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DYNAMIC ACOUSTIC PROPERTIES OF PAKISTANI ENGLISH: A DESCRIPTION OF FORMANT VARIATIONS OF F1 & F2 PRODUCED BY PAKISTANI SPEAKERS

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ABSTRACT
The current study explores the variations of formant frequency of English vowels produced by eighty students of BS English and English language at NUML and International Islamic University Islamabad. The research defines the acoustic monophthongal variations under the influence of gender and four standard regional varieties of Pakistan and presents a macro-level description of Monophthongs of Pakistani English. The respondents belong to Balochi, Pushto, Punjabi, and Sindhi languages. This study explores monophthongal formant variations among these speakers through the lenses of the 'Formant Frequency Model' (Lindblom, 1979). For this purpose, the poem entitled, "The North Wind and the Sun" has been used to collect the required data. The formant values have been extracted from PRAAT, a software presented by (Boersma & Weenink, 2019). The manually extracted data from PRAAT were analyzed via statistical tools of SPSS and ANOVA. The findings of this research disclose that monophthongal formant variations are related to the unclear realization of sounds like /ə / and /ʌ/, paucity in realizing the vowel pairs of English, identical articulation of /ɒ/ and /ɔ:/ among the groups. The findings of the research would contribute to the phonological system of Pakistani English, which is an Asian- variety of the Outer-Circle. The findings would assist English language teachers to teach pronunciation of English with an acoustic-phonetic perspective.
Keywords: PakE, Acoustic & Statistical Analysis, Formant Frequencies, Monophthongs

INTRODUCTION
The problems related to the production or articulation of unaccustomed phonemes in a second language (L2) by non-native speakers have been a well-known phenomenon. The problems of vowel articulation are pertinent to the south Asian variety of Englishes because languages differ substantially due to the distinct no of vowels and acoustic features related to vowels. For example, Castilian Spanish consumes 5 phonetic vowels {/a/, /e/, /i/,/o/,/u/}. These vowels are closely related to F1-F2 space or quadrilateral vowels (Hualde, 2005). The quadrilateral vowel shape differs from the monophthongs of Standard British English. South Asian Varieties of English being syllable-timed languages possess a distinct number of vowels with unique vowel articulation (Crystal, 2003; Mesthire & Bhatt, 2008). The Englishes in Asia also bear distinct phonological characteristics (Mesthire, 2004; Deterding, 2010; Deterding & Kirkpatrick, 2006; Gut, 2004; Schmied, 2004). The speakers of South-Asian varieties of English being bilingual speakers do face problems of L1 influence on the L2. The L1 influence is reflected via vowel articulation by these speakers. The quantitative research on vowel formant frequencies needs to be done in the context of Pakistan, which is a South Asian Variety of Englishes. The vowel formants particularly the F1 and F2 are significant for the acoustic investigation of vowels.

Research Questions

1. What are the acoustic features of monophthongs of Pakistani English with respect to their formant frequencies of F1 & F2?
2. To what extent do monophthongs vary among different genders and L1 backgrounds?

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REVIEW OF LITERATURE

English being an international language is in consistent contact with other languages. The very contact caused the emergence of new varieties (Trudgill, 2004 & 2008). The forms of English of the post-colonial era are exceptional varieties made in unusual conditions (Schneider, 2003). The new varieties of English are introduced as 'World Englishes'. Erling (2006) states, that 'World Englishes' refers to a form of English with local flavor and native features. Jenkins (2009) uses 'World Englishes 'to refer to the evolving local forms of English with genuine and unique structures. The new varieties are highly influenced by cultural, regional, or local languages, and social factors (Kilickaya, 2009).

One of the new forms of Englishes is termed 'South Asian English' which includes a form of English used in India, Bangladesh, Nepal, Bhutan, Sri Lanka, Maldives, and Pakistan. Sheikh (2012), states, "There is a strong tendency in non-native varieties to restructure the sounds of native English to suit their purpose." Therefore, the restructuring of sounds is need-based as well as influenced by the first language (p.3).

Kachru (1983), investigated segmental features pertinent to the feature of 'South Asian English'. Pickering and Wiltshire (2000), have investigated Hindi/Urdu, Bengali, and Tamil Englishes to find out lexical stress patterns. Nelson (1982) and Kachru (1983), explained the SAE variety of English, PakE, a syllable-timed variety which is unlike the stress-timed nature of RP. Pakistani English is an Asian variety with an exclusive phonetic structures and different accents. It is extremely influenced by cultural, religious, regional, and social factors. The influence is seen at the Phonological, Morphological, and syntactical levels (Irfan, 2017).

Vowels possess a central place in the phonological system of any language. They are vital to assure the exact implementation of the segmental and suprasegmental features of a language. For instance, vowels occupy a central place in any syllable and are called nuclei. Words in a language are combination of sounds and syllables. The vowel sounds are crucial to make a combination of words. They perform a multifunctional role in the phonology of any language. They are produced with an open vocal tract. English vowel sounds have more vocalic richness and can have variations in different contexts. Languages differ as (Barber et al, 2009) said, "First, their phonological systems can differ. Secondly, the realizations of the same phoneme can be different. Thirdly, the distribution of phonemes can differ" (p. 247). Vowel analysis is an indispensable feature of the acoustic investigation of any language. The acoustic investigation provides a piece of precise information about vowels. The vowel phonemes being persistent in patterns are investigated more as compared to consonants (Moore, 2003; Kent & Charles, 2002).

There has been great literature on research in acoustic phonetics which has investigated the acoustic features of vowels of different languages. The acoustic researches on Indian English vowels include (Peterson & Barney, 1952; Chen et al., 2001). Similarly, acoustic studies include (Maxwell & Jannet, 2009; Fadte, Fernanddes & Karmali, 2022; Deterding, 2003; Kewley-Porr et al, 1996;) on an Indian English accent, Konkani dialect, Singaporean accent, and Japanese accent English vowels, respectively. The acoustic investigation on French, Shanghai Chinese, Turkish, Spanish, Japanese, and Modern Hebrew has been made by (Ouni & Yves, 2003; Chen, 2008; Gordon & Ayla, 2006; Borzone-de-Manrique, 1979; and Borzone-de-Manrique & Massone 1981; Homma, 1973; Aronson et al, 1996), respectively. Some other acoustic studies have investigated the vowels of Northern Irish English. These researchers include (Murillo, 2016; Corrigan, 2010; Wells, 1982; McCafferty, 2007; Hickey, 2008.) Some other researchers (Dommelen & Hazan, 2010; Kebede, 2012) have investigated the issues of vowel articulation of English speakers of Norwegian, and Persian, respectively. Acoustic research on the articulation of vowels of L2 by L1 speakers of Latin American, German, and Greek done by (Iverson & Evans, 2009; Lengeris & Hazan, 2010). Moreover, the acoustic studies on Asian Englishes by (Bilal, 2011; Sailaja, 2009; Garesh, 2006; Kachru, 2005; Gonzalez & Alberca, 1978; Bautista & Gonzalez, 2006) are of great significance in identifying the central vowels having no difference in articulation.

The acoustic studies on Pakistani English by (Mesthire and Bhatt, 2008; Mahmood, et al, 2011; Bilal, et al, 2011) are related to short and front vowels. Abbasi (2018) has investigated the difference between low and high vowel quality cause of low and high frequencies. The brief description of Pakistani English (PakE) under the influence of local languages has been given by (Rahman,2004; Abbasi, 2015; Pickering & Wiltshire, 2000; Haque, 2007). The merging of back vowels (Bilal et al, 2021), and the relationship between phonemic transcription and pronunciation by Mahmood (2013), also provide assistance to know about the phonological system of PakE. Hussain, & Mahmood (2011)

investigated the vowel alternation and substitution phenomenon by Punjabi and Urdu speakers of Pakistan.

Though acoustic studies on Pakistani vowels have investigated different aspects as mentioned above, a detailed study on acoustic parameters of F1 & F2 with respect to four L1(Balochi, Punjabi, Pushto, Sindhi) and gender-mediated effects is still needed because the articulation of monophthongs creates problems for non-native speakers due to the basic phonetic features of vowels like height, back-ness, and lip rounding, which are different across languages. These features cause vowels to have different formant frequencies. The frequencies are called F1 & F2 formants which reveal the differences between front-back and high-low vowels. The high formant value shows the front vowels and is presented by F1. And the low formant value is shown as F2. The present study aims to measure and analyze the acoustic properties of F1 &F2 of vowels of PakE, under the influence of L1 and Gender.

Theoretical Framework

The Formant Frequency Model by Lindblom (1979) is a well-established framework for the study of vowel sounds in language. It posits that vowels are differentiated from one another on the basis of their formant frequencies, which are the resonant frequencies of the vocal tract. The model suggests that these formant frequencies are closely linked to the duration of the vowel sounds and can be influenced by factors such as tongue and lip position.

The present study takes ontological insights from the 'Formant Frequency Model' (Lindblom, 1979) to study the acoustic features of the monophthongs of PakE. The model is the most functioning method to examine vowel differences because "vowels are characterized by their formants as well as duration" (Farid, 2021, p. 34). This model helps to investigate the relationship between the vowels. The variations of vowel formant frequencies are closely dependent on the duration of the vowels as stated by Watt and Tillotson (2001), "the formant frequency varies according to vocal tract and duration, and therefore any varies resulting from tongue movement and lip shape influence the formant frequency" (p. 34).

In the context of the present study, the Formant Frequency Model provides a theoretical framework for examining the acoustic features of the monophthongs of PakE. By taking ontological insights from this model, the study aims to investigate the relationship between the different vowel sounds in PakE and how they are differentiated from one another based on their formant frequencies. This model is particularly relevant to the present study because it provides a systematic way to examine the acoustic features of the monophthongs of PakE, which is difficult to analyze otherwise. By using the Formant Frequency Model, the study can investigate the ways in which different vowel sounds are produced and how these variations are related to tongue and lip position, and duration.

Overall, this model is a crucial component of the present study as it provides a theoretical framework for examining the acoustic features of the monophthongs of PakE and helps to shed light on the variations of frequencies of vowel sounds.

METHODOLOGY

The current study is a quantitative research about the variations of formant frequencies (F1 & F2) of monophthongs produced by L1 Pakistani speakers of Balochi, Pushto, Punjabi, and Sindhi languages who have studied English as a second language. The methodology of this study involves the collection and analysis of vowels' acoustic data to study the monophthongs of PakE (a language).

PARTICIPANTS

Eighty (80) Pakistani students doing BS English and English Language courses, studying at the National University of Modern Languages, and International Islamic University, Islamabad, were selected for the present research. The rationale behind selecting the study sample was the availability of the participants as well as their ability to read English text. They were doing their BS-English or Diploma in English after their intermediate. These 80 participants (40 males and 40 females) were selected through "the **Purposive Sampling or Criterion Sampling** technique".

- **First language (L1):** Punjabi (majhi), Sindhi (Vicholi), Bloachi (southern Quetta), and Pushto (Yusuf Zai)
- Students of BS English and ELT at NUML and BS English Students at International Islamic University Islamabad.

MATERIALS

For the collection of data, the poem **'The North Wind and the Sun' abbreviated (NWS)** which has all 12 monophthongs was presented to all 80 participants. The *Journal of the International Phonetic Association* (2021) provides justification for using this poem. For instance, researchers have been using this poem since 1975. It is considered a better source to investigate the frequencies of vowels. The text of the poem is a valuable research instrument. It has semantic density. It has proper correspondence between phonemic analysis and transcription. It is used to investigate English phonology and being **'P A N P H O N I C'** it has all phonemes available in one text. Since 1975, acoustic analysis of almost 158 world languages has been done via NWS.

PROCEDURES

The participants were asked to read the poem naturally. The recordings were made in the soundproof environment of the FM studio at NUML and IIUI through *Sony Sound Forge 11-pro*. The recorded files were converted into mp-3 files. The total 4,960 (62-80) word tokens were measured on PRAAT to get the formant values of monophthongs in Hz. The statistics collected from PRAAT were presented in spectrographs. Then statistical descriptions were made via the use of SPSS and ANOVA.

DATA ANALYSIS

The recorded voice data were manually analyzed via PRAAT (software) for acoustic parameters of F1 &F2 or the formants. The values of F1 & F2 were taken separately but the average values of frequencies were analyzed. The formant values of F1 & F2 of males and females were arranged on an excel sheet. The data were organized after encoding the qualitative forms into quantitative numerical form as group 1, group 2, group 3, and group 4 for Balochi, Punjabi, Pushto, and Sindhi, respectively. Almost 4 words against each monophthong were analyzed and values for both F1 & F2 were collected and measured. The spectrographic images were also taken against each vowel sound of all 80 participants 40 males and 40 females from Balochi, Punjabi, Pushto, and Sindhi speakers. The manually taken values from PRAAT were measured on SPSS and further investigation has been done via ANOVA software.

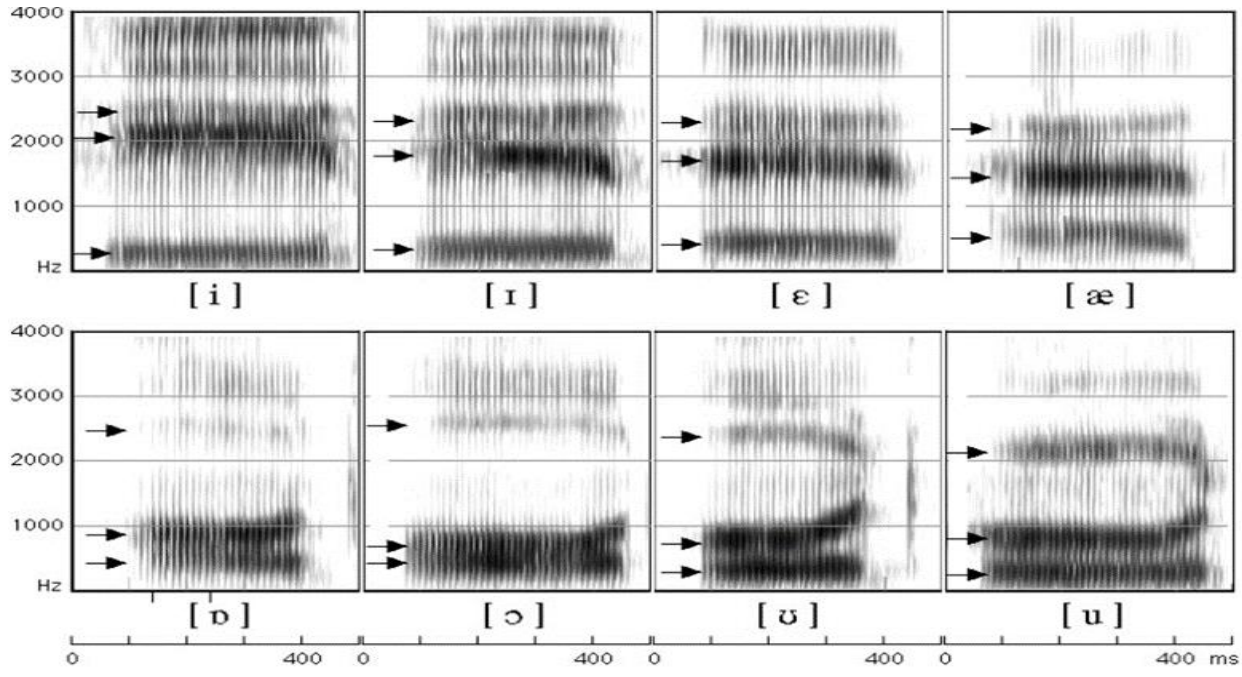
Measurements of F1 & F2 Frequencies

The formant frequencies of F1 & F2 were collected manually by visual investigation of wideband spectrographic view on **PRAAT** software. The graphic demonstration of sounds in terms of time or duration, intensity, and frequency is called **Spectrogram.** In a spectrographic representation, the duration of the vowel is exemplified on the x-axis, whereas the frequency is displayed on the y-axis. Intensity is shown by the relative darkness of the frequencies on the y-axis. As shown below;

Figure 1: *Sample Spectrogram of SBE Vowels*

Part 1: Analysis of Praat Spectrograms

The words containing monophthongs were measured on PRAAT (Boersma & Weenink, 2017), and numerical values were taken in Hz for F1 &F2 and duration in milliseconds. The vowels were



segmented and a spectrographic image of the sounds was taken too. The formant Frequencies of F1 and F2 of both male and female participants from each group were taken manually and the mid-point of the targeted word was visually displayed on the formant tracks on PRAAT. The paucity of space forced the researcher to present the spectrographic view of merely one phoneme.
(Ladeforged, 2006:185-187)

Figure 1: *Spectrographic representation of vowel /i/ (Balochi)*

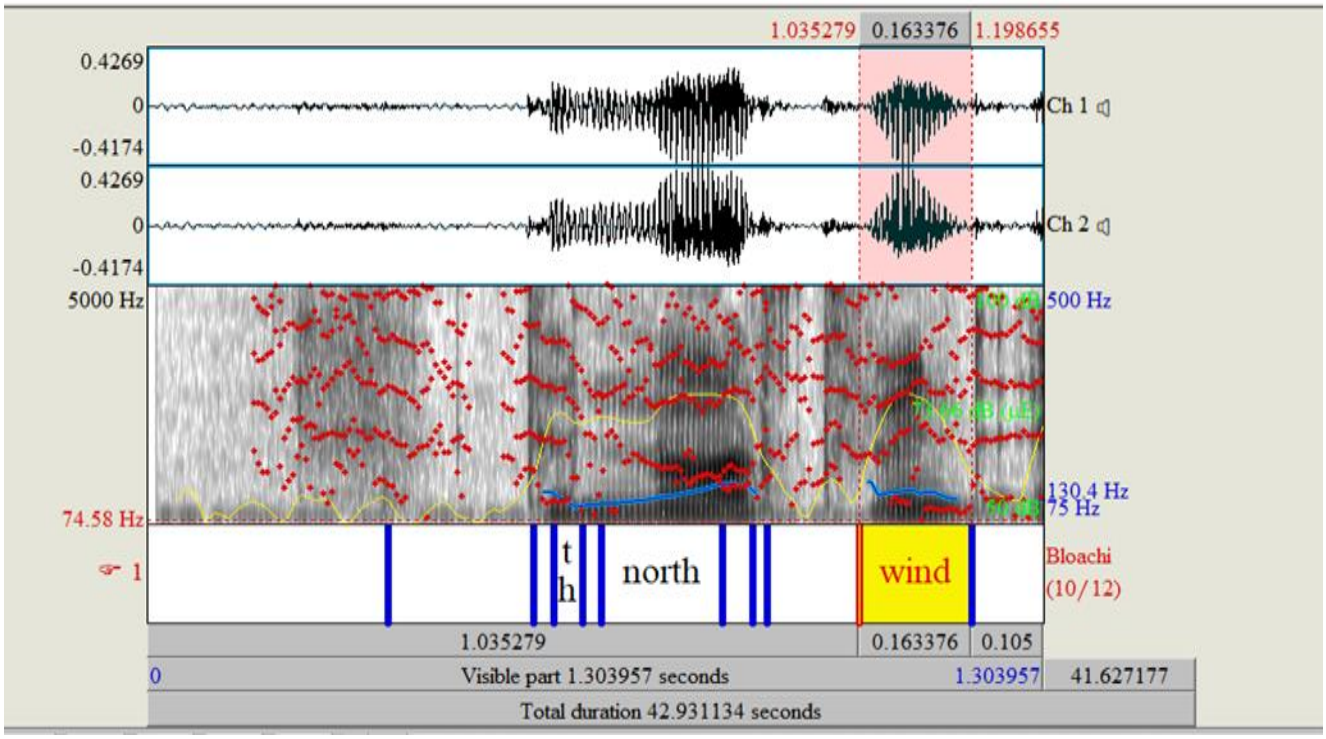


Figure 2*: Spectrographic representation of vowel /i/ (Pushto)*

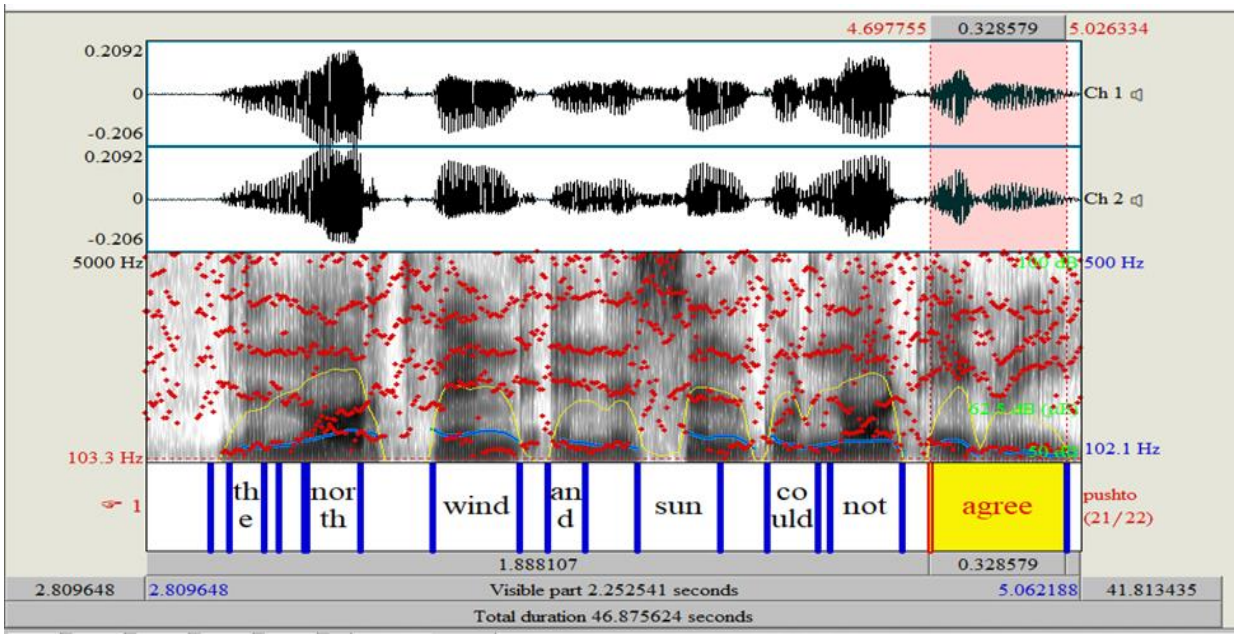


Figure 3*: Spectrographic representation of vowel /i/ (Punjabi)*

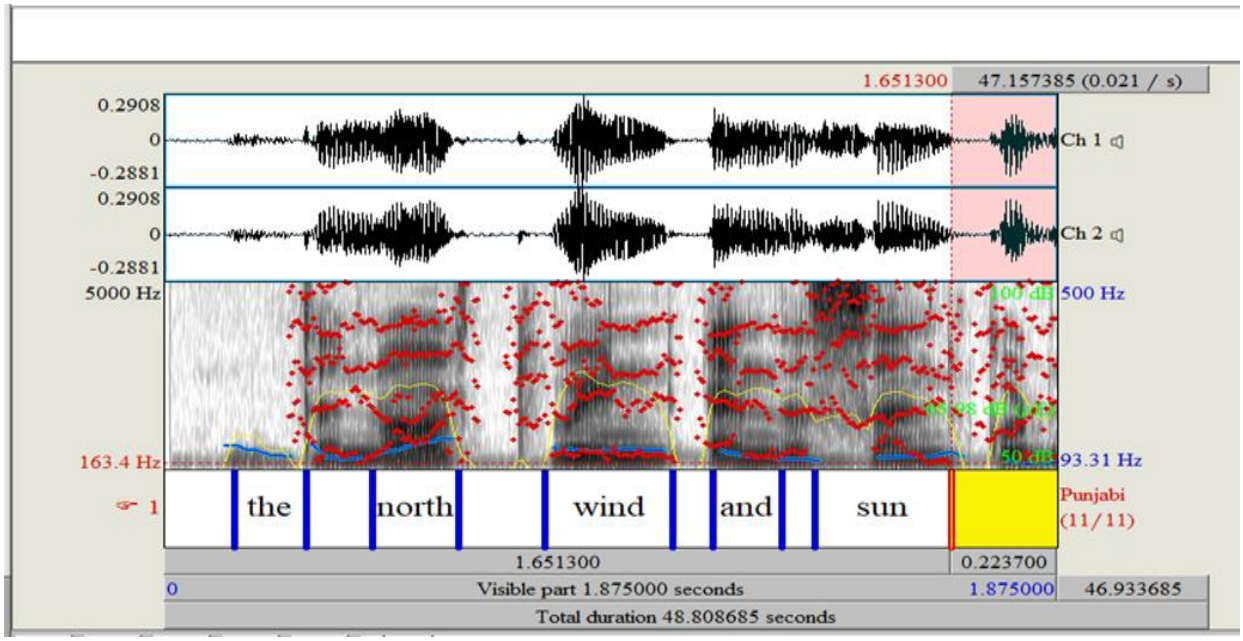
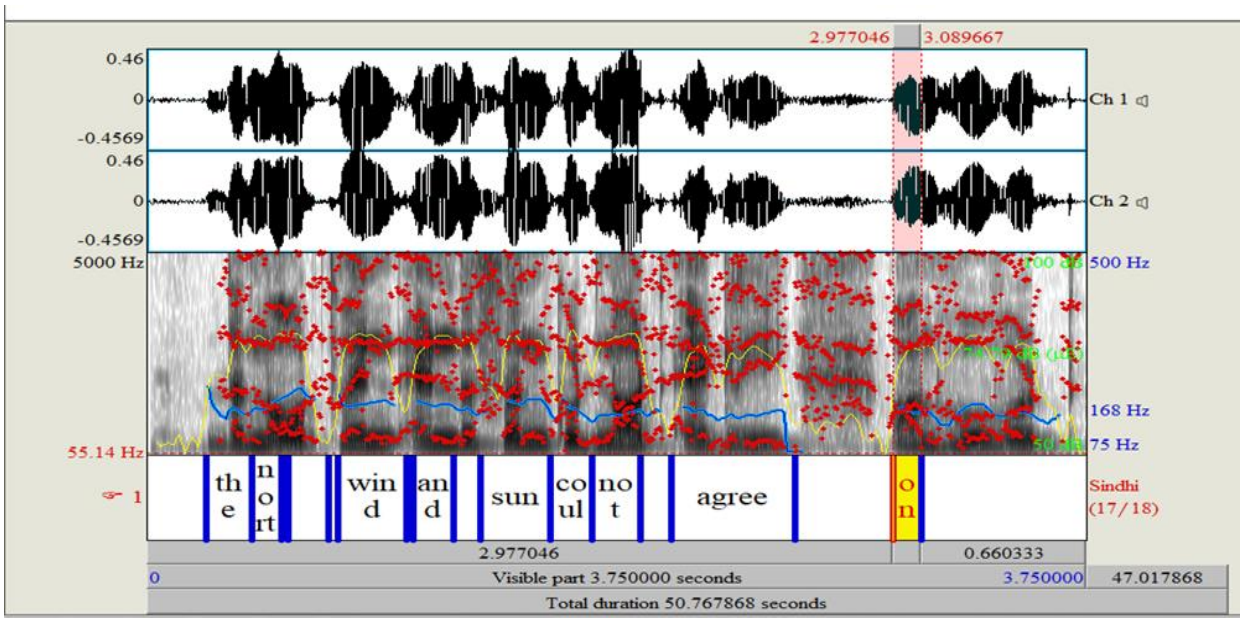


***Figure 4**: Spectrographic representation of vowel /i/ (Sindhi)*



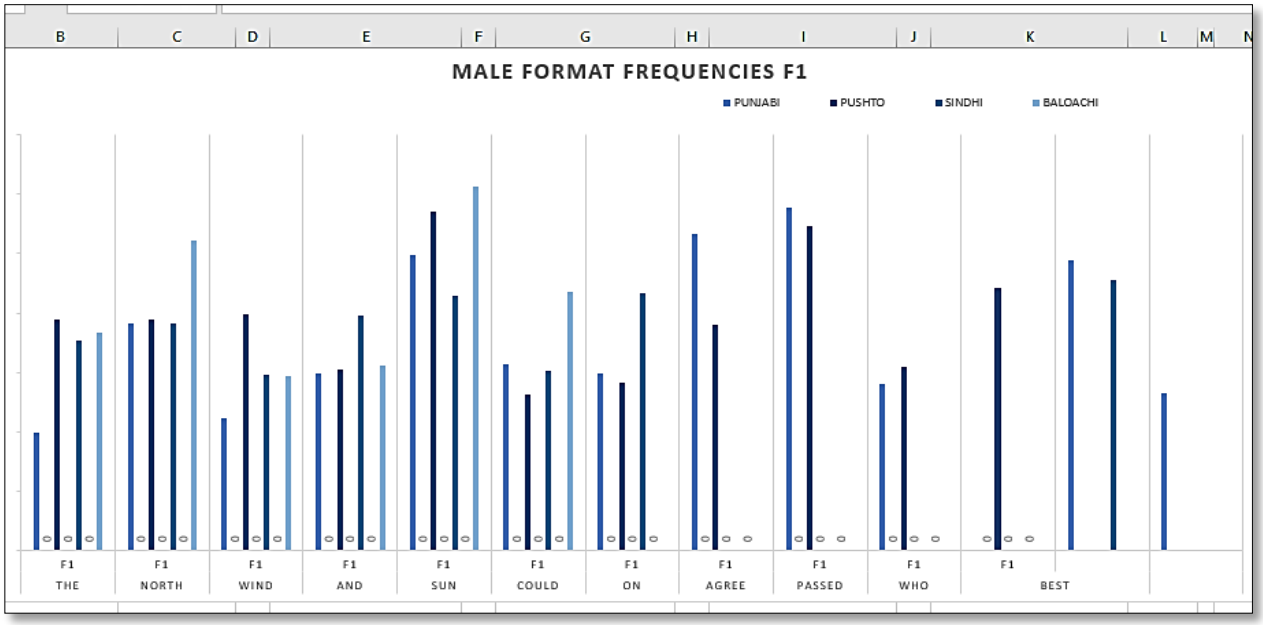
Description

The window displayed above is a PRAAT spectrograph. The study has taken parameters like a waveform, the spectrogram, and the formant tracks. Tier one is the sound wave and the second tier is the spectrograph of the same audio recording. The vertical axis from the right represents formant frequencies in Hz, while the vertical axis from the left represents the intensity of vowels in dB or decibels (decibels). Simultaneously, the horizontal lines represent both the entire duration of the file and the duration of the phonemes in milliseconds. The blue line in the second tier represents the opening of the vocal folds and, consequently, the vibration that occurs during the articulation of sound. The overall duration of figure-1,2,3 and 4 is 42.93, 46.87, 48.80, and 50.76 milliseconds, for Balochi, Pushto, Punjabi, and Sindhi speakers. The duration of the viewable portion is 1.30, 2.25, 1.87, and 3.75 milliseconds. These durations show differences in vowel articulation among groups and indicate that Sindhi speakers have more resonance and also depict the concept of lengthening vowels. The values differ for the /i/ sound among speakers like 0.16 dB, 1.88 dB, 1.65 dB, and 2.9 dB produced by Balochi, Pushto, Punjabi, and Sindhi speakers, respectively. The formant values are 130 Hz, 102 Hz, 93 Hz, and

168 Hz for Balochi, Pushto, Punjabi, and Sindhi speakers, respectively. These formant values show gender and L1-mediated vowel variations.

Part 2: Analysis of Vowel Formant Frequencies F1 & F2

The values of all the vowels were saved on Microsoft Excel Spreadsheet, and an average value of F1 and F2 was calculated for each vowel separately, taking into account the differences due to gender and



L1.

Figure 1: *Formant Frequencies Male Speakers*

Description

The dark blue lines indicate the production of sounds by Sindhi and Pushto speakers, whereas the light blue and royal blue lines indicate the production of sounds by Punjabi and Balochi speakers. The graph shows that Sindhi and Pushto speakers (males & females) have high formant frequencies and produce sounds with more duration as compared to the Punjabi and Balochi speakers. The speakers have shown that the phonemes like /e/ and / æ/ are distinct and thus have a difference in the formants F1 & F2.

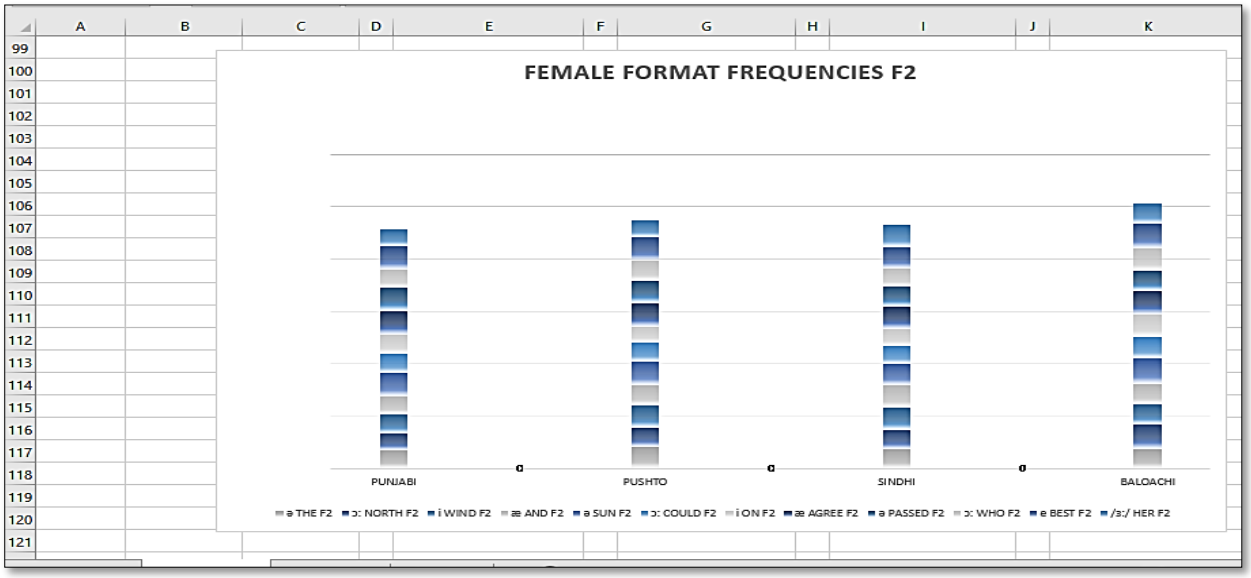


Figure 2: *Formant Frequencies Female Speakers*

Description

Female formant frequencies are depicted in Figure 2. The vowels /e/ and /æ/ have been articulated with clarity and distinction. The typical frequencies for Balochi, Pushto, Punjabi, and Sindhi speakers range from 2081 to 1744. Female speakers of Sindhi and Pushto have higher frequencies than female speakers of Balochi and Punjabi.

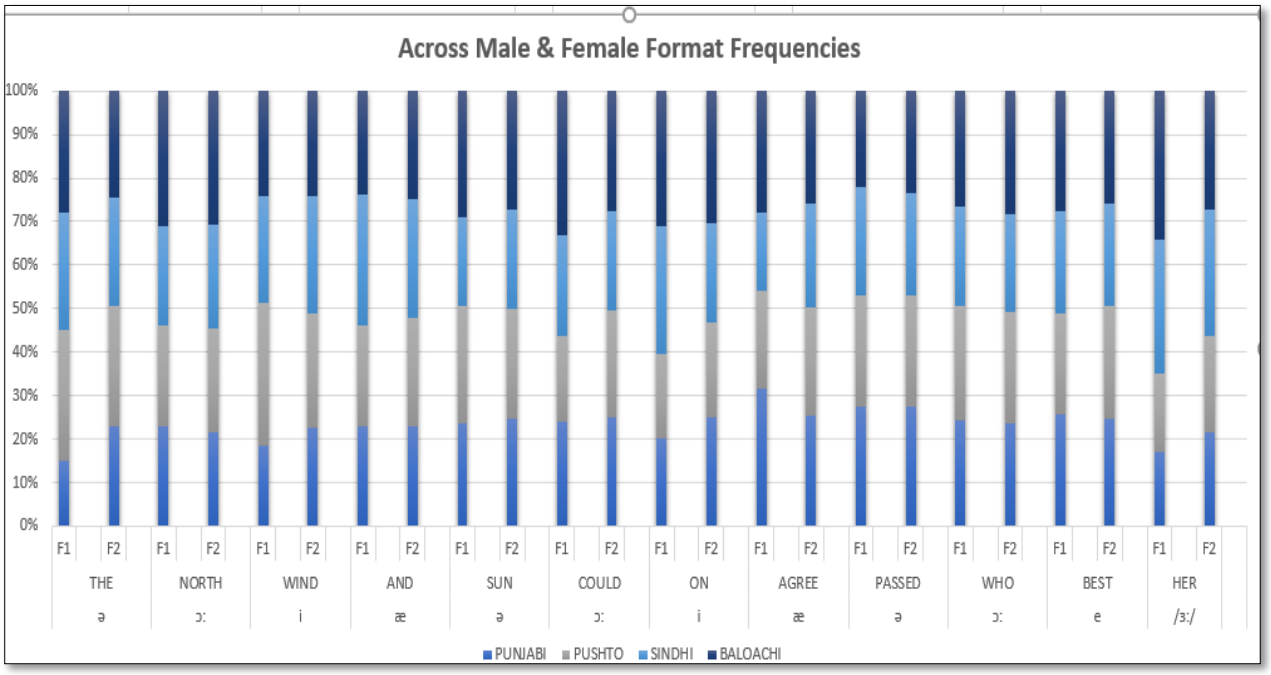


Figure 3: *Formant Frequencies Across Speakers*

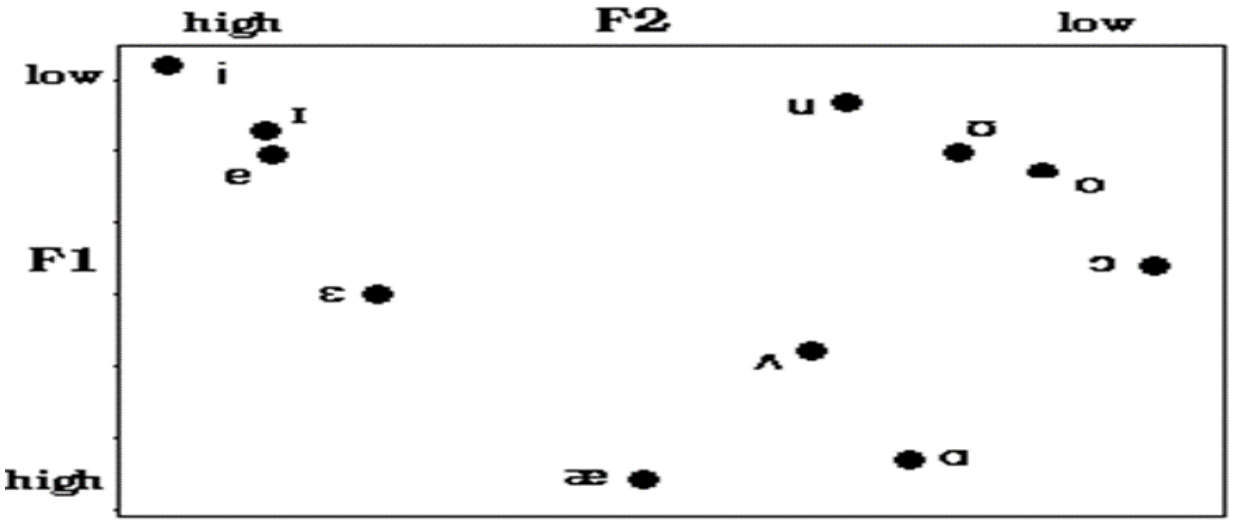
Description

Figure 3 depicts monophthongal variances in terms of F1 and F2 formant frequencies among Balochi, Pushto, Punjabi, and Sindhi speakers (both male and female). The graph depicts the high-frequency speech patterns of Sindhi and Pushto speakers. The average values of F1 & F2 across speakers have been given below;

Vowel	**[i]**	**[I:]**	**[e]**	**[3:]**	**[ʌ]**	**[a:]**	**[ɔ:]**	**[u]**	**[u:]**	**[ə]**	**[æ]**	**[ɒ]**
F1	521	486	622	498	624	577	606	630	504	575	504	539
F2	524 1488	1842	2128	1928	1570	1832	1568	1790	1481	2116	1530	

Table 1: *F1 and F2 Formant Frequencies*

The vowel or monophthongs presented on the given graph, in which the horizontal axis represents the first formant frequency of (F1) or the height of the tongue which determines the frequency of the first formant F1 like high F1 = low vowel (i.e., high frequency F1 = low tongue body) and low F1 = high vowel (i.e., low frequency F1 = high tongue body). The vertical axis denotes the frequency of the second formant (F2) or the frontness or backness of the tongue usually determines the second format F2. E.g. High F2 = front vowel Low F2 = back vowel as shown below; (Ladeforged, 2006:185-187).



(Ladeforged, 2006:185-187)

Part 3: SPSS Analysis

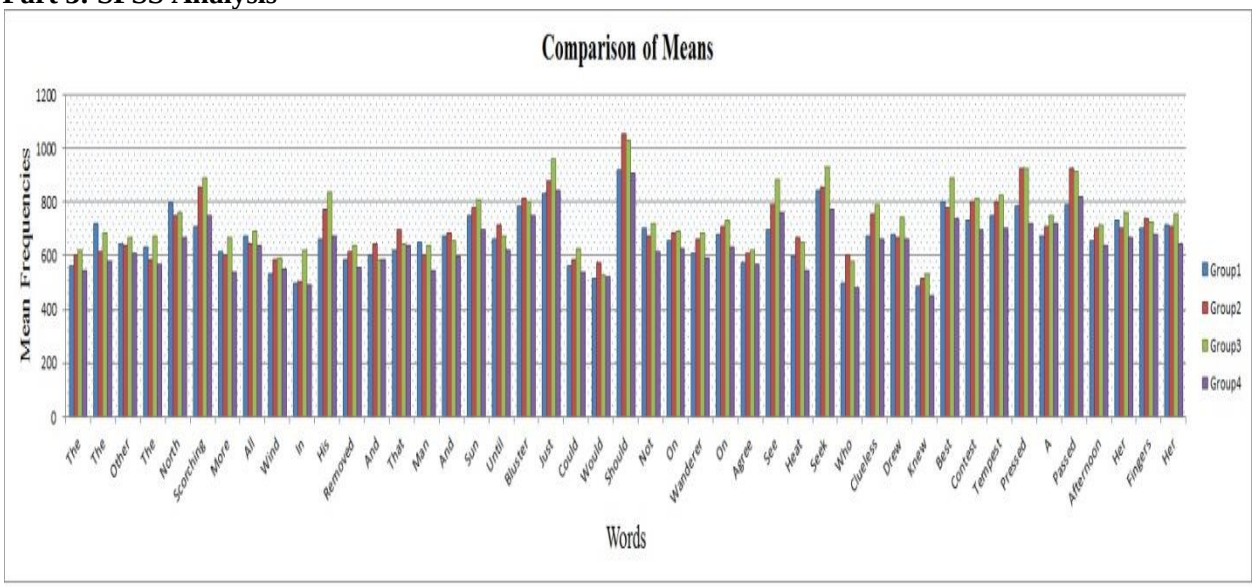


Figure 1: *Comparison of Means for Formant F1*

Description

Figure 1 illustrates the comparison of means of the F1 formant. Group 1, Group 2, Group 3, and Group 4 indicate Balochi, Pushto, Punjabi, and Sindhi speakers, respectively. Therefore, blue, red, green, and purple color represents the Balochi, Pushto, Punjabi, and Sindhi speakers. The comparative analysis demonstrates that the vowel 'u' has the highest value of F1 among 12 vowels for all types of speakers whereas the vowel 'u:' has the smallest value for Group 1 and Group 4 speakers. On the other hand, the vowel 'u' for 'Would' has the smallest value for Group 3 and Group 2. The vowel 'i' for 'wind' has the smallest value for Group 2 speakers. This confirms the F1 variations among the groups.

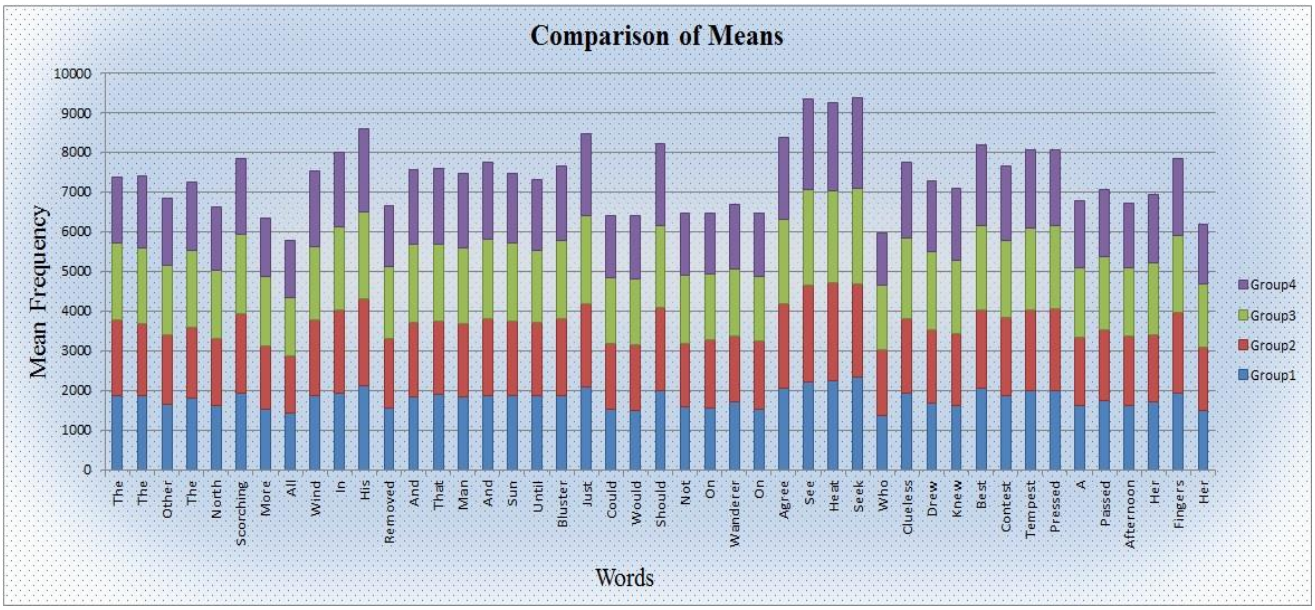


Figure 2: *Comparison of Means for Formant F2*

Description

The figure 2 depicts the comparison of the means of the F2 formant. Group 1, Group 2, Group 3, and Group 4 indicate Balochi, Pushto, Punjabi, and Sindhi speakers, respectively. Therefore, blue, red, green, and purple color represents Balochi, Pushto, Punjabi, and Sindhi speakers. The comparative analysis demonstrates that the vowel ‘iː’ in ‘Seek’ has the highest value of F1 among 12 vowels for Group 1 and Group 4 speakers whereas the vowel ‘iː’ in “Heat” has the highest value for Group 2 and the vowel ‘iː’ in ‘See’ has the highest value for the speakers of Group 3. On the other hand, the vowel ‘uː’ in ‘Who’ has the smallest value for Group 1 and Group 4 speakers while the vowel ‘ɔː’ in ‘all’ has the smallest value for Group 2 and Group 4 speakers. The comparative analysis of formant F2 illustrates vowel-to-vowel variations among the groups.

Comparison

The descriptive statistics compare the formant F1 and F2 means of Balochi (Group 1), Pushto (Group 2), Punjabi (Group 3), and Sindhi (Group 4) speakers. The F1 formant comparisons demonstrate that the vowel 'u' has the highest value among all 12 vowels for all types of speakers, while the smallest value varies among the groups. On the other hand, the F2 formant comparisons show that the highest value of F2 varies among the groups, with the vowel 'iː' in 'Seek' having the highest value for Group 1 and Group 4, the vowel 'iː' in 'Heat' having the highest value for Group 2, and the vowel 'iː' in 'See' having the highest value for Group 3 speakers.

The descriptive statistics show that the mean values of formant F1 and F2 vary among the groups, with Group 3 having the highest mean value for F1 and Group 2 having the highest mean value for F2. The standard error for all groups is relatively low, indicating that the mean values are relatively stable. The 95% confidence interval for mean values provides an estimate of the range in which the true mean value is likely to fall. The 5% trimmed mean, median, variance, and standard deviation provide further information on the distribution of the data.

The minimum and maximum values show the range of the data, and the interquartile range provides information on the spread of the middle 50% of the data. The skewness and kurtosis provide information on the shape of the data distribution. A skewness value close to zero indicates that the data is symmetrical, while a positive or negative value indicates that the data is skewed in one direction. A kurtosis value close to zero indicates that the data has a normal distribution, while a positive value indicates a peaked distribution, and a negative value indicates a flat distribution. Overall, the statistical comparison of formant F1 and F2 means among Balochi, Pushto, Punjabi, and Sindhi speakers show that there are differences in the means, standard errors, and distributions of the data among the groups.

Part 4: ANOVA Analysis

The ANOVA test was applied to determine the difference in the vowels between the four groups. The results of the test for each group are presented in tables.

Group	Mean Square	F	Sig.
Group 1	100076.876	6.022	.025
Group 2	127.241	.007	.935
Group 3	27161.755	1.143	.299
Group 4	114214.119	7.264	.015

For Group 1, the mean square is 100076.876. The F value is 6.022 and the significance level is .025. This indicates that there is a significant difference between the vowels in Group 1. For Group 2, the mean square is 127.241. The F value is .007 and the significance level is .935. This indicates that there is no significant difference between the vowels in Group 2. For Group 3, the mean square is 27161.755. The F value is 1.143 and the significance level is .299. This indicates that there is no significant difference between the vowels in Group 3. For Group 4, the mean square is 114214.119. The F value is 7.264 and the significance level is .015. This indicates that there is a significant difference between the vowels in Group 4. Thus the ANOVA test shows that there is a significant difference in the vowels between all Groups.

DISCUSSION OF RESULTS

Group 1: Balochi Speakers

Below is the table of /ɔ:/ and /ɒ/

Gender	F1 (Hz)	F2 (Hz)	Articulated Sound
Female	892	1850	/ɔ:/ (front vowel)
Female	788	1832	/ɔ:/ (front vowel)
Male	788	1832	/ɔ:/ and /ɒ/ (merged)

Table 2*: Vowel Sound Variations of Balochi Speakers*

The data reveals group-wise variations like Balochi female speakers pronounced /ɔ:/ sound with high frequency e.g. F-1 892 Hz and F-2 1850 Hz as compared to the male speakers e.g. F-1 788 Hz and F-2 1832 Hz. The high-frequency F1 shows the low tongue body and the high F-2 shows front vowel production. The formant values of F-1 & F-2 of male speakers reveal that they have articulated /ɔ:/ and / ɒ / in a similar way. This analysis sheds light on the idea that Balochi female speakers pronounced back vowels as front vowels and male speakers have merged them. They may not pronounce sounds such as /ə / and /ʌ / possibly because their vowel system lacks these sounds.

Group 2: Pashto Speakers

Below is the table of /I:/, /u:/, /ɑ:/, /ɜ:/, and /ɔ:/.

English Phoneme	Pashto Articulation
/ɔ:/	/a:/ (long vowel)
/I:/	/i/ and /æ/ (open-back vowels)
/ɑ:/	/Λ/ and /ə/
/ɜ:/	/ɹ/ (consonant)

Table 3*: Vowel Sound Variations of Pushto Speakers*

The Pushto speakers have shown variations for certain English sounds like the English phoneme /ɔ:/ was pronounced by them as the long vowel /a:/. The Pushto speakers of the Yousafzai dialect face problem in the articulation of long vowels. They pronounced the /I:/ sound as open-back vowels /i/ and /æ/. The open long vowel phoneme /ɑ:/ was articulated as /Λ/ and /ə/. Further, they pronounced the long vowel /ɜ:/ similar to /ɹ/ sound which is a consonant. Thus, these speakers have shown difficulty in the articulation of English long vowels like /I:/ /u:/, /ɑ:/, /ɜ:/, and / ɔ:/.

Group 3: Punjabi Speakers

Below is the table of /ɒ/, /i:/, /i/, /ɑ:/, /u/, /u:/, /ɔ:/

English Phoneme	Punjabi Articulation	F1 (Hz)	F2 (Hz)
/ɒ/	/ɑ/ (back open vowel)		
/i:/	long vowel (female speakers only)		
/i/	short vowel (female speakers only)		
/ɑ:/	distinct (male and female speakers)	875	1693
/u/	distinct (male and female speakers)	496	1527

/u:/	distinct (male and female speakers)	402	1667
/ɒ/ and /ɔ:/	short vowels merged	469	1258
	(male and female speakers)	485	1338

***Table 4**: Vowel Sound Variations of Punjabi Speakers*

The Punjabi speakers pronounced the English open back vowel / ɒ / as back open vowel /ɑ/. The female Punjabi speakers made a clear distinction between the high front vowels /i:/ and /i/ and pronounced the former as long and later as a short vowel. The formant frequency values of F1 and F2 with durational differences revealed that these sounds have distinct articulation by the females. The F1 & F2 formant values of vowels like /ɑ:/, /u/, and /u:/ have shown variation by both male and female speakers. The F1 frequency for these vowels was 875 Hz, 496 Hz, and 402 Hz and F2 was 1693 Hz, 1527 Hz, and 1667 Hz for /ɑ:/, /u/, and /u:/ respectively. These phonemes have been pronounced in a distinct manner. The phones like /ɒ/, and /ɔ:/ have been pronounced as short vowels and merged together because their F1 & F2 values were almost the same. The F1 value was 469 and the F2 value was 1258 for the former and the F1 value was 485 Hz and the F2 1338 Hz for the latter.

Group 4: Sindhi Speakers

Phoneme	Articulation	Male	Female
/e/, /æ/, /ɛ/	Deficient in difference	Both	Both
/e/	Pronounced as /æ/ in ‘and’	Both	Both
/3:/	Pronounced as /ɪ/ in ‘fingers’	Both	Both
/u:/ and /u/	Identical pronunciation	Both	Both
/ɑ:/, /ʌ/, and /ɔ:/	High resonance (Male) High pitch (Female)	High resonance	High pitch
/æ/	Differences in height and frontness of the tongue	771-F1, 1957-F2	694-F1, 2044-F2

***Table 4**: Vowel Sound Variations of Sindhi Speakers*

Finally, the Sindhi speakers show a deficiency of difference in the articulation of front vowels like /e/, /æ/, and /ɛ/. Thus, no clear identification is possible for these sounds. The sound like /e/ in ‘pressed’ has been pronounced like the ‘sheep’ sound in ‘and’. The sound ‘3:’ in ‘her’ is similar to ‘fingers’. This confirms that Sindhi speakers hinder the comprehension of the listeners for these /e/, /æ/, and /ɛ/ English phonemes. Similarly, the F1 & F2 formants related to height and length of the tongue for vowel articulation exhibited low height and lengthening of front vowel articulation by females and males have shown more height and shortening of vowels. The formant values of F1 & F2 of /u:/ and /u/ have shown identical pronunciation by both male and female speakers of group 4 or Sindhi speakers. The male speakers have shown high resonance and females more pitch for phonemes like /ɑ:/, /ʌ/, and /ɔ:/. The F1 & F2 values 694-F1, 2044-F2 by females and 771-F1 and 1957-F2 by males for /æ/ show differences in the height and frontness of the tongue by the speakers.

CONCLUSION

The study investigated the pronunciation of English phonemes by native speakers of Balochi, Pushto, Punjabi, and Sindhi. The results revealed significant variations in the pronunciation of English sounds by these speakers. The Balochi female speakers pronounced the /ɔ:/ sound with a high frequency, while the male speakers merged /ɔ:/ and /ɒ/. The Pashto speakers faced difficulty in the articulation of long vowels and pronounced the /ɔ:/ sound as the long vowel /a:/. The Punjabi speakers pronounced the English open back vowel /ɒ/ as back open vowel /ɑ/. The female Punjabi speakers made a clear distinction between the high front vowels /i:/ and /i/. The Sindhi speakers were deficient in differentiating between the sounds /e/, /æ/, and /ɛ/. They pronounced the /e/ sound as /æ/ in the word ‘and’ and the /3:/ sound as /ɪ/ in the word ‘fingers’. Both male and female Sindhi speakers pronounced the /u:/ and /u/ sounds identically.

This study highlights the importance of taking into account the linguistic backgrounds of non-native English speakers when teaching English pronunciation. It highlights the need for English language teachers to be aware of the linguistic backgrounds of their students and to adapt their teaching methods accordingly. The study provides valuable insights into the pronunciation patterns of these language groups and will be useful for linguists, English language teachers, and speech therapists in their work.

This study contributes to the field of vowel research by providing a comprehensive examination of vowel production and perception in a specific language or dialect. The findings and methodology used in this study can serve as a foundation for future research on vowels, both within this language or dialect and in other languages and dialects. The results of this study can also inform the development of new teaching methods or speech therapy techniques, as well as the design of new technologies for speech recognition and synthesis. Additionally, this study highlights the importance of considering the role of individual differences and linguistic context in the study of vowels, which can inform future research in this area. Overall, this study has the potential to make a significant impact on the understanding of vowel sounds and their role in language and communication.

This study was conducted in specific regions of a country, and future research could benefit from a more global perspective by conducting similar studies in other regions or countries. Moreover, the categorization of vowels used in this study was based on a specific linguistic framework, and future research could benefit from using alternative frameworks or approaches to categorize vowels. By addressing these delimitations in future research, the findings and conclusions of this study could be further strengthened, and the study of vowels could be advanced.

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