Gender, age, and settlement related changes in vowel duration: A study with relation to Kashmiri

Musavir Ahmed
Department of Linguistics
University of Kashmir
musavir@uok.edu.in

Afreen Nazir
Department of Linguistics
University of Kashmir
afreennazir18@gmail.com

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Abstract

This research article compares the duration of 16 vowels among four age groups of male and female Kashmiri speakers to determine the relationship of vowel duration with gender, aging, and settlement. Recordings for 16 monosyllabic words of */hVtʰ/* structure, with each word having one of the 16 vowels of the language, were taken from a total of 24 males and 24 females, each divided into four age groups of 20-30 years, 31-40 years, 41-50 years, and 50 years and above. Half of the females and males were from rural Kashmir and half were from Urban Kashmir. The results reveal significant differences in duration between males and females, progressive increase in duration with increase in age and certain differences in duration between rural and urban speakers. Acoustic analysis of speech samples was carried using PRAAT.
Keywords: acoustics, vowel duration, Kashmiri, age, gender, settlement

Resumen

Este artículo de investigación compara la duración de 16 vocales entre hablantes de Cachemira masculinos y femeninos de cuatro grupos etarios de para determinar la relación entre la duración de las vocales con el género, la edad y la zona. Se tomaron grabaciones de 16 palabras monosilábicas de estructura /hVtʰ/, cada palabra con una de las 16 vocales del idioma, de 24 hombres y 24 mujeres divididos en cuatro grupos de edad: de 20-30 años, 31- 40 años, 41-50 años y 50 años y más. La mitad de las mujeres y de los hombres eran de zonas rurales de Cachemira y la otra mitad de zonas urbanas de Cachemira. Los resultados revelan diferencias significativas de duración entre hombres y mujeres, un aumento progresivo de la duración con el aumento de la edad y ciertas diferencias de duración entre hablantes rurales y urbanos. El análisis acústico de las muestras de voz se llevó a cabo utilizando PRAAT.
Palabras clave: acústica, duración de las vocales, cachemir, edad, género, zona

Introduction

Young adults tend to speak faster than older adults (Verhoeven et al., 2004, Jacewicz et al., 2009). Older adults produce longer-duration vowels and consonants than young adults, and duration among elderly can be around 20-25% longer than younger speakers (Smith, Wasowicz & Preston, 1987). In a study aimed at understanding the impact of ageing on duration of vowels and other acoustic characteristics, Benjamin (1982) recorded longer duration in the speech of 68–82-year-old adults in comparison to 21–32-year-olds among both male and female speakers. Ramig (1983) cited physiological factors such as "visual acuity, processing time, general neuromuscular slowing, peripheral degeneration of the speech mechanism, and psychosocial variables" (p. 224) as possible reasons why the physical condition of elderly persons affected their speaking rate. In a

study on age-related changes in vowel characteristics in European Portuguese, Albuquerque et al. (2019) have concluded that vowel duration expands with increase in age in both genders. Benjamin (1997) concluded that ageing affected vowel production, voice onset time, phoneme segment duration, and speaking rate. Schötz (2006) reported age-related changes in speaking rate (segment duration), intensity range, F0, and the frequencies of the first two formants.

Available studies on gender and vowel duration also suggest that vowels spoken by women are comparatively longer than those spoken by men (Benjamin, 1982). Jacewicz et al. (2007b) have reported significant differences in duration between male and female speakers with female vowel duration slightly longer than men's vowels. Simpson (1998), in a study involving 60,000 vowel tokens from read and spontaneous speech of 25 female and 29 male speakers, has concluded that female vowel durations were consistently longer than male ones. Hillenbrand et al. (1995) have also reported that vowels spoken by female American English speakers were longer in duration than male speakers. Longer duration among females has also been attributed to their tendency to take longer pauses and an increase in duration of segments preceding the pauses (Whiteside, 1996). Durational differences have also been ascribed to the contrasts regarding cross-sectional vocal tract dimensions between men and women (Simpson, 2002).

Several socio-phonetic studies conducted on American English have confirmed that vowel durations vary across dialects (Jacewicz, et al., 2007a). Deser (1990) has reported significant vowel duration differences between speakers of Southern and Northern dialects of American English, concluding that speech of Southerners is comparatively slower than that of Northerners. Wetzell (2000), while comparing vowel duration in speakers from North Carolina with speakers from the North-eastern United States, has also reported differences in speaking rate and vowel duration. In a comparative study on vowel characteristics of Northern Standard Dutch spoken in Netherlands and Southern Standard Dutch spoken in Flanders, Adank, et al. (2007) have reported significant differences in the duration of vowels across several regional dialects.

Method

This study, conducted in Kashmiri, aimed to determine the relation between the duration of its 16 vowels and gender, age, and settlement among Kashmiri speakers. The subjects were 24 female and 24 male Kashmiri speakers, divided into four age groups each, with half of the females and males from rural Kashmir, and the other half of the subjects from urban Kashmir. The subjects had no known history of any speech dysfunction, laryngeal pathology, or neurological disease. The age groups were 20-30 years, 31-40 years, 41-50 years, and 50 years and above.

Table 1 - Categorization of female Kashmiri consultants.

	Age Group	Number	Mean Age
Female Speakers	20-30 Years	6	24.7
	31-40 Years	6	36.9
	41-50 Years	6	45
	50 years and above	6	56.2
All Female Speakers	All Age Groups	24	40.7

Table 2 - Categorization of male Kashmiri consultants.

	Age Group	Number	Mean Age
Male Speakers	20-30 Years	6	26.3
	31-40 Years	6	34.4
	41-50 Years	6	47.6
	50 years and above	6	58.7
All Male Speakers	All Age Groups	24	41.7

Data was elicited from 16 monosyllabic Kashmiri words of */hVtʰ/* structure, with each word having one of the 16 vowels in Kashmiri. The 16 vowels in Kashmiri are /i/, /i://e/, /e:/, /a/, /a:/, /ɨ/, /ɨ:/, /ə/, /ə:/, /o/, /o:/, /ɔ/, /ɔ:/, /u/, /u:/. The vowels are shown in Figure 1 below.

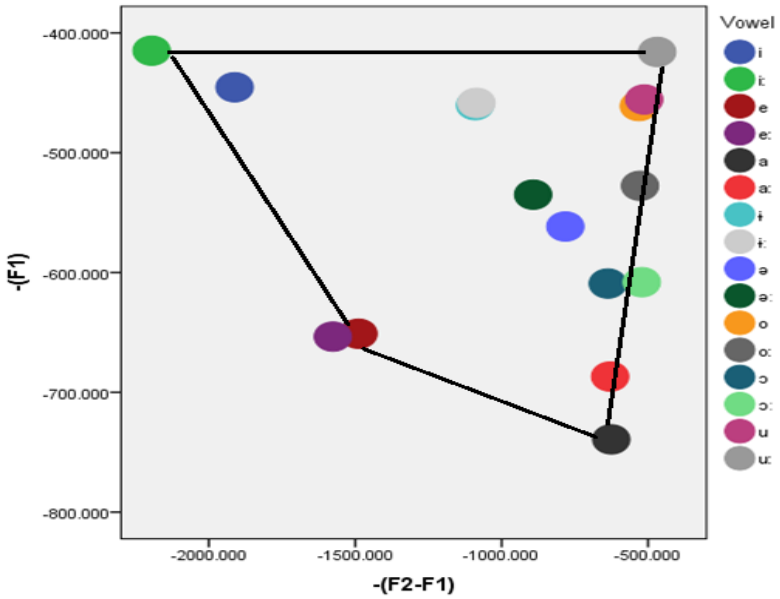

Figure 1 – Kashmiri vowel sounds.

The */hVtʰ/* (Glottal fricative + Vowel + Aspirated dental plosive) syllabic structure has higher frequency of usage in Kashmiri, and extraction of vowel duration in the syllable structure is comparatively less complicated. Words like */hitʰ/* 'excuse', */hItʰ/* 'resentment', */hutʰ/* 'comparable' are in common usage across all areas of Kashmir. Recording was done in a one-on-one setting at different locations as per the convenience of the subjects. Maximum attempts were made to have a setting with little noise or background disturbance. The subjects read out words from the list. Each word was repeated three times. When the subject was not able to read the words, he/she was requested to repeat them following the researcher. The recording was done with a Sony ICD-UX560F voice recorder at a sampling frequency of 44.1 KHz. Once the recording was finished, the sound files were saved and transferred to a laptop in .wav format.

For acoustic analysis of the recorded speech samples, the researchers used PRAAT. PRAAT is a versatile software for speech analysis and synthesis, developed by Paul Boersma and David Weenink from the Phonetics Sciences department at the University of Amsterdam. The study used the PRAAT 6.9.09 version. After creating three objects for the three speech samples for each word uttered by the subjects, waveforms were analysed for clarity of features. One speech sample was selected for the extracting of duration and the rest were removed. This was repeated for all the 16 words that each speaker produced. The duration was extracted manually, based on the auditory judgement of four normal adult native speakers of the language under investigation. All values in PRAAT were extracted using the default settings of the program. ANOVA and other statistical tests were carried out to ascertain the level of significance between the various variables and vowel duration.

Results

In Kashmiri, the mean duration for all vowels spoken by females was 0.174 seconds and for males it was 0.164 seconds, which provides evidence in support of the general finding that vowel duration among females is higher than that among males.

Table 3 - Mean vowel duration and standard deviation in female Kashmiri speakers.

Vowel	Mean Duration (in seconds)	Standard Deviation
/i/	0.115	0.017
/iː/	0.227	0.029
/e/	0.108	0.017
/eː/	0.165	0.014
/a/	0.125	0.01
/aː/	0.244	0.02
/ɨ/	0.130	0.012
/ɨː/	0.266	0.022
/ə/	0.108	0.028
/əː/	0.157	0.032
/o/	0.135	0.015
/oː/	0.236	0.013
/ɔ/	0.149	0.023
/ɔː/	0.231	0.058
/u/	0.138	0.017
/uː/	0.251	0.03

Table 4 - Mean vowel duration and standard deviation in male Kashmiri speakers.

Vowel	Mean Duration (in seconds)	Standard Deviation
/i/	0.113	0.013
/iː/	0.223	0.019
/e/	0.101	0.024
/eː/	0.164	0.016
/a/	0.113	0.019
/aː/	0.207	0.054
/ɨ/	0.122	0.039
/ɨː/	0.247	0.039
/ə/	0.106	0.023
/əː/	0.154	0.019
/o/	0.125	0.04
/oː/	0.224	0.026
/ɔ/	0.136	0.025
/ɔː/	0.243	0.032
/u/	0.110	0.019
/uː/	0.239	0.03

However, the mean duration for /ɔː/ was 0.013 seconds higher in males than females, which was found to be an exception to the general rule. The difference in duration between males and females ranged from one millisecond (0.001 seconds) to 37 milliseconds (0.037 seconds); the minimal difference in mean duration was minimum for the mid-front long vowel /eː/ and a maximum difference in mean duration was found for the low back long unrounded vowel /aː/. Among the 16 vowels, significant differences of more than 10 milliseconds (0.01 seconds) were found only in eight of the vowels /a/, /aː/, /ɨː/, /oː/, /ɔ/, /ɔː/ (-0.012 seconds), /u/, /uː/. The remaining eight vowels were found to be below or equal to 10 milliseconds.

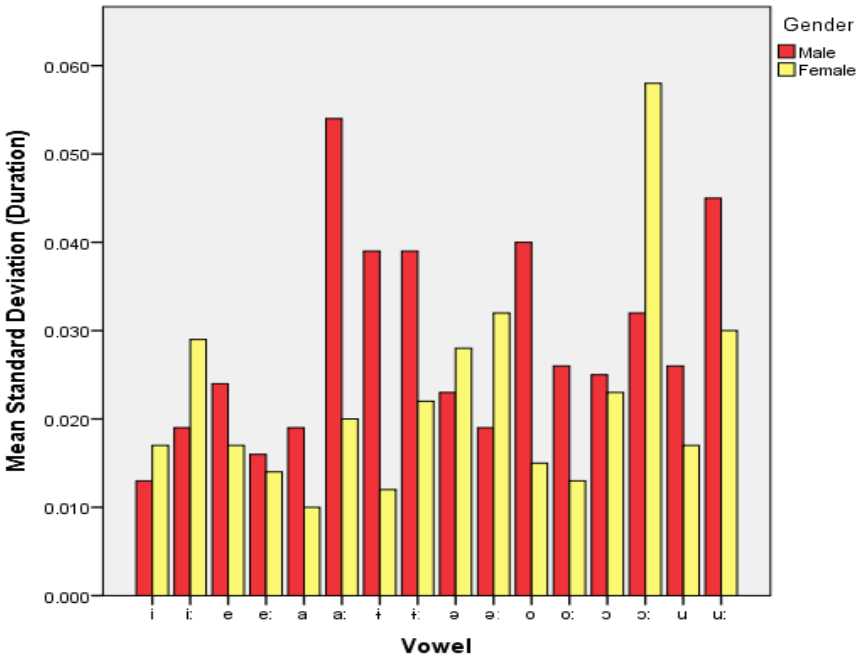

Figure 2 - Mean Standard Deviation in Duration.

Among female speakers, maximum standard deviation, or inter-speaker variability of 58 milliseconds was found in the production of the low back rounded vowel /ɔː/, while in the case of males it was 54 milliseconds for vowel /aː/. A minimum standard deviation or inter-speaker variability of 10 milliseconds was found for vowel /a/ among females and 13 milliseconds for /i/ among males. The difference in duration in a short vowel and its longer counterpart was not found to be significantly different between males and females. Among the eight long-short vowel pairs, a maximum difference of 136 and 125 milliseconds was found between the high front /i/ and /iː/ in females and males respectively, and a minimal difference of 48 and 49 milliseconds was found between the mid-central vowel pair /ə/ and /əː/ in females and males respectively.

A t-test conducted to ascertain differences in vowel duration in the two genders showed that mean vowel duration in female Kashmiri speakers is significantly different from mean vowel duration of male Kashmiri speakers (p=.013).

The results provide additional evidence suggesting that vowel duration increases with age in both female and male speakers. For females aged between 20-30 years, the mean vowel duration was found to be 0.164 seconds; 0.169 seconds for age group 31-40 years, and 0.179 seconds for those aged between 41-50 years. The highest mean duration, of 0.187 seconds, was found for females aged 50 years and above.

A one-way ANOVA test showed a significant difference in vowel duration between means of various age groups among female Kashmiri speakers (p=0.01). However, a post-hoc Tukey's test for multiple comparisons showed significant difference between females in the age group 20-30 and those aged 50 years and above.

Table 5 - Results of Post hoc Tukey's Test between various age groups among females.

(I) Age-Group	(J) Age-Group	Mean Difference (I-J)	Sig.
20-30	50 onwards	-.025542*	0.01
50-onwards	20-30	.025542	0.01

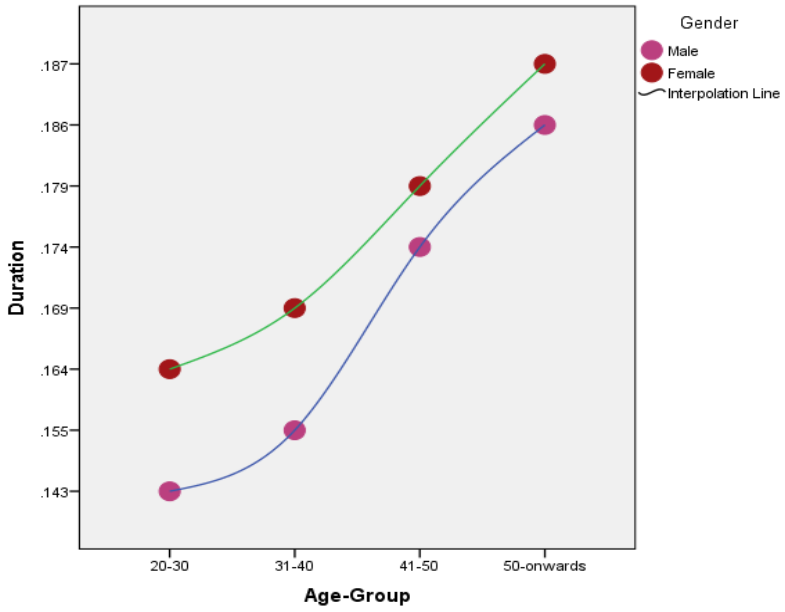

Figure 3 - Mean duration of the four age groups of male and female Kashmiri speakers.

A similar trend was found in the case of male Kashmiri speakers; the lowest mean vowel duration of 0.143 seconds was found for age group 20-30; 0.155 seconds for the age group 31-40 and 0.174 seconds for speakers aged 41-50 years. The highest duration of 0.186 seconds was found to be for speakers aged 50 years and above. The differences in mean vowel duration between young male and female speakers are significantly higher than between elderly male and female speakers.

Table 6 - Results of Post hoc Tukey's Test between various age groups among males.

(I) Age-Group	(J) Age Group	Mean Difference (I-J)	Sig.
20-30	41-50	-.031219*	.001
	50-onwards	-.043635*	.000
31-40	50-onwards	-.032469*	.000
41-50	20-30	.031219*	.001
50-onwards	20-30	.043635*	.000
	31-40	.032469*	.000

A one-way ANOVA test carried to ascertain the level of significance showed a highly significant difference in mean vowel duration between various age groups among male Kashmiri speakers ($p<0.01$). A post-hoc Tukey's test for multiple comparisons showed significant difference in mean vowel duration of male Kashmiri speakers in age group 20-30 with speakers in age-group 41-50 and highly significant difference with speakers aged 50 and above. The speakers in age-group 31-40 also showed highly significant difference in mean duration with speakers aged 50 and above.

With an increase in age, the differences in vowel duration between males and females of comparable age groups was found to decrease, with the highest difference between males and females of age group 20-30 and the lowest difference between age group 50 years and above.

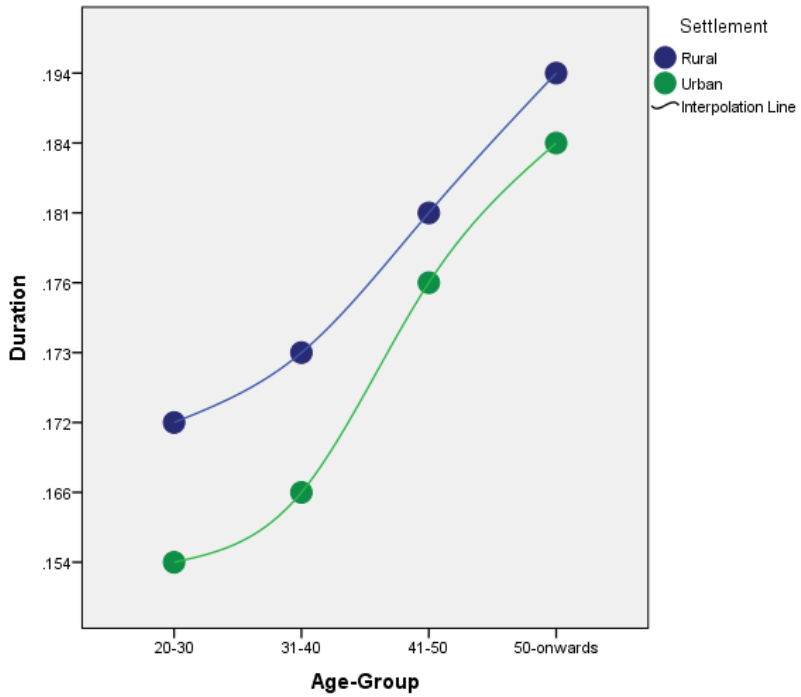

Figure 4 - Mean duration of all age groups of female rural and urban speakers in Kashmir.

In Kashmiri, the mean vowel duration in female speakers from rural Kashmir was found to be higher than female speakers from urban areas. The mean duration of vowels spoken by female rural Kashmiri speakers was 0.180 seconds in comparison to 0.170 seconds for female urban Kashmiri speakers. A t-test carried to determine differences between mean vowel duration between rural and urban female Kashmiri speakers did not show any significant differences (p=0.109).

Like female speakers, the mean vowel duration in rural male Kashmiri speakers was higher than urban male Kashmiri speakers: the mean vowel duration was 0.170 seconds in rural males and 0.159 seconds in urban males.

A t-test conducted to determine the difference in vowel duration between rural males and urban males showed a significant difference in mean vowel duration of the two groups of speakers (p=0.037).

The results indicate that keeping all other things neutral, among all groups, urban male Kashmiri speakers speak the fastest followed by rural male and urban females who speak at same rate. Rural Kashmiri female speakers speak at the slowest rate. The maximum difference between rural females and urban females was 0.018 seconds for age group 20-30 and a minimal difference of 0.01 seconds was found for age group 50 and onwards.

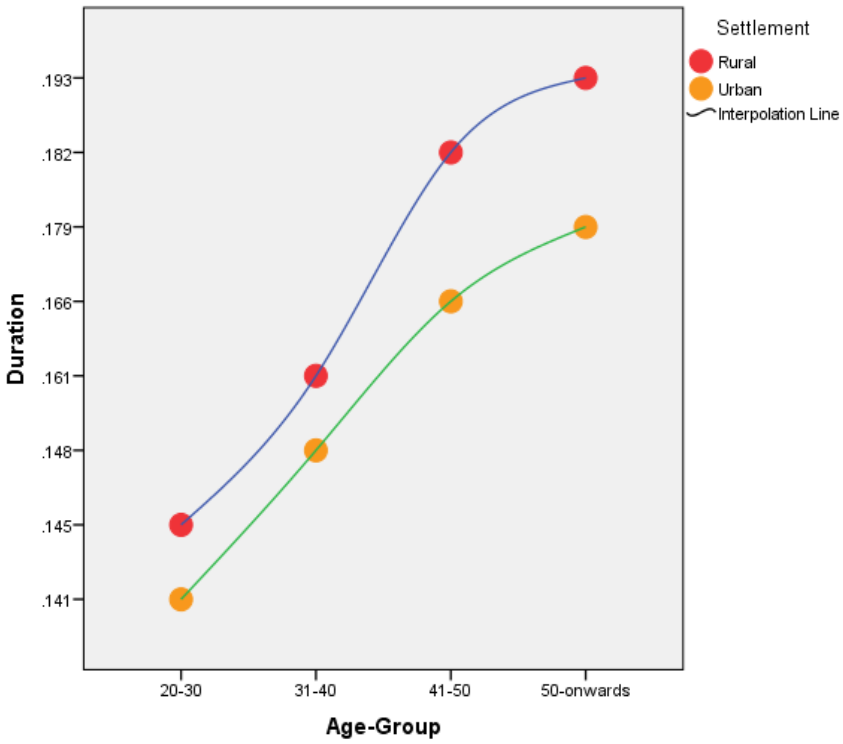

Figure 5 - Mean duration of all age groups of male rural and urban Kashmiri speakers.

Conclusions

There is hardly an acoustic study available on vowel duration of languages spoken in the Indian subcontinent. The study, which is the first of its kind in the Kashmiri language, compared the duration of vowels among male and female speakers, speakers of different age groups and speakers from rural and urban areas of the Kashmir division in the J&K union territory in India. The results, although based on limited data, point to some interesting conclusions. Firstly, it provides evidence which substantiates the earlier finding that vowels spoken by female speakers of a language are longer in duration than those produced by male speakers of the same language. Secondly, the results suggest that younger speakers of a language utter comparatively shorter vowels than adult speakers and with increase in age, vowel duration increases in both male and female speakers. Difference in vowel duration between young males and females is comparatively higher than between older males and females; the male-female difference in vowel duration tends to reduce with increase in age. The study also suggests that urban speakers have shorter duration vowels as compared to rural speakers. This was found to be the case with both male and female speakers. However, statistical tests revealed an important difference between urban and rural males only. The findings of this study can be of significant use in studies on speech intelligibility and its wide-ranging applications, speech categorization, development of speaking and language-teaching aids, signal processing and comparative-acoustic studies, among others. The above findings may be further substantiated by studies based on a comparatively large data set.

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