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Acoustic Space in Kashmiri Vowels

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Abstract

The present study "Acoustic space in Kashmiri Vowels" will take into consideration the acoustic space of the vowels in Kashmiri which will mainly focus on the first two formants and duration. As depicted by earlier studies on Kashmiri vowels, duration is considered as important phonemic criteria to distinguish between vowels. Thus, based on the backdrop of these facts, the present study aims to undertake an acoustic study of Kashmiri vowels with a focus on formants and duration

Key Words: Duration, Formants, Phoneme, Vowel, Inventory, Acoustic, nasalization.

Introduction

One of the 22 scheduled languages of India, the Kashmiri language, known as the kəːshur or kəːshir zabaːn by its native speakers, is one with more than 6 million speakers and literature more than 800 years old (Kachru, 1981). A language from the Dardic sub-group (Grierson (1919), Morgenstierne (1961), Fussman (1972)), Kashmiri is spoken primarily in the Kashmir Valley, in Jammu and Kashmir. According to George Abraham Grierson, who compiled the still used *A dictionary of the Kashmiri language*, published from Calcutta: Asiatic Society of Bengal in 1932, 'Kashmiri is a mixed language having as its basis a language of the Dard group of the Dardic family allied to Shina' (Grierson, 1919). Zakharyin (1984) is however, of a different opinion. As cited by Koul (Wali, Koul, 1997:XVIII), Zakharyin

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(1984:43) concludes that Kashmiri belongs to the IA family. He remarks,

> *'The more we learn about the Dardic languages…the more evident it becomes that G.A Grierson might have been wrong to separate Kashmiri from the Indo-Aryan stock and that perhaps J.Block (sic.) (1934) was right in stating that Kashmiri only primordially had been Dardic and later underwent a very heavy Indo A(r)yanization.'*

Vowels of Kashmiri

According to Koul (2005), Kashmiri has peculiar phonetic and phonological characteristics which it does not share with other Indo-Aryan languages. The phonemic inventory of Kashmiri vowels consists of 15 vowels- six high, six mid and three low vowels.

	Front		Central	Back
High	i	i:	ɨ	u
Mid	e	e:	ə	o
Low			a	ɔ

(Koul,2000)

However, there is literature that suggests that the vowel inventory consists of 16 vowels, with an extra long rounded low vowel. For example, *Kashmiri: A Guide into Language and Culture* by Rey Pina, Ciara Rangel and Rahul Chakraborty of the Texas State University cite the presence of 16 vowels in Kashmiri, and gives the following vowel chart:

Vowels	Front Unrounded		Central		Back Rounded	
High	i	i:	ɨ	ɨ:	u	u:
Mid	e	e:	ə	ə:	o	o:
Low			a	a:	ɔ	ɔ:

Figure 1 (http://www.koshur.org/Kashmiri/transcription.html)

Moreover, the 'ɔ: is supported by Kachru (1969) and Handoo (1973) with the only available example in the language being /sɔ:d/, meaning 'one and a quarter' ' (Ganai, 2012). There are however variations of Kashmiri spoken in the region; which have more examples of this vowel being used

in their phonemic inventory. E.g /gɔ:ʃ/ for 'light' and /sɔ:s/ for 'ashes' in Kishtwari, and /gɔ:raj/ for 'will tell you', 'dʒɔ:n/ for 'good' and /gɔ:d/ for 'cowshed' in Poguli are words that use the long /ɔ:/.

Kashmiri vowels have a few peculiar characteristics that other Indo Aryan languages do not have. For example, the central high vowels in Kashmiri have not been found in any IA language so far. Nasalisation, which is phonemic in the language, is possible with all the vowels. Koul (2005) gives us detailed examples of words where each of the Kashmiri vowels has been nasalised. He goes on to talk about the distribution of vowels in the language and says:

> *The vowels /ə/ /o/ /ɔ:/ do not occur in the word final position. The short vowels /ɨ/, /e/, /u/, /ɔ/ do not occur in the word-initial position. Usually the semi-vowel /y/ is added in the initial position of the words beginning with /i/, /i:/, /e/, and /e:/. Similarly, the semi-vowel /v/ is added to the words beginning with /u/, and /u:/.*

There is something else, called the *matra* vowels, which is found in Kashmiri. *Matra* vowels were first talked about by Grierson, and have continued to invite the attention and curiosity of linguists ever since. Bailey (1937) talks about how these vowels are almost inaudible to non-Kashmiri ears. Morgenstierne (1941:69) gives us an explanation for their existence. He says:

> *The matra vowels must have been different vowel phonemes –u, -i and –ü. At that time, present –i and –u were probably long, as is still sometimes the case in poetry. Modern –ü is very rare and –i occurs chiefly in loanwords from Persian. Such words may have been introduced after the shortening of –i and –u.* [Kachru, 1972: 294]

Vowel Space

Early speech perception studies (Delattre, Liberman, Cooper and Gerstman, 1952; Miller, 1953) showed that the frequencies of first three formants were the most important cues to vowel identification. Dispersion theory (DT) claims that speech sounds are selected via constraints that are based on a principle of sufficient perceptual contrast.

In this theory the vowels of a given language are arranged in the acoustic vowel space so as to minimize the potential for perceptual confusion between the distinct vowel categories. Using computer programs to generate the optimal configurations for vowel systems of various sizes, this approach to vowel inventories has proved fairly successful (Liljencrants and Lindblom, 1972; Lindblom, 1975, 1986; Disner, 1984).

Disner, 1983 also talks about the quantum theory of speech (QTS) as an alternative approach to vowel systems. According to this theory, there are certain regions of stability in the phonetic space. In particular, it is claimed that there are stable regions corresponding to the point vowels /i/, /a/, and /u/. Thus this theory predicts that the point vowels should be in approximately the same locations across all languages, regardless of vowel inventory size. Furthermore, this theory predicts that, since the point vowels are in phonetically stable regions, they should show less within-category variability than non-point vowels. (Stevens, 1972, 1989).

Dispersion theory (DT) and the quantum theory of speech (QTS) both propose general universal principles to account for the observed cross-linguistic tendencies regarding vowel inventory size and structure. In contrast to these approaches, the notion of a language-specific base - of- articulation is presented as an account for the observation that similar sounds across two languages can differ due to a consistent, language-specific adjustment of the articulators. This notion has been a part of the traditional phonetic literature over the ages: Disner (1983) cites its origin as the work of John Wallis in 1653.

Various studies have shown how an acoustic vowel space based on the first two formants for vowels with the vertical axis representing the frequency of the first formant (F1) and horizontal axis representing F2 or F2-F1 can provide a graphic representation showing the relationship between vowel position and formant values, (Narang et. al. 2010 on Thai, Parihar, 2009 on Bagri, Misra 2009 on Hindi and Punjabi, and Lohagun, 2013 on Nepali). High vowels such as /i/ and /u/ have a low F1 frequency, but low vowels like /æ/ and /ɑ/ have a high F1

frequency. Therefore, the relative value of F1 is associated with tongue height. The horizontal axis shows the frequency gap between the first two formants (F2-F1). Based on these, front vowels tend to have a relatively high separation between F1 and F2, whereas back vowels tend to have a relatively low F1-F2 separation (Baken & Orlikoff, 2000). Since formant patterns represent articulatory positioning in relation to the rest of the vocal tract, they have been used to not only effectively assess the perceptual degree of speech intelligibility in English speakers but can also provide insights into where the articulatory breakdown is occurring (Kent, Netsell & Abbs, 1979; Ziegler & von Cramon, 1988; Kent et al., 1989; Kent, et al.1992).

The Present Study

The current study looks at the acoustic space of the vowels in Kashmiri in terms of the first two formants and duration (including the long ɔ: and excluding the matra vowels). 'A random sample of 6 male and 6 female subjects was taken for the current study. The subjects were selected from a pool of educated, native speakers of Kashmiri, all P.G. students in Kashmir University. Due to technical reasons, e.g. recording quality and background noise, the data of 4 female and 2 male participants ultimately served as the select sample. Words chosen were such that the vowel phonemes occur in all the positions, i.e. initial, medial and final. The speakers were asked to pronounce each word thrice. Thus there are 864 (3words* 6 speakers* 16 vowels* 3repetitions) samples. 864 words in all were recorded. Out of this sample of 864 words, we selected words having vowel at medial position and only the middle articulation of the three repetitions. This gave us a select sample of 288 words.

Data was recorded in a sound proof room of Jawaharlal Nehru University New Delhi using PRAAT; Goldwave was used for noise reduction, while Wavesurfer was used for spectrograms. The analysis was mostly done using PRAAT. The voice files were converted into WAV file in order to save them for future use.

Data Analysis

Data was tabulated after extracting the vowel duration, F1 (First

formant) and F2 (Second Formant) values of all the vowels. F2-F1 was calculated for plotting on x-axis and F1 was plotted on Y-axis. Negative values were used so that the figures closely approximate the cardinal vowels.

Acoustics Space

Tables 1, 2 and 3 (in the appendix) and Figures 1 and 2 show all the 16 vowels plotted to show how the acoustic space is organized in Kashmiri.

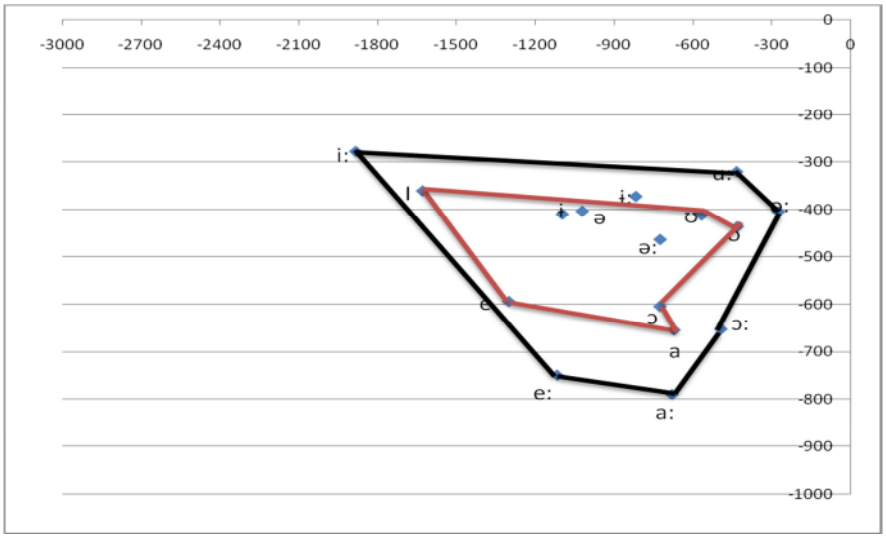

Figure 1: Acoustic Space of Kashmiri Vowels in case of Male Speakers

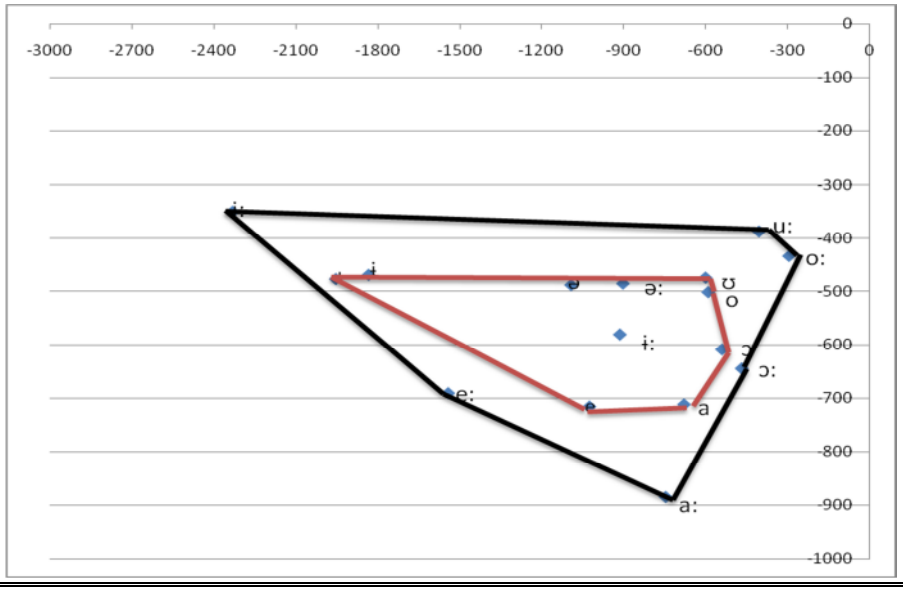

Figure 2: Acoustic Space of Kashmiri Vowels in case of Female speakers

	Male	**Female**	**Male : Female**
Peripheral Vowels	162808.6	313934.7	**01:01.9**
Central Vowels	73844.3	134456.3	**01:01.8**
Peripheral : Central	**2.20 : 1**	**2.33 : 1**	

Table 4: Acoustic Space -area as calculated by Irregular Polygon Area Calculator

The six long peripheral vowels give the overall acoustic space used in Kashmiri vowels. With male speakers' acoustic area 162808.6 and female speakers' acoustic area 313934.7, it is evident that the female acoustic space and the area is nearly twice as large as compared to the male speakers as expected, (female formant values are expected to be higher because of relatively smaller size of the resonance chambers). The area of male speakers' short vowels is 73844.33 and for females it is 134456.3. i.e., 1:1.8 meaning 80% larger than the male speaker's central vowels.

Similarly Figures 1 and 2 above also show that the shorter vowels /**ɪ, e, a, ɔ, o,** ʊ/ show centralization as well as can be seen in the two figures above. Comparing the peripheral vs. central vowels in male and female articulations we find that the peripheral vowels acoustic space area is 2.20 times larger than the central vowels in male speakers, while it is 2.33 times larger in female articulations. In other words in case of males, the longer vowels have an acoustic space 55% larger than the shorter vowels, and the females' longer vowels have an acoustic space 58% larger than their shorter vowels.

Shorter vowels in Kashmiri thus show a remarkable qualitative difference as well in terms of centralization as indicated by F1 and F2 quality.

The rest of the four vowels are located in the inner space as indicated in Fig. 2 and 3. Two pairs of central vowels ɨ and ɨː, and ə and əː, also show qualitative difference acoustically in terms of F1 and F2, and in articulatory terms of tongue height and front/back criteria. Male speakers seem to show lesser qualitative difference between these vowels

whereas the female speakers pronounce ɨ very differently from ɨ:. ɨ: being much more front as compared to ɨ.

Durational contrast

As indicated by a number of earlier descriptions on Kashmiri vowels, duration is phonemic is all the six peripheral vowels and also in case of the two pairs of central vowels. Table 2 in the Appendix shows the durational differences between these vowels in male and female speakers' utterances. On an average, the male speakers pronounce their long vowels 77% longer than their corresponding short vowels, while female speakers pronounce their long vowels as 90% longer than their corresponding short vowels, i.e. the ratio of short to Long vowels in case of males and females are 1:1.77 and 1:1.90 respectively.

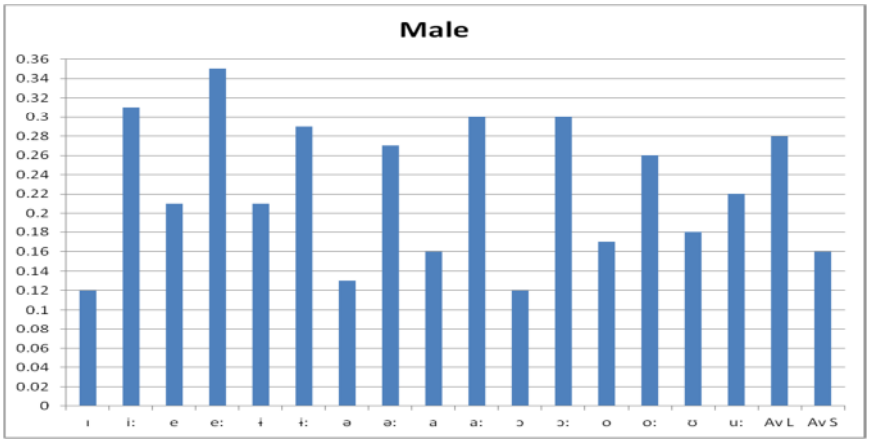

Figure 2 Duration of Kashmiri Vowels in case of Male speakers

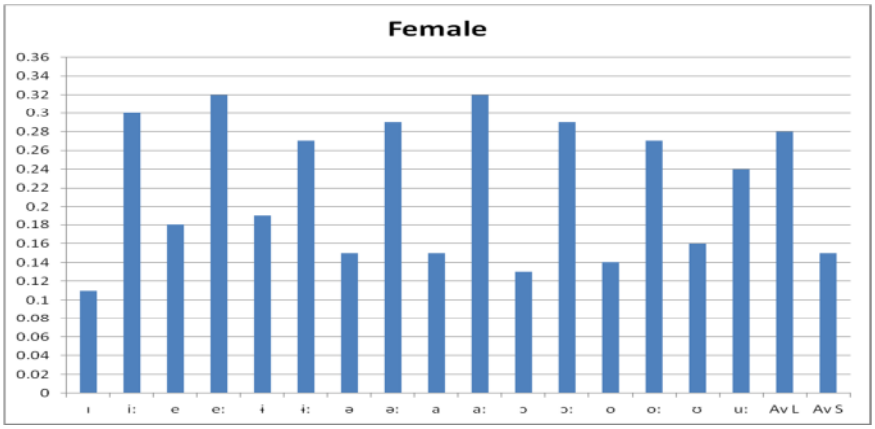

Figure 3 Duration of Kashmiri Vowels in case of Female speakers

In other languages generally phonemic length is 1:2 or 1:3 i.e. long vowels are twice or thrice as long as short vowels. e.g. In a study, Misra et al. 2010, Hindi and Thai durational contrast is discussed and it was shown that the contrast between long and short vowels in Thai is maintained at an average of 1: 2.7; minimum distinctness is at 1: 2, while the maximum is1: 4. The long vowels are two to nearly four times longer than the short ones, showing a much more significant phonemic role assigned to duration than spectral quality in case of Thai vowels, with practically no centralisation of short vowels. In case of Hindi speakers show the durational contrast in vowels of Hindi as articulated by five male and five female subjects. The three short vowels are on an average 0.91ms in male speech and 0.101ms in female speech and long vowels are on an average 2.4 times longer in female and 2.2 times longer in male speech. These vowels also have spectral qualities quite distinct and different from their corresponding long vowels. Centralization of vowels and durational properties seem to be linked in Hindi. (Misra et al, 2010 pp.341). Since Kashmiri language is using only a small durational difference, it is not surprising that the same difference is accompanied by vowel quality difference as well just as reported in Hindi, with three short vowels more centralised as compared to their corresponding long vowels.

Conclusion

Earlier studies on Kashmiri vowels have indicated duration as an important phonemic criteria to distinguish between eight pairs of vowels (in studies showing 16 vowels phonemes) and seven pairs of vowels plus /ɔ/ as the 15th vowel (in studies showing 15 vowel phonemes). The present study provides acoustic evidence in favour of 16 vowel phonemes with a clear distinction between /ɔ/ and /ɔː/ phonemes as well. Secondly the study also shows that the long and short contrasting vowel phonemes are also qualitatively different as indicated by their formant frequencies.

The short vowels are clearly centralised as well in the speech of male as well as female articulations. Acoustic space with F2-F1 plotted against F1 shows the qualitative contrast between six pairs of peripheral

long vowels and their corresponding short, centralised vowel phonemes. The graphic representation in this study will help the place all the vowel phonemes in an acoustic space corresponding to cardinal vowel space. Similarly qualitative difference can also be seen in case of the two pairs of central vowels / ɨ/and/ ɨː /, /ə/ and əː/. Hence, what has earlier been claimed, and perceived by native speakers as durational contrast in Kashmiri vowels is actually a qualitative as well as a quantitative contrast between eight pairs of vowel phonemes.

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Appendix

Table 1: F1, F2 values and duration of all vowels of Kashmiri in case of Male and Female

Vowel	F2	F1	F2	F1	Duration	Duration
ɪ	2430.22	476.459	1986.867	359.577	0.12	0.11
i:	2681.60	349.907	2158.297	276.517	0.31	0.3
e	2233.69	691.04	1892.519	593.379	0.21	0.18
e:	1741.87	715.981	1864.528	749.358	0.35	0.32
ɨ	2302.76	468.677	1504.214	409.064	0.21	0.19
ɨ:	1495.04	580.814	1186.745	371.374	0.29	0.27
ə	1580.79	487.79	1422.068	402.668	0.13	0.15
ə:	1388.13	485.007	1185.232	462.595	0.27	0.29
a	1391.44	711.822	1323.883	653.661	0.16	0.15
a:	1631.50	884.84	1467.657	789.703	0.3	0.32
ʊ	1074.52	473.86	975.5	410.853	0.18	0.16
u:	792.295	386.83	750.75	319.196	0.22	0.24
o	1092.072	501.07	864.89	435.231	0.17	0.14
o:	728.195	433.00	675.70	403.486	0.26	0.27
ɔ	1113.053	644.66	1327.36	603.714	0.12	0.13
ɔ:	1149.449	608.96	1143.20	651.865	0.3	0.29

Table 2: Formant Values of Male and Female Speakers

	Male		Female	
Vowels	**(F2-F1)**	**(-F1)**	**(F2-F1)**	**(-F1)**
ɪ	-	-	-	-
i:	-	-	-	-
e	-	-	-	-
e:	-	-	-	-
ɨ	-	-	-	-
ɨ:	-	-	-	-

ə	-	-	-	-
əː	-	-	-	-
a	-	-	-	-
aː	-	-	-	-
ʊ	-	-	-	-
uː	-	-	-	-
o	-	-	-	-
oː	-	-	-	-
ɔ	-	-	-	-
ɔː	-	-	-	-

Table 3: Duration of Kashmiri Vowels in case of Male and Female Speakers

Short Vowels	**Male**	**Female**	**Long Vowel**	**Male**	**Female**	**Short vs Long**	**Short vs Long (Female)**
ɪ	0.12	0.11	**iː**	0.31	0.3	01:02.6	01:02.7
e	0.21	0.18	**eː**	0.35	0.32	01:01.7	01:01.8
i	0.21	0.19	**iː**	0.29	0.27	01:01.4	01:01.4
ə	0.13	0.15	**əː**	0.27	0.29	01:02.1	01:01.9
a	0.16	0.15	**aː**	0.3	0.32	01:01.9	01:02.1
ɔ	0.12	0.13	**ɔː**	0.3	0.29	01:02.5	01:02.2
o	0.17	0.14	**oː**	0.26	0.27	01:01.5	01:01.9
ʊ	0.18	0.16	**uː**	0.22	0.24	01:01.2	01:01.5
Averag	**0.16**	**0.15**	**Avera**	**0.2875**	**0.2875**	**01:01.77**	**01:01.90**

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