample graphs are:

High Tone - ਬਾਂਹ /bə̀/ (Arm)

Praat

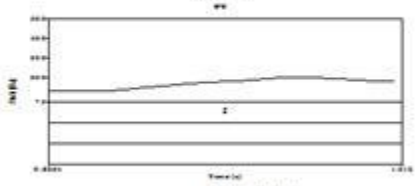

Fig: 1 (a)

Matlab

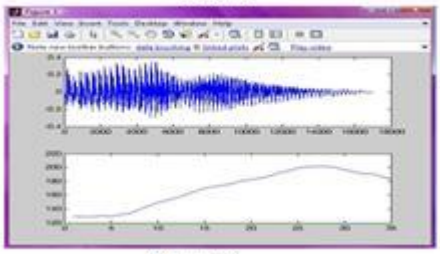

Fig: 1 (b)

No Tone - ਹੁਲਾਰਾ /hUlara/ (Fun & frolic)

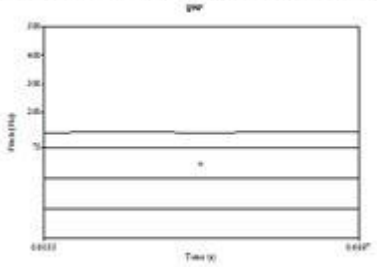

Fig: 2 (a)

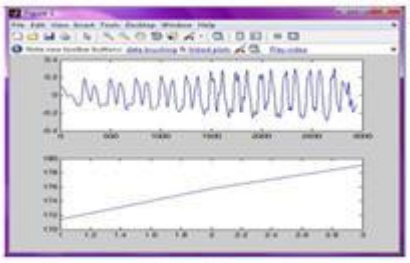

Fig: 2 (b)

High Tone - ਸਹਿਜ /sə́dʒ/ (Slowness)

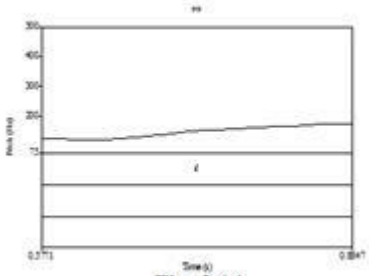

Fig: 3 (a)

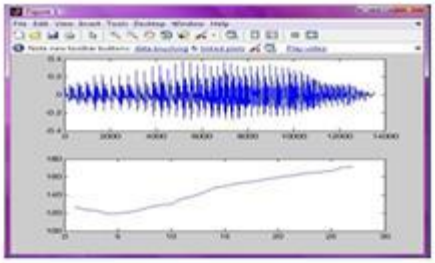

Fig: 3 (b)

Low Tone - ਢੋਹ /ʈò/ (Back-Rest)

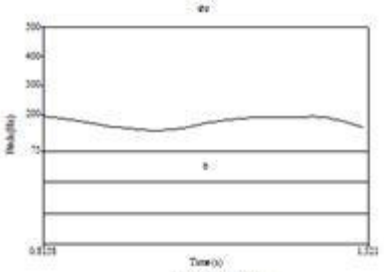

Fig: 4 (a)

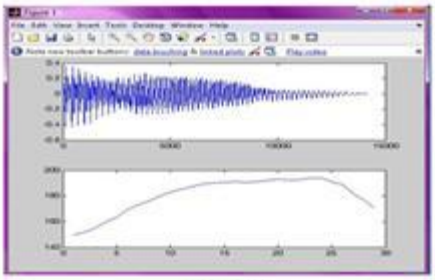

Fig: 4 (b)

High Tone - ਕਾਨ੍ਹਾ /kaná/ (Lord Krishna)

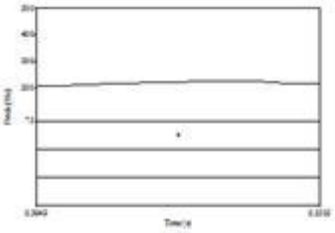

Fig: 5 (a)

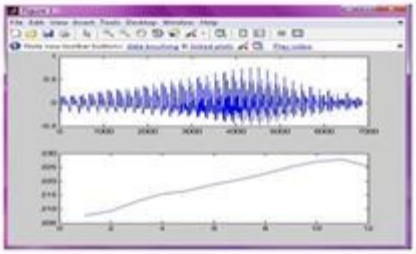

Fig: 5 (b)

High Tone - ਗਿਲ੍ਹਟੀ /gĺɔʈi/ (Hard swollen gland)

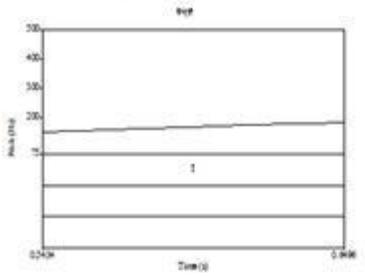

Fig: 6 (a)

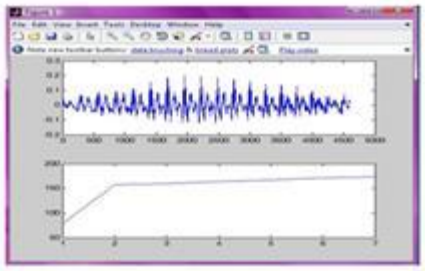

Fig: 6 (b)

Tone extend to next syllable - ਇਹਨਾਂ /énà/ (These)

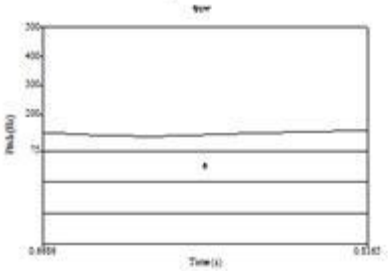

Fig: 7 (a)

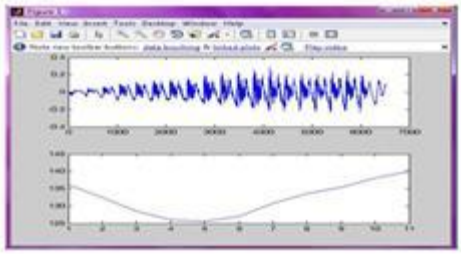

Fig: 7 (b)

Low tone – ਪੜ੍ਹਾਉਣਾ /pəɖàUɳa/ (to teach)

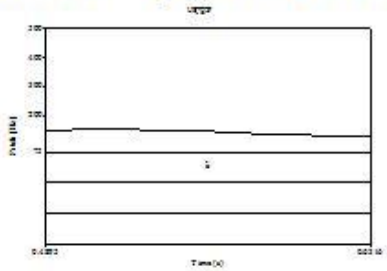

Fig 8 (a)

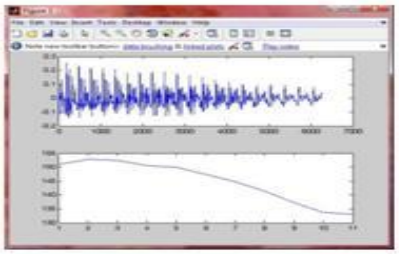

Fig 8 (b)

Mean average value of F_0 of the above sample graphs:
Fig 1 (a) - 199.8 hz ; Fig 3 (a) - 171.3 hz
Fig 4 (a) - 148.1 hz ; Fig 5 (a) - 186.6 hz
Fig 6 (a) - 141.4 hz ; Fig 7 (a) - 141.6 hz
Fig 8 (a) - 128.8 hz

7.3 Tone Analysis

The F_0 plots were observed for change in pitch contours at the syllable level as well as its extended effect on the adjoining syllables. Tone patterns as observed from the F_0 plots generated through PRAAT and MATLAB for the entire word-list were observed to study the pattern of tones. The data was examined to check whether the tone occurs at the word level or syllable level. The tone was observed at the syllable level. It was noted that words with initial [ਹ] /h/ do not contain any tone. [ਹ] /h/ is always tonal in the final position and is tonal in medial position in some cases, which is determined by the preceding and succeeding sounds. The non tonal example words are listed in Annexure II. A special phenomenon was observed in case of words starting with a vowel and [ਹ] /h/ in the middle position. The words with [ਹ੍] i.e. half /h/ bear rising tone in most of the cases. The tone on the medial [ਹ੍] i.e. half /h/ is observed sometimes on preceding vowel and sometimes on succeeding vowel.

8. Conclusion

In the present analysis, we have observed the following with respect to the sound [ਹ] /h/:

(1) The occurrence of tone has been found at the syllable level only.
(2) [ਹ] /h/ in the initial position has no tone.
(3) [ਹ] /h/ in the middle position exhibits occasional rising tone.
(4) In the words containing ਹ /h/ in the middle with one of these vowels ਇ /I/, ਉ /U/, ਅ /ə/ in the initial syllable position, tone is extended to the next syllable as well as observed in figure 7 (b).

(5) [ਹ] /h/ generally exhibits rising tone word-finally, when preceded by a tonal consonant it is marked for a low tone as observed in figure 4.

(6) Words ending with [ਹ੍] i.e. half /h/ have high tone (HT).

(7) Words with [ਹ੍] i.e. half /h/ in the middle reflect high tone when [ਹ] /h/ is pronounced in conjunction with the consonant forming the conjunct such as ਬੰਨ੍ਹਿਆ /bə̃nə́Ia/ (to tie), whereas in words having a long vowel following the conjunct character containing [ਹ੍] half /h/ as in ਬੰਨ੍ਹਾਇਆ /bə̃nàIa/ (to get it tied), tend to exhibit low tone (LT) as the stress shifts or gets divided due to the presence of a long vowel.

(8) It was found that the mean average value of F_0 (in hz) of full /h/ is greater than half /h/ through experimental verification across samples. The mean values are:

Full H		Half H		
Medial HT	Final HT	Medial HT	LT	Final HT
171.3	199.8	141.4	128.8 h	186.6

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ANNEXURE I

List of analyzed words

S.No.	Words h	IPA transcription
1	ਹਸਬ	/həsəb/
2	ਹਿਸਾਬ	/hIsab/
3	ਹਿਕਾਇਤੀ	/hIkaIti/
4	ਹਿਮਾਚਲ	/hImatʃI/
5	ਹੁਲਾਰਾ	/hUlara/
6	ਐਹਰ	/ɔɾ/
7	ਅਹਿਦ	/ɔd/
8	ਇਹਨਾਂ	/ɛnə̃/
9	ਕੁਹਣੀ	/kʊɳi/
10	ਸਹਿਜ	/sɛdʒ/
11	ਅਹਾਰ	/əɦar/
12	ਅਹਿੰਸਕ	/əɦĨsək/
13	ਇਸਤਿਹਾਰ	/Iʃtɛɦar/
14	ਇਹਾਤਾ	/Iɦata/
15	ਸ਼ਹੀਦ	/ʃəɦid/

ANNEXURE I - Contd

S.No.	Words h	IPA transcription
16	ਸਹਿ	/sɛ/
17	ਸ਼ਹਿ	/ʃɛ/
18	ਖੁਹ	/kʰʊ/
19	ਗਾਹ	/gà/
20	ਚਾਹ	/tʃà/
21	ਸੰਨ੍ਹ	/sə̃nɔ́/
22	ਸਾਨ੍ਹ	/sanɔ́/
23	ਕਾਨ੍ਹ	/kanɔ́/
24	ਕੰਨ੍ਹ	/kə̃nɔ́/
25	ਗੜ੍ਹ	/gəɖɔ́/
26	ਖੇਲ੍ਹਰ	/kʰəlɔ́ɾ/
27	ਖੜ੍ਹਾਉਣਾ	/kʰəɖɔ́aUɳa/
28	ਚੜ੍ਹਦਾ	/tʃɖɔ́da/
29	ਗਿਲ੍ਹੜਾ	/gilɔ́ɖa/
30	ਖਲ੍ਹੀਰ	/kʰəlɔ́ir/

ANNEXURE II

Non-Tonal Words with medial ਹ /H/

S.No.	Medial	IPA transcription
1.	ਅਹਾਰ	/əɦar/
2.	ਅਹਿੰਸਕ	/əɦĨsək/
3.	ਇਸਤਿਹਾਰ	/Iʃtɛɦar/
4.	ਇਹਾਤਾ	/Iɦata/
5.	ਸ਼ਹੀਦ	/ʃəɦid/