MedCrave
Step into the World of Research

International Journal of Acoustics and Ultrasonics

Case studies

Open Access

CrossMark

Effect of aspiration on steady-state vowel duration for aspirated consonants

Abstract

In this paper an attempt has been made to study the effect of aspiration on steady-state vowel duration (S.S.V.D) of spoken Garhwali Hindi sounds in isolation. Subjects were considered as five males and five females in age 20-25years. The recording was done in partial acoustically treated room and speech signal was digitized at the sampling frequency of 16KHz. S.S.V.D were obtained using linear predicative coding analysis. It has been observed that the steady-state vowel duration for voiced aspirated consonants is greater than voiceless aspirated consonants.

Keywords: Vowels, vowel duration, consonant, voice, voiceless, aspirated, speaker, steady-state vowel duration (S.S.V.D)

Volume 1 Issue 4 - 2018

SK Adhikari

Department of Physics, Birendra multiple Campus, Tribhuvan University, Nepal

Correspondence: S K Adhikari, Department of Physics, Birendra multiple Campus, Tribhuvan University, Bharatpur, Nepal, Tel +00977-9845196194, Email sheshkant@rediffmail.com

Received: June 25, 2018 | **Published:** July 27, 2018

Introduction

The termination of second formant of steady-state vowel is observed by noting the two extreme points on the wide band spectrogram through which the formant becomes parallel to time axis. Acoustically, aspiration can be described as noise (random stippling) mostly at the frequencies near second and third formants of the following or preceding vowels. The sound/p^h, t^h, $ṭ^h$, k^h; b^h, d^h, g^h/are designated as aspirated sounds while the rest/p, t, ṭ, k; b, d, ḍ, g / are un aspirated.

Peterson & Lehiste[1] Studied the duration of vowel sounds in American English and they found that vowel duration is longer before voiced consonants than they are before voiceless consonants. Two explanations have been proposed for this variation in vowel duration. One is that vowel duration acts in English as an additional cue in distinguishing voiced and voiceless consonants and that vowel duration variations are learned as a part of the language structure.

Ahmad et al.[2] in study of Hindi constant in CVC syllable final position also found that vowel duration (steady state vowel) preceding voiced stops is greater than that of vowels preceding voiceless stops and ratios are found to be 1.33:1. Upadhyay[3] found this ratio to be 1.13:1. In their perceptual study using electronic segmentation technique, Ahmad, Rizvi and Gupta found that vowel duration unlike Raphael.

Denes[4] and Raphael[5] in their perception experiments in American English using synthetic speech and Hogan et al.[6] in their perception study of Canadian English using natural speech varied the steady-state vowel portion of CVC sounds either by gating out the steady portion of vowel or splicing in steady-state vowel and found that the final consonant is perceived as voiceless when preceded by vowels of short duration and as a voiced when preceded by vowels of longer duration.

Other cues related to the identification of stops in either position of CVC syllables were not distributed in these experiments. Only the total vowel duration (vowel nucleus) was varied by changing the duration of steady-state vowel. This means that the steady-state vowel duration ratio for vowels preceding voiced stops to those proceeding voiceless ought to be greater than one.[7–11]

Test materials

In the present study, ten vowels of Garhwali Hindi language/Λ, a, I, i, U, u, e, ɛ, O, Ɔ /were analyzed. The vowels were in the environment of 6 consonants/p^h, t^h, k^h; b^h, d^h, g^h/.The test material consists of at least 60 meaningful words with /CVC/ format.

Subject

Ten subjects (5 male 5 female) in the age 20-25years adults were selected on the criteria that they had Garhwali Dialect of Hindi as their mother tongue, able to read Garhwali and normal speech, language and hearing function.

Procedure

The subjects were instructed to read, the token written on the flash card as naturally as possible. The recording was done in partial acoustically treated room for individual subjects by presenting one flash card at a time using a SANYO voice activated recording system (TRC- 860C). This was connected to the computer (Pentium IV) having SOFT-WARE OF PRRAT. The speech signal was digitized at the sampling frequency of 16kHz.

Observation

As shown in (Tables 1–3) (Figure 1) & (Tables 4–6) (Figure 2).

Result and discussion

In case of male (Table 1) shows that the range of S.S.V.D. varies from 17.84msec to 39.60msec for voiced and 16.08msec to 34.82msec for voiceless consonants.

The range of S.S.V.D. varies from 18.35msec to 39.60msec for labial, 17.84msec to 38.08msec for dental and 18.35msec to 38.52msec for velar in case of voice consonant. In case of voiceless consonant S.S.V.D varies from 17.74msec to 34.82msec for labial, 16.08msec to 33.29msec for dental and 16.40msec to 32.41msec for velar.

Effect of place of articulation on S.S.V.D. was studied by analyzing the data presented in Table 1. It has been found that the order of the average S.S.V.D. for voiced consonants is large for velar

(Avg. 27.84sec) followed by labial (Avg. 27.83msec) and dental (Avg. 26.99msec) sounds. The order for voiceless consonants is dental (Avg. 25.09msec) followed by labial (Avg. 24.70msec) and velar (Avg. 23.93msec) sounds.

Table 1 Effect of aspiration on S.S.V.D. (in msec.) for aspirated consonants for male speakers

Vowel	Voice			Voiceless		
	Labial	Dental	Velar	Labial	Dental	Velar
/ʌ/	22.00	21.37	20.55	21.45	20.97	18.62
/a/	27.96	25.49	27.18	24.75	25.02	24.64
/I/	20.43	19.90	23.43	20.03	17.84	17.32
/i/	24.81	28.31	28.76	22.40	24.20	25.87
/U/	18.35	**17.84**	18.35	17.74	**16.08**	16.40
/u/	21.20	20.00	24.64	20.32	19.00	21.01
/e/	30.35	31.47	31.45	20.03	30.77	27.14
/ɛ/	34.33	34.83	37.45	33.69	32.42	32.41
/O/	**39.60**	32.65	29.00	31.80	31.29	23.60
/Ɔ/	39.28	38.08	38.52	**34.82**	33.29	32.29
Avg.	27.83	26.99	27.84	24.70	25.09	23.93

Table 2 shows that the ratio of S.S.V.D. for voice to voiceless consonants varies from 1.05 to 1.16 and the ratio of average value of S.S.V.D. preceding voiced stop to that of vowels preceding voiceless consonants is 1.12 for male speakers.

Table 2 Effect of aspiration on S.S.V.D. (in msec.) for aspirated voice and voiceless consonants for male speakers

Vowels	Voice consonants	S.D	C.V	Voiceless consonants	S.D	C.V	Ratio
/ʌ/	21.30	0.59	2.77	20.35	1.24	6.10	1.05
/a/	26.88	1.03	3.83	24.80	0.16	0.64	1.08
/I/	21.25	1.56	7.34	18.40	1.17	6.36	1.15
/i/	27.30	1.77	6.48	24.16	1.42	5.88	1.13
/U/	18.18	0.25	1.38	16.74	0.72	4.30	1.09
/u/	21.95	1.96	8.93	20.21	0.84	4.16	1.09
/e/	31.09	0.53	1.70	25.98	4.46	17.17	1.19
/ɛ/	35.54	1.37	3.85	32.84	1.91	5.82	1.08
/O/	33.75	4.40	13.04	28.90	3.75	12.97	1.16
/Ɔ/	38.63	0.50	1.29	33.47	0.85	2.54	1.15
Avg.	27.59	1.08	3.92	24.58	0.48	1.95	1.12

Figure 1 shows the variation of S.S.V.D. with aspirated consonant (voice and voiceless) for male speakers. From graph it has been found that, the S.S.V.D for voice consonant is greater than voiceless consonant for male speakers.

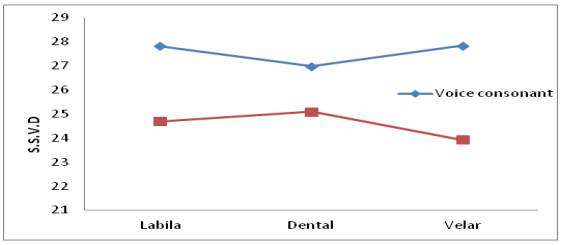

Figure 1 Graph between S.S.V.D and Aspirated (Voice and Voiceless) Consonants for male speaker.

In case of female: Table 4 shows that the range of S.S.V.D. varies from 16.04msec to 40.31msec for voiced and 13.85msec to 29.77msec for voiceless consonants.

Table 3 Analysis by t-test in 5% of level of significance for male speakers

Voice consonants(X)	$(X-\bar{X})^2$	Voiceless consonants((Y)	$(Y-\bar{Y})^2$	Calculated t-test value
21.30	39.56	20.35	17.89	
26.88	0.50	24.80	0.05	
21.25	40.20	18.40	38.19	
27.30	0.08	24.16	0.18	
18.18	88.55	16.74	61.47	
21.95	31.81	20.21	19.98	
31.09	12.25	25.98	1.96	1.05
35.54	56.25	32.84	68.23	
33.75	37.95	28.90	18.66	
38.63	121.88	33.47	79.03	
$\bar{X}$ = 27.59	∑=429.03	$\bar{Y}$ = 24.58	∑=305.64	

Table 4 Effect of aspiration on S.S.V.D. (in msec.) for aspirated consonants in isolation for female speakers

Vowel	Voice			Voiceless		
	Labial	Dental	Velar	Labial	Dental	Velar
/ʌ/	26.37	22.15	23.64	20.33	21.44	18.83
/a/	30.70	28.29	26.88	28.20	25.15	24.82
/I/	23.25	22.13	23.81	21.15	15.80	20.11
/i/	27.10	23.24	25.02	20.56	20.85	25.01
/U/	**16.04**	18.31	20.04	14.94	**13.85**	18.98
/u/	25.29	22.19	23.24	20.21	17.21	21.63
/e/	30.97	28.18	28.10	26.26	27.37	25.30
/ɛ/	33.36	29.66	31.81	28.31	27.62	**29.77**
/O/	31.73	26.37	25.92	25.92	25.04	28.42
/Ɔ/	**40.31**	30.22	28.73	25.71	28.08	25.47
Avg.	28.51	25.07	25.72	23.16	22.24	23.83

The range of S.S.V.D varies from 16.04msec to 40.31msec for labial, 18.31msec to 30.22msec for dental and 20.04msec to 31.81msec for velar in case of voice consonant. In case of voiceless consonant S.S.V.D varies from 14.94msec to 28.31msec for labial, 13.85msec to 28.08msec for dental and 18.33msec to 29.77msec for velar.

Effect of place of articulation on S.S.V.D. was studied by analyzing the data presented in Table 5. It has been found that the order of the average S.S.V.D. for voiced consonants is large for labial (Avg. 28.51sec) followed by velar (Avg. 25.72msec) and dental (Avg. 25.07msec) sounds. The order for voiceless consonants is velar (Avg. 23.83msec) followed by labial (Avg. 23.16msec) and dental (Avg. 22.24msec) sounds.

Table 5 shows that the ratio of S.S.V.D. for voice to voiceless consonants varies from 1.06 to 1.25 and the ratio of average value of S.S.V.D. preceding voiced stop to that of vowels preceding voiceless consonants is 1.15 for female speakers.

Figure 2 shows the variation of S.S.V.D. with aspirated consonant (voice and voiceless) for male speakers. From graph it has been found that, the S.S.V.D for voice consonant is greater than voiceless consonant for male speakers.

Citation: Adhikari SK. Effect of aspiration on steady-state vowel duration for aspirated consonants. *Int J Acous Ult.* 2018;1(4):9–11.
DOI: 10.15406/ijau.2018.01.00002

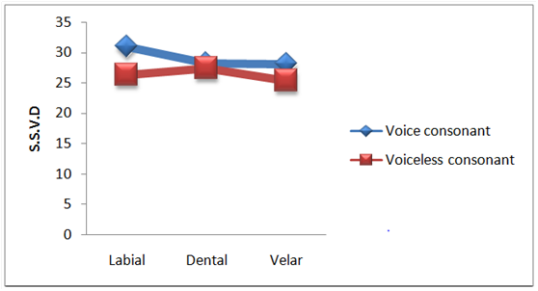

Figure 2 Graph between S.S.V.D and Aspirated (Voice and Voiceless) Consonants for female speakers.

Table 2 and Table 5 show that standard deviation of voice is more than voiceless so that voice consonants are more deviated than voiceless consonants for male female speakers. The coefficient of variation of voice consonants is greater than voiceless consonants for male and female speakers so that steady-state vowel duration for voiceless is more stable and homogeneous than voice consonants.

Table 5 Effect of aspiration on S.S.V.D. (in msec.) for aspirated voice and voiceless consonants for female speakers

Vowels	Voice conso-nants	S.D	C.V	Voiceless consonants	S.D	C.V	Ratio
/ʌ/	24.05	1.75	7.27	20.20	1.07	5.30	1.19
/a/	28.62	2.73	9.54	26.06	1.52	5.83	1.10
/I/	23.06	0.70	3.04	19.02	2.32	12.20	1.21
/i/	25.12	1.58	6.29	22.14	2.04	9.21	1.13
/U/	18.13	1.64	9.05	15.92	2.21	13.88	1.14
/u/	23.57	1.29	5.47	19.68	1.84	9.35	1.20
/e/	29.08	1.11	3.82	26.31	0.85	3.23	1.11
/ɛ/	31.61	1.67	5.28	28.57	0.90	3.15	1.11
/O/	28.01	2.64	9.42	26.46	1.43	5.40	1.06
/ɔ/	33.09	5.14	15.56	26.42	1.18	4.47	1.25
Avg.	26.43	1.49	5.64	23.08	0.65	2.82	1.15

Table 6 Analysis by t-test in 5% of level of significance for female speakers

Voice consonants(X)	$(X-\bar{X})^2$	Voiceless consonants((Y)	$(Y-\bar{Y})^2$	Calculated t-test value
24.05	5.66	20.20	8.30	
28.62	4.80	26.06	8.88	
23.06	11.36	19.02	16.48	
25.12	1.72	22.14	0.88	
18.13	68.89	15.92	9.99	
23.57	8.18	19.68	11.56	
29.08	7.02	26.31	10.43	
31.61	26.83	28.57	30.14	1.83
28.01	2.50	26.46	11.42	
33.09	44.36	26.42	11.16	
$\bar{X} = 26.43$	∑=181.32	$\bar{Y} = 23.08$	∑=119.24	

Tabulated value for 5% of level of significance is 1.96 which is greater than calculated value 1.05 for male speakers and 1.83 for female speakers. Hence null hypothesis accepted and which shows that there is connection between steady-state vowel duration of vowel length of voice and voiceless consonants.

Hence steady-state vowel duration for voice consonants is greater than voiceless consonants for aspirated consonants for both male and female speakers.

The ratio of S.S.V.D. for voice to voiceless consonants varies from 1.05 to 1.16 and the ratio of average value of S.S.V.D. preceding voiced stop to that of vowels preceding voiceless consonants is 1.12 for male speakers.

For female speakers the ratio of S.S.V.D. for voice to voiceless consonants varies from 1.06 to 1.25 and the ratio of average value of S.S.V.D. preceding voiced stop to that of vowels preceding voiceless consonants is 1.15.

Acknowledgement

None.

Conflict of interest

Author declares there is no conflict of interest.

References

1. Lehiste I. *Acoustic Phonetics*. The MIT Press; 1960.
2. Ahmed A, Rizvi SHS, Gupta SK. Identification of Hindi Stop Consonants in Syllable –Position. *JIEEE*. 1985;31:162–170.
3. Updhyay RK, Rizvi SHS, Ahmad A. Duration analysis of Hindi final stops in meaningful CVC utterance. *J Acoust Soc Ind*. 1993;21**:**127–131.
4. Denes P. Effect of duration on the perception of voicing. *J Acoust Soc Am*. 1955;27**:**761–764.
5. Raphael LJ. Preceding vowel duration as a cue to perception of voicing characteristics of word final consonants in American English. *J Acoust Soc Am*. 1972;51**:**1296–1303.
6. Hogan JT, Rozspal AJ. Evaluation of vowel duration as a cue for the voicing distinction in the following word-final consonants. *J Acoust Soc Am*. 1980;67**:**1764–1771.
7. Fant G. *Acoustic theory of speech production*. 2nd ed. Mouton The Hague Paris;1970.
8. Chiba T, Kajiyama M. *The vowel-Its Nature and Structure*.Tokyo;1941.
9. Majumder DD, Dutta AK, Gangulee NR. Some Study on Acoustic Features of Human Speech in Relation to Hindi Speech Sound. *Indian J Physics*. 1973;47:598–613.
10. Davis S, Summers WV. Vowel length and closure duration in word-medial VC sequences. *Journal of Phonetics*. 1989;17:339–353.
11. Fowlert CA. Vowel Duration and Closure Duration in Voiced and Unvoiced Stops. Haskins Laboratories Status Report on Speech Research SR-107/108. 1991:123–140.