Acoustic Investigation of /l, j, v/ as Approximants in Urdu

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Outline

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- Approximants
- Background
- Methodology of the Research
- Acoustic Analysis: Experiment 1
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Motivation of the Research

- To investigate the acoustic properties of /l, j, v/ as approximants in Urdu.
- To define a scientific method for the identification of these sounds.
- To explore the dual behavior of Urdu approximants; fricative and approximants
- To find out contexts in which Urdu approximants change their behavior.

Approximants

- Ladefoged coined the term “approximant” and defined it as approximants belong to the two phonetic classes; one is resonant oral and second is consonant[1].

- Trask[2] placed approximants in between vowels and fricatives because of the constriction of the airflow and claims that approximants produce frication noise.

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[1] P. Ladefoged, *A Course in Phonetics*, 4th ed., Bill Hoffman, Ed. Calefornia, Los Angeles, USA: Earl McPeek, 1975.
[2] I. E. Colombo, *On the Phonetic Status of Labial Approximants in Dutch*. University of Amsterdam, 2015.

Background (1/2)

- The term ‘Spirant approximant’ or approximant like version of fricative is used by IPA[3] and an openness diacritic [˕] is used to indicate it like; [ʋ β˕]
- Spirant approximant [ʋ] is found in Dutch[4] and it is assumed that the approximant behave as a fricative when it comes at onset and coda position.
- /j/ with [˕] is also used in Spanish to show the noise or turbulence in the /j/ in emphatic speech[5].

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[3]International Phonetic Association, *Handbook of the International Phonetic Association: A guide to the use of the International Phonetic Alphabet*. Cambridge, United Kingdom: Cambridge University Press, 1999.

[4] I. E. Colombo, *On the Phonetic Status of Labial Approximants in Dutch*. University of Amsterdam, 2015.

[5] E. Martinez-Celdran, "Problems in the classification of approximants," Journal of the International Phonetic, vol. 34, no. 2, pp. 201-210, Dec 2004.

Background (2/2)

- Different acoustic measures; duration and formant analysis have been studied in American English[6], Korean[7] and Sindhi[8] language to differentiate different approximants from one another
- The purpose of this work is to analyze the acoustic properties of Urdu approximants by using such measures and also identify a scientific method to justify the properties of these sounds

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[6] C. Y and E. Wilso, "Acoustic measures for linguistic features distinguishing the semivowels /w j r 1/ in American English," *The Journal of Acoustical Society of America*,vol.92, no.2, pp. 736-757, August 1992.
[7] M. C. Kim and A. J. Lotto, "Acoustic measurements of Korean approximants," *The Korean language in America*, vol.9, pp. 72-77, 2004.
[8]A. Keerio, L. D. Dhomeja, A. A. Shaikh, and Y. A. Malkani, "Coparative Analysis of Vowels, diphthongs and Glides of Sindhi," *Signal and Image Processing*, vol. 2, no. 4, December 2011.

Methodology (1/2)

Phonemes	No. of Utterances		
	Initial	Middle	Final
/l/	10	10	10
/j/	10	10	-
/v/	10	10	-

- PRAAT used for recording and analysis
- Data recorded in an anechoic chamber at sampling rate of 8 kHz
- Total 280 utterances recorded from 4 speakers (2 males and 2 females)

Methodology (2/2)

- Aspirated versions /l^h, j^h and v^h/ have also been studied
- Words selected from Urdu Lughat[9] and Oxford dictionary[10]

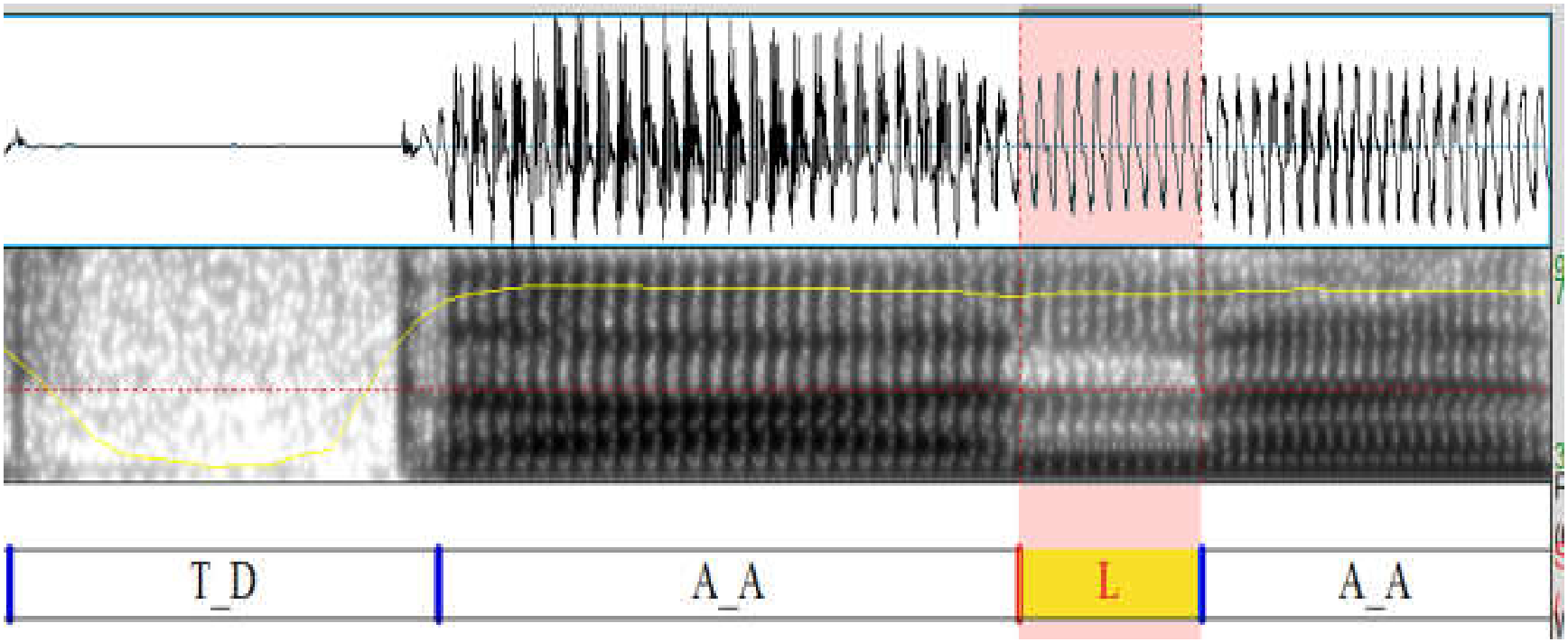
Phonemes	Selected words
/l^h/	دولھا / /ɖu:l^ha:/ /Groom/ and چولھا / /ʧu:l^ha:/ /Stove/
/j^h/	No instance of /j^h/ was found
/v^h/	وھیل / /v^he:l/ /Whale/.

[1] *Urdu Lughat: Tarixi Usuul Per*, 1st ed. Karachi, Pakistan: Muheet Urdu Press, 2013, vol. 3.
[2] *Oxford Urdu-English Dictionary*, 1st ed. Karachi, Pakistan: Oxford University Press, 2013.

Acoustic Analysis: Experiment 1

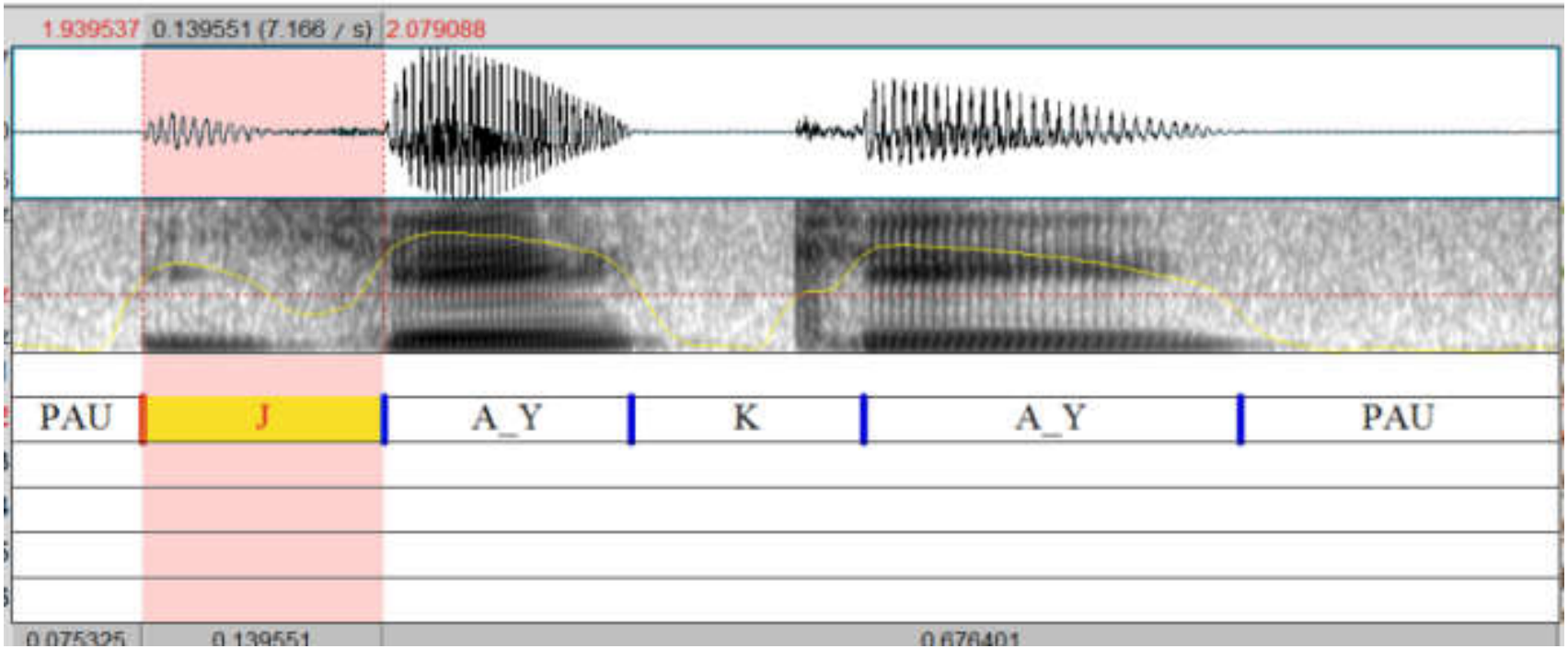
/l/ sound

- It exists at all three word positions
- It forms lighter formants than its neighboring vowels



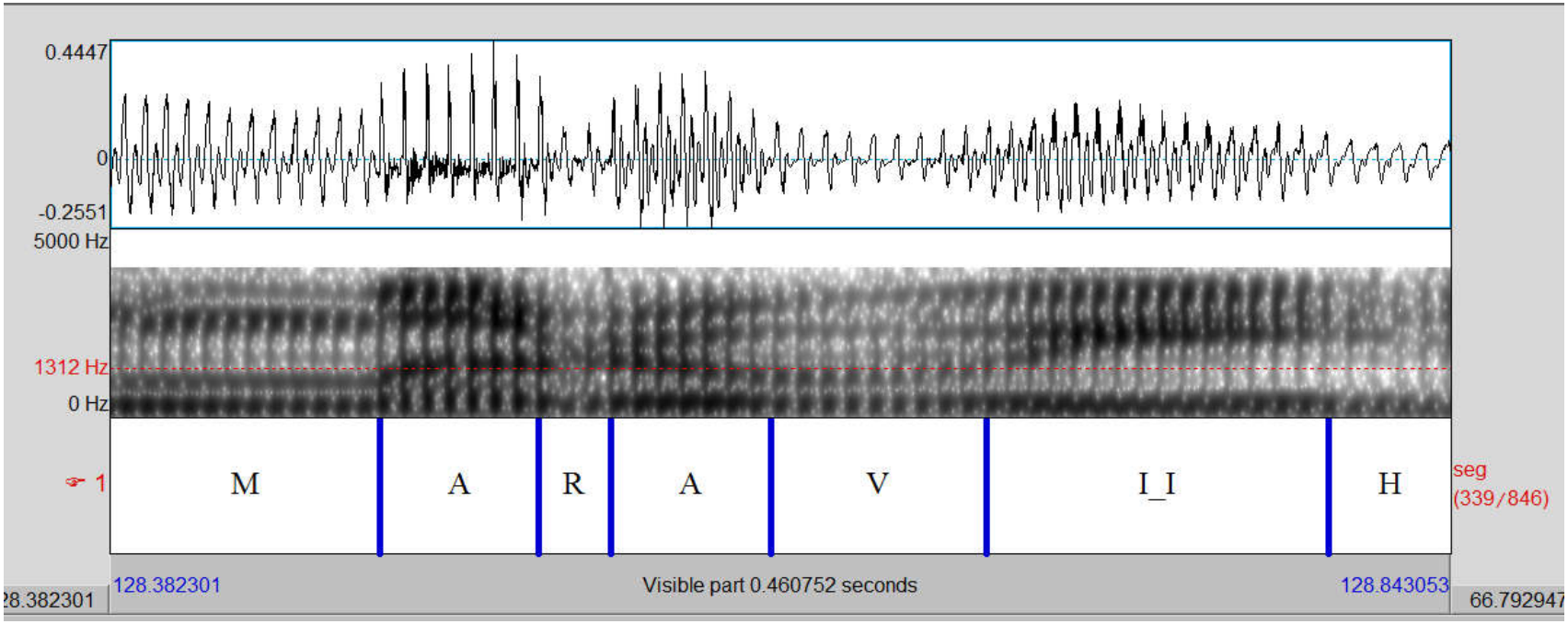
/j/ sound

- It occurs at only two positions; initial and middle
- It can take three types of properties; formants, frication and combination of both



/v/ sound

- It also has a tendency to occur as fricative or approximant
- At word middle position, F2 of the preceding vowel falls



Duration Analysis

Urdu phonemes	Duration at word initially with pause	Duration at word medially	Duration at word finally with pause
/l/	105ms	78ms	118ms
/j/	93ms	65ms	-
/v/	70ms	56ms	-

- /l/ shows longest duration at word final position with pause
- /v/ shows lowest duration value at word medial position

Formant Analysis

Urdu phonemes	Formant values word initial		Formant values word medial		Formant values word final	
	F1	F2	F1	F2	F1	F2
/l/	292	1584	325	1584	295	1592
/j/	311	1830	306	1867	-	-
/v/	290	1212	324	1289	-	-

- /j/ indicates higher F2 values than other sounds
- /v/ shows lowest F2 values than other sounds

/l^h, j^h and v^h/ Analysis

- /l^h/ was not pronounced in word /دولھا/ /ɖu:l^ha:/ /Groom/. instead speakers have pronounced /l/ and /h/ separately as /ɖulha: /دولہا/.
- /v^he:l/ /وھیل/ /Whale/ was pronounced as /ve:l/ /ویل/ /Whale/ without the aspirated sound. The speakers have changed the aspirated /v^h/ into un-aspirated /v/
- In dictionaries words like /وھیل ،دولھا ،چولھا/ were also written as /وہیل، دولہا، چولہا/
- The alternative orthographies of such words shows that /l^h/ is gradually replacing with /l+h/ sounds and /v^h/ with its un-aspirated version /v/

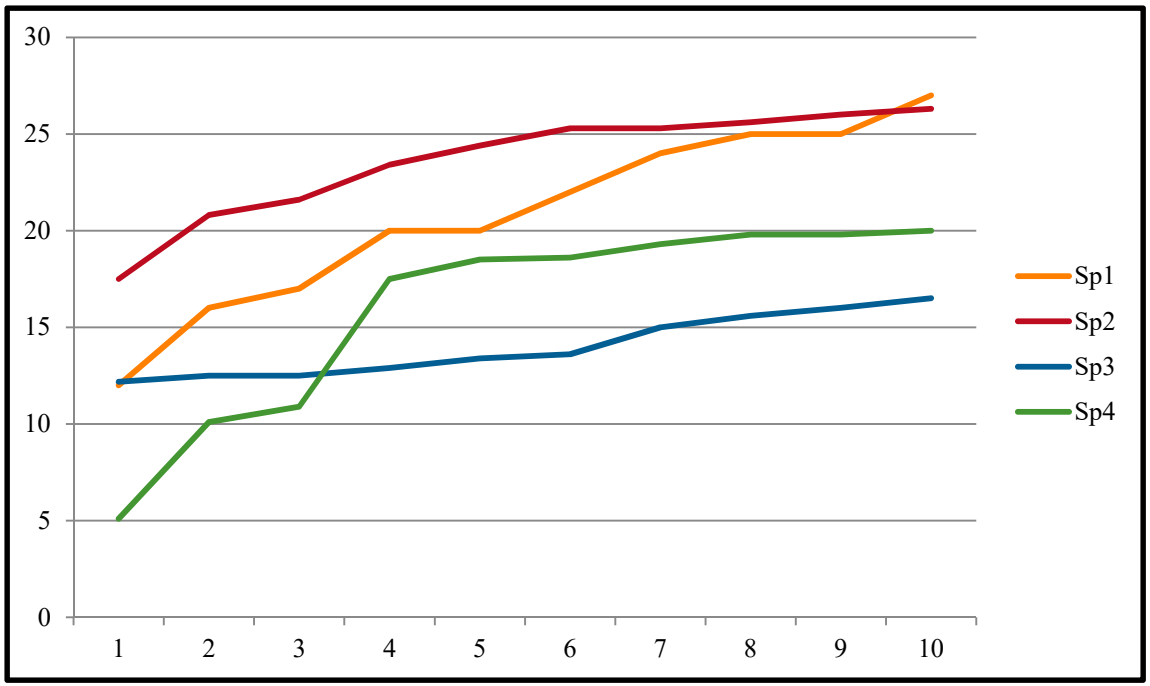
HNR Analysis: Experiment 2

- Harmonicity to Noise Ratio (HNR) measures the acoustic periodicity
- HNR values have been calculated using PRAAT
- Number of frames of each sound utterance and their values were extracted after analyzing periodicity
- The values are calculated to find out median of the sound

	Threshold for the median values of HNR
Female	Voiceless fricative: less than 3dB Voiced fricative: up to 17dB Approximant: above 17dB
Male	Voiceless fricative: less than 3dB Voiced fricative: above 3dB Approximant: above 10dB

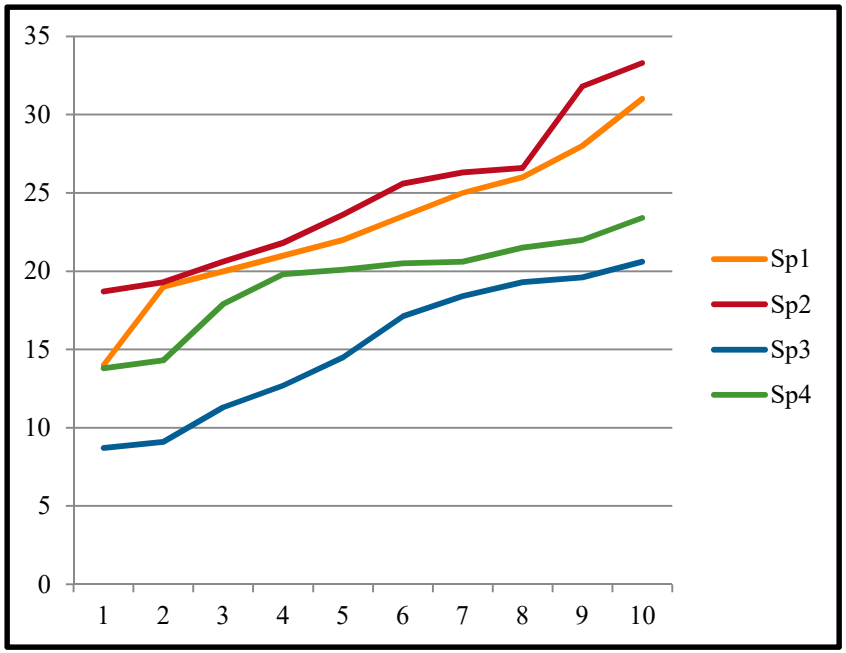
No. of Sp	Positions	Approximant (%)	Fricative (%)	Mixed (%)
Sp1 (F)	/l/ initial	70	30	-
	/l/ medial	90	10	-
	/l/ final	100	-	-
	/j/ initial	20	20	60
	/j/medial	50	50	-
	/v/ initial	60	40	-
	/v/ medial	70	30	-
Sp2 (F)	/l/ initial	90	10	-
	/l/ medial	100	-	-
	/l/ final	100	-	-
	/j/ initial	70	30	-
	/j/medial	100	-	-
	/v/ initial	60	40	-
	/v/ medial	90	10	-
Sp3 (M)	/l/ initial	100		
	/l/ medial	80	20	-
	/l/ final	100	-	-
	/j/ initial	100	-	-
	/j/medial	100	-	-
	/v/ initial	80	-	20
	/v/ medial	90	10	-
Sp4 (M)	/l/ initial	90	10	-
	/l/ medial	100	-	-
	/l/ final	80	20	-
	/j/ initial	60	40	-
	/j/medial	100	-	-
	/v/ initial	50	50	-
	/v/ medial	100	-	-

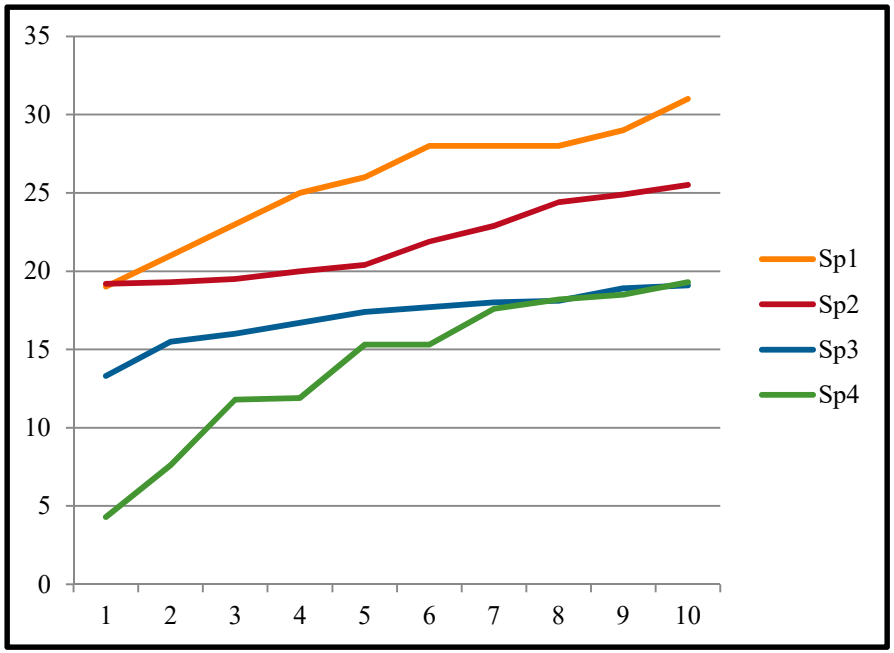
Graph Analysis /l/



- /l/ median values at initial position
- 100% approximant behavior in Sp3
- Abrupt behavior in Sp4

Graph Analysis /l/

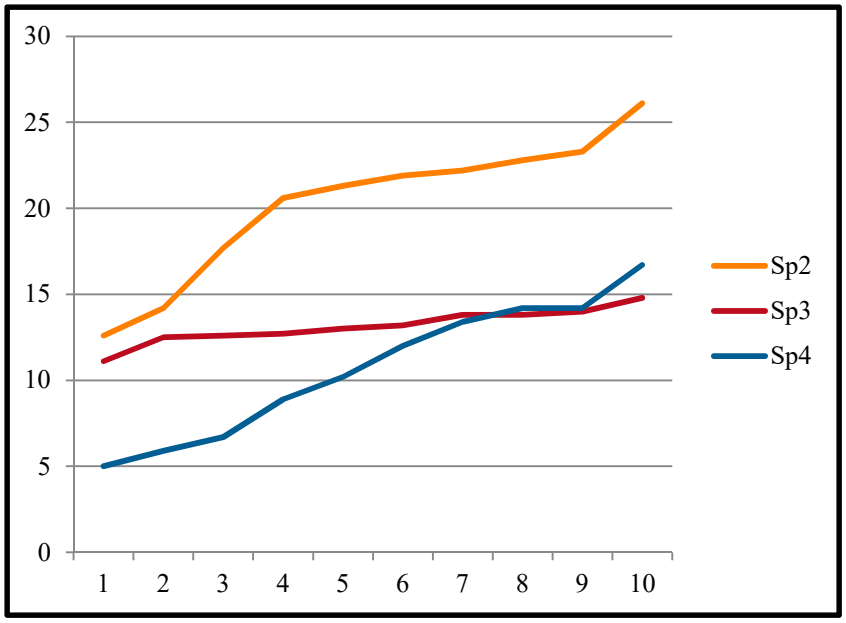




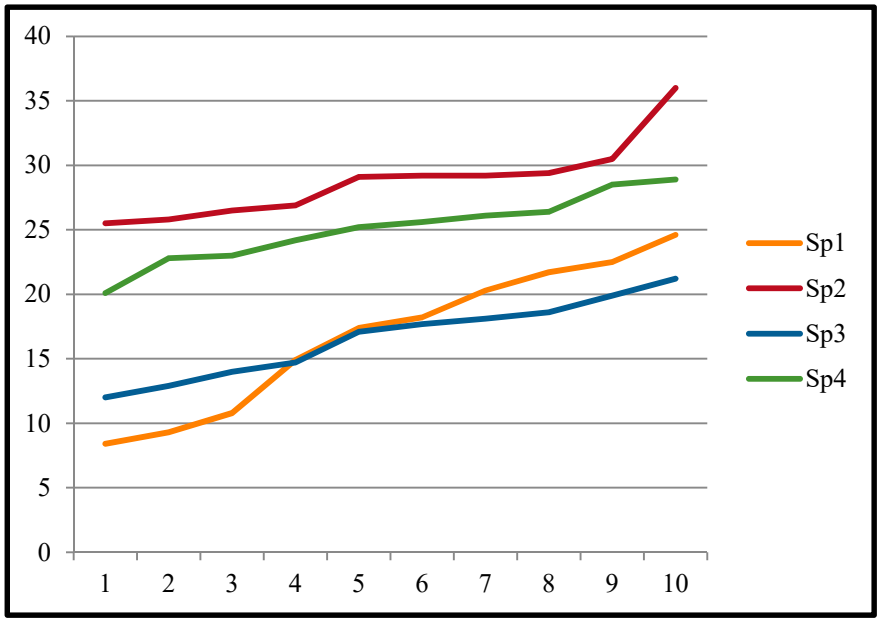
- /l/ median values at medial position
- Some utterances of Sp1 and Sp3 have fricative property

- /l/ median values at final position
- Only 2 utterances of Sp4 are fricative occurred with following pause

Graph Analysis /j/

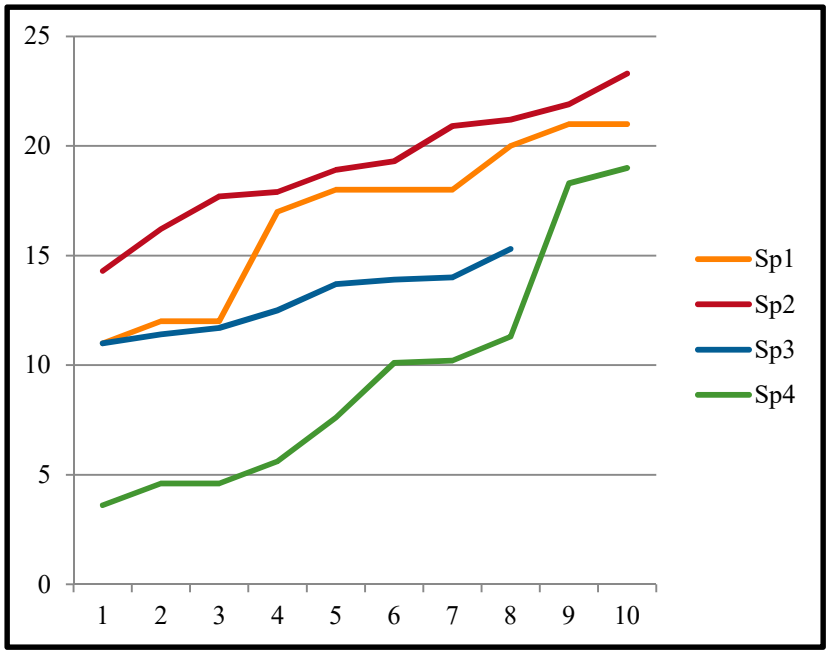


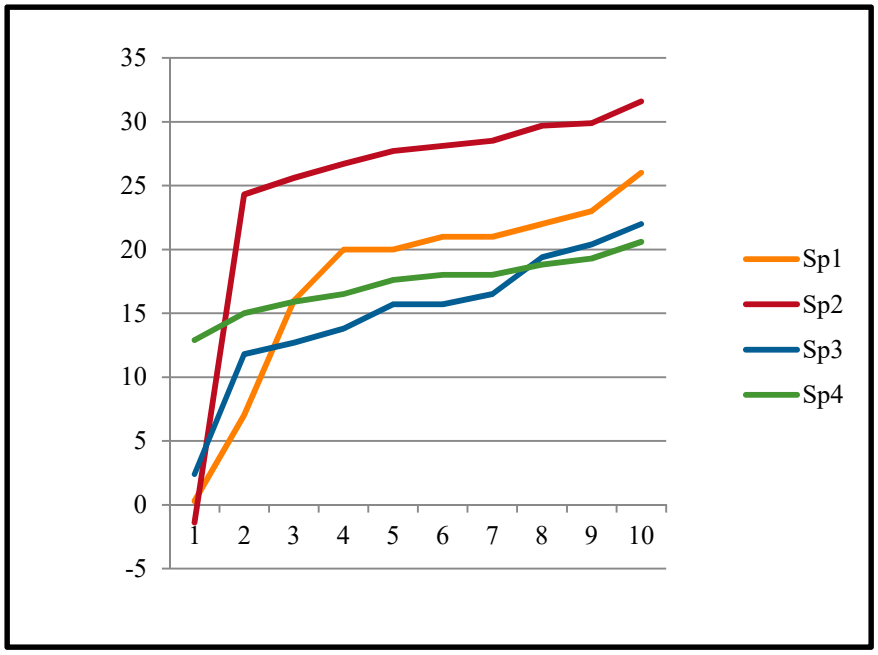
- /j/ median values at initial position
- Sp3 represents 100% approximant behavior



- /j/ median values at medial position
- /j/ has approximant behavior in Sp 2, 3 and 4

Graph Analysis /v/





- /v/ median values at initial position
- The fricative behavior of /v/ utterances is also due to the impact of neighboring fricatives on /v/ sound.

- /v/ median values at medial position
- Sp2 and 4 has more gradual behavior of /v/ as approximant

Research Findings (1/2)

- Speaker specific behaviors have been observed in the analysis of /l, j and v/
- The dual property of /j/ in Sp1 is occurred when it is preceded by pause and when the syllable is stressed
- /j/ takes the acoustic property of fricative to differentiate itself from high vowels like /i:/, /e:/ or /u:/
- when /j/ comes with /a:/ sound in unstressed context it becomes approximant
- It is also observed that sometimes /j/ takes frication because of its neighboring fricative consonant.

Research Findings (2/2)

- /l/ takes frication when it is followed by a pause
- /l/ changes its acoustic property or lose formants when it comes with any fricative sound i.e. /h, x, s/ etc.
- /v/ behaves like approximant when it comes at word medial position
- /v/ can also become voiceless fricative due to neighboring /h/ sound indicating neighboring fricatives can influence target sound.
- It is also observed that the Sp4 is using the fricative quality in case of unstressed context and in stressed context; it is using more approximant like property

Conclusion and Future Dimensions

- /l, l^h, j, v and v^h/ sounds of Urdu have been investigated in this study to find out their acoustic properties as approximants
- These sounds show dual property of fricative and approximants although the percentage of approximant is greater than the fricative
- Acoustic analysis indicates that /l/ shows longest duration at final position than others and /v/ shows lowest F2 values than others
- Results tells that /l^h/ is now pronounced as /l and h/ and /v^h/ is mostly changed into its un-aspirated version by the speakers
- In future, acoustic properties of /r/ and /ɽ/ and their aspirated versions which are claimed to have approximant like behavior would be analyzed using scientific methods.

Thank You

Any Questions?