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Acoustic Analysis Of Lasi Accented English Vowels: A Comparative Study

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Abstract
This study investigates the acoustic variations of Lasi accented English vowels produced by native Lasi speakers in terms of their formant frequency, duration and vowel quality. In this regard, speech samples were collected from fifty nonnative English speakers whose native language is Lasi (a dialect of Lasi). Ten participants were selected from high-middle class, aged between 10-15 years. Speech samples adopted from (Wells, 1962) were made in CVC context with (hVd) pattern by embedding vowels in an isolated word and in a carrier sentence. A Del laptop was used for recording the data through PRAAT-2016 speech processing software with set sampling frequency 16000 Hz recoding response with conference mic having 16000 Hz input frequency response in blare and echo free environment. Vowel formant frequencies (F1, F2), and duration by using PRAAT were measured to extract typical spectrograms and formant tracks. The deduced data were used to create comparison charts formant frequencies and durational ones along with dialectical vowel inventories with comparison to their peripheral counterparts. Analysis showed that almost all English vowels show variation in terms of height of tongue and its forwarded and retrieved position. Acoustic analysis shows that vowels /ɔ:// æ/ and /ʌ/are unintelligible in terms of height of tongue whereas in terms of backness of tongue, these vowels /ɒ/, /ɔ:/, /u:/ and /ɜ:/are unintelligible as native British English listeners.

1. Introduction
Lasi was given the status of an official language in the province of Sindh (Cole, 2006). According to the 1998 census, there are 30.4 million Lasi speakers; statistics also declared officially on the government website of Pakistan (Keerio, 2010). Lasi is written in extended Arabic script in Pakistan and Devanagari and Grumukhi script in India (Veesar, 2015a; 2015b; Zahid, A., 2016; Ali, 2021; Ali & Azam, 2021; Amin & Ali, 2021; Pathan, M.S.K 2023, Pathan, M. S. K. (2022), Pathan, M. S. K. (2023); Ali, et, al., 2021; Ali, et, al., 2023). Lasi has six dialects: Vicholi, Thareli, Kachchi, Lari, Lasi and Utradi (Northern) (Grierison, cited in Allana, 1998). The geographical locations in Sindh name various dialects in Lasi. For instance, Vicholi is spoken in central Sindh, i.e., Hyderabad, Jamshoro. Thareli is spoken in Thar i.e., Therparker. Kachchi dialect is spoken in Gujrat India. Lari is spoken in Lar. Lasi dialect is spoken in Lesbela located in Balochistan. Utradi dialect is spoken in upper (Northern part of Sindh) Sindh.
Lasi dialect is spoken in district Lasbela and some parts in Thatta and Badin. Lasi at Las is named Lasi. It is the language of common people at Lasbela.
Most of the speakers of district Labela, speak Lasi language, and approximately 70% people of Lasbela speak Lasi language as their mother tongue which is actually a dialect of Lasi. According to the survey of Safer magazine in 2015 there are more than 200000 (.2 million) speakers of Lasi. According to census report 1951 Lasi at Lasbela is 92 percentages. Lasi is different from other dialects, as Baloch (2008) argues that there is always separate color and effect of the area on the language.

2. Vowels
Articulation of speech sounds needs energy therefore respiratory system pushes air out of lungs (Peter Ladefoged & Keith Johnson , 2006). Lodge (2009) argues that when air comes up from lungs by passing through vocal cords and vibrate in vocal tracts to produce vowels pronounced with opened mouth, no contact between the tongue and the top of mouth or teeth and no obstruction to the flow of air for the sound. Vowels are articulated with a relatively free flow of air and all are typically voiced. (Yule, 2004). However, Peter Roach believes to study the sounds of speech scientifically is not easy to define exactly what they mean because there are some English consonant sounds at onset position in the words like 'Hay and Way' are articulated without obstructing the flow of air (Roach, 1998). Therefore, different sound groups; vowels and consonants have distinctive distributions so they require different way for the analysis. Peter Roach views to understand vowel in two dimensions of tongue considering its shape and the position. The shape refers tongue having vertical distance between its upper surface and the palate whereas the position refers its horizontal distance for the frontness and the backness of the

tongue body. Analysis of consonants is done with reference to their place and manner of articulations whereas vowels are analyzed as front versus a back and a high versus a low area.

2.1. British English Pure Vowels

British English has twelve pure vowels; /iː/, /ɪ/, /e/, /æ/, /ɒ/, /ɑː/, / ɔ/, /ʊ/, /uː/, /ə/, /ɜː/, /ʌ/. Out of these, seven vowels are short; /ɪ/, /e/, /æ/, /ɒ/, /ʊ/, /ə/, /ʌ/ and five vowels are long; /iː/, /ɑː/, /ɔ/, /uː/, /ɜː/. Among these vowels, there are four front, five back and three central vowels.

Table 1: British English pure vowels (Roach, 1998)

Short Vowels	*Words*	*Long Vowels*	*Words*
/ɪ/	Pit	/iː/	Key
/e/	Pet	/ɑː/	Car
/æ/	Pat	/ɔː/	Core
/ɒ/	Pot	/uː/	Coo
/ʊ/	Put	/ɜː/	Cur
/ə/	About		
/ʌ/	Putt		

3. Acoustic Classification of Vowel Sounds

Phonetics describes speech whereas acoustic phonetics studies its physical properties as sound waves in the air. Ladefoged (2006) considers that acoustic analysis provides instrumental approach through visual representation of the sound because acoustically vowel sounds have distinctive 'overtone pitches' which characterize quality for individual sound and the overtones are called formants. The formants are symbolized as F1 for the first formant and F2 for the second formant and F3 for the third formant. The lowest three formants are different from each other for the vowels. To understand how formants arise, the sound travels from vocal tracks to the lips then its energy moves from the listener to hearer while some of the sound energy reflects back into the vocal tract which becomes energy source for vowel quality with its frequency level due to interacted and reflected sound waves.

3.1. Acoustic properties of RP Vowels

Discussion of acoustic classification of vowels leads to understand acoustic properties of vowels as three factors are involved first the height of the body of the tongue, second, the front-back position of the tongue and third the degree of lip rounding however, scholars of acoustic phonetics find third factor difficult to define precisely therefore prefer first two factors sufficient to identify acoustic properties of vowels along with measurement of duration (Deterding, May 1997), (James Hillenbrand, 1995). Therefore, F1 represents height of the tongue whereas F2 represents frontness and backness of tongue. As F1 is related to the height of the tongue therefore if the F1 value was lower the cavity would be the longer or vice versa.Whereas,F2 is concerned with the length of the oral cavity in terms of frontness and backness of the tongue body therefore if the F2 was/were lower, the cavity would be longer and back vowels would be produced whereas F1 and F2 values are roughly in between the two extremes, the central vowels was/were produced (Gordon E. Peterson, Harold L. Barney, 1952), (Keerio, November 2010) and (Gordon Hunter & Hanna Kebede, 2012). For comparative acoustic analysis of Lasi accented English vowels, vowel quality from 'A study of the formants of the pure vowels of British English' (Wells, 1962) has been adopted as counterparts as many of the standard formant values for English vowels have been depended on citation words spoken specially for the purpose of obtaining the measurements. The classical study of Peterson and Barney related to vowel quality and measurement of vowels (Gordon E. Peterson, Harold L. Barney, 1952) was replicated by James Hillenbrand in his study 'Acoustic characteristics of American English vowels'. Therefore, this study is also replication from classical study of British Standard English (R.P) and the quality of R.P vowels is given in Table 2 which is used as peripheral counterpart for the comparison of Lasi accented and British English. *Acoustic Analysis Of Lasi Accented English Vowels: A Comparative Study*

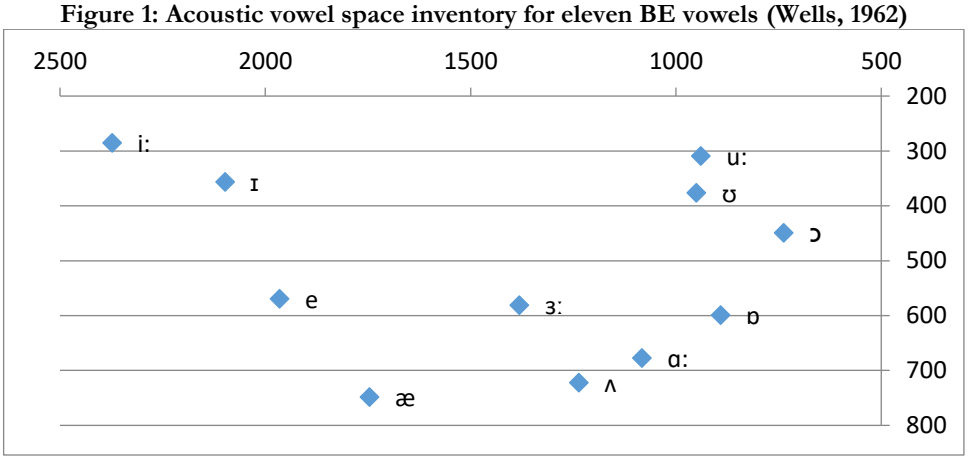
Table 1: Properties of RP Vowels (Wells, 1962)

S. No	*Vowels*	*F1(Hertz)*	*F2(Hertz)*	*Duration (millisecond)*
1.	[iː]	285	2373	293
2.	[ɪ]	356	2098	139
3.	[e]	569	1965	170
4.	[æ]	748	1746	210
5.	[ɑː]	677	1083	335
6.	[ɒ]	599	891	178
7.	[ɔ]	449	737	283
8.	[Ʊ]	376	950	142
9.	/uː/	309	939	294
10	[ʌ]	722	1236	148
11	[ɜː]	581	1381	261

Ladefoged (2001) recommends plotting the vowels of different dialects in the same acoustic vowel space because it provides an excellent way of comparing different dialects of a language. He also writes that this kind of plot arranges vowels in a similar

way to the vowels in the IPA vowel chart. The formant frequencies are spaced in accordance with the Bark scale, a measure of auditory similarity, so that the distance between any two sounds reflects how far apart they sound.

Figure 1: Acoustic vowel space inventory for eleven BE vowels (Wells, 1962)



3.2. Acoustic Analysis of Native Accented English

Classical study by Peterson and Barney was foundation for acoustic analysis on the basis of General American English vowels which were studied as acoustical measurements of the formant or energy concentration positions in the speech waves. Men, women and children; 33, 28 and 15 respectively were recruited to pronounce twin list of ten words for 1520 speech tokens. The recruited population presented broader regional sampling of the United States even some of them were nonnative speakers of General American English. This study contributed to understand the variations that appear in a broad sample of speech with the use of formant values, acoustic vowel plot and speech spectrograms, used the application of powerful statistical methods in the analysis of the data and revealed both the production and the identification of vowel sounds by an individual depend on his previous language experience (Gordon E. Peterson, Harold L. Barney, 1952). Similarly J.C Wells' 'A study of the formants of the pure vowels of British English' was also foundation for acoustic analysis involving one speaker as research participant for data collection (Wells, 1962). James Hillenbrand proposed acoustic characteristics of American English vowels in 1995 and involved 117 participants; 45 men, 46 women and 46 Children and the purpose of the study was to replicate and extend the classic study of vowel acoustics by Peterson and Barney (James Hillenbrand, 1995). David Deterding measured British English vowels acoustically with comparison to data taken from a standard database for his study of 'The Formants of Monophthong Vowels in Standard Southern British English Pronunciation' in 1997. Ettien Koffi studied 'The Acoustic Vowel Space of Central Minnesota English: Focus on Female Vowels' and it was first study in its kinds (Koffi, 2013) to undertake the acoustic vowel space of the dialect of American English spoken by female residents of Central Minnesota and he adopted the analysis methodology used in (Gordon E. Peterson, Harold L. Barney, 1952) and (James Hillenbrand, 1995).

3.3. Acoustic Analysis of Foreign Accented English

Apart from two colonial verities of English; British and American, new trend of making foreign accents of either English as variety has emerged since last few decades therefore sufficient related published literature has paved way to measure acoustic properties of foreign accented English with comparison to concerned counterpart. Hence, English language or foreign-accented English is the most studied language acoustically. In 2012, Gordon Hunter and Hanna Kebede studied 'Formant frequencies of British English vowels produced by native speakers of Farsi' by adopting studies; (Wells, 1962) and (Deterding, May 1997). Packer and Lorincz studied 'Acoustic vowel space analysis of an English language learner' to understand vowel quality along with variation and intelligibility of GAE vowels produced by a native Arabic speaker (Claire Brakel Packer & Kristen Lorincz, 2013). Vowel quality and intelligibility of lax vowels of GAE were assessed by involving 10 Somali male speakers as non-natives speakers of GAE and acoustic signals were compared with Peterson and Barney's landmark study of 1952. A study was carried out to analyze vowel quality through formant values produced by native speakers of Chinese and American English for English vowels (Hsueh Chu Chen & Wang, Mei Jung). The languages use similar script or have a similar writing style as used by Lasi, and their elemental sounds have been studied acoustically in the study of modern Persian language vowels (Ansari, 2004). Acoustic analysis of Urdu and Siraiki language at the Centre for Research in Urdu Language Processing (CRULP) was studied to carry out by Amna (2003) and Sarwar(2004). Abdul Malik Abbasi investigated the spoken English of Lasi ESL learners through an acoustic and articulatory phonetics by examining the English consonants which illustrated eleven problem-posing English consonants (Abbasi, 2012). So there is no such comprehensive study reported in published literature so far on the subject of acoustic-phonetics related to the elements of vowel sounds of English as Lasi accented English with similar analysis based on L1 dialect specific acoustics variations. Works reported in the literature to date on the language has been either on articulatory-phonetics or the language 's writing system, grammar, dialects and history etc.

4. Vowels of Lasi Language

According to Jatoi (1996) and Amin & Ali (2021), contains ten vowels which are given in below:

Table 3. Vowels of Lasi Language

S. No	*IPA Symbols*	*Lasi*	*Lasi*	*Translation*
01	/iː/	اِي	سِيرَ	Wave of the sea
02	/ɪ/	اِ	سِرَ	A brick
03	/e/	اي	سيرَ	Unit of Weight (One kilo)
04	/ɜː/	اَي	سَئيرَ	Walk
05	/ə/	اَ	سَرَ	Name of Plant
06	/ɑː/	آ	سارَ	Remember
07	/ɔː/	اَو	چَو ندئو	You will say
08	**/O/**	او	چَوندو	He will say
09	/ʊ/	اُ	سُرَ	Tune
10	/uː/	اُو	سُورَ	Pain

(Jatoi, 1996)

4.1. Research Concern

Acoustic Analysis of Sindhi Speech by Ayaz Keerio is landmark in the history of Sindhi, because the langue has been studied instrumentally for the first time. Keerio (2010) cites studies of Trumpps, Khubchandani, Sir Grierson and Paroo Nihalani for grammar, phonology, history, the stop consonants and dialectical geography of Lasi. Zahid Ali (2016); Pathan, M. S. K. (2023) has analysed the morpho-syntactic and morpho-phonemic properties of the Sindhi verb in his doctoral thesis. Jatoi's replicated work describes vowel and consonant sounds, morphology and history of Sindhi language (Jatoi, 1996). Sarfraz Raza's phonemic inventory with acoustic analysis of voiced implosives of Sindhi. In Haider's study (2004), Vowel-Consonant Segmentation is carried out between Sindhi and Arabic languages acoustically and the study guides for development of efficient speech recognition systems for both languages. There is least availability of acoustically analyzed Lasi accented English apart from Amin & Ali (2021) regarding morpo-phonemic analysis of Lasi lexemes. Therefore, the study aims at analyzing the acoustic variation of English vowels when produced by native Lasi speakers as non-natives English speakers. Further, a comparative analysis has been carried out to find subtle or major differences in acoustic properties of British and Lasi accented English vowels. The current study attempts to find out acoustics variation through comparative analysis in the properties of English vowels when produced by L1 Lasi and L1 English speakers.

5. Research Methodology

This section outlines discussion regarding research methodology, targeted population, stimuli list data collection process and its analysis as per objectives of the study in order to find answers in accordance with the research questions.

5.1. Methodology

The study is based on quantitative approach, which contributes to a better understanding of the phenomena under investigation (Manfred Krug, Julia Schlu¨ ter, 2013), because it provides rich in-depth data and ensure their generalizability to larger contexts. As the study is characterized by the use of numbers to represent its data and emphasis is on the use of statistics to make generalizations from samples to populations. The participants belonged to following towns:

Table 4: Targeted population

S. No	*Name of City*
1.	Uthal
2.	Bela
3.	Winder
4.	Hub Choki
5.	Kanraj
6.	Goth Ismaili
7.	Lyari (Kund Malir)
8.	Kundi

5.2. Participants

Ten participants of native speakers of Lasi participated in the research. Participants were from high-middle class. The age of the subjects ranged between 15-20 years. In order to obtain information about age, education and gender, participants were asked to fill a given printed sheet and some of them refused to fill in order to save time but the required information was noted.

5.2.1. Stimuli

The participants were given a list of words to pronounce in CVC (hVd) context. To explain the context, the vowels in isolation or /hVd/ context are referred as 'null environment' which was used in (Gordon E. Peterson, Harold L. Barney, 1952), (Wells, 1962), and (James Hillenbrand, 1995). Hence, the list of English words was provided to the participants to produce in the following manner:

i. Participants pronounced the vowels in isolated words as same word used to be repeated three times in same sequence; hence, 33 speech samples were collected from each participant.
ii. Participants pronounced the vowels in isolated words as three different words with different vowel sounds were pronounced randomly hence 33speech samples were collected from each participant.
iii. Participants pronounced vowels in carrier sentences (Say the word____ again/ Say the word___ please) as sentence was repeated randomly hence 33 samples were collected from each participant.

In this way recoding of 99 speech samples was collected from each participants making sum of 4950 samples from 50 speakers.

Table 2: Adopted from (Wells, 1962)

Vowel	***CVC(hVd)***	***Word***
/*iː*/	/hiːd/	Heed
/ɪ/	/hɪd/	Hid
/e/	/hed/	Head
/ æ/	/hæd/	Had
/ɑː/	/hɑːd/	Hard
/ɒ/	/hɒd/	Hod
/ɔː/	/hɔːd/	Haw'd
/ʊ/	/hud/	Hood
/*uː*/	/huːd/	Who'd
/ʌ/	/hʌd/	Hud
/ɜː/	/hɜːrd/	Heard

In English, there are twelve pure vowels. Central vowel **/ə/** in word like **'about'** is not included in the stimuli list. For the reason **[ə]** does not exist in the stressed syllable of English word (Roach, 1997 & Lodge, 2009).

5.3. Data Collection Process

The data were collected through snowball technique (a friend-of-a-friend) to involve participants and their friends in order to decrease social distance and increase a sense of familiarity (Labov, 1972). The participants were required to pronounce stimuli list as discussed above. Therefore, a Del laptop was used for recording the data through PRAAT-2016 speech processing software with set sampling frequency 16000 Hz recoding response. The recording was done with conference mic, which had 16000 Hz input frequency response too.

5.4. Data Analysis Procedures

The study measured the vowel formant frequencies (F1, F2), and duration by using PRAAT, which is the most widely used and very powerful speech analysis software (Manfred Krug, Julia Schlu¨ ter, 2013). For dialectical specification Mean average value of each vowel was calculated on Microsoft Excel program, which was also used to create F1, F2 and durational charts based on dialectical specification. Mean values for F1, F2 and duration were compared with those of vowels accented by native speakers of English and got answer for research question to know acoustic variations between Lasi and English accented vowels. Moreover, Excel was used to convert mean values of F1 and F2 in accordance with the Bark scale suggested by Zwicker and Terhardt (1980) and (Peter Ladefoged & Keith Johnson , 2006) for acoustic vowel space inventory. The vowels were plotted on inverted scales of F1 against F2 to show their quality for open/close and front/back dimensions hence research objective to find out acoustics properties of English vowels when produced by Lasi native speakers. Moreover, PRAAT was used to extract typical spectrogram and formant tracks for individual English vowel accented by Lasi native speakers. Furthermore, to achieve research objectives, it was observed whether vowels pronounced by the nonnative speakers were intelligibility to British English hearers or not. In order to evaluate vowel intelligibility, it is stated in (Koffi, 2012) the median frequency range is 135 Hz for F1, and 170 Hz for F2 for vowel of same type produced by native and nonnative speakers whereas exceeding the limit indicates unintelligibility of vowel(s). The F1 median frequency distance shows (un)intelligibility in terms of height of tongue whereas the F2 median frequency distance shows (un)intelligibility in terms of backness of tongue. F1 acoustic distance was measured between adjacent pairs of vowels because the first formant possesses 80% of the total acoustic energy of the vowel whereas the second formant is not as prominent as the first formant even it is not as expanded as the first formant.

6. Acoustic Analysis of Lasi accented English Vowels

Eleven British English vowels, accented by Lasi speakers belonging to Lasi dialect, have been under taken acoustically and detailed analysis is as it follows:

Figure 2: Comparison of F1 Mean Values for British and Lasi Accented English Vowels.

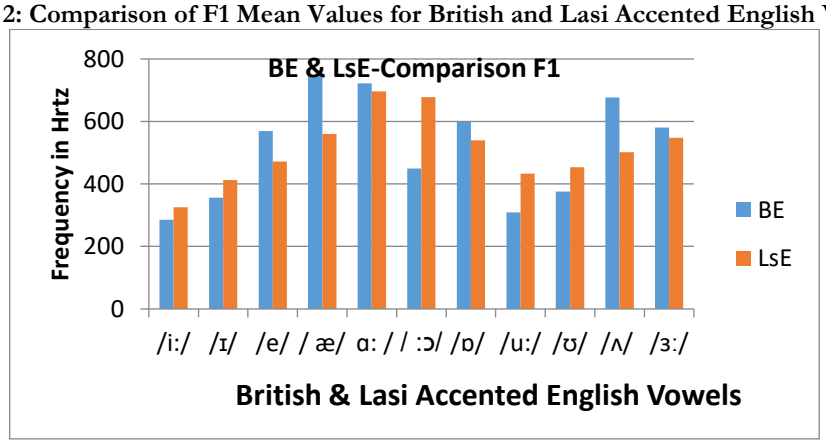


Figure 3: Comparison of F2 Mean Values for British and Lasi Accented English Vowels

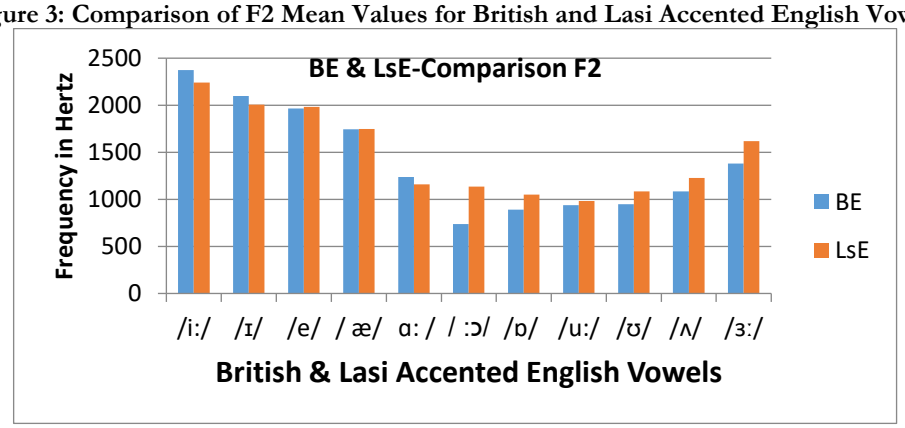


Figure 4: Comparison of British and Lasi English Vowels for Durational Mean Values

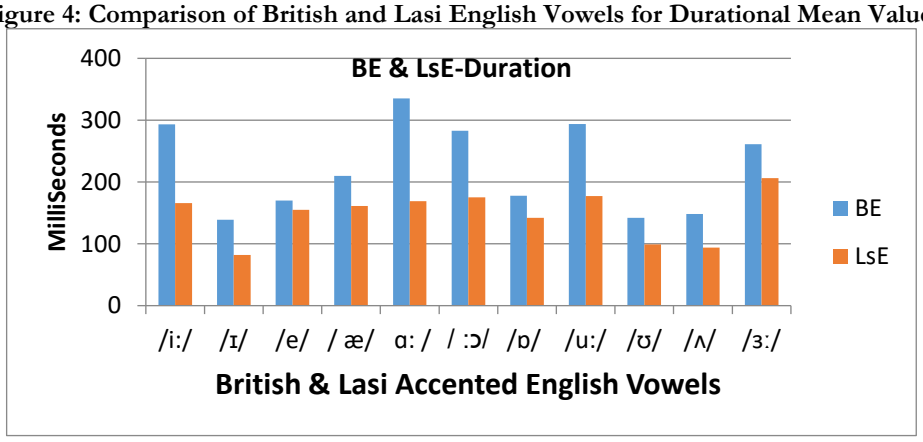


Figure5: F1 & F2 Formant Frequency in Hertz for Eleven Lasi Accented English Vowels

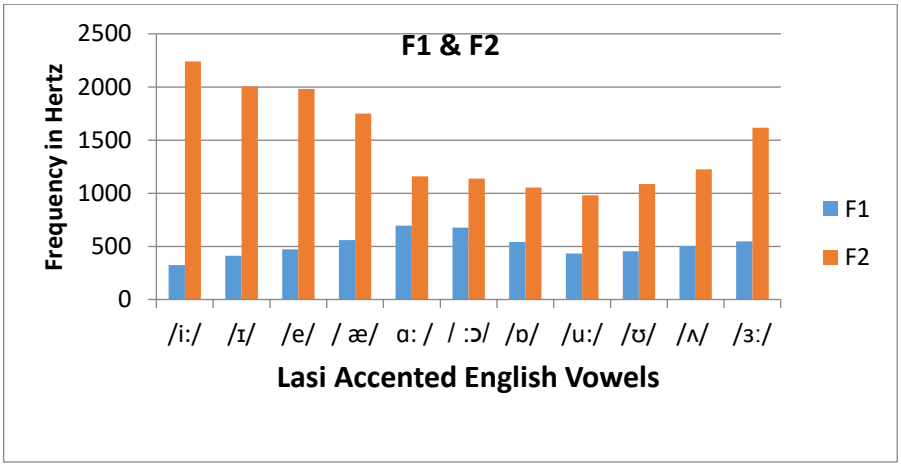


Figure 6: Acoustic Vowel Space for Eleven English Vowels Accented by Lasi Speakers

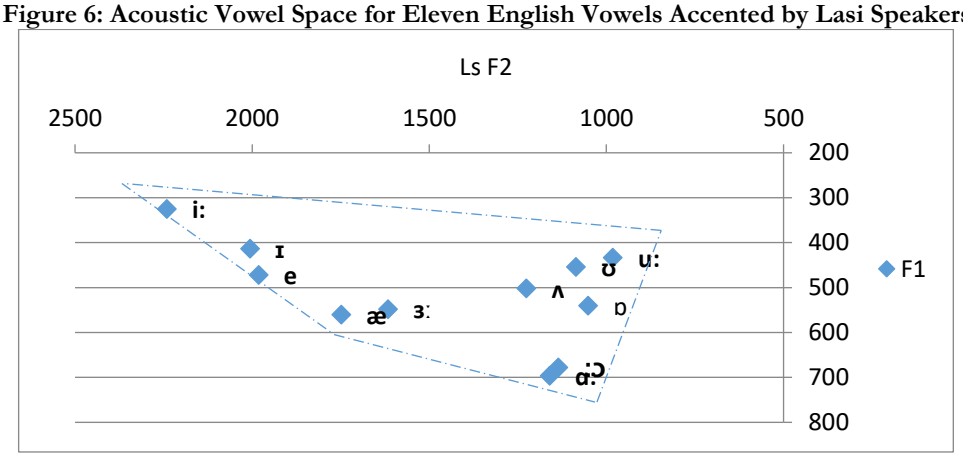


Figure 7: Comparative Acoustic Vowel Plot for Eleven British Standard & Lasi Accented English Vowels

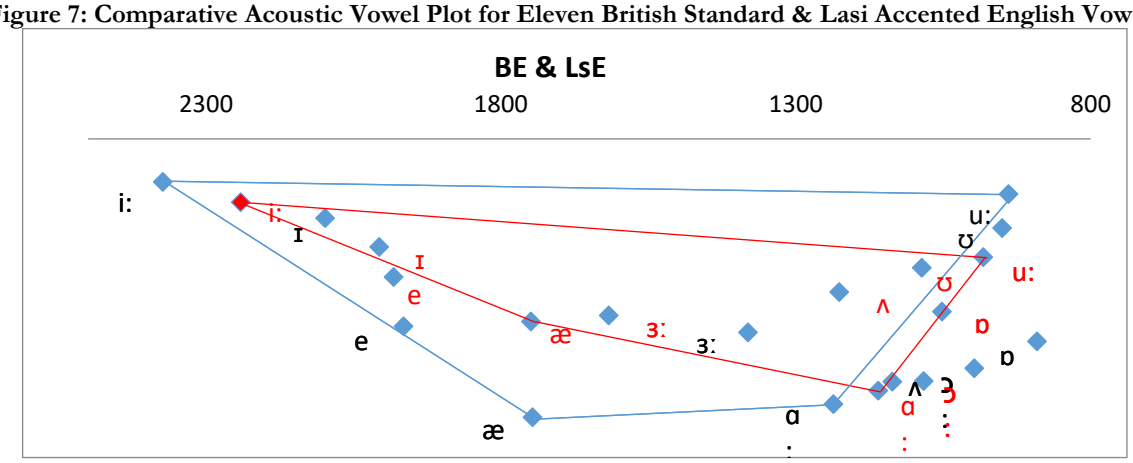


Table 7: Mean values of First Formant in Hertz (F1), Second Formant in Hertz (F2) and Duration in milliseconds for eleven British and Lasi-Vicholi accented English vowels

Vowels	***BE-F1***	*SlsE F1*	***BE-F2***	*SlsE F2*	*BE Duration*	*SlsE Duration*
/i:/	285	325	2373	2241	293	166
/ɪ/	356	413	2098	2006	139	82
/e/	569	472	1965	1982	170	155
/ æ/	748	560	1746	1749	210	161
ɑ: /	722	696	1236	1160	335	169
/ɔ: /	449	678	737	1136	283	175
/ɒ/	599	540	891	1052	178	142
/u:/	309	433	939	982	294	177

/ʊ/	376	454	950	1086	142	99
/ʌ/	677	502	1083	1226	148	94
/ɜ:/	581	548	1381	1617	261	206

Table 8: F1 Distance in Hertz between BE and SUE Vowels measured for vowel Intelligibility

Vowels	*F1 Frequency*	*F1 Difference*
British English /i:/ vs. Lasi English /i:/	285-325	40
British English /ɪ/ vs. Lasi English /ɪ/	356-413	57
British English /e/ vs. Lasi English /e/	569-472	97
British English / æ/ vs. Lasi English / æ/	748-560	188
British English /ɑ: / vs. Lasi English /ɑ: /	722-696	19
British English /ɔ: / vs. Lasi English /ɔ: /	449-678	229
British English /ɒ/ vs. Lasi English /ɒ/	599-540	59
British English /u:/ vs. Lasi English /u:/	309-433	124
British English /ʊ/ vs. Lasi English /ʊ/	376-454	78
British English /ʌ/ vs. Lasi English /ʌ/	677-502	220
British English /ɜ:/ vs. Lasi English /ɜ:/	581-548	33

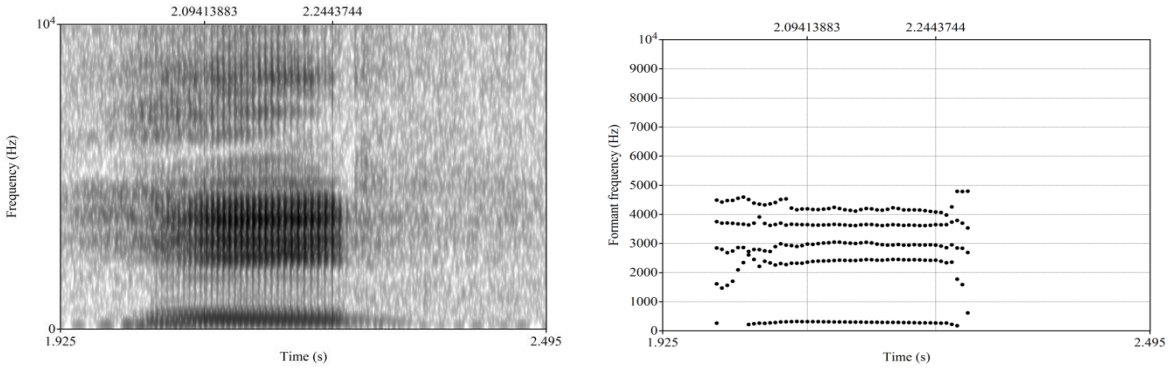
Table 9: F2 Distance between BE and SUE Vowels measured for vowel Intelligibility

Vowels	*F2 Frequency*	*F2 Difference*
British English /i:/ vs. Lasi English /i:/	2373-2241	132
British English /ɪ/ vs. Lasi English /ɪ/	2098-2006	92
British English /e/ vs. Lasi English /e/	1965-1982	17
British English / æ/ vs. Lasi English / æ/	1746-1749	3
British English /ɑ: / vs. Lasi English /ɑ: /	1236-1160	77
British English /ɔ: / vs. Lasi English /ɔ: /	737-1136	399
British English /ɒ/ vs. Lasi English /ɒ/	891-1052	161
British English /u:/ vs. Lasi English /u:/	939-982	43
British English /ʊ/ vs. Lasi English /ʊ/	950-1086	136
British English /ʌ/ vs. Lasi English /ʌ/	1083-1226	10
British English /ɜ:/ vs. Lasi English /ɜ:/	1381-1617	236

6.1. Acoustic Analysis of Lasi Accented English Vowel/i:/

Lasi speakers pronounced English high close-front vowel /i: / in 166 milliseconds with the lowest F1 (325 Hz) and the highest F2 (2241 Hz) shown in above figures. Therefore, the vowel has the greatest difference between its F1 and F2 as compared to rest of the vowels accented by the L2 speakers as shown in Figure…. Because of its lowest F1 and the highest F2 values, it is identified as SlsE close-high front vowel accented shown above. Further, SlsE adjacent vowel pair /i:/ and /ɪ/ have 88 Hz F1 acoustic distance (shown in Table …), which shows null confusion. Furthermore, BE and SlsE vowel /i:/ is produced with F1 (285, 325 Hz) and F2 (2373, 2241 Hz) by the native and the non-natives speakers respectively shown in tables mentioned above. So, it can be argued that acoustic distance between BE and SlsE vowel /i:/ is (40 Hz) and (132 Hz) for F1and F2 respectively. Hence the F1 and the F2 median frequencies distance lowered and retrieved tongue body from its peripheral counterpart but caused no unintelligibility of the vowel. Furthermore, the L2 speakers take comparatively less time to pronounce the vowel in 166 milliseconds whereas the L1 speakers produce it in 293 milliseconds.

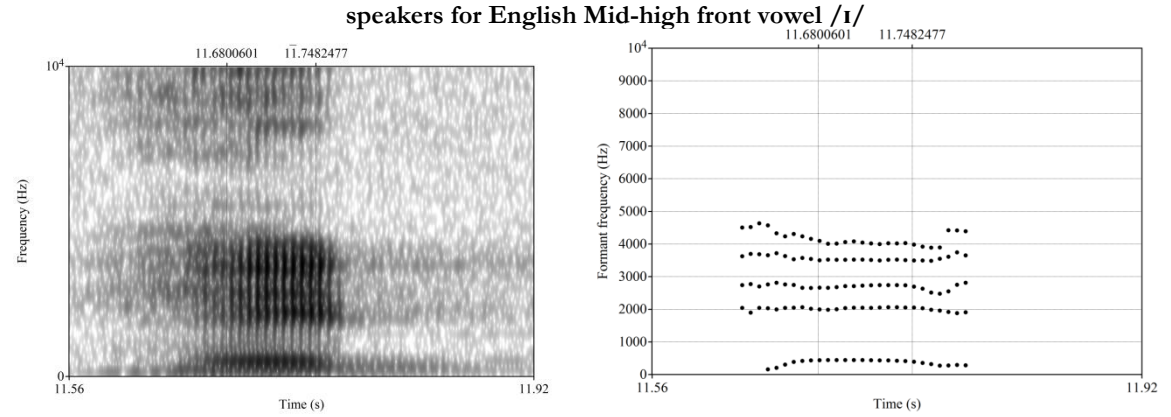
Figure 8: A typical spectrogram (left) Formant tracks (right) of the word utterance "Heed" accented by Lasi speakers for English close-high front vowel



6.2. Acoustic Analysis of Lasi Accented English Vowel /ɪ/

Lasi speakers pronounced English mid-high front vowel /ɪ/in 82 milliseconds with the second lowest F1 (413 Hz) and the second highest F2 (2006 Hz) among all the targeted vowels pronounced by Lasi speakers as shown in the above figures and table. It is seen that that formants are closer to each other as compared to those in vowel /i:/. Further, SlsE adjacent vowel pair /ɪ/ and /e/ have 59 Hz F1 acoustic distance (shown in Table 118), which shows slight confusion. Moreover, BE and SlsE vowel /ɪ/ is produced with F1 (356, 413 Hz) and F2 (2098, 2006 Hz) by native and non-natives speakers respectively shown in with acoustic distance; F1 (57 Hz) and F2 (92 Hz) shown above. Hence, the data shows the vowel is intelligible though produced slightly in lowered and retrieved tongue body from its peripheral counterpart respectively. Furthermore, the non-natives took comparatively less time (82 milliseconds) to pronounce vowel /ɪ/ whereas the natives produce it in 139 milliseconds.

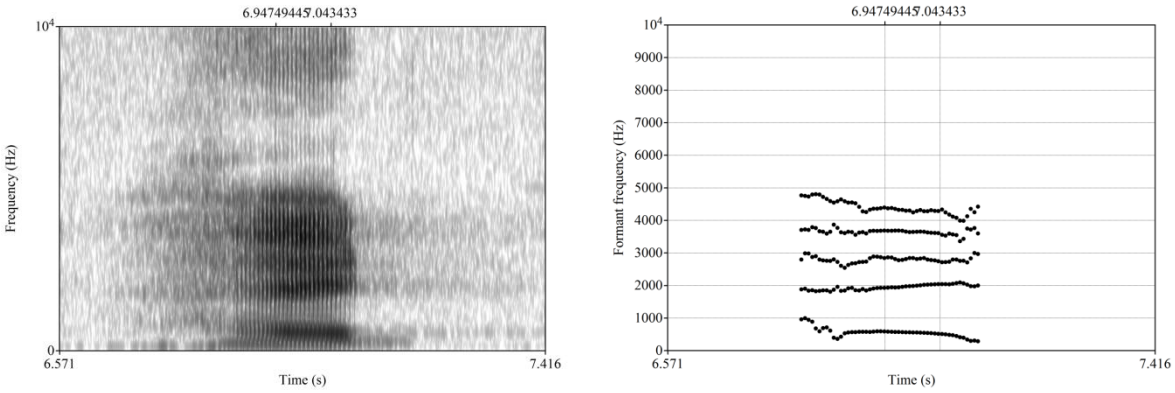
Figure 9: A typical spectrogram (left) Formant tracks (right) of the word utterance "Hid" accented by Lasi speakers for English Mid-high front vowel /ɪ/



6.3. Acoustic Analysis of Lasi Accented English Vowel/e/

Lasi speakers produced English mid-front vowel /e/ in 155 milliseconds with second lowest F1 (472 Hz) and F2 (1982) values among four front vowels of SlsE. Because of its decreasing F1 and F2 values, the vowel is produced as mid front vowel. Whereas, BE and SlsE vowel /e/ is pronounced with F1 (569, 472 Hz) and F2 (1965, 1982 Hz) by native and non-natives speakers respectively Table 123 with acoustic distance; F1 97 Hz and F2 17 Hz, which authenticates the vowel is intelligible though SlsE vowel/e/ is pronounced slightly in raised and retrieved tongue body from its peripheral counterpart. Furthermore, there is subtle difference in duration because the L2 speakers pronounce vowel /e/ in 155 milliseconds whereas the L1 speakers do so in 170 milliseconds.

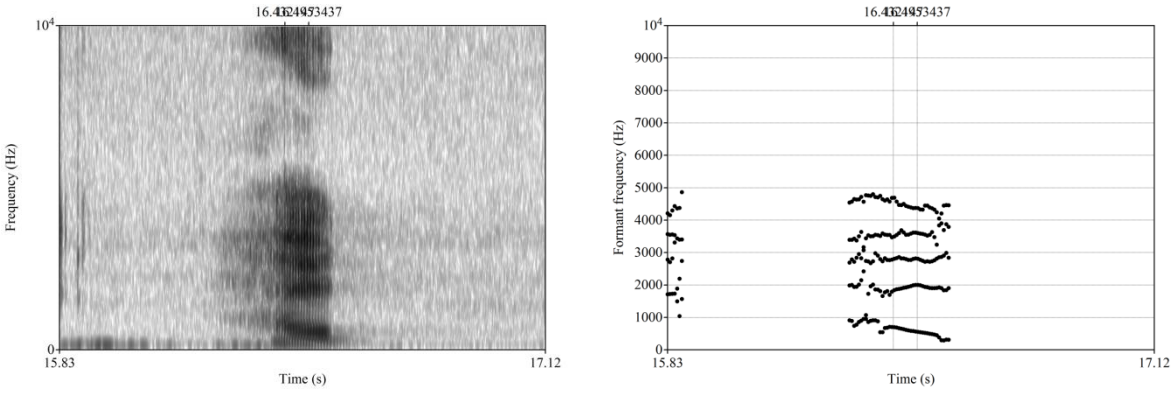
Figure 10: A typical spectrogram (left) Formant tracks (right) of the word utterance "Head" accented by Lasi speakers for English mid front vowel



6.4. Acoustic Analysis of Lasi Accented English Vowel/æ/

Lasi speakers pronounced English low-front vowel /æ/ in 161 milliseconds with the lowest F1 (560 Hz) and the highest F2 (1749 Hz) among four front vowels of SlsE. Therefore, F1 and F2 formants are the closest among four front vowels accented by the L2 speakers. It is shown that the speakers pronounce the vowel in accented fashion as SlsE low front vowel. Moreover, SlsE adjacent vowel pair; /æ/ and /e/ have null confusion because F1 acoustic distance between both vowels is 88 Hz. Furthermore, BE and SlsE vowel /æ/ is pronounced with F1 (748, 560 Hz) and F2 (1746, 1749 Hz) by the native speakers and non-natives respectively with acoustic distance; F1 188 Hz and F2 3 Hz. The F1 distance shows that the vowel is pronounced in raised tongue height from its peripheral counterpart, and it is observed as unintelligible one too to BE hearers. So the raising of the vowel led to occupy least space therefore it caused far more restricted vowel plot than that of BE. Moreover, the L2 speakers took less time (161 milliseconds) to pronounce vowel /æ/ whereas the L1 speakers pronounced same vowel in 210 milliseconds.

Figure 11: A typical spectrogram (left) Formant tracks (right) of the word utterance "Had" accented by Lasi speakers for English low front vowel

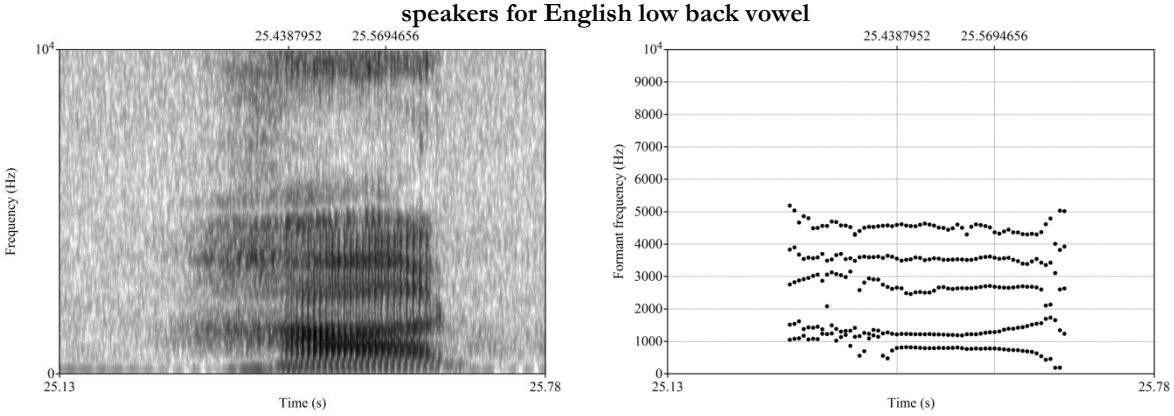


6.5. Acoustic Analysis of Lasi Accented English Vowel/ɑ:/

Lasi speakers pronounced English low-back vowel /ɑ:/ in 169 milliseconds with the highest F1 (696 Hz) and F2 (1160 Hz) values among five back vowels of SlsE. It is shown that formants are closest to each other and this vowel is accented as SlsE back low vowel. Further, BE and SlsE vowel /ɑ:/ is pronounced with F1 (677, 696 Hz) and F2 (1083, 1160 Hz) by the native and the non-natives speakers respectively with acoustic distance; 19 Hz and 17 Hz for F1 and F2 respectively. therefore, the vowel is neither accented in different fashion nor unintelligibility is observed though it is pronounced slightly with lowered and forwarded tongue body from its peripheral counterpart. Furthermore, SlsE vowel /ɔ:/ is adjacent vowel to /ɑ:/instead of /ɒ/ shown in Figure… therefore vowels; /ɑ:/ and /ɔ:/ have absolute confusion because F1 distance between them is 18 Hz.

Furthermore, the L2 speakers take less time (169 milliseconds) to pronounce the vowel as compared to the L1 speakers doing so in 335 milliseconds for same vowel.

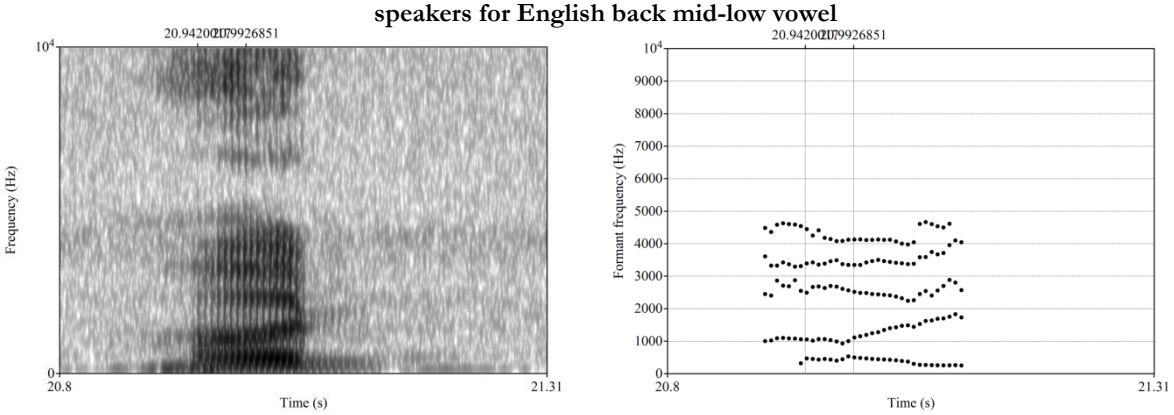
Figure 12: A typical spectrogram (left) Formant tracks (right) of the word utterance "Hard" accented by Lasi speakers for English low back vowel



6.6. Acoustic Analysis of Lasi Accented English Vowel/ɒ/

Lasi speakers pronounced English back-mid low vowel /ɒ/ in 142 milliseconds with third highest F1 (540 Hz) and F2 (1052 Hz) among five back vowels of SlsE. It is seen that its formants formed more distance as compared to those of SlsE vowel /ɑ:/ discussed in preceding vowel analysis part. Even greater distance between F1and F2 is observed than that of SlsE vowel /ɔ:/ as vowel /ɒ/ has lesser F1 value than the /ɔ:/ so tongue body raises and lowers for SlsE vowels; /ɒ/ and /ɔ:/ respectively. Therefore, Figure … shows this vowel is pronounced as SlsE back mid vowel rather back mid-low. Hence, Lasi speakers akin to those of Lari, Vicholi, Utradi and Thareli would pronounce /ɔ:/instead of /ɒ/. For instance, shod as shored, cod as cord, wad as ward and poll as Paul and vice versa. Furthermore, BE and SlsE vowel /ɒ/is pronounced with F1 (599, 540 Hz) and F2 (891, 1052) respectively with median frequencies distance; F1 59 Hz and F2 161 Hz therefore the distance indicated the vowel is intelligible to BE hearers though it is pronounced with raised and forwarded tongue body as compared to its peripheral counterpart. Moreover, BE back mid vowel /ɔ:/and SlsE back mid vowel /ɒ/ have F1 and F2 (449-540 Hz) and (737-1052 Hz) respectively show median frequencies distance; F1 91 Hz and F2 315 Hz. The F2 distance shows that SlsE back mid vowel /ɒ/ with comparison to BE back mid vowel /ɔ:/ is unintelligible to BE hearers. Moreover, the L2 speakers take comparatively less time to pronounce vowel /ɒ/ in 142 milliseconds whereas the L1 speakers produce vowels; /ɒ/ and /ɔ:/ in 178 and 283 milliseconds.

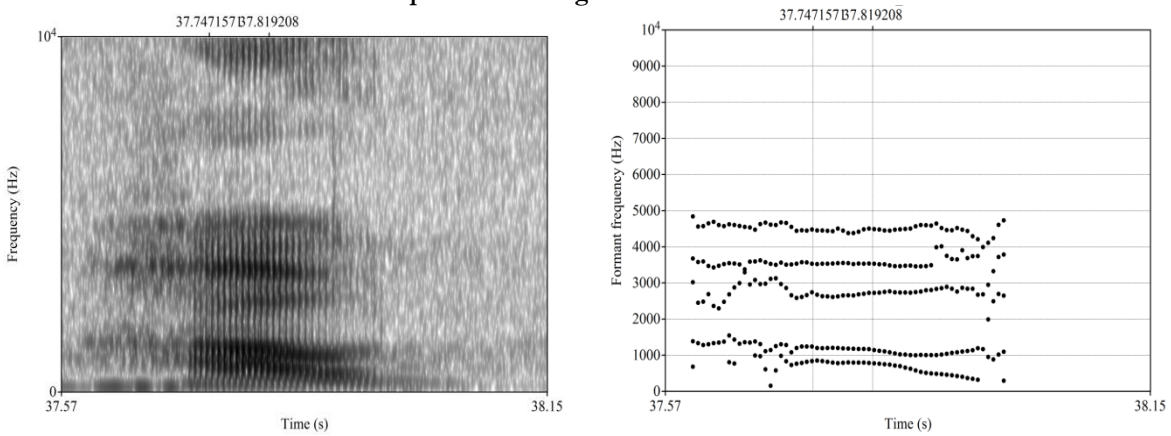
Figure 13: A typical spectrogram (left) Formant tracks (right) of the word utterance "Hod" accented by Lasi speakers for English back mid-low vowel



6.7. Acoustic Analysis of Lasi Accented English Vowel/ɔ:/

Lasi speakers pronounced English back-mid vowel /ɔ:/ in 142 milliseconds with second highest F1 (678 Hz) and F2 (1136 Hz) among five back vowels of SlsE. The vowel formants are closer to each other as compared to those of vowel /ɒ/. The SlsE vowel /ɔ:/ has greater F1 value than that of /ɒ/ therefore, tongue height lowers and raises for the vowels respectively so this vowel is pronounced as back mid-low rather than back mid and vice versa is discussed in preceding vowel analysis part. Like Lari, Vicholi, Utradi and Thareli speakers, the participants from this dialect would pronounce /ɒ/ instead of /ɔ:/. For instance, the L2 speakers pronounced Hod as Haw'd and vice versa. Furthermore, BE and SlsE vowel /ɔ:/ is pronounced with F1 (449, 678 Hz) and F2 (737, 1136 Hz) by the native and the non-natives speakers with acoustic distance; F1 229 Hz and F2 399 Hz, which authenticated unintelligibility of the vowel to BE hearers. Moreover, the L2 speakers pronounced vowel /ɔ:/ in 142 milliseconds whereas L1 speakers produced vowels; /ɒ/ and /ɔ:/ in 178 and 283 milliseconds.

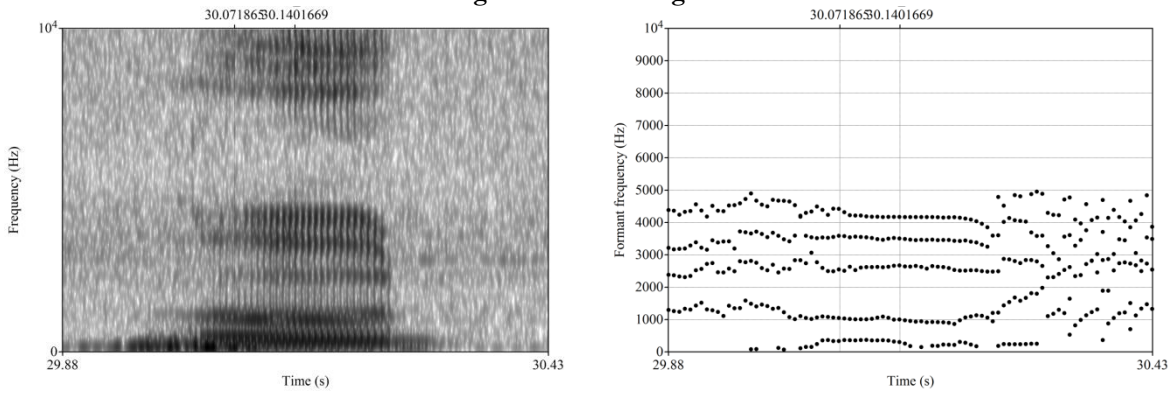
Figure 14: A typical spectrogram (left) Formant tracks (right) of the word utterance "Haw'd" accented by Lasi speakers for English back mid vowel



6.8. Acoustic analysis of Lasi accented English vowel [ʊ]

Lasi speakers produce English back mid-high vowel /ʊ/ in 99 milliseconds with second lowest F1 (454 Hz) and third highest F2 (1086 Hz) among five back vowels of SlsE. Therefore, first and second formants form more distance from each other as compared to those of SlsE adjacent vowel /u:/ so it is pronounced as SlsE back mid-high vowel. BE and SlsE vowel /ʊ/ is produced with F1 (376, 454 Hz) and F2 (950, 1086 Hz) by the native and the non-natives speakers with median frequencies distance observed 78 Hz and 136 Hz for F1 and F2 respectively shown in Tables … and …. the measured distance shows the vowel is intelligible though it is pronounced with lowered and forwarded tongue body than its peripheral counterpart. However, SlsE adjacent vowel pair /ʊ/ and /u:/ have 21 Hz F1 acoustic distance, which indicates moderate confusion just with 01 Hz difference from dividing line of absolute and moderate confusion index. Moreover, there is also durational variation as the L2 and the L1 speakers took 99 and 142 milliseconds respectively to pronounce the same vowel.

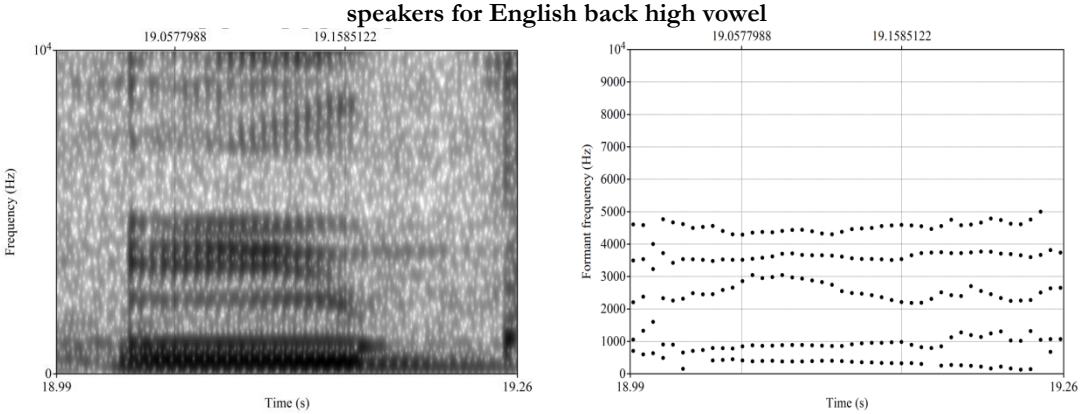
Figure 15: A typical spectrogram and formant tracks of the word utterance "Hood" accented by Lasi speakers for English back mid-high vowel



6.9. Acoustic Analysis of Lasi Accented English Vowel/u:/

Lasi speakers produce English back high vowel /u:/ in 177 milliseconds with the lowest F1 (433 Hz) and F2 (982 Hz) among five back vowels of SlsE. Therefore, the formants are closer to each other as compared to those of vowel /ʊ/. Therefore, SlsE vowel /u:/ is pronounced as back high vowel. Further, BE and SlsE vowel /u:/is produced with F1 (309, 433 Hz) and F2 (939, 982 Hz) by the native and the non-natives speakers with median frequencies distance; F1 124 Hz and F2 43 Hz, which indicated that the vowel is intelligible to BE hearers though it is pronounced with lowered and forwarded tongue body from its peripheral counterpart. Moreover, the L2 speakers took comparatively less time to pronounce vowel /u:/ in 177 milliseconds whereas the L1 speakers produced same vowel in 294 milliseconds.

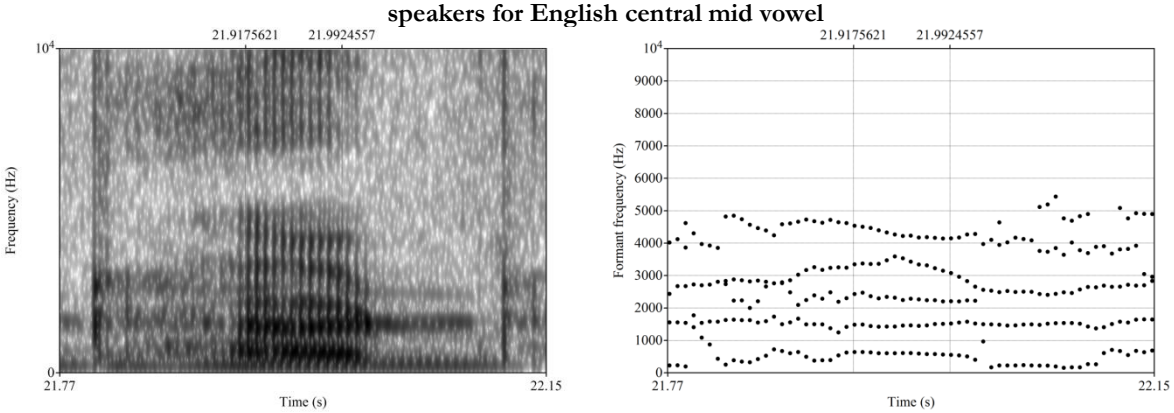
Figure 16: A typical spectrogram (left) Formant tracks (right) of the word utterance "Who'd" accented by Lasi speakers for English back high vowel



6.10. Acoustic Analysis of Lasi Accented English Vowel/ʌ/

BE and SlsE vowel /ʌ/ is produced with F1 (722, 502 Hz) and F2 (1236, 1226 Hz) by native and non-natives speakers with F1 and F2 median frequencies distance 220 Hz and 10 Hz. The F1 measured distance indicated the vowel is unintelligible and pronounced in accented fashion with raised tongue height as compared its peripheral counterpart. Hence it is accented as central mid vowel rather than central mid low. Therefore, it is observed that SlsE/ɒ/and/ʊ/ are adjacent vowels to /ʌ/ so to measure confusion index for /ʌ/-/ɒ/and/ʌ/-/ʊ/ have F1 (502-540 Hz) and (502-454 Hz) with media frequencies distance; 38and 48 Hz respectively indicated moderate confusion. Even typical spectrogram and formant tracks for vowel /ʌ/ show that its F1 acoustic energy is almost similar to that of vowel /ɒ/ and /Ʊ/. Moreover, the L2 speakers took comparatively less time to pronounce vowel /ʌ/ in 94 milliseconds whereas L1 speakers produced same vowel in 148 milliseconds.

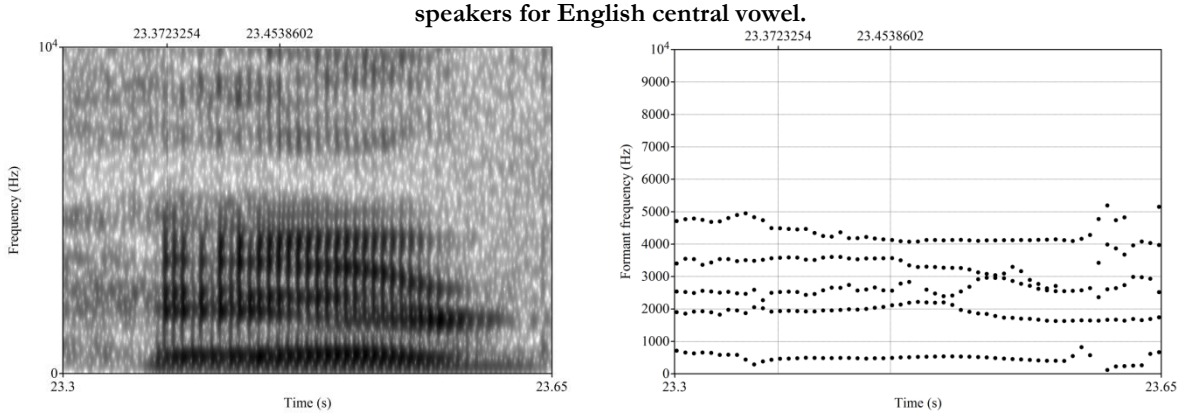
Figure 17: A typical spectrogram (left) Formant tracks (right) of the word utterance "Hud" accented by Lasi speakers for English central mid vowel



6.11. Acoustic Analysis of Lasi Accented English Vowel [ɜ:]

BE and SlsE central vowel /ɜ:/is pronounced with F1 (581, 548 Hz) and F2 (1381, 1617 Hz) by the native and the non-natives speakers with F1 and F2 median frequencies distance is 33 Hz and 236 Hz. The F2 distance indicates the vowel is unintelligible and pronounced in accented fashion with tongue forwarded as compared its peripheral counterpart. SlsE acoustic vowel space shows that the vowel/æ/is adjacent to the vowel/ɜ:/. So F1 acoustic distance between both SlsE vowels; /ɜ:/ and /æ/ (548-560 Hz) is 12 Hz, which shows the vowel /ɜ:/ is subsonic and merger is complete. Therefore, first formant energy for the vowel /ɜ:/ is similar to that of vowel /æ/. Moreover, the L2 speakers took comparatively less time to pronounce the vowel /ɜ:/ in 206 milliseconds whereas the L1 speakers produced same vowel in 261 milliseconds.

Figure 18: A typical spectrogram (left) Formant tracks (right) of the word utterance "Heard" accented by Lasi speakers for English central vowel.



It is analyzed that Lasi accented English vowels; /ɜː//ʌ//ɒ// æ//e/and /iː//ɪ//ɔː//uː//ʊ/were raised and lowered respectively whereas only one /ɑː / vowel remained almost similar in height as compared to their peripheral counterparts. Furthermore, vowels; /ɑː //ɔː //ɒ//uː//ʊ//ɜː/and /iː//ɪ/ were produced with tongue forwarded and retrieved respectively whereas vowels; /e// æ//ʌ/were almost similar in tongue backness as compared to their peripheral counterparts. Acoustic analysis of vowels also indicated that vowel merger was also completed for adjacent pairs of vowels /æ/ and /ɜː/, /ɑː/ and /ɔː/. The analysis also indicated that vowels; /ɔː/ and /ɒ/ overlapped each other and placement of vowel /ʌ/ is novelty in SlsE acoustic vowel space too. Furthermore, SlsE vowels; /iː//ɪ//e/ɑː //ɒ//uː//ʊ/ and / æ//ɔː//ʌ/ are intelligible and unintelligible respectively with comparison to Height of BE vowel(s) for BE hearers. Whereas, SlsE vowels; /iː//ɪ//e// æ//ɑː //ɒ//uː//ʊ//ʌ/ and /ɔː//ɜː/are intelligible and unintelligible respectively with comparison to backness of BE vowel(s) for BE hearers. Moreover, the findings indicated that SlsE adjacent pairs of vowels; /æ/ and /ɜː/, /ɑː/ and /ɔː/ have absolute confusion, vowels; /uː/ and /ʊ/, /ʌ/and /ʊ/, /ʌ/and/uː/ have mild/moderate confusion and vowels;/ɪ/ and /e/ have slight/minimal confusion whereas /iː/ and /ɪ/, /æ/ and /e/, /ɒ/ and /ɔː/have null confusion.

7. Acoustic Variation

The findings related to Lasi accented English vowels results indicated that vowels; /ɜː/, /ʌ/, /ɒ/, /æ/, /e/ and /iː/, /ɪ/, /ɔː/, /uː/, /ʊ/ were raised and lowered respectively whereas only one /ɑː/ vowel remained almost similar in height as compared to their peripheral counterparts. Moreover, considered vowels: /ɑː/, /ɔː/, /ɒ/, /uː/, /ʊ/, /ɜː/and /iː/, /ɪ/ were produced with tongue forwardness and retrieved respectively whereas rest of vowels: /e/, / æ/, and /ʌ/ were almost similar in tongue backwardness as compared to their peripheral counterparts. To sum up, it is identified that almost all English vowels show variation in terms of height of tongue and its forwardness and retrieved position when produced by speakers of Lasi. The vowels vary in terms of height as the height of tongue is lowered comparing it does in peripheral counterparts (British English Vowels). Therefore, comparative vowel inventory is narrow for variations in Lasi.

8. (Un)Intelligibility of Lasi Accented English Vowels

The findings for Lasi accented English show that nonnative speakers produce certain sounds are intelligible and others are unintelligible to British English hearers as speakers of SuE produce vowels, like /iː/, /ɪ/, /e/, /ɑː/, /ɒ/, /ʊ/, /ɜː/ and /æ/, /ɔː/, /uː/, /ʌ/, are intelligible and unintelligible respectively with comparison to height of BE vowel(s) for BE hearers. However, SuE vowels, like /iː/, /ɪ/, /e/, /æ/, /ɑː/, /ʊ/, /ʌ/ and /ɔː/, /ɒ/, /uː/, /ɜː/ are intelligible and unintelligible respectively with comparison to backwardness of BE vowel(s) for BE hearers. Whereas, SuE vowels, like /iː/, /ɪ/, /e/, /æ/, /ɑː/, /ʊ/, /ʌ/ and /ɔː/, /ɒ/, /uː/, /ɜː/, are intelligible and unintelligible respectively with comparison to backwardness of BE vowel(s) for BE hearers. Furthermore, StE vowels, like /iː/, /ɪ/, /e/, /ɑː/, /ɔː/, /uː/, /ʊ/, **/ɜː/** and /æ/, /ʌ/, /ɒ/, are intelligible and unintelligible respectively with comparison to Height of BE vowel(s) for BE hearers. Whereas, StE vowels: /iː/, /e/, /æ/, /ɑː/, /ɒ/, /ʊ/, /ʌ/ and /ɔː/, /uː/, **/ɜː/** are intelligible and unintelligible respectively with comparison to backwardness of BE vowel(s) for BE hearers. For SvE vowels: /iː/, /ɪ/, /e/, /ɑː/, /ɒ/, /uː/, /ʊ/, **/ɜː/** and /æ/, /ɔː/, /ʌ/ are intelligible and unintelligible respectively with comparison to Height of BE vowel(s) for BE hearers. On the other hand, SvE vowels: /iː/, /ɪ/, /e/, /æ/, /ɑː/, /ʊ/, /uː/ and /ɔː/, /ɒ/, /ʌ/, **/ɜː/** are intelligible and unintelligible respectively with comparison to backwardness of BE vowel(s) for BE hearers. The analysis indicated that SlrE vowels: /iː/, /ɪ/, /e/, /ɑː/, /ɒ/, /uː/, /ʊ/, **/ɜː/** and /æ/, /ɔː/, /ʌ/ are intelligible and unintelligible respectively with comparison to Height of BE vowel(s) for BE hearers. Whereas, SlrE vowels: /ɪ/, /e/, /æ/, /ɑː/ and /iː/, /ɔː/, /ɒ/, /uː/, /ʊ/, /ʌ/, **/ɜː/** are intelligible and unintelligible respectively with comparison to backwardness of BE vowel(s) for BE hearers.

Furthermore, SlsE vowels: /iː/, /ɪ/, /e/, /ɑː/, /ɒ/, /uː/, /ʊ/ and /æ/, /ɔː/, /ʌ/ are intelligible and unintelligible respectively with comparison to the height of BE vowel(s) for BE hearers. However, SlsE vowels: /iː/, /ɪ/, /e/, /æ/, /ɑː/, /ɒ/, /uː/, /ʊ/, /ʌ/ and /ɔː/, /ɜː/are intelligible and unintelligible respectively with comparison to backwardness of BE vowel(s) for BE hearers.

In conclusion, it is specified in terms of the height of tongue, vowel **/ɔː/** is pronounced in accented fashion for British English hearers, even this vowel is pronounced in accented fashion when it is compared to same vowel of Lasi. Moreover, vowels /

æ/ and /ʌ/ do not exist or have not identified in Lasi. In terms of backwardness of tongue, these vowels /ɒ/, /ɔ:/, /u:/ and /ɜ:/are unintelligible to British English hearers. The vowels exist in Lasi language but the speakers pronounce them in accented fashion for BE vowels even the vowels are pronounced in accented fashion if it is compared to vowels of native language. Similarly, vowel /ʌ/ does not exist in Lasi language or has not been identified yet.

9. Mutual Confusion between Adjacent Vowels Pairs of Lasi Accented English Vowels

Acoustic analysis finds out mutual intelligibility concern where adjacent vowel pairs of Lasi accented English vowels show various confusion index levels as shown below:

9.1. Lasi Accented English

The findings examined that SlsE adjacent pairs of vowels; /æ/ and /ɜ:/, /ɑ:/ and /ɔ:/ have absolute confusion, vowels: /u:/ and /ʊ/, /ʌ/and /ʊ/, /ʌ/and/u:/, have mild/moderate confusion and vowels;/ɪ/ and /e/, and have slight/minimal confusion whereas /i:/ and /ɪ/, /æ/ and /e/, /ɒ/ and /ɔ:/ have null confusion. Acoustic analysis of vowels also indicated that vowel merger was also completed for adjacent pairs of vowels /æ/ and /ɜ:/, /ɑ:/ and /ɔ:/.

Table 10: Confusion Index Level for Lasi Accented English Vowels

Confusion Index Level	*SUE*	*STE*	*SVE*	*SLE*	*SLSE*
Absolute	/ʊ/ - /u:/ /ʌ/- /ɒ/ /ɜ:/ -/æ/	/ɪ/-/e/ /ʌ/ -/u:/ **/ɜ:/**-/ æ/	/Ʊ/ - /u:/ /ʌ/-/u:/ /ʌ/-/Ʊ/	/Ʊ/-/u:/	/æ/ -/ɜ:/ /ɑ:/- /ɔ:/
Mild/moderate	/ɑ:/-/ɔ:/	/ɒ/ -/u:/ /u:/-/ʊ/	/æ/-/e/ /ɑ:/-/ɔ:/ /ɜ:/-/æ/	/ɑ:/- /ɔ:/ /ʌ/-/u:/ /æ/-/ɜ:/	/u:/- /ʊ/ /ʌ/-/ʊ/ /ʌ/-/u:/
Slight/minimal	/e/-/æ/	-	-	-	/ɪ/ - /e/
Null	/i:/- /ɪ/ /ɪ/-/e/ /ɔ:/-/ɒ/	/i:/- /ɪ/ / æ/-/e/ /ɑ: /-/ɔ:/	/i:/-/ɪ/ /ɪ/-/e/ /ɒ/-/ɔ:/	/æ/-/e/ /ʌ/-/Ʊ/	/i:/-/ɪ/ /æ/-/e/ /ɒ/-/ɔ:/

10. Conclusion

This study presents analysis of acoustic properties of Lasi accented English vowels required for making the study as foundation for nonnative English variety viz. Lasi English. The research gape was found because publications have been available for various fields of linguistics but none was found for acoustics of Lasi accented English vowels produced by native Lasi speakers. The purpose of the study was to identify acoustic properties of vowels, with consideration of vowel variation through comparative analysis between Standard British and Lasi accented English vowels. Furthermore, vowel intelligibility was observed to point out vowels that are pronounced in accented fashion hence British English hearers would be unable to comprehend the accented vowels. Delimitation of the study was to adopt J.C Wells' Study of eleven monophthongs of British English in order to produce work in its first in kind to achieve research objectives and answer the research questions.

The study presents two fold contributions; first it contributes towards foreign accented English: Lasi English and second, it identifies mispronunciation. Hence this study helps to carry further research in the field like mispronunciation of English vowels by non-native English speakers. Furthermore, it provides a foundation to explore and highlight the variation that English vowels are subject to change, when produced by L2 English speakers.

The research is quantitative in nature because speech samples were collected through speech processing software thence spectrograms and formant tracks were produced meanwhile mean values for first formant, second formant and duration in Hertz and milliseconds were deduced respectively for vowel quality. Statistical data were converted into comparative charts, used to create vowel inventories and generated tables as per requirement of the study.

Analysis shows that almost all English vowels show variation in terms of height of tongue and its forwarded and retrieved position when produced by speakers of Lasi language belonging to its five dialects. The height of tongue is lowered, and tongue body is retrieved as compared to it does in its peripheral counterparts (British English Vowels). Therefore, comparative vowel inventories are narrow for Lasi accented English vowels (Zahid, 2016; Veesar & Mustafa; 2021; Pathan, M.S.K 2023, Pathan, M. S. K. (2022), Pathan, M. S. K. (2023); Amin & Ali, 2021; Ali & Azam, 2021; Ali et al., 2021; Rasheed et al., 2023). Moreover, acoustic analysis shows that vowels /ɔ:/ /æ/ and /ʌ/ are unintelligible in terms of height of tongue body as native British English listeners would not understand the sounds pronounced by native Lasi speakers. Furthermore, vowel /ɔ:/ is pronounced in accented fashion for British English hearers even this vowel is pronounced in accented fashion if it is compared to same vowel of Lasi. In addition, vowels / æ/ and /ʌ/ do not exist or have not been identified in Lasi.

In terms of backness of tongue, these vowels /ɒ/, /ɔ:/, /u:/ and /ɜ:/are unintelligible to British English hearers. The vowels exist in Lasi language but the speakers pronounce them in accented fashion for BE vowels even the vowels are pronounced in accented fashion if they are compared to those of native language of the targeted participants. Similarly, vowel /ʌ/ does not exist in Lasi language or has not been identified yet.

Further, acoustic analysis identifies mutual intelligibility concern where adjacent vowel pairs of Lasi accented English vowels show various confusion index levels as various pairs of vowel sounds become subsonic and other vowel pairs show moderate, minimal and null confusion.

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