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A Socio-Phonetic Investigation of the Acoustic Features of English Vowel Sounds by Lassi English Second Language Speakers

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ABSTRACT

This study presents the first comprehensive acoustic analysis of English monophthongs produced by native Lassi Sindhi speakers. Despite the limited research on the Lassi dialect, its speakers engage with English as a second language, often displaying pronunciation patterns influenced by their first language. LassiTen monophthongs (/iː, ɪ, æ, e, ɑː, ɛ, uː, ʊ, ɔː, ʌ/) were elicited from ten local Lassi speakers (five male, five female) using a carrier sentence paradigm, resulting in 300 tokens (10 vowels × 10 speakers × 3 repetitions). The recordings were captured via smartphones and analyzed in Praat to measure vowel duration, fundamental frequency (F0), and first and second formant frequencies (F1–F2). The results indicate distinct gender-based differences: male speakers exhibited significantly longer vowel durations (short vowels: M-158 ms, F-98 ms; long vowels: M-279 ms, F-196 ms), whereas female speakers demonstrated higher F0 values across all vowels (averaging-220 Hz vs. -120 Hz). Spectral analysis revealed expanded vowel spaces for females, with elevated F1–F2 coordinates compared to males. The findings establish normative acoustic benchmarks for Lassi-influenced English, highlighting physiological and sociolinguistic factors in vowel production. The implications include enhancing ESL pronunciation instruction with dialect-sensitive materials and informing speech technology development for South Asian English varieties. To develop tools that consider L1 vowel patterns to provide personalized feedback for Lassi learners. The research advances linguistic inclusivity by recognizing and affirming local dialectal variations, rather than pathologizing them. The findings have the potential to influence national curriculum guidelines, promoting the integration of dialect-sensitive English instruction in provinces such as Balochistan and Sindh.

Keywords: Acoustic Analysis; Formant (F1-F2) Lassi Dialect; Sindhi; Fundamental Frequency; Duration

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1. Introduction

Humans communicate primarily through language, which enables people to interpret and transmit messages to one another. Language therefore acts as a communication tool between people and between countries. Pakistan's official language is English. One of the English-speaking nations with the quickest rate of growth is Pakistan, where a sizable section of the populace speaks the language. In Pakistan, 18 million people, or 11% of the entire population, speak English, making it the third-largest English-speaking nation in Asia [1]. Acoustic studies play a crucial role in the field of linguistics (the scientific study of language). Acoustic analysis helps us understand how sounds are produced and perceived. Acoustic phonetics is the branch of phonetics that deals with the physical properties of speech sounds. Phonetics, in general, addresses the production, transmission, and reception of speech sounds, while phonology focuses on the patterns of these sounds in a language. Phonology also examines phonemes, which are the smallest units of sound in a language. Each language has its own set of phonemes. For instance, English has forty-four phonemes, Urdu has thirty-seven, and Hindi has thirty-eight. Furthermore, phonetics is divided into three main branches: The study of how sound is produced by the vocal organs is known as articulatory phonetics. The field of acoustic phonetics studies how sound waves move from speakers to listeners. Researchers in acoustic phonetics measure the characteristics of sounds using a variety of scientific instruments. Examples include strength (sound loudness), formants (important vowel shapes), duration (length), and frequency (sound pitch). Hearing and Perceptual of Sounds Auditory phonetics is the study of how listeners hear and perceive sounds.

Sindhi is one of the oldest languages in the world, featuring 52 consonantal sounds. Additionally, the Sindhi language has 10 vocalic sounds. Some researchers suggest that Sindhi has eight diphthongs, although the exact number is still debated. [2] proposed that Sindhi has eight diphthongs: [ɪi: əʊ, eɪ, əe, əo, ʊu, ʊu:, əi:], and provided their minimal pairs. The Arabic script used in Pakistan serves as the basis for Sindhi's unique written script. Vicholi, Lari, Utradi (northern), Thari, Kachchi, and Lassi are the six varieties of the language. Vicholi Hyderabad, Hala, Matyari, and Jamshoro are among the cities in central Sindh province where Sindhi is spoken. Some areas of Karachi, including the towns of Lyari, Kemari, and Malir, as well as Therparker and Kachchi in Gujarat, India, are home to Thari speakers. Lassi in the Lesbela district of Baluchistan province, Lari in Lar, and the northern region of Sindh are home to Utradi speakers. Like other Indo-Aryan languages, Sindhi has its own distinct qualities in addition to shared linguistic traits.

Phonetics and Phonology

Ten vocalic and fifty-two consonant sounds are used in Sindhi. It contains many aspirated stops and implosive sounds that are uncommon in other Indo-Aryan languages. Hindi, Urdu, and other Indo-Aryan languages, for example, have a different sequence of vowels and fewer consonants. There are about 38 phonemes in Hindi and about 37 in Urdu. Although scholars disagree on the precise number, Sindhi features eight diphthongs. In general, Sindhi has more diphthongs than Hindi and Urdu. Vicholi, Lari, Utradi, Thari, Kachchi, and Lassi are some of the dialects of Sindhi, and each has unique characteristics. There are also other dialects of Urdu and Hindi. Urdu has dialects like Dakhini and Rekhta, while Hindi has dialects including Braj Bhasha, Awadhi, and Bhojpuri. In Pakistan, Sindhi is written in Arabic, while in India, it is written in Devanagari. Urdu employs a modified version of the Persian script, while Hindi uses the Devanagari script. Sindhi demonstrates lexical stress, where stressed syllables are longer and have a higher pitch than unstressed ones. According to phonetic research, Sindhi is a language with stress accents. Although it is less noticeable and mostly associated with syllable weight rather than lexical stress, stress is also used in Hindi and Urdu.

Historical Development

Throughout its long literary history, Sindhi has been impacted by Persian and Arabic literature because of historical trade and conquests. Hindi and Urdu, particularly Urdu, which has many Persian and Arabic loanwords, have also been impacted by Persian and Arabic. Although Sindhi and other Indo-Aryan languages have many characteristics in common, Sindhi is distinguished by its own

phonetic inventory, stress patterns, and dialectal variety. Lassi language belongs to Indo-Aryan language of Pakistan belonging to the Sindhi group and dialects are Sindhi [3]. Lassi is the predominant group in the lowlands of Lesbela District. Lesbela district is in southern part of Baluchistan, Pakistan. The word Lesbela is derived from two words first is Las which means plain while the other part of the word is Bela, which means the Jungle. Lassi is different from Balochi and Brohi languages. However, most Lassi people can speak either Sindhi or Balochi both languages. Before partition between Pakistan and India in British colony the Baluchistan was divided into three parts, such as Kalat, Chagi, and Lesbela. Lesbela and Kalat were split up, nevertheless. Lassi is the name of the locals. The five main tribes of Lassi Sindhis are the Roonjha, Sheikh, Jamot, Angaria, and Burraf, though there are many more. The Lassi language also refers to them as Pan Raj. It also has a lot of subgroups. Other tribes in Lassi include the Kaskhali, Mundhra, Bandicha, and Channa. Due to their high social status, Lassi has historically been agricultural landlords. They are Sindhi speakers of the Lassi dialect. According to [4], Lassi is a dialect of Sindhi. The structure of Syntex, or the analysis of sentences, is unique to Lassi Sindhis. Like subject, object, and verb. **Figure 1** illustrates the map of Lesbela where Lassi is spoken.

Nonetheless, the English language has distinct subject, verb, and object sentence structures. Additionally, there are certain dialectal differences between Lassi and Sindhi. For example, in Lassi Sindhi, “cho to kareen” means “what do you do,” whereas in Sindhi, “cho to karian” means “why do you do.” The term “cho” signifies “why” in Lassi Sindhi, but “why” in the other five Sindhi dialects. Nearly 70% of the population in the Lesbela district speaks Lassi Sindhi, a dialect of Sindhi, as their mother tongue. Additionally, there are 574,292 people living in the Lesbela district, with a male to female ratio of 52.1% to 47.1%. Lesbela’s headquarter is Uthal town. Bela, Hub, Dureji, Uthal, and Gaddani are the five tehsils that make up the district of Baluchistan. Additionally, Hub Chowki (also known as the district Lesbela’s industrial region), Bela, Uthal, Sonmiani, Winder, Dureji, and Khathor are the main towns in the district where the bulk of Lassi live [5]. Exploring English pronunciation issues and analysing the acoustic properties of English vowels that ESL students pronounce are the primary objectives of the study. Four facets of human speech have been examined in this study: duration, F1 and F2 (vowel quality), and F0 (fundamental frequencies). The voice samples are the foundation of this research.The paper includes ten vowels—/i:/ /ɪ/ /æ/ /e/ /a:/ /ɛ/ /u:/ /ʊ/ /ɔ:/ /ʌ/. These vowel sounds are analyzed using a voice sample of size 10×10×3=300. Very little research has been done on it, especially regarding its acoustic characteristics and how they affect ESL students’ English. To give ESL learners a precise road map for improving their English pronunciation, technology must be used to study the pronunciation issues, particularly the vocalic production of English vowels. The research query further focuses on what are the acoustic realizations of English vowel sounds produced by Lassi speakers.

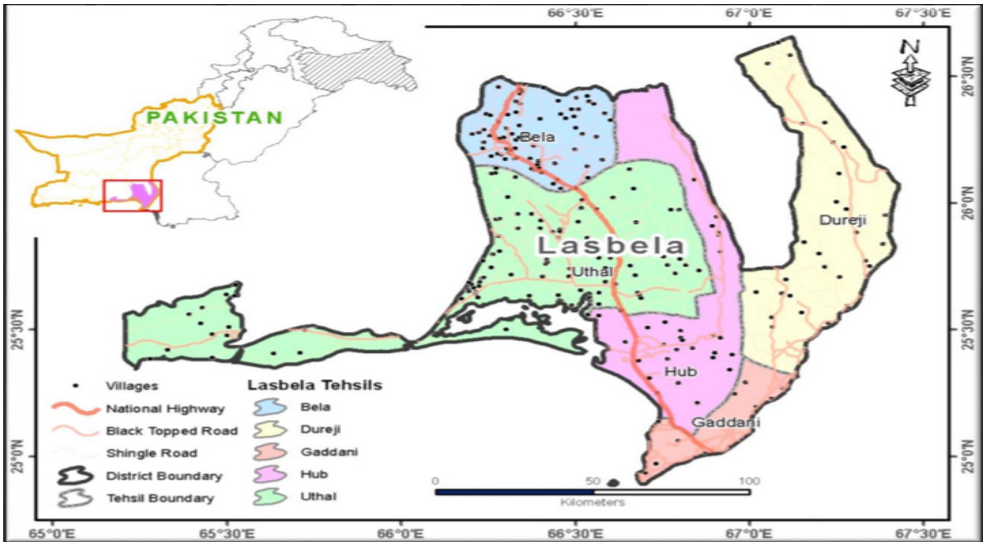

Figure 1. A Map of Lesbela.

2. Prior Works

The study alked about how South Asians, particularly those from Pakistan, make spelling mistakes when learning English, which causes their pronunciation to differ from that of other English-speaking nations. Nonetheless, a lot of Pakistani students attempt to make the right words, but they miss some vowel and consonant sounds, which affects pronunciation [6]. English Speech Anxiety in English Language Classrooms due to a lot of things or factors included is examined by [7]. The first significant—and one could argue crucial—factor contributing to speech anxiety is the English language instructor, who has excellent speaking and pronunciation skills. As a result, the speech anxiety of beginning students grows. Additionally, according to [8], there are 44 sounds in the English language. There are twenty vowels and twenty consonants, which are further separated into eight diphthong vowels and twelve monophthongs. There are twenty-four consonants in the English language, according to [9] /p, b, t, d, k, g, m, n, ŋ, ʧ, ʤ, f, v, θ, ð, s, z, ʃ, ʒ, h, r, j, v, w, l/, in contrast to the following 20 vocalic sounds: /eɪ, aɪ, ɔɪ, əʊ, aʊ, ɪə, eə, ʊə, i, ɪ, ɜ: ə, u, ʊ, e, ʌ, ɔ:, æ, ɑ, ɒ/.

Lassi Sindhi

Lassi is a Sindhi dialect. Lassi Sindhi's word order has also been compared to standard Sindhi. In Las, Sindhi was positively supported by the migration, their reign, the native language at the royal palace, and the language of the Darbar or palace. The word "Lassi" which means "plain," is originally Sindhi. Lassi is the dialect of Sindhi spoken in Las and Kohistan. According to their research, [10] discovered that while subject, object, and verb (SOV) are the dominant word order in Lassi and Sindhi, both languages allow for other word orders in oral communication without compromising sentence meaning; in some ways, this flexibility has not been observed in written and spoken English.

English Vowel

According to [11] Indian English does not distinguish between strong and weak vowels. According to [12] American English differs significantly from Pakistani English. According to Formant Frequency-F1 values, Pakistani English produces more of the vowel /ɒ/ than American English, while American English produces more of the vowels /u:/, /o:/, and /ʊ/. Native English speakers in the United States, Britain, Canada, New Zealand, and Australia may have done so because they pronounce vowels especially back vowels very clearly. It is possible for ESL speakers to make mistakes when pronouncing English vowels. In addition [13], indicates in their study that vowels in Pakistani English are realized differently than in RP and American English, resulting in diversity in pronunciation, based on the examination done above. But the truth is that because all the South Asian English including Bangladeshi, Pakistani, and Indian English were British colonies, their pronunciations differ from American English. It may therefore be the case that British English is frequently used by Pakistanis. To strengthen their speaking or listening skills, ESL speakers, nevertheless, frequently watch Hollywood films. As a result, it may occasionally influence the use of American English as well. According to a study by [14] Pashto speakers and other ESL speakers pronounce distinct sounds, which poses variable degrees of articulation difficulties for Pashto speakers. As a result of their insufficient practice, ESL speakers mispronounce vowels and consonants. Pashto speakers, for instance, pronounce words with a /p/ sound rather than a /f/ sound.

Fundamental Frequency, Duration and Pitch

Primary stressed vowels are distinguished from other vowels mainly by fundamental frequency [15]. The average duration of English vowel sounds, according to a study by [16] is 66 milliseconds for unstressed and 75 milliseconds for stressed sounds [17]. The study observed that voiced stops in Pakistani English Speech and Sindhi had pre-voicing, while voiceless plosives did not. Moreover, males exhibited longer Voice Onset Time for voiceless plosives than females. Female voiced plosives sometimes have longer Voice Onset Time than male ones. Acoustic analysis shows no vowel effects on VOT values for Sindhi and English plosives. Additionally, Abbasi [18] found that the average vowel quality, such as F1 and F2 values, were higher for stressed long vowels compared to English vowels, while they were lower for unstressed long and English vowels. Furthermore, according to Abbasi's study has shown significant differences in speech between Paki-

stani English and American in the determination of three key acoustic parameters: F1, F2, and the duration of five Pakistani English vowels between American and PaKE. Learners move vowels closer to the front side or position and higher. In essence, the fundamental frequency (F0) is the number of cycles in one second (measured in Hertz) that the vocal folds complete.

According to a study by [19] Sindhi ESL speakers had trouble telling the difference between the sounds- /e/, /æ/, and /ɛ/. Both male and female Sindhi speakers pronounced the /u:/ and /u/ sounds found because the /e/ sound in the word "and" was pronounced as /æ/, and the /3:/ sound in the other word "fingers" as /ɪ/. They also study other native languages of Pakistan, including Panjabi, Balochi, and Pashto. Those are referred to as Pakistan's primary languages. In Pakistan, these languages are also referred to as regional and province languages. Additionally, he discovered in their research that Pashto speakers had difficulty pronouncing long vowels. In place of the long vowels /a:/, Pashto speakers generated long vowels like /ɔ:/. According to [20] the fundamental function of intensity, pitch, and duration in the formation of a newborn language examines the significance of early exposure to a variety of sonic stimuli for language learning. Male adult speakers have mean F0 values of 120 Hz, female adult speakers have mean F0 values of 220 Hz, while youngsters aged ten or so have mean F0 values of 336 Hz. Because each person's vocal tract varies in size, the primary resonance frequency of the mouth and throat differs. For male adult speakers, the vocal track is roughly 17 cm long.

Research Question

What are acoustic features produced in the pronunciation of English vowels by Lassi ESL speakers?

3. Materials and Methods

Methods

The study gives details on the acoustic characteristics of English vowel sounds made by Lassi-Sindhi ESL speakers. Specific comparisons between the central vowels, short vowels, and long vowels based on duration and pitch F0, F1, and F2.

Purposive Sampling Technique

The University students from Lesbela Baluchistan were chosen to participate with ages ranging from 15 to 40, the participants are diverse in age. Ten Lassi Sindhi ESL speakers in total-five male and five female—were included in the samples and participants. Every participant was a native speaker of Lassi Sindhi and was from the Lesbela district of Sindh. Additionally, the participants were from Bela, Hub Chowki, and Sonmiani Dam in the Lesbela district. The Praat software and cell phones were utilized by the instruments. The recording process was conducted without background voices or noise.

Recording Procedure

Native speakers of Lassi Sindhi recorded ten voice recordings, five of which were male and five of which were female. The Praat software application was used to analyse the voice samples after they were recorded using a cell phone. For every vowel, a total of four characteristics were measured. The parameters included the duration of the vowel sound, F0 (pitch), F1 (formant frequency), and F2. Additionally, ten vowels, ten speakers (five males and five females), and three repetitions of each vowel were recorded after 300 voice samples. For example: (10×10×3=300). Voice samples were gathered using WhatsApp and converted to Praat software after they were recorded. The voice samples were recorded, loaded into the Praat software, and then selected the "view and edit" option to extract the voice samples' spectrograph. The token vowels were then examined. However, it was recorded in a brief statement like "I say neat now," and just the vowel sounds in the entire sentence were examined. Next, the F1 formant was measured using the F1 key, and the F2 formant was measured using the F2 key. Nevertheless, milliseconds were used to measure the duration.

Stimuli

Ten (10) vowels that are incorporated into words within a carrier phrase were chosen. Three hundred voice samples in all were examined. We measured four parameters. Quality of Voice: F1-F2 (Hz) F0 (Hz) is the pitch. Vowel duration (ms). Google is where the vowels were

chosen. **Table 1** shows speech stimuli with carrier phrase for Lassi speakers to record their English speech.

Table 1. English words, vowels, and carrier sentences.

VOWELS	WORDS	SENTENCE
/iː/	Neat	I say neat now
/ɪ/	Sit	I say sit now
/æ/	Cat	I say cat now
/e/	Bed	I say bed now
/ɑː/	Far	I say far now
/ɛ/	Bird	I say bird now
/uː/	Shoot	I say shoot now
/ʊ/	Good	I say good now
/ɔː/	Door	I say door now
/ʌ/	But	I say but now

Data collection and procedure

Ten English vowels were recorded: /iː/, /ɪ/, /æ/, /e/, /ɑː/, /ɛ/, /uː/, /ʊ/, /ɔː/, and /ʌ/. The word list was presented in sentences during the recording period, and each sentence was to be read aloud without any echo or background noise. Three repetitions of each sentence were made. Each male and female participant's recording was captured independently. The table displays the terms that were chosen for the experiment. **Table 2** shows speech stimuli i.e., vowel IPA symbols with embedded words.

Table 2. Lassi speakers produced English words.

VOWELS	WORDS
/iː/	Neat
/ɪ/	Sit
/æ/	Cat
/e/	Bed
/ɑː/	Far
/ɛ/	Bird
/uː/	Shoot
/ʊ/	Good
/ɔː/	Door
/ʌ/	But

Measurements

The fundamental frequencies (F1 and F2), pitch (F0), and duration of each vowel sound were all measured by hand using a laptop screen spectrographic display. From the formant area, the formant frequencies F1 and F2 were manually determined. A system international unit of sound, the Hertz, was used to measure the formant frequencies. On the laptop screen, F0 was likewise measured and displayed as a spectrographic image. The Praat speech processing tool was used to obtain the data; these tools are essential for sound measurements.

Results

Vowel quality (F1 and F2), durational values, and F0 are the results of examining the English 10 vowel sounds acoustically realized by Lassi Sindhis ESL speakers.

Vowel Duration

When studying vowel sounds, the duration of the vowels is crucial. In order to categorize the English vowel sounds of Lassi Sindhis ESL speakers, the current study looks at vowel duration. We looked studied each speaker's vowel duration for each of the ten English monophthongs. Both short and long vowel sounds were obtained for every vocalic sound. The short vowels in English are /ɪ/, /e/, /ɛ/, /ʊ/, /ae/, and /ʌ/. whereas /iː/, /ɑː/, /uː/, and /ɔː/ are the long English vowel sounds instead. Praat software was used to measure the durational value of the ten English vowel sounds. The duration values were shown visually at the spectrogram's bottom. The Praat displayed the durational value in seconds, but it was later converted to milliseconds. Additionally, the duration was assessed in three-time intervals, and each word was repeated three times. **Table 3** illustrates durational values of Lassi vowel sounds.

Table 3. Mean durational values of Lassi vowels.

Lassi vowel	/iː/	/ɪ/	/æ/	/e/	/ɑː/	/ɛ/	/uː/	/ʊ/	/ɔː/	/ʌ/
Duration (ms)	226	137	175	181	206	202	177	142	187	128

The experiment's results show that the maximum mean durational value for females for short vowels is 98 milliseconds, while the mean durational value for males is 158 milliseconds. For long vowels, the mean durational value for females is 196 milliseconds, while the mean durational value for males is 279 milliseconds. **Figure 2** shows the average durational value for short vowels. The typical durational value for long vowels is shown in **Figure 3**.

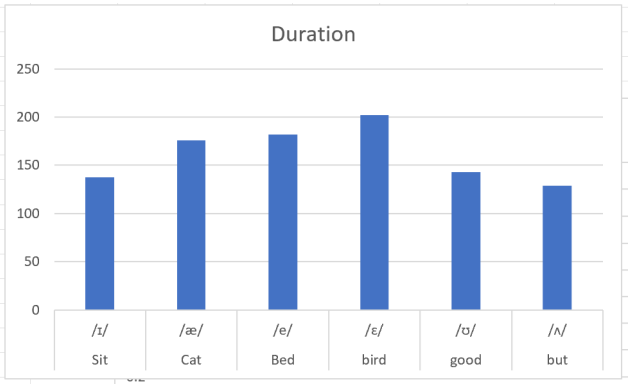

Figure 2. Mean durational value of short vowels.

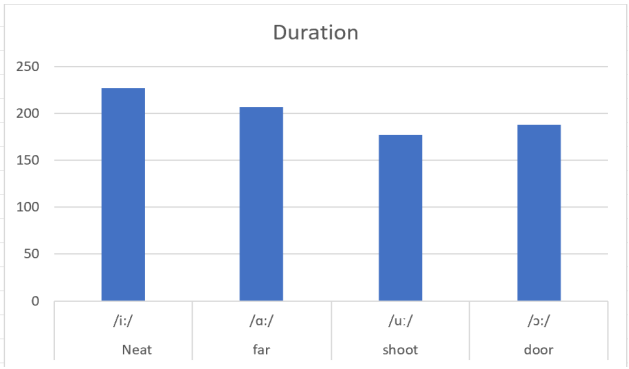

Figure 3. Mean durational values of long vowels.

Apart from one vowel, /u:/, as seen in the **Figure 4** below, the duration values for all the vowels were longer in males than in females, according to the data analysis.

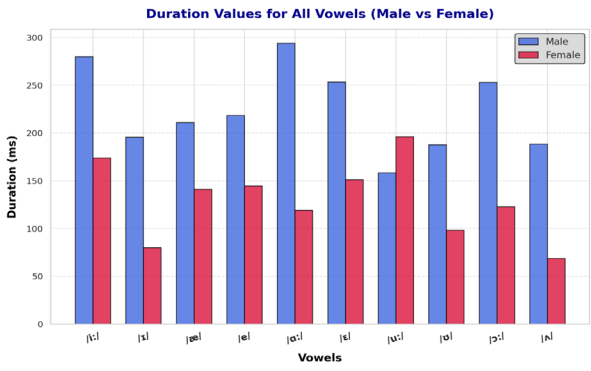

Figure 4. Durational values across speakers.

Fundamental frequency (F0)

Pitch and F0, another term for a sound's fundamental frequency, are connected. The information gathered showed that speakers of Lassi Sindhi male and female have different basic values. **Figure 5** graphic illustration below shows the average value of F0 for all male and female vowels.

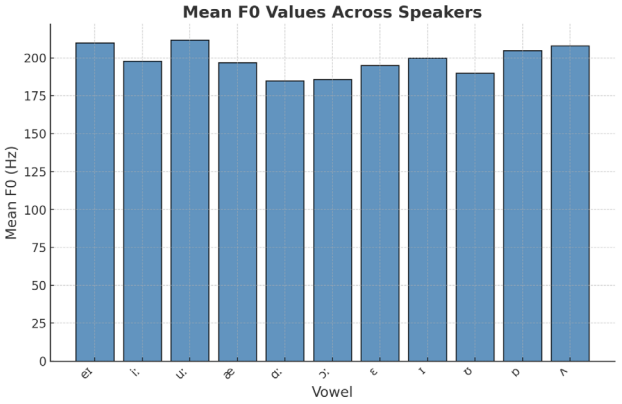

Figure 5. Mean F0 values across speakers.

Compared to male speakers, female speakers had a comparatively greater F0 value. The mean F0 value for female speakers is illustrated in the **Figure 6**, while the mean F0 value for male speakers is shown in a separate **Figure 7**.

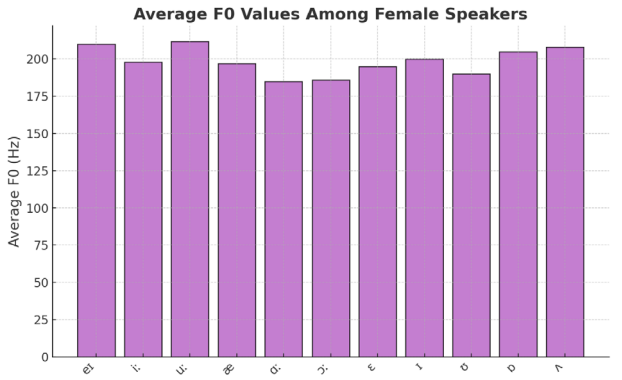

Figure 6. Mean F0 values among Female Speakers.

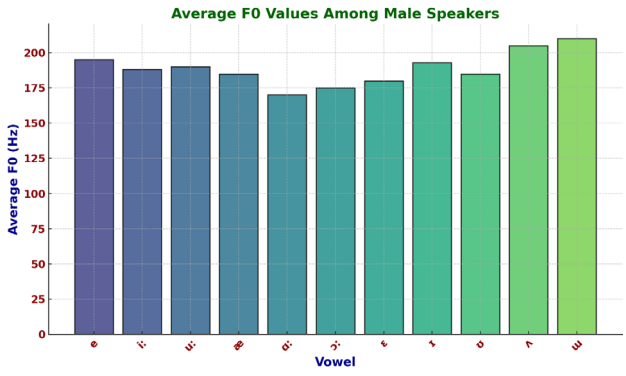

Figure 7. Mean F0 values by male speakers.

The outcome demonstrates that all the female F0 (pitch) values are greater than the male F0. The F0 values are higher for female speakers than for male speakers, to sum up. Additionally, compared to long vowels, short vow-

els have a greater F0 value.

Vowel Quality (F1 and F2)

Vowel qualities are F1 and F2. The formants are strong in vocalic sounds, yet they all have voiced sounds in a language [21]. The study of acoustics and the measurement of vowel quality depend heavily on formant value. The first two vowel forms are crucial for acoustic quantification of vowel quality, which is why this study is concentrating on measuring their quality.

The four corner vowels of vowel can be seen in the graph, initiating from /iː/ (high, front vowel) to /ɛ/ (low, front vowel), then from /ɛ/ to /ɑ/ (low, back vowel), then from /ɑ/ to /u/ (high, back vowel), and then lastly from /ɑ/ to /iː/ and the remaining vowels lie between these four corner vowels. The clear vowel quality is observed high back vowel /ʊ/, and low back vowel /ɑ/. Additionally, the height of the tongue is correlated with the vowel sound's F1 value. The F2 value has an inverse relationship with tongue back-ness, however it is related to lip rounding and tongue back-ness. The gender differences in vowel quality are also discernible. When comparing female speakers to male speakers, the average values of F1 and F2 are comparatively high. **Figure 8** illustrates vowel quality values of female speakers, whereas **Figure 9** illustrates first and second frequencies of vowel sounds of male speakers.

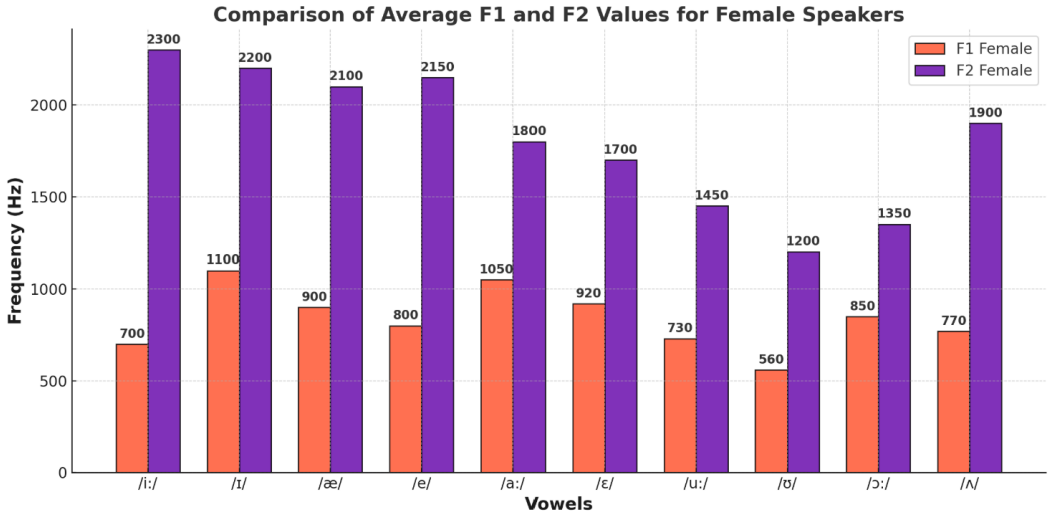

Figure 8. Mean F1-F2 values of female speakers.

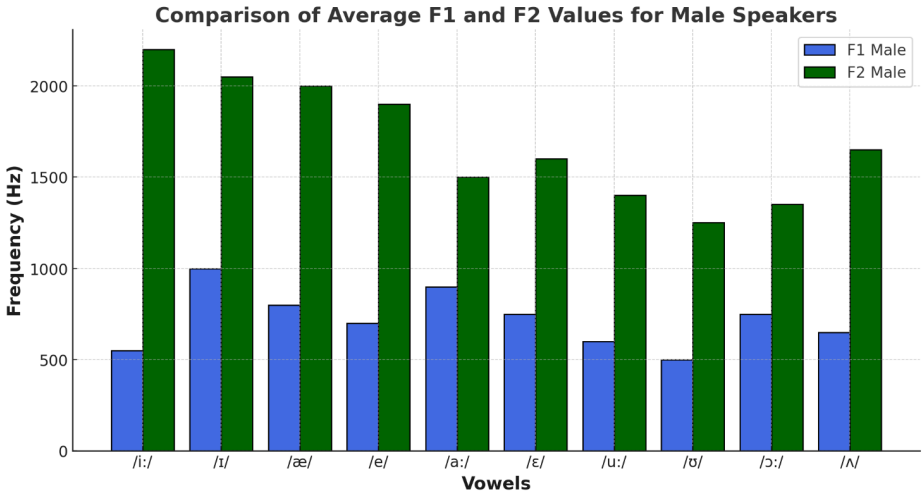

Figure 9. Mean F1-F2 values of male speakers.

The mean values of F1 and F2 of ten Lassi Sindhi vowel sounds are produced as illustrated in **Table 4**.

Table 4. the mean value of ten Lassi vowels sound.

WORDS	LASSI VOWELS	F1 (Hz)	F2 (Hz)
Neat	/iː/	561.7016	2221.125
Sit	/ɪ/	1063.576	2118.127
Cat	/æ/	764.0333	2044.647
Bed	/e/	677.962	2018.413
Far	/ɑː/	864.1917	1640.533
Bird	/ɛ/	771.8029	1619.245
Shoot	/uː/	554.1384	1381.285
Good	/ʊ/	525.6216	1342.834
Door	/ɔː/	747.2863	1361.678
But	/ʌ/	644.0711	1712.709

4. Discussion

The findings indicate that while there is a noticeable variation in durational values between males and females, the difference is larger for long vowels than for short ones. Male speakers have a greater durational value of vowels than female speakers, suggesting that Lassi female speakers spew words more quickly than male speakers, which in turn causes the durational value of male speakers to be longer. The intriguing aspect of this is that most of the earlier research has discovered that male speakers had a lower durational value for vowels. Males in unstressed words in Swedish have a longer durational value of vowels than females, according to research by [22]. Additionally, the study discovered that women's vowel F0 values were higher than men's. The vocal folds of males are longer and thicker. To have the same pitch results as men, women need a higher F0 number [23]. The results indicate that the resonant frequency of vowels was higher in females than in males. The acoustic realizations of eleven English vowels produced by Lassi Sindhi were investigated in this work. The first two formant frequencies of Lassi vowels, average duration, and fundamental frequency (F0) were all examined in the study. The Lassi vowels were divided into short and long vowels based on the average durational values.

According to the study's findings, male Lassi speakers have a lower utterance rate than female speakers since their vowel durational values were bigger. This groundbreaking work will support future Lassi research. This study provides the first comprehensive acoustic analysis of English vowel production by native Lassi Sindhi speakers. By examining duration, fundamental frequency (F0), and formant values (F1–F2) across ten monophthongs, gender-based patterns were identified: male speakers exhibited longer vowel durations, while female speakers produced higher pitch and more expanded vowel spaces. These differences highlight the interplay of physiological and sociolinguistic factors influencing Lassi ESL speech. These findings address a gap in Sindhi-dialect research and establish benchmarks for Lassi-influenced English pronunciation.

5. Conclusions

This study offers a groundbreaking acoustic analysis of English vowel production by native Lassi Sindhi speakers, shedding light on key patterns in duration, fundamental frequency (F0), and vowel quality (F1 and F2). The findings indicate distinct gender-based variations, with female speakers displaying higher F0 and F1–F2 values, while male speakers exhibited longer vowel durations. These differences not only reflect physiological distinctions but also emphasize the impact of sociolinguistic factors on speech production. The variance in vowel articulation, especially regarding temporal and spectral features, provides significant insights into the difficulties faced by Lassi ESL speakers in acquiring English phonology. These findings offer essential baseline data for acoustic modelling of dialect-influenced English pronunciation, thereby facilitating the creation of more inclusive and dialect-sensitive pedagogical approaches and speech technologies. This study addresses the lack of acoustic research on the Lassi dialect and aids future linguistic inquiry. Applying these findings to ESL instruction can improve pronunciation training and language technologies, especially in multilingual environments like Pakistan.

Future investigations grounded in these acoustic norms can enhance dialect-inclusive language instruction and technology design. Whether developing pronunciation applications or revising ESL syllabi in Pakistan, this study's benchmarks enable more effective, culturally responsive approaches to English learning. This study's scope was limited by a small convenience sample of ten speakers and focused solely on monophthongs. Future research should: Expand speaker populations across ages and socio-economic backgrounds, include additional pho-

netic features—diphthongs, consonant inventories, and intonation, conduct perception experiments to link acoustic deviations with intelligibility in real-world communication and compare Lassi ESL production with other Sindhi dialects and regional English varieties.

This study is among the first to conduct a rigorous acoustic analysis of vowel production by Lassi speakers, who represent a significantly understudied Sindhi dialect. The distinct F0 and formant values observed between male and female speakers contribute to broader discussions on socio-phonetics and gendered speech variation within South Asian English. The formant trajectories and vowel centralization patterns provide baseline data for future comparative studies involving Indo-Aryan dialects and ESL pronunciation research. Considering the observed deviations in vowel duration and quality, it is recommended that ESL instructors prioritize clear communication rather than focusing on accent reduction. The findings underscore the necessity of explicit teaching of vowel length and quality distinctions, with particular emphasis on contrasts such as tense–lax and central–back vowels (/iː/ vs /ɪ/, /ʌ/ vs /ɑː/). ESL programs should consider the influence of learners' first languages and tailor instructional materials to reflect their phonetic realities, especially in linguistically diverse settings such as Pakistan. Train speech applications with your data to improve recognition of underrepresented dialects. To develop tools that consider L1 vowel patterns to provide personalized feedback for Lassi learners. The research advances linguistic inclusivity by recognizing and affirming local dialectal variations, rather than pathologizing them. This contributes to decolonial approaches to language education. The findings have the potential to influence national curriculum guidelines, promoting the integration of dialect-sensitive English instruction in provinces such as Balochistan and Sindh.

In summary, the study recommends for phonetic awareness training, the study introduces learners to the basic anatomy of vowel sounds using formant visuals (F1, F2) and spectrograms and to use tools like Praat or acoustic models in class to help students visualize their pronunciation in real time. For gender sensitive strategies, the study acknowledges the pitch and vowel space differences between male and female learners when offering corrective feedback and adapt listening materials that reflect both male and female vocal ranges, supporting perceptual atonement. For dialect aware instruction, the study recognizes that Lassi learners might transfer L1 vowel patterns to English (e.g., substitution or centralization of certain vowels) and avoid penalizing accent variation; instead, focus on intelligibility over native-like accuracy. For the use of technology, the study encourages the use of mobile apps and speech recognition software for autonomous pronunciation practice and integrates AI-powered feedback tools that highlight vowel-specific errors and track acoustic features over time. For teaching suprasegmentals, the study incorporates stress patterns, intonation contours, and rhythm training to improve naturalness and fluency and to demonstrate how pitch (F0) can change meaning or stress and encourage controlled pitch range development. For contextual pronunciation integration, the study recommends the embed pronunciation instruction into vocabulary, reading, and speaking tasks—not as isolated drills and to use task-based learning (e.g., role-play, storytelling, presentations) to promote real-world application of phonetic targets.

Author Contributions

Conceptualization, M.Z. and A.M.A.; methodology, A.M.A.; software, A.M.A.; validation, A.M.A., I.H. and M.Z.; formal analysis, M.Z.; investigation, M.Z.; resources, A.M.A.; data curation, I.H.; writing—original draft preparation, M.Z.; writing—review and editing, A.M.A.; visualization, A.M.A.; supervision, A.M.A.; project administration, A.M.A. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement

Written informed consent has been obtained from the participants to publish this paper.

Data Availability Statement

The data will be available on request if required.

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Conflicts of Interest

The authors declare no conflict of interest.

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