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Acoustical Analysis of Pakistani English Speech Produced by Sindhi English Second Language Learners

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Abstract

The English language is widely spoken all around the world and is commonly regarded as the global lingua franca. The current paper aims to explore the acoustic properties of L2 English vowels, uttered by six Pakistani ESL learners residing in the Sindh province of Pakistan. The paper examines L2 English vowels (monophthongs) i.e., /æ/, /e/, /ɑ/, /ɜ/, /i:/, /ɪ/, /u:/, /ʊ/, /ɒ/, /ʌ/, /ə/, and /ə/ in minimal pairs. A total of (12×12×6=864) voice samples were analyzed in *Praat Speech Processing Tool.* Each recording had one vowel minimal pair. Each pair was uttered thrice by the speaker. The samples were recorded by the speakers through a mobile phone recorder without any background sound or echo. The data collection was done through convenience sampling. The paper considered four parameters for the acoustic analysis of English vowels i.e., F0 (fundamental frequency), F1 and F2 (vowel quality), and duration.

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Vowel quality, durational value, and the fundamental frequency of voice are acoustically described in the study. The study has classified 12 English monophthongs into two groups of short and long vowels based on their durational values i.e., /e/, /ɜ/, /ɪ/, /ʊ/, /ʌ/, and /ə/ as the short English vowel sounds and /æ/, /ɑ/, /i:/, /u:/, /ɒ/, and /ɔ/ as long vowel sounds. The study further found that the F0 of all long vowels was high except for vowel /ɑ/ while all the short vowels have low F0 value except /ɜ/. Finally, vowel space of L2 English vowels was developed.

Keywords: English, Sindhi, Vowel duration, Fundamental frequency, Vowel quality (F1-F2), ESL

1. Introduction

The focus of the study is to analyze the acoustic properties of English vowels uttered by ESL learners. This paper inspects four parameters of human speech i.e., F1 and F2 (vowel quality), F0 (Fundamental frequencies), and duration of the English vocalic sounds. This analysis is based on 36 voice samples. The vowels designated for this study are /æ/, /e/, /ɑ/, /ɜ/, /i:/, /ɪ/, /u:/, /ʊ/, /ɒ/, /ʌ/, /ɔ/, and /ə/. Six vowel minimal pairs were recorded through a mobile phone recorder without any background sound and were analyzed in the *Praat Speech Processing Tool*. To examine acoustic properties and realizations, 12 English words were taken.

This study focuses on four parameters of speech sounds i.e., F0, F1, F2, and duration. F1 measures the height of the tongue in the mouth cavity while F2 measures the back-ness of the tongue in the oral cavity; F0 is related to the vibration of vocal folds while the duration of the vowel is the length of the vowel sound. English is widely spoken all around the globe either as L1 (first language/mother tongue) or as L2 (second language). It is a non-phonetic language; not written the way it is spoken. A lot of research has been done on English and its different accents by Peterson (1952), Chen (2001), Maxwell (2009), and Deterding (2003). The sound system of English comprises 44 sounds having 24 consonantal sounds and 20 vocalic sounds (Roach, 2004). Vocalic sounds are further branched as monophthongs, diphthongs, and triphthongs. There are a total of 12 monophthongs and 8 diphthongs. Triphthongs are the most complex English vowel sounds. They can be difficult to pronounce and recognize as well; there is a glide from one vowel sound to another and then to another in triphthongs; production happens rapidly and at the same time without any interlude (Roach, 2009). This paper aims to study only English monophthongs acoustically, organized in minimal pairs.

2. Literature Review

According to Connor (1980), there are 24 consonantal and 20 vocalic sounds (12 monophthongs and 8 diphthongs) in the sound system of English language. Jones (1976) affirms that ESL learners should be taught English vowels through the vocalic system of their mother tongue for better pronunciation while Mahar and Memon (2009) argue that production of vowel sound greatly varies across speakers therefore, it is difficult to describe them as compared to consonants. The present study focuses on vowel quality (F1 and F2), fundamental frequency (F0) and duration of English vowel sounds in CVC pattern. Tongue and lip are the main articulators of first two formats i.e., F1 and F2 (Ladefoged, 1993; Pfitzinger, 2003). The first formant (F1) is associated with how high or low the tongue is positioned, while the second formant (F2) is linked to the tongue's front-to-back position and the rounding of the lips (Raphael, 2006). Parson (1987) says that due to the different size of vocal tract, formant frequencies vary from person to person. Parson (1987) further says that males' vocal tract is 17cm long while their nasal cavity is 13cm long. While, Abbasi et al. (2018) reveals that Females have 10 to 15 percent higher formant frequencies because they have smaller vocal tracts. Abbasi et al. (2018) examined the acoustic characteristics of English vowels of Pakistani ESL learners and determined that the F1 value of Pakistani ESL learners is higher than females while the F2 value of Pakistani female ESL is higher than male speakers.

To form an accurate vowel plot, the average values of formants should be calculated (Ladefoged, 2001). According to many phoneticians, to acoustically quantify the vowel quality, F1 and F2 of the vocal tract are examined. Tongue height is inversely proportional to the value of F1 (Raphael, Borden, & Harris, 2006). Whereas, Abbasi et al. (2018) explain that F2 is associated with tongue back-ness and lip rounding suggesting that the further forward the tongue is positioned in the mouth, the higher the F2 value, while the lips remain either spread or neutral. According to Wang and Heuven (2006), by analyzing sound frequencies accurately, the quality of vowels can be measured. Abbasi et al. (2018) found differences in the vowel plot of Pakistani male and female ESL learners.

According to Gordon (2004), the fundamental frequency (F0) plays a crucial role in distinguishing primarily stressed vowels from other vowels. Essentially, F0 represents the number of cycles completed by vocal folds in one second, and it is measured in Hertz, as explained by Ogden (2009). Fundamental frequency (F0) corresponds to perceived pitch; a higher F0 is heard as a higher pitch. Abbasi, Pathan, & Channa (2018) revealed that men have an average F0 value of 120 Hz, while women's average F0 is 220 Hz. Additionally, children around the age of ten years exhibit an average F0 of 336 Hz. They further noted that the variation in resonance frequency is influenced

by the different sizes of the vocal tract. Abbasi et al. (2018) found that the F0 value of English vowels is higher among females than males. He further revealed that the duration of vowel production is higher among Pakistani male ESL learners than females.

Chen (1970) discusses that universally the duration of vowels is much longer before the voiced consonants than before the voiceless consonants. Sheikh (2012) conducted a study on Pakistani English vowels and found that Pakistani English speakers pronounce some diphthongs as monophthongs by pronouncing the first vowel of the diphthong longer and leaving the other. He further found that there was no distinction between long and short vowels observed in Pakistani English while the current study has found a difference in long and short vowels. Abbasi et al. (2018) revealed that Pakistani ESL learners pronounce English vowels higher and more toward the front position. Abbasi (2012) found that Sindhi-speaking ESL learners speak Sindhi-accented English because they rely on English's orthography which is non-phonetic. Hillenbrand et al. (1995) analyzed the acoustic properties of English monophthongs in native American speech. He determined six parameters for each vowel sound i.e., F1, F2, F3, F4, F0, and duration. The table below shows the formants and duration of American English vowels uttered by native American speakers.

Table 1: Average formant frequencies and duration of English vowels uttered by native American speakers analyzed by Hillenbrand et al. (1995).

		/i/	/ɪ/	/e/	/ɛ/	/æ/	/ɑ/	/ɔ/	/o/	/ʊ/	/u/	/ʌ/	/ɝ/
Dur	M	243	192	267	189	278	267	283	265	192	237	188	263
	W	306	237	320	254	332	323	353	326	249	303	226	321
	C	297	248	314	235	322	311	319	310	247	278	234	307
F0	M	138	135	129	127	123	123	121	129	133	143	133	130
	W	227	224	219	214	215	215	210	217	230	235	218	217
	C	246	241	237	230	228	229	225	236	243	249	236	237
F1	M	342	427	476	580	588	768	652	497	469	378	623	474
	W	437	483	536	731	669	936	781	555	519	459	753	523
	C	452	511	564	749	717	1002	803	597	568	494	749	586
F2	M	2322	2034	2089	1799	1952	1333	997	910	1122	997	1200	1379
	W	2761	2365	2530	2058	2349	1551	1136	1035	1225	1105	1426	1588
	C	3081	2552	2656	2267	2501	1688	1210	1137	1490	1345	1546	1719
F3	M	3000	2684	2691	2605	2601	2522	2538	2459	2434	2343	2550	1710
	W	3372	3053	3047	2979	2972	2815	2824	2828	2827	2735	2933	1929
	C	3702	3403	3323	3310	3289	2950	2982	2987	3072	2988	3145	2143

F4	M	3657	3618	3619	3677	3624	3687	3486	3384	3400	3357	3557	3334
	W	4352	4334	4319	4294	4290	4299	3923	3927	4052	4115	4092	3914
	C	4572	4575	4422	4671	4409	4307	3919	4167	4328	4276	4320	3788

2.1 Research Questions

Do Sindhi ESL learners produce acoustic variations in lexical stress, vowel quality, and durational values while pronouncing English Monophthongs in English speech?

3. Research Methodology

This study reports on the acoustic properties of English vowels as produced by ESL learners who are Sindhi L1 speakers. Specific comparisons will be made between tense and lax vowels, and long and short vowels, based on F0, formant frequencies (F1, F2), and duration. In addition, the vowel space of these ESL learners will be compared to that of native English speakers based on previously reported values (Hillenbrand et al. 1995).

3.1 Speakers

All the participants were ESL learners studying at Sindh Madressatul Islam University, Karachi, except for one female participant who studies at Sir Syed University of Engineering and Technology, Karachi. The participants' ages ranged between 18 to 20 years. Six ESL learners took part in the study and recorded their voice samples, comprising four females and two males. All participants were native speakers of Sindhi. The recording process was conducted in a controlled environment without any background noise or echo.

3.2 Recordings

A total of 36 voice samples were analyzed using the *Praat Speech Processing* Tool. The participants were seated in a quiet room to ensure no background noise or echo. The recordings were made directly through an iPhone X's recorder, without the use of an external microphone. The voice samples were initially in mp4 format, but they were converted to mp3 format using an online audio format converter on Google before being analyzed with the *Praat Speech Processing* Tool.

3.3 Stimuli

Twelve monosyllabic words were chosen as words for the analysis. The words were carefully chosen from Google. The words were arranged in vowel minimal pairs to

attain correct pronunciations. The words chosen were in the CVC pattern. The minimal pairs selected for this experiment are shown in **(Table. 2).**

Table 2: Minimal pairs of English vowels

S. N	Vowels	Words
1)	/æ/	Bad
	/e/	Bed
2)	/ɑ/	Ark
	/ɜ/	Irk
3)	/i:/	Heat
	/ɪ/	Hit
4)	/u:/	Pool
	/ʊ/	Pull
5)	/ɒ/	Not
	/ʌ/	Nut
6)	/ɔ/	Bought
	/ə/	But

3.4 Procedure

During the recording session, the participants were provided with a word list and instructed to read each word pair aloud. Each pair had three 3 repetitions. The participants were asked to give a short break between each repetition. Each word pair was recorded separately, in a separate recording. The subjects were seated in a room without any background sound or echo and were instructed to maintain the speech rate normal as in normal speech.

3.5 Measurements

All the measurements of duration and formant frequencies (F1, F2, and F3) for each token vowel sound were manually taken by visually inspecting a wideband spectrographic display on a computer screen. The token vowel sound was selected from the start to the end and duration was measured in milliseconds on spectrographic display. The formant frequencies (F1, F2, and F3) were measured manually from formant tracks. These frequencies were recorded in Hertz. Additionally, the fundamental frequency (F0) of the token vowel sound was also manually measured by visually inspecting the spectrogram. The data collected for the examination was analyzed in the *Praat Speech Processing Tool.* The analyzed data yielded results regarding the duration of English vowels, their vowel quality (F1 and F2), and fundamental frequency (F0). The investigation of vowel quality allowed for the plotting of the vowel space, depicting the distribution of English vowels.

4. Analysis

4.1 Vowel Duration

The vowel duration plays a crucial role in classifying vowel sounds as tense or lax therefore the present study examines the vowel duration for the lax/tense classification of the L2 English vowel sounds. The vowel duration of all the 12 English monophthongs was examined across all the speakers and the average duration of each vocalic sound was obtained which classified /e/, /ɜ/, /ɪ/, /ʊ/, /ʌ/, and /ə/ as the short English vowel sounds and /æ/, /ɑ/, /i:/, /u:/, /ɒ/, and /ɔ/ as long/tense vowel sounds. The mean duration of the long vowel is 219 milliseconds while the short vowels average duration is 119 milliseconds. The mean duration of /æ/ is 255 milliseconds, and the duration of /æ/ is longer among all the tense vowel sounds while /ɑ/ has the shortest durational value among all the long vowels i.e., 187 milliseconds. Furthermore, the durational value of /ʊ/ is the shortest among all the vowel sounds i.e., 68 milliseconds. The mean duration of L2 vowel sounds is illustrated in (**Fig. 4**).

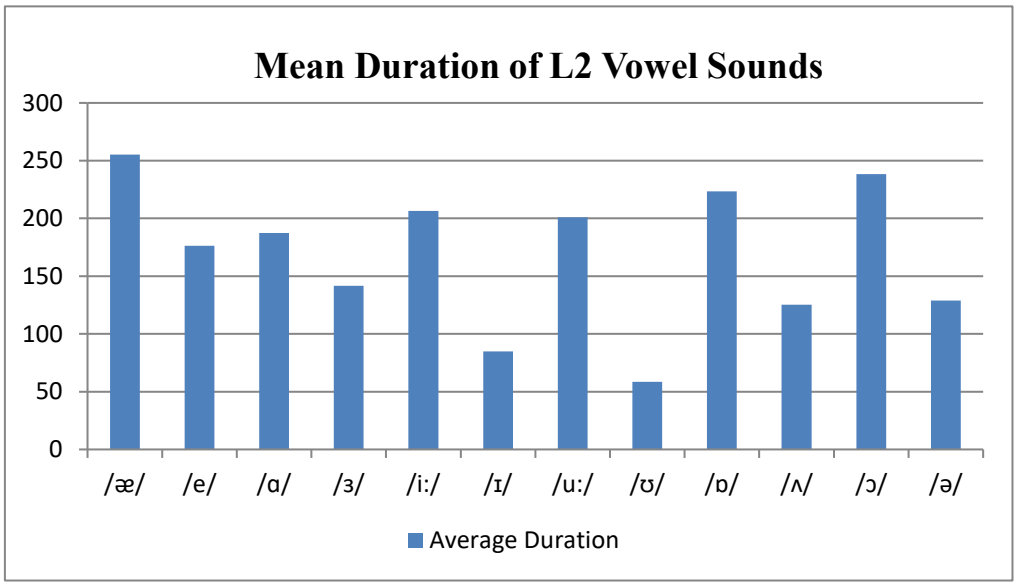

Fig. 4: Mean duration of L2 vowel sounds of ESL learners.

4.2 Fundamental Frequency (F0)

The intrinsic fundamental frequency of vowels (IFV) was determined by analyzing the fundamental frequency of English vowels. Several researchers, such as Lubker, McAllister, & Lindblom (1977) and Petersen (1978), have observed a correlation between tongue height and intrinsic F0. They found that the fundamental frequency (F0) of high vowels tends to be higher than that of low vowels.

The results reveal that the fundamental frequency (F0) of high vowels i.e., /i/ and /u/ is higher than other vowels. The F0 value of /i/ was 222 Hz and 212 Hz of the /u/ vowel. The value of F0 of /i/ is higher than /u/ because the tongue position of the /i/ vowel is higher than /u/ as illustrated in (**Fig. 6**). The /ɒ/ vowel had the lowest F0 value among all the vowels i.e., 182 Hz because of the lowest tongue position in the mouth cavity. The mean fundamental frequency of L2 English vowels is illustrated in (**Fig. 4).**

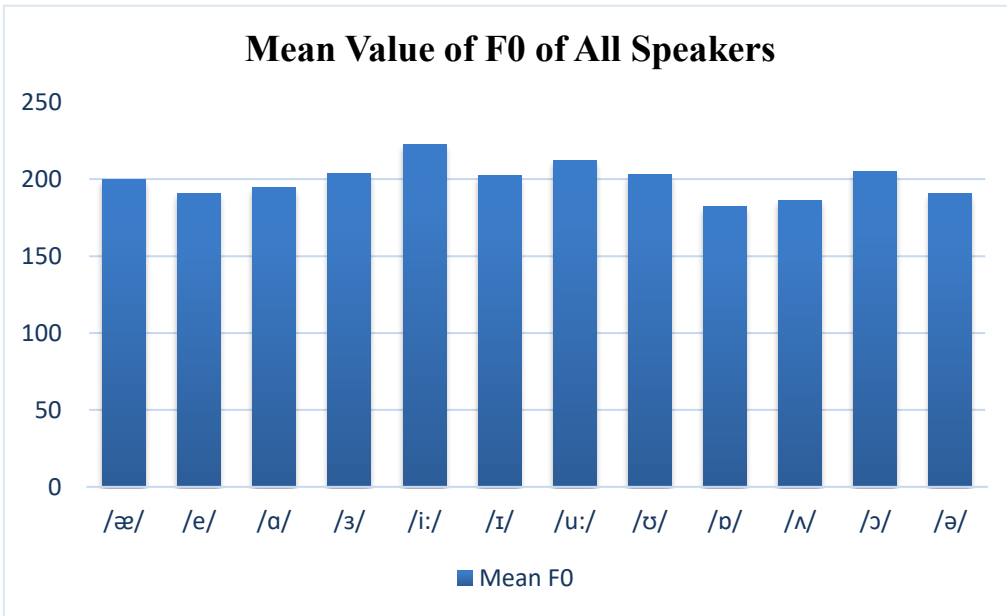

Fig. 4: Mean value of F0 among all speakers

Male speakers had an average F0 ranging from 105 Hz to 200 Hz, while female speakers had an average F0 ranging from 220 Hz to 270 Hz. Specifically, male speakers had an average F0 of 141 Hz for long vowels and 117 Hz for short vowels. On the other hand, female speakers had an average F0 of 243 Hz for long vowels and

236 Hz for short vowels. Figure 5 depicts the mean F0 values for both male and female speakers.

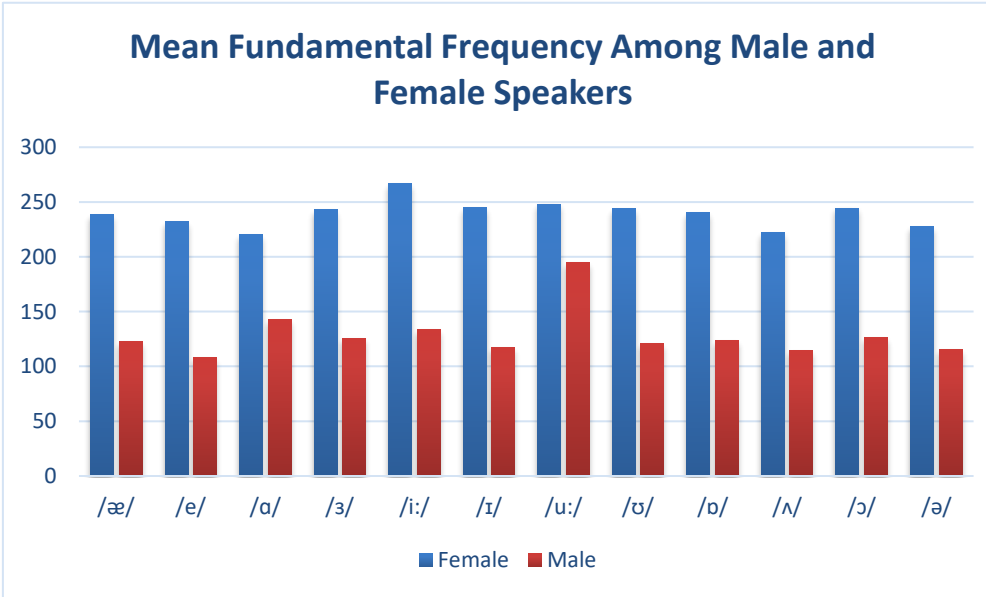

Fig. 5: Mean value of F0 among the speakers

4.3 Vowel Quality (F1 and F2)

Formants play a crucial role in the acoustic analysis and quantification of vowel quality, as highlighted by Keerio et al. (2014). While formants are present in all voiced sounds of language, they are particularly prominent and stable in vocalic sounds, as noted by Moore (2003). Phonetics experts argue that the first two formants of vowels are essential for acoustically quantifying vowel quality. Therefore, this study focuses on measuring the first two formants of English vowels.

The value of F1 in a vowel sound is related to the height of the tongue, and it has an inverse relationship with tongue height. On the other hand, F2 is related to the backness of the tongue and lip rounding, and it also has an inverse relationship with tongue back-ness. Specifically, the further back the tongue is positioned in the mouth, the lower the value of F2.

To plot the vowel space of L2 English vowel sounds, the first two formants of English vowels were measured. The resulting vowel space for English vowels can be seen in **(fig. 6)**.

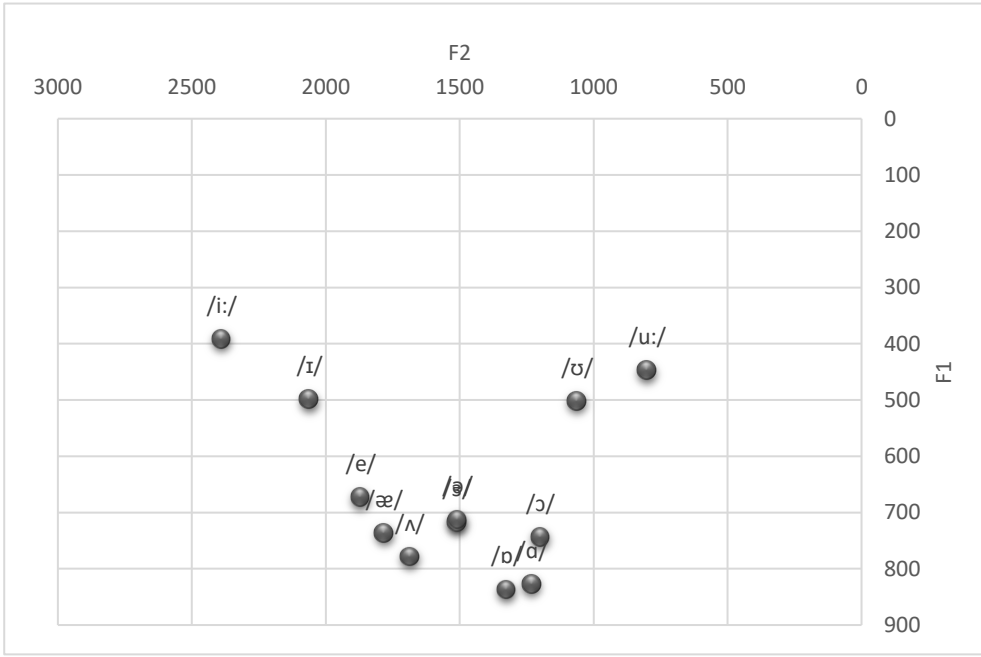

Fig. 6: Vowel space of English vowels

In Figure 6, the vowel space of English vowels produced by learners is depicted. The plotted vowel space displays the four corner vowels of English, starting from the high, front vowel /i:/ to the low, front vowel /æ/, then from /æ/ to the low, back vowel /ɑ/, and finally from /ɑ/ to the high, back vowel /u:/. Additionally, the vowel space clarifies that the short vowel /ɪ/ is a high, front vowel, while /e/ is a mid, front vowel. On the other hand, the short vowel /ʊ/ is a high, back vowel, /ɔ/ is a long, mid, back, and rounded vowel, and /ɒ/ is a low, back, and slightly rounded vowel. Furthermore, the vowel /ʌ/ is a short, low, and central vowel. There is an overlapping area in Figure 6, representing the mid, central vowels /ə/ and /ɜ/.

When comparing the vowel quality (F1 and F2) of female speakers to male speakers, it is observed that the female speakers exhibit higher values. **(fig. 7)** illustrates the vowel space of female speakers, while **(fig. 8)** displays the vowel space of male speakers.

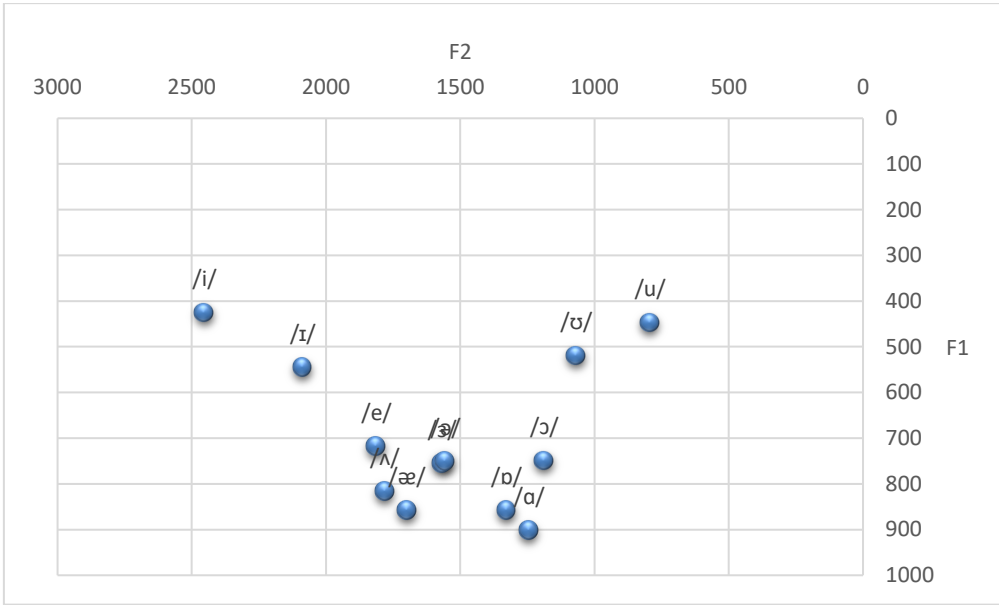

Fig. 7: Vowel space of English vowels of female speakers

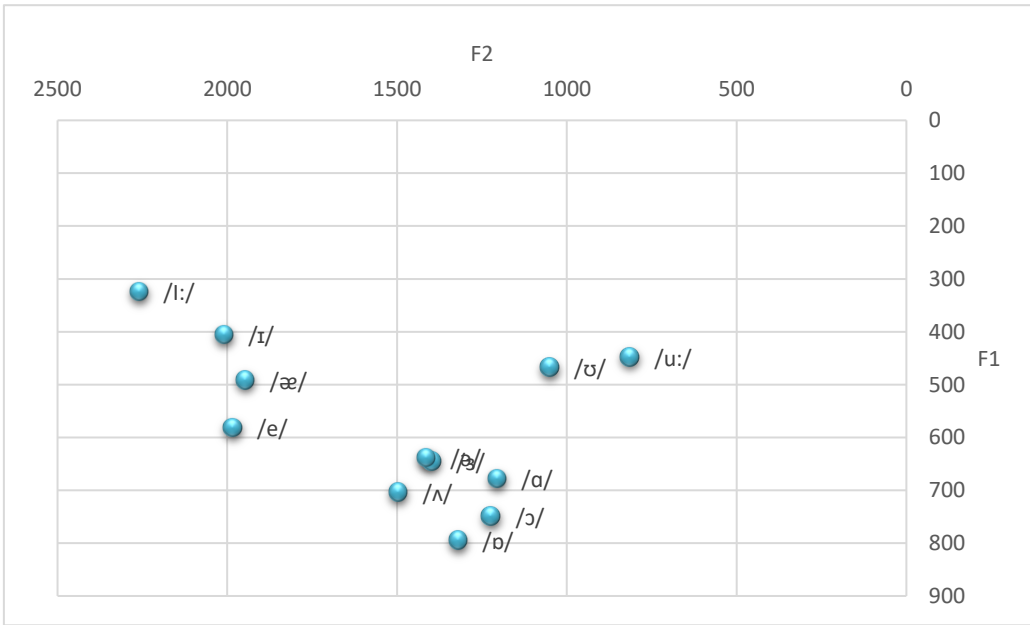

Fig. 8: Vowel space of English vowels of male speakers

The mean values of F1 and F2 of English vowels are shown in (**Table. 3**).

Table 3: Mean F1 and F2 of English Vowels

S. N	Minimal Pairs	English Vowel	F1	F2
1)	Bad	/æ/	736.357	1780.78
	Bed	/e/	672.98	1869.06
2)	Ark	/ɑ/	827.343	1230.56
	Irk	/ɜ/	718.096	1510.2
3)	Heat	/i:/	391.992	2388
	Hit	/ɪ/	498.81	2060.45
4)	Pool	/u:/	447.666	800.01
	Pull	/ʊ/	501.831	1061.13
5)	Not	/ɒ/	837.385	1325.01
	Nut	/ʌ/	778.936	1685.46
6)	Bought	/ɔ/	743.657	1198.25
	But	/ə/	712.799	1507.92

This paper presents an analysis of the acoustic properties of English vowels produced by six ESL learners. The voice samples collected from the participants were analyzed using Praat software. The study focuses on both long vowels, including /æ/, /ɑ/, /i:/, /u:/, /ɒ/, and /ɔ/, and short vowels, including /e/, /ɜ/, /ɪ/, /ʊ/, /ʌ/, and /ə/.

Among all the vowel sounds, /æ/ exhibited the longest duration, while /ʊ/ had the shortest duration. Interestingly, the vowel sounds /i:/ and /u:/ had approximately the same duration, showing a similarity in their acoustic properties.

The present paper also compared the durational values of vowels of ESL learners to that of native American English speakers (Hillenbrand et al., 1995). The comparison revealed that American English speakers' durational value of vowel sounds is significantly higher than ESL learners as shown in (**Fig. 9**).

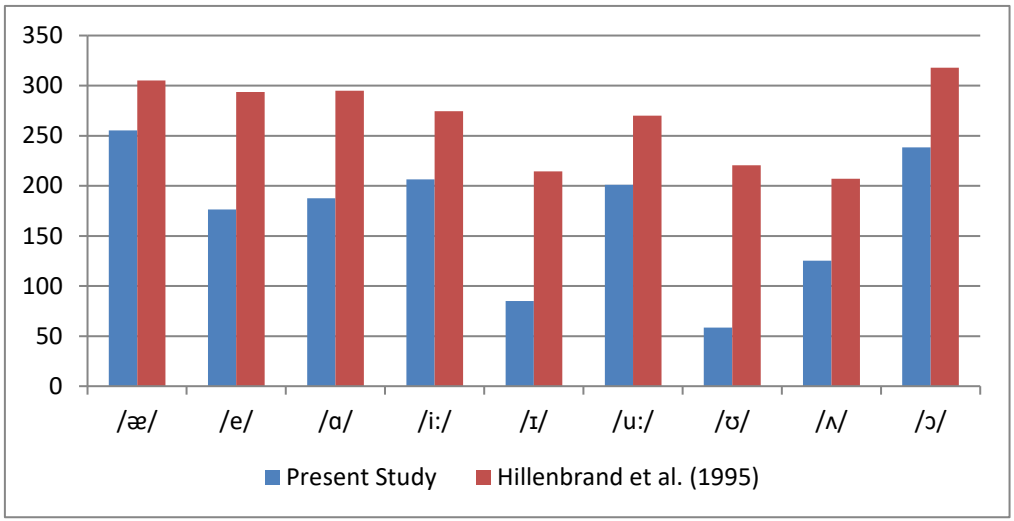

Fig. 9: Mean durational values of English vowel sounds for both men and women from the present study and from Hillenbrand et al. (1995).

5. Discussion

This study aimed to determine the intrinsic F0 of vowels (IFV) and the findings align with previous research by Lubker, McAllister, & Lindblom (1977) and Petersen (1978), showing that high vowels tend to have higher F0 values than low vowels. Specifically, the vowel /i/ had the highest F0 value as it is a high vowel, while /ɒ/ had the lowest F0 value among all the vowels.

The study also analyzed the vowel quality (F1-F2) of the vowel sounds. The results revealed that /iː/, /æ/, /ɑ/, and /uː/ are four corner vowel sounds. Additionally, the vowel /ɒ/ had the highest value of F1, indicating that the tongue is at its lowest position in the mouth cavity. In contrast, /iː/ had the lowest F1 value, suggesting that it is a high, front vowel. The vowel /uː/ exhibited the lowest F2 value among the other vowels, indicating that it is a high, back vowel, while /iː/ had the highest F2 value, indicating a more forward position of the tongue during its utterance, making it a front vowel.

The study observed that there was almost complete overlapping between the vowels /ɜ/ and /ə/, indicating that ESL learners had difficulty distinguishing between these two vowels.

Furthermore, the study found that females had higher values of F1 and F2 compared to males, which is consistent with the findings of Abbasi et al. (2018). The present study also compared its results with the work by Hillenbrand et al. (1995), who analyzed American English monophthongs produced by native American English speakers. Hillenbrand et al. (1995) measured six parameters for each vowel, including F1, F2, F3, F4, F0, and duration, and analyzed voice samples from 45 men, 46 children, and 48 women. The comparative vowel space of the current study and Hillenbrand et al. (1995) is presented in **(Fig. 10)**.

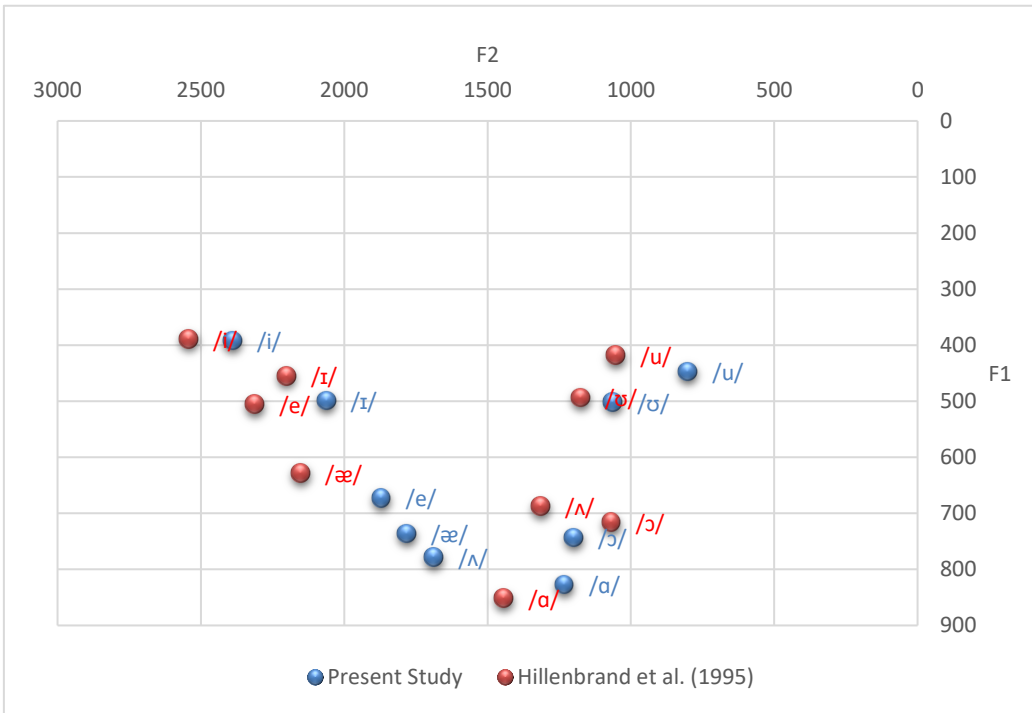

Fig. 10. Acoustic vowel diagram showing average formant frequencies for both men and women from the present study and from Hillenbrand et al. (1995).

The vowel space reveals that front and back vowels are more forward in native American English speakers than the ESL learners who are L1 speakers of Sindhi. The vowel sounds /e/ and /æ/ of ESL learners are significantly backward, lowered, and slightly centered in the vowel space than native English speakers. The low, central vowel /ʌ/ of ESL learners is more forward and lowered in vowel space than the native American English speakers.

7. Conclusion

This study focused on analyzing the acoustic properties of L2 English vowels (monophthongs) produced by six university ESL learners. The research investigated the average durational value, fundamental frequency (F0), and vowel quality (F1-F2) of these English vowels. By analyzing the average durational value, the L2 English vowels were classified into two groups: long and short vowels. The results of the average fundamental frequency indicated that high vowels tend to have higher F0 values compared to low vowels. Moreover, the study analyzed the vowel quality (F1-F2) to create a vowel space plot for L2 English vowels.

Additionally, the research conducted a comparative analysis with the previous study by Hillenbrand et al. (1995). This acoustic study provides valuable insights for future investigations concerning the acoustic analysis of Pakistani English vowels.

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Appendix

Word	Vowel	Participants	F1	F2	F3	F0	Duration
		Female 1	903.091	1748.89	2933.21	213.347	283.195
		Female 2	858.514	1958.38	2769.36	255.398	208.024
		Female 3	869.349	1285.96	2439.55	242.63	297.386
Bad	/æ/	Female 4	803.461	1800.18	3161.31	242.35	180.165
		Male 1	429.838	2083.61	2598.81	139.01	292.886
		Male 2	553.89	1807.66	2483.89	107.14	269.873
		Average	736.357	1780.78	2731.02	199.979	255.255
		Female 1	641.783	1745.15	2885.02	207.872	123.798
		Female 2	750.753	1961.31	2724.04	266.424	151.135
		Female 3	719.462	1604.48	3063.01	242.88	161.368
Bed	/e/	Female 4	762.015	1938.57	3299.98	212.493	169.59
		Male 1	587.864	2132.19	2738.53	123.884	211.013
		Male 2	576.002	1832.64	2509.55	92.477	240.644
		Average	672.98	1869.06	2870.02	191.005	176.258
		Female 1	877.258	1146.52	3141.92	207.28	179.077
		Female 2	850.41	1346.78	2261.53	236.509	182.516
		Female 3	1015.09	1262.81	2773.53	223.625	195.384
Ark	/ɑ/	Female 4	864.765	1219.29	2525.38	213.478	179.407
		Male 1	766.114	1213.35	2955.36	136.969	192.597
		Male 2	590.422	1194.63	2561.65	149.426	195.949
		Average	827.343	1230.56	2703.23	194.548	187.488
		Female 1	592.697	1494.25	2184.33	243.025	179.241
		Female 2	750.536	1445.94	2012.35	245.664	92.374
		Female 3	874.959	1678.08	2782.9	266.064	138.367
Irk	/ɜ:/	Female 4	800.274	1649.41	2841.52	216.565	156.278
		Male 1	619.788	1369.64	2798.1	132.556	117.381
		Male 2	670.322	1423.92	2668.47	118.928	166.986
		Average	718.096	1510.2	2547.94	203.8	141.771
Heat	/i:/	Female 1	416.734	2925.57	3308.52	253.005	230.615
		Female 2	351.492	2731.73	3651.05	286.045	182.883

		Female 3	429.892	1197.78	3190.35	260.444	242.303
		Female 4	504.751	2956.88	3606.6	268.594	218.032
		Male 1	337.311	2281.69	2913.8	142.176	241.913
		Male 2	311.77	2234.34	2511.31	125.494	123.605
		Average	391.992	2388	3196.94	222.626	206.559
		Female 1	483.386	2176.09	3087.22	225.464	82.633
		Female 2	593.951	2208.65	2903.34	254.799	93.364
		Female 3	586.72	1387.9	2614.39	267.952	121.785
Hit	/ɪ/	Female 4	517.103	2573.59	3370.82	230.17	88.357
		Male 1	445.288	2100.97	2607.77	134.231	65
		Male 2	366.41	1915.5	2442.66	100.477	58.32
		Average	498.81	2060.45	2837.7	202.182	84.91
		Female 1	458.472	716.287	3297.1	243.069	206.947
		Female 2	416.333	781.465	2556.97	261.654	211.179
		Female 3	420.075	899.3	2959.47	234.199	215.248
Pool	/u:/	Female 4	494.512	777.125	2784.2	253.817	188.43
		Male 1	536.403	777.281	2672.05	144.757	215.53
		Male 2	360.202	848.599	2431.39	134.639	168.195
		Average	447.666	800.01	2783.53	212.023	200.922
		Female 1	478.263	962.354	3283	193.892	38.799
		Female 2	547.31	1179.66	2434.76	269.131	64.415
		Female 3	553.748	1156.42	3261.66	271.417	75.739
Pull	/ʊ/	Female 4	496.572	970.09	2892.62	242.354	54.722
		Male 1	499.133	1043.22	2628.82	136.798	56.902
		Male 2	435.959	1055.01	2566.75	104.306	60.156
		Average	501.831	1061.13	2844.6	202.983	58.456
		Female 1	971.494	1305.49	3659.91	222.9	242.105
		Female 2	752.812	1340.19	2688.3	243.708	194.769
		Female 3	904.642	1309.49	3086.06	237.416	263.788
Not	/ɒ/	Female 4	804.72	1356.32	2614.21	258.775	192.693
		Male 1	863.403	1378.44	2743.11	129.159	250.466
		Male 2	727.236	1260.1	2647.01	118.304	196.362

		Average	837.385	1325.01	2906.43	201.71	223.364
		Female 1	913.076	1905.44	3524.23	214.976	170.058
		Female 2	811.959	1701.35	2425.16	218.083	136.577
		Female 3	790.144	1391.95	2681.67	229.153	142.474
Nut	/ʌ/	Female 4	750.771	2124.28	2890.11	225.739	124.167
		Male 1	774.363	1543.34	2613.26	129.293	88.663
		Male 2	633.3	1446.43	2640.91	98.873	89.329
		Average	778.936	1685.46	2795.89	186.02	125.211
		Female 1	707.305	1177.14	3334.34	234.855	255.682
		Female 2	729.556	1197.9	2222.99	248.113	231.138
		Female 3	835.35	1195.84	3414.46	244.325	271.163
Bought	/ɔ/	Female 4	724.836	1175.74	2822.2	250.36	209.372
		Male 1	783.222	1261.95	2706.94	137.096	284.505
		Male 2	681.675	1180.91	2613.97	115.283	178.858
		Average	743.657	1198.25	2852.48	205.005	238.453
		Female 1	703.621	1679.53	3190.94	226.749	161.642
		Female 2	777.606	1472.58	2303.02	224.265	147.656
		Female 3	780.55	1555.79	3172.09	235.384	177.057
But	/ə/	Female 4	738.854	1513.02	2547.98	225.046	127.423
		Male 1	679.716	1516.32	2487.52	133.544	80.271
		Male 2	596.447	1310.3	2522.06	97.813	78.867
		Average	712.799	1507.92	2703.94	190.467	128.819