



## Acoustic Characteristics of Schwa Vowel in Punjabi

Swaran Lata<sup>1</sup>, Prashant Verma<sup>2</sup>, Simerjeet Kaur<sup>3</sup>

<sup>1</sup>JNU, New Delhi, India

<sup>2</sup>WSI, New Delhi, India

<sup>3</sup>WSI, New Delhi, India

slata@deity.gov.in, vermaprashant1@gmail.com, simer.uni@gmail.com

### Abstract

The research area of phonological study of Schwa /ə/ in Punjabi is a need of linguistic survey of Punjabi language. Punjabi is tonal language in which schwa occurs in only word-initial and word-medial. Word-initial schwa is found in frequent use. The word-medial schwa is generally used functionally to break the consonant clusters and is not represented orthographically. It also acts as tone bearing unit (TBU) in many tonal words. It may be nasalized also. Consonantal release vowel Schwa is observed in isolated words with closed-syllable ending. Thus schwa may have different acoustic properties in these contexts.

The study of first two formants also helps in measuring the acoustic properties of vowels, thus the spectrographic study of schwa needs to be carried out for which the F1 variations and acoustic space in terms of F1 & F2 will be examined by recording speech data of 10 native Punjabi speakers. The investigation of said work is based on the words containing schwa in different positions and phonetic coverage of various contexts. The co-articulation effects on variability of schwa will be reported.

**Index terms:** Tonemes, Punjabi, Schwa /ə/, Indo-Aryan, Pitch, Fundamental Frequencies, Formants(F1 & F2), Tone Bearing Unit (TBU), ITU, Speech, TTS, Acoustics, Prosody, Length, Geminated, Release vowel, Burst Energy, Cardinal vowel chart.

### 1. Introduction

In linguistics, particularly phonetics and phonology, schwa is the mid-central vowel sound amidst the vowel chart, signified by the IPA sound /ə/. It was first utilized in English texts between 1890 and 1895. The schwa has been the subject of much research by phonologists yet substantially less consideration has been dedicated to study of the phonetic attributes of schwa vowel. Punjabi is a tonal language wherein schwa is a short neutral vowel sound, and like every single other vowel, its exact quality changes depending upon the adjacent consonants. In Punjabi, schwa also occurs in geminated words i.e long or doubled consonants occur frequently in Punjabi Lexicon. Schwa is not represented orthographically in word-medial position however it is phonetically realized. In some words, it also acts as tone bearing unit(TBU) or is nasalized and at other times, it is also required to break a consonant cluster. A kind of consonantal release at the end of the words ending in closed syllable is observed which is schwa vowel and is termed as release vowel(RV).

The cardinal vowels of Punjabi as given below describe schwa as a mid-central vowel. On the basis of part of the

tongue used in the process of articulation, vowels are classified as front vowels, central vowels and back vowels. On the basis of height of the tongue in the articulation of vowels, the vowels have been classified as high and low vowels. The long vowels are considered as tense vowel & short vowels as lax. /ə/ being short vowel is a lax vow.

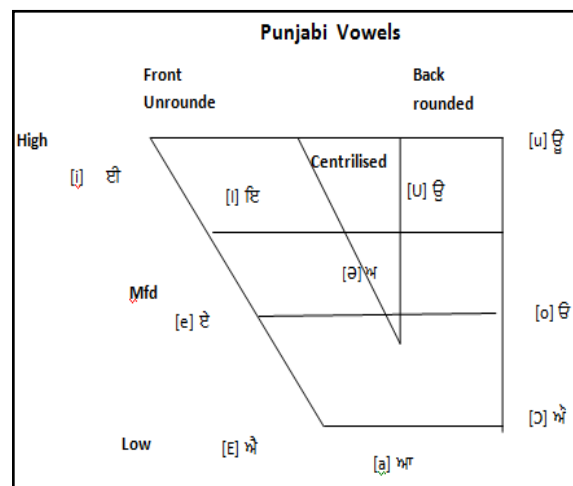


Figure 1: Cardinal vowel chart

The following examples corroborate the above:

(i) Word-initial schwa or inherent schwa in a consonant cluster(CC) and schwa as a tone bearing unit:

eq: : ਅਸਾਨ(/əsan/(V.CVC)), ਕਸਕ (/kəsək/(CV.CVC)), ਸੜਕ (/səɾək/(CV.CVC))

(ii) Schwa with nasalization

e.g. ਰੰਭਣਾ(/rəbəṇa/(CV.CV.CV)), ਬਸੰਤ(/bəṣəṭ/(CV.CVC))

(iii) Schwa associated with geminated consonant as onset

e.g. ਭਿੰਜਣਾ (/pidʒdʒəṇa/(CV.CCV.CV)), ਬੁੱਝਣਾ(/budʒdʒəṇa/(CV.CCV.CV))

(iv) Schwa as Release vowel: Schwa doesn't occur in word-final position (Panday Pramod [2014]) however it is observed as consonantal release in words ending with closed syllable

e.g. ਝਾਂਜਰ (/tʃʌdʒərə/(CV.CVC.V(release vowel))), ਗੁਆਂਢਣ (/ɡʊɑ̃dʒəṇə/(CV.CVC.V(release vowel))), ਢੱਕਣ (/ʈəkʌṇə/(CV.CVC.V(release vowel)))

## 2. Objective

The aim of this paper is to interpret the quality of “Schwa” vowel through phonetic investigations based on word analysis. The contextual variation of phonetic occurrence of schwa in the different phonological settings as explained above is to be examined. The ten speakers from Malwai region will be used as informants. The variations in quality of schwa as observed from first formant, acoustic space and Release burst energy in various contexts will be reported.

## 3. Methodology

The list of phonetically balanced words was collated for this experimental analysis. Phoneme level annotation of the data was done based on auditory perception. Data was tabulated and presented. Analysis of vowel quality was carried out.

### 3.1 Collection of data

The word lists were prepared using available published dictionary from authentic sources such as Punjabi-English Dictionary, Punjabi University [2011]. The word selection was done based on the criteria of occurrence of /ə/ as discussed in the section 1.

### 3.2 Informants

The informants were selected from region of Punjab where Malwai dialect is spoken. The numbers of informants used are 4 male and 6 female between 25-40 age groups. Each informant recorded the entire set of words thrice.

### 3.3 Recording specification

For the recording of the Punjabi speech data, standardized procedure for speech corpora development based on the ITU (International Telecommunication Union) recommendations has been adopted. The recording of the 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.

### 3.4 Speech analysis Tool- PRAAT

The annotation of the recorded speech data has been carried out using the PRAAT software since it is a very flexible tool to do speech analysis. The middle sample was selected for analysis for capturing the exact pronunciation. The spectrographic analysis of all the male & female samples was carried out and phoneme level annotation was done. First two formants (F1 & F2), Intensity & duration of the vowel were recorded for each word by using PRAAT software.

## 4. Analysis

### 4.1 Variation in Schwa Quality in Indo-European languages

Den Siliverman [2009], discussed the origins of schwa and variation in its phonetic properties based on co-articulatory influence of flanking consonants. He has concluded.

- Schwa is short in duration and seems to have a mid-centralizing-tendency.
- Phonologically it is a featureless vowel; however it is a candidate for epenthesis.
- Some schwas may have their origins in the audible release of a consonant when this consonant is followed by another consonant.
- Release into schwa phenomena has been explained in which C1 may be released into a light vowel before the C2 construction is fully achieve

According to [Flemming , 2007], F2 varies more than F1 probably due to the fact that associated consonants necessarily involve a mouth closing/ jaw raising gesturing thus lowering F1

### 4.2 Acoustic parameters

The paper attempts the following parameters to describe the schwa quality:

- **Formants F1, F2**
- **Acoustic space in terms of F1 and F2**
- **Burst Energy(BE)**

The acoustic space is calculated in order to determine the tongue position involved in articulation. The few examples of different categories with F1 , F2-F1 and burst energy values have been recorded. The highlighted schwa in the below tables are consider for analysis. Burst energy i.e. (Intensity \* Duration) of schwa vowel was recorded to determine the quality of a vowel viz lax/tense.

- (i) **Schwa as a pure vowel or inherent in a consonant cluster(CC) and schwa as a tone bearing unit**

Table 1: Schwa : pure vowel or inherent

Words	F1	F2-F1	Burst Energy
ਹਸਬ /həsəb/	669.50	836.00	7.62
ਹਸਬ /həsəb/	606.10	900.60	9.18
ਕਸਕ /kəsək/	594.25	786.50	7.58
ਕਸਕ /kəsək/	590.75	815.70	8.29
ਸਰਬ /sərab/	626.10	939.10	9.04

ਸਰਬ /səɾəb/	599.50	969.70	8.27
ਸੜਕ /səɾək/	614.00	995.90	9.06
ਸੜਕ /səɾək/	610.50	1074.30	6.22
ਸ਼ਗਨ /ʃəɡən/	573.40	1111.60	8.39
ਸ਼ਗਨ /ʃəɡən/	577.70	1062.40	8.37
ਸੰਕਟ /səkət/	582.20	1051.00	7.75
ਬਸੰਤ /bəɪsət/	492.50	1034.90	6.21
ਅਸਾਨ/əsən/	625.10	901.30	6.61
ਅਮੀਰ /əmīr/	634.22	780.00	7.55
ਅਫੀਮ /əpʰim/	649.33	591.50	7.49
ਅਣਖ /əŋəkʰ/	711.22	815.56	4.76
ਅਭਿਆਸ /əbīas/	637.00	669.90	6.08
ਅਕਾਲ /əkāl/	660.00	824.00	6.17
ਅਨੰਦ /ənəd/	665.10	893.80	3.89
ਅਝੱਕ /ətʃəkʰk/	603.80	1097.50	10.42
ਅਝੱਕ /ətʃəkʰk/	751.80	927.00	9.32
ਦੁਰ ਲੱਭ/durɪəbb/	814.30	657.89	9.66
ਦੱਕਣ /təkʰən/	683.30	982.50	4.82
ਝੱਗ /tʃəgg/	<b>748.10</b>	<b>938.40</b>	<b>12.08</b>
ਲੱਭਣਾ /ləbbəŋa/	655.30	845.40	4.20
ਬੱਘੀ /bəggī/	584.20	873.67	4.87
ਅੱਗੇ /əgge/	620.80	927.10	7.44
ਖੱਲੂਖਾਰਾ/kəllukəra/	654.60	906.40	5.05
ਖੱਸਾ/ kəssa /	592	970	5.37
<b>Average</b>	<b>637.93</b>	<b>899.84</b>	<b>7.30</b>

Based on the above data the range of F1 lies between approx 500-800 and F2-F1 between 600-1100.

(ii) Nasalised schwa

Table 2: Schwa : Nasalised

Words	F1	F2-F1	Burst Energy
ਅਨੰਦ/ənəd/	541.30	956.90	17.59
ਬਸੰਤ/ bəsət/	560.80	945.10	16.91
ਸੰਕਟ/ səkət/	523.10	904.10	11.76
ਅੰਗੂਰ/ əgur/	499.78	774.63	11.85
ਧੰਦਾ/ t̪əda/	476.50	1080.70	15.15
ਧੰਨ/ t̪ən/	819.10	731.50	11.45
ਸੰਢਣਾ/ s̪əḍəŋa/	522.00	1131.70	11.76
ਕੰਧੂਈ /kəḍuī/	453.67	1003.10	8.99
ਗੰਧਲਾ/ g̃əḍəla/	475.80	1140.10	11.07

ਬੰਧੂਆ /b̃əḍuā/	471.33	888.00	10.44
ਰੰਭਣਾ /r̃əb̃əŋa/	585.10	947.10	12.45
ਅੰਧੇਰਾ /əḍəra/	491.40	1103.50	8.93
<b>Average</b>	<b>534.99</b>	<b>967.20</b>	<b>12.36</b>

Based on the above data the range of F1 lies between approx 450-650 and F2-F1 between 700-1100.

(iii) Schwa associated with geminated consonant as onset

Table 3: Schwa : geminated consonant

Words	F1	F2-F1	Burst Energy
ਬੁੱਝਣਾ /b̃od̃ɜḍəŋa/	510.90	1351.00	5.61
ਰਿੱਝਣਾ /r̃id̃ɜḍəŋa/	504.70	1396.90	5.48
ਤਿੱਜਣਾ /p̃id̃ɜḍəŋa/	493.10	1434.30	6.15
ਲੱਭਣਾ /ləbb̃əŋa/	564	934	5.03
ਇੱਧਰ /idd̃ər/	624.40	1104.60	9.45
<b>Average</b>	<b>539.42</b>	<b>1244.16</b>	<b>6.34</b>

Based on the above data the range of F1 lies between approx 500-650 and F2-F1 between 900-1450.

(iv) Schwa as Release vowel

Table 4: Schwa: release vowels as highlighted

Words	F1	F2-F1	Burst Energy
ਘਰ /kəɾə/	523.42	1151.99	12.52
ਝੱਗ /tʃəggə/	515.51	1071.14	13.39
ਝੂਠ /tʃuṭʰə/	549.13	969.48	11.84
ਝਾਂਜਰ/tʃɪd̃ɜɾə/	539.99	1142.14	8.17
ਦੱਕਣ/ təkʰənə/	556.94	1049.66	10.33
ਧੰਨ /t̪ənə/	556.42	1042.37	13.21
ਧੜ /t̪əɾə/	554.08	1127.48	13.36
ਅਣਘੜ/ən̪k̪əɾə/	565.48	1129.04	7.94
ਅਝੱਕ /ətʃ̪əkʰkə/	518.20	1021.40	11.78
ਸਾਂਝ /s̪əd̃ɜ/	436.98	1329.87	10.62
ਬੋਝ /b̃od̃ɜ/	451.06	1236.61	12.81
ਡਿੱਘ /ḍ̪iḡə/	564.83	1037.73	12.36
ਤਾਂਘ /t̪əḡə/	517.84	1051.04	11.19
ਪੀਂਘ /p̪iḡə/	490.42	1098.24	10.95

ਊਘ /ʊgə/	597.81	880.13	13.64
ਮਾਘ /màgə/	535.37	1010.25	11.65
ਉਝਬੁਘ /ʊdʒəbʊgə/	471.43	987.69	11.27
<b>Average</b>	526.17	1078.60	11.59

Based on the above data the range of F1 lies between approx 450-650 and F2-F1 between 800-1200.

## 5. Discussion

Based on the above findings, the acoustic space is depicted in the below graph(Fig 2) for various phonological settings.

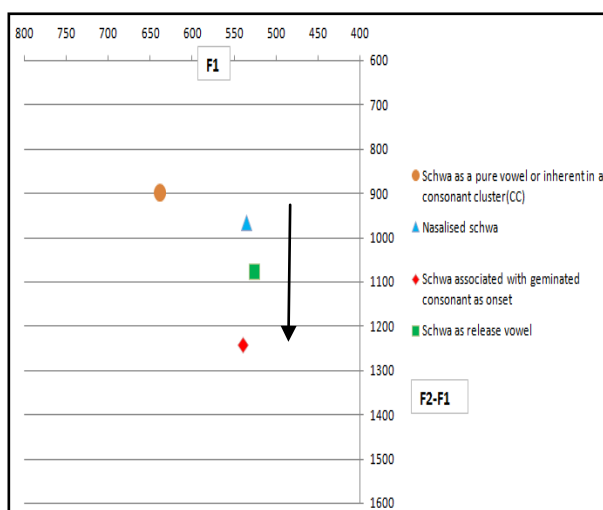


Figure 2: Acoustic space values of schwa

The variations as observed from above data analysis are reported below with reference to pure vowel /ə/ characteristics:

Table 5: Results finding

Sr. No	Categories	Findings
5.1	Schwa as a pure vowel or inherent in a consonant cluster(CC)	Average(F1=637.93, F2-F1=899.84, BE=7.30, Duration=.11) F1 and F2-F1 lie in normal range, schwa being Mid-central
5.2	Nasalised schwa	Average(F1= 534.99, F2-F1=967.20, BE=12.36, Duration=.18) The tongue position goes still higher as F1 reduces further as compared to schwa as at sr. no. 2 as observed in the Fig 1.

5.3	Schwa associated with geminated consonant as onset	Average(F1= 539.42, F2-F1=1244.16, BE=6.34 , Duration-.09) F1 ranges show the tongue height shifted upward and increase in F2-F1 shows that schwa is being articulated with tongue shifting backwards from the mid-position
5.4	Schwa release vowel(RV)	Average(F1= 526.17, F2-F1=1078.60, BE=11.59 , Duration-.17) The F1 value of release vowel is comparable to nasalized schwa. The F2-F1 value corroborated with tongue shifted backwards from central position as in the case of Schwa associated with geminated consonant

The variability in the phonetic realisation of schwa is evident from fig1. The arrow depicting increase in values of F2-F1 indicates the tendency of /ə/ from central to back position due to co-articulation variations. The maximum value of F2-F1 is observed in case of /ə/ associated with geminated consonant as onset, which could be phonetically represented by /ʌ/, which is open-mid near back unrounded vowel e.g. ਭਿੱਜਣਾ/ pìdʒdʒʌṇə/, ਬੁੱਝਣਾ/budʒdʒʌṇə/. According to the table 5, the burst energy of nasalized and release vowel is 60-70% higher, hence these schwas are comparatively tenser though they still would be considered as a short vowel. This vowel /ʌ/ can be considered as reduced /ə/ as is observed from duration parameter.

## 6. Conclusion

In view of the above, the cardinal vowel chart as discussed in section 1 can be represented as:

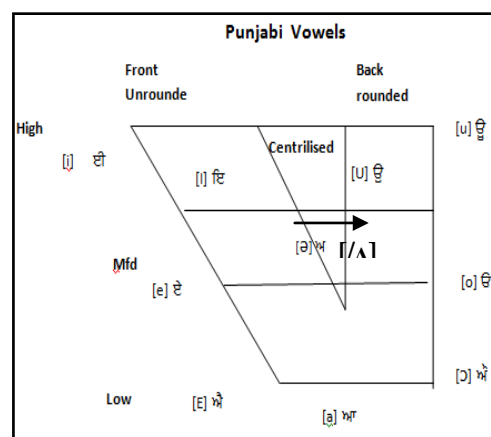


Figure 3: Proposed Cardinal Vowel chart –Punjabi

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