

A DESCRIPTIVE ANALYSIS OF ENGLISH VOWEL SOUNDS BY L1 PAHARI LEARNERS

Nadia Safeer¹, Sadia Malik², Dr. Uzma Anjum³

Original Article

1. English Scholar, Air University, Islamabad.
Email: nadiasafeer2020@gmail.com
2. English Scholar, Air University, Islamabad
Email: sagacioussadia@gmail.com
3. Associate Professor, Department of English, Faculty of Social Sciences, Air University, Islamabad. Email: uzmaraja2000@gmail.com

Abstract

This study aimed to analyze the acoustic characteristics of English vowels produced by Pahari L1 learners of Pakistani English (PakE) from Murree and Islamabad. The researchers used PRAAT version 6.1.04 to measure the F1 and F2 formants and duration of ten monosyllabic words with the CVC structure in the 'hVd' context. They compared the results with those of native British English speakers and analyzed the data using t-tests in SPSS and R software for graphical representation. The findings revealed significant differences between PakE and British English recordings, confirming that PakE is a distinct and rule-governed variety of English with its own phonology. The results have practical implications for PakE language teachers to improve their students' pronunciation skills and for designing speech technologies that aim to improve the accuracy of PakE pronunciation. The study contributes to the phonological system of PakE and can be helpful for future research in the field of phonetics and speech technologies, particularly for Asian English varieties.

Keywords: acoustic, formants, PRAAT, Euclidean, vowel duration and quality, R representation, PakE

INTRODUCTION

"In today's globalized world, language is a complex system that is shaped both by its innate properties and by the active involvement of its users, and thus, the authority of monolingual native speakers is not superior to that of multilingual speakers who are equally fluent" (Mufwene & Escobar, 2022).

Pakistani English (PakE) is a unique variety of English that has evolved over the past two centuries due to regional cultures and ways of life, resulting in systematic modifications that differentiate it from British English (BE) (Deterding, 2010). As a form of Asian English, PakE exhibits phonetic variations in both segmental and suprasegmental features, which are influenced by the amount of time spent using the second language (L2) (Pratiwi et al., 2022; Nagle, 2022). Previous studies have also shown that individuals who speak Asian languages tend to exhibit phonetic variations when speaking in a second language (Fang, 2022). Other studies investigated the influence of regional languages on PakE, including Punjabi and Urdu (Hussain et al., 2022; Bilal et al., 2011a, 2011b, 2011c, 2021) among others. These studies provided insight into the diverse linguistic landscape of Pakistan and the development of PakE (Abbasi et al., 2021; Abbasi et al., 2022). Despite not being a native language, English has become nativized in Pakistan and the official language.

The Pahari language, spoken in the northern Himalayan region of the Indian subcontinent, includes dialects such as Pahari-Pothwari, Chamiyali, and Hindko. Pahari-Pothwari is spoken mainly in Pakistan, while Chamiyali is spoken in parts of India and Pakistan (Khaliq et al. 2022). The Pahari dialect spoken in Murree has distinct characteristics, including a rich vocabulary influenced by the local environment and culture, retroflex consonants, and a unique tone and intonation. The pronunciation of Pahari spoken in Murree is influenced by the neighbouring languages, particularly Punjabi and Urdu. Studies on the Murree dialect have found differences in its phonetic features, including Pahari-accented English and longer durations of English vowels compared to native English speakers (Riaz et al., 2022). These findings provide insights into the acoustic differences between Pahari and English vowels, which can be used to improve the pronunciation of Pahari speakers learning English as a second language. The studies by Abbasi et al. (2021), Abbasi and Rasheed (2022), and Khan (2014) provided valuable resources for further research in the field of acoustic phonetics.

Khan (2014) analyzed the acoustic characteristics of Pahari oral vowels, finding they have a shorter duration, higher formant frequencies, and higher fundamental frequency than English vowels. The Pahari oral vowel inventory consists of the following twelve vowels:

Table 1.1
Oral Vowels of the Pahari Language (Khan, 2014)

S.No.	IPA Symbols	Features
1	i:	(unrounded) front-close-long
2	ɪ	(unrounded) front-close-short
3	e:	(unrounded) mid-front-long
4	e	(unrounded) mid-front-short
5	æ:	(unrounded) front-mid-long
6	æ	(unrounded) front-mid-short
7	a:	(unrounded) central-mid-long
8	ə	(unrounded) central-mid-short
9	o:	(rounded) back-mid-long
10	o	(rounded) back-mid-short
11	u:	(rounded) back-close-long
12	ʊ	(rounded) back-close-short

Note: **Table 1.1** shows the summary of the Pahari oral vowels as presented by (Khan, 2014).

This study explores the “**acoustic properties**” of English vowel sounds produced by native Pahari speakers residing in Islamabad and Murree. It seeks to identify systematic differences between English (BrE) and the Pahari-accented English vowels which can contribute to the differences **in spoken words** of English sounds by Pahari speakers. Through acoustic analysis using PRAAT, the study examines formant frequencies, vowel duration and quality, and spectral characteristics of English vowels produced by Pahari speakers.

Research Questions

This study has these research questions to answer:

1. To what extent do the acoustic properties of English vowel sounds by Pahari L1 learners vary in relation to the demographic factor “Age”?
2. In what way do English vowel pairs differ in their quality and duration when produced by different age groups?

LITERATURE REVIEW

This section presents a thorough analysis of the existing research on acoustic phonetics, with a specific focus on vowel sounds in various languages. The sections are interlinked, providing a comprehensive overview of the relevant background information and theoretical frameworks.

Source Filter Theory

Gunnar Fant's book "*The Acoustic Theory of Speech Production*" (1960) introduced the Linear Source-Filter Theory or Source-Filter Theory, which explains speech sound production in terms of sound energy sources and sound filtering effects. According to Fant, "speech wave is the response of the vocal tract filter systems to one or more sound sources" (p.15). The Source Filter Theory of Speech Production proposes that the sound source for speech is the glottis, which produces air pulses that are filtered by the vocal tract. The shape of the "vocal tract filters the sound" produced by the glottis in a way that creates different speech sounds. This theory has been extensively studied, with research exploring its applications to mammal vocal communication early speech development, and voice production (Tokuda, 2021), and stochastic voice creation models (Cataldo et al., 2021). This theory provides a useful framework for understanding speech production and communication, and the current study utilizes this theory to examine factors affecting speech production (Perroux et al., 2022).

English Vowels Sounds

Chen et al. (2009) studied American English vowels produced by native speakers of Mandarin and found significant differences in formant frequencies compared to native American English speakers. Bilal et al. (2011a) analyzed the front vowels of English produced by Pakistani speakers and found differences in the articulation of mid-front vowels compared to native speakers. Carlet and Cebrian (2022) confirmed these results in their work on the front vowels of Pakistani English. Various studies have focused on the significance of sound segments in language, such as the uniformity and drift of fricative and apical vowel sounds in Suzhounese (Faytak, 2022), the role of segment type in second language learners' perception and identification of target-language phonemes.

Analysis of the Vowel Quality and Duration Using Praat

Praat is a free software that analyzes and reconstructs the acoustic characteristics of speech sounds, particularly helpful in analyzing vowel sounds. Abbasi et al. (2022) demonstrated their various applications in analyzing speech samples. The quality of vowels is determined by tongue position and other articulators, while pitch is a separate aspect. Vowel sounds are classified by their F1 and F2 formants, which are consistent across languages, speakers, and contexts, making the theory of acoustic invariance important (Behr, 2022; Abbasi et al., 2022). Vowel duration is crucial for distinguishing between short and long vowels, which are phonemic in different languages. Vowel duration is affected by context and suprasegmental features. Another study has found that duration varies based on factors such as tone, stress patterns word position.

The Role of Demographic Variables in Vowel Studies

In acoustic phonetics, demographic variables such as age, education, and geographical location are important factors to consider in investigating the acoustic features of vowels in various languages. For example, researchers have studied the use of demographic factors in English vowel sound wave studies (Hussain et al., 2022). Therefore, understanding the demographic variables of a particular group of individuals is essential in analyzing the acoustic characteristics of vowels in various languages.

Demographic Variable (Age)

Age plays a crucial role in the acquisition of language, and the articulation of language requires time to become proficient. The acquisition of language is one of the various traits that human beings learn during the aging process (Ru, 2016). The language learning process changes with age, and acoustic researchers often consider age as a factor in studying language differences among different age groups). Acquisition of language at an early age is arbitrary, and language proficiency is acquired with time and social exposure to the speech community.

Studies on Pahari Language

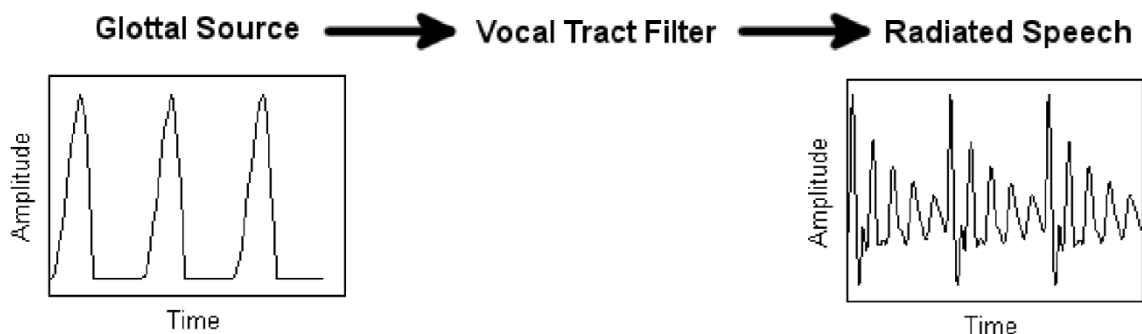
Pahari language is influenced by Punjabi, Urdu, Hindi and English loanwords. Research has explored various aspects of its phonetics and phonology, including the tonal system and acoustic properties of its vowels. Ongoing studies can aid in understanding the complexities of this unique language, which is an important part of South Asia's linguistic diversity (Khan, 2013; Riaz et al., 2022). However, there is a gap in the literature about the production of English vowel sounds by Pahari speakers. This gap is addressed in the current study, which is unique because it applied Euclidean Distance Theory to normalize vowel frequencies, Hertz, to bark values, and used R software for plotting vowels and their graphical representations.

METHODOLOGY

In the current study, the “**Source-Filter Theory**” was applied to analyze the “acoustic features” of English vowel sounds spoken by native “Pahari learners”. The theory helps to identify the various sound energy sources involved in producing vowel sounds, including quasi-periodic glottal pulse and turbulence noise, and how they are modified by the vocal tract filter to create distinctive spectral characteristics for each vowel sound (Fant, 1960).

Figure 1

Conceptual Representation of Source Filter Model of Speech Production adopted from (Fant, 1960).



Research Design

The present study is quantitative and uses **PRAAT software version 6.1.57** (Boersma & Weenink, 2021) to analyse acoustic data of English vowel sounds produced by Pahari native speakers. The study is the first to focus on vowel articulation based on the demographic variable “**Age**”. The collected speech samples are analysed for formant frequencies, duration of vowel sounds and contrast in typical English vowel pairs. Normalized **bark values** are used for vowel frequencies, and a **t-test** is applied to determine differences between the groups using **SPSS software**. The **R Software** was used to plot vowels for their graphical representation.

Sampling Criteria

The study used **Purposive Sampling** to gather data from Pahari speakers, which is a non-probability sampling method that selects participants based on specific criteria relevant to the research objectives (Palinkas et al., 2015).

Participants

The study involved 10 participants, with data collected from Pahari speakers in Murree and Islamabad who varied in age. Recordings were collected as 5 participants from location A and 5 from location B based on their availability. Participants were divided into three age groups: **15-20 years, 21-25 years, and 26-30 years.**

Speech Sample

The speech sample comprised a list of **ten** hVd contexts monosyllabic English words, including vowels such as “/i:/, /ɪ/, /e/, /ɛ/, /æ/, /ʌ/, /u:/, /ʊ/, /ɔ:/, and /ɑ:/”. The words' structure was restricted to CVC where these vowels are presented, and the word list was recorded in a carrier sentence: “**I can say hVd again.**”

Table 2

Vowel sounds Word list in “hVd” context as adopted from Hillenbrand et al. (1995)

Vowel	Word
/i:/	heed
/ɪ/	hid
/e/	hayed
/ɛ/	head
/æ/	had
/ʌ/	hud
/u:/	who'd
/ʊ/	hood
/ɔ:/	hawed
/ɑ:/	hod

Demographic Information

The following **Table 1.2** presents the demographic information of the participants included in the study. The total number of participants is 10, with an equal distribution of gender; 5 females and 5 males. The age of the participants ranges from 16 to 30 years, and the majority of them (6 out of 10) have received 16 years of education, while the remaining 4 have completed 12 years of education.

Table 3
Demographic Information of the Participants

Speakers	Sex	Age
Speaker 1	Male	30
Speaker 2	Male	24
Speaker 3	Male	27
Speaker 4	Male	17
Speaker 5	Male	16
Speaker 6	Female	18
Speaker 7	Female	18
Speaker 8	Female	27
Speaker I9	Female	24
Speaker 10	Female	23

Euclidean Distance

The Euclidean distance theory is used in this study to compare the vowel data of different individuals. This theory calculates the distance between two points in a two-dimensional vowel space by using the average F1 and F2 values for each category. The Euclidean distance is used to determine the separation between categories, which partially meets the criterion for vowel space (De Decker & Nycz, 2011; Mairano et al., 2019). In this study, this theory is used as a dependent variable in the statistical analysis of the normalized vowel data. To facilitate acoustic measurements, Zwicker and Terhardt (1980) introduced a method for converting frequencies in Hertz to bark scale, which has been utilized by Deterding (2010) in their research on vowel acoustics.

The formula for this conversion is provided below:

$$Z_i = 26.81 / (1 + 1960 / F_i) - 0.53$$

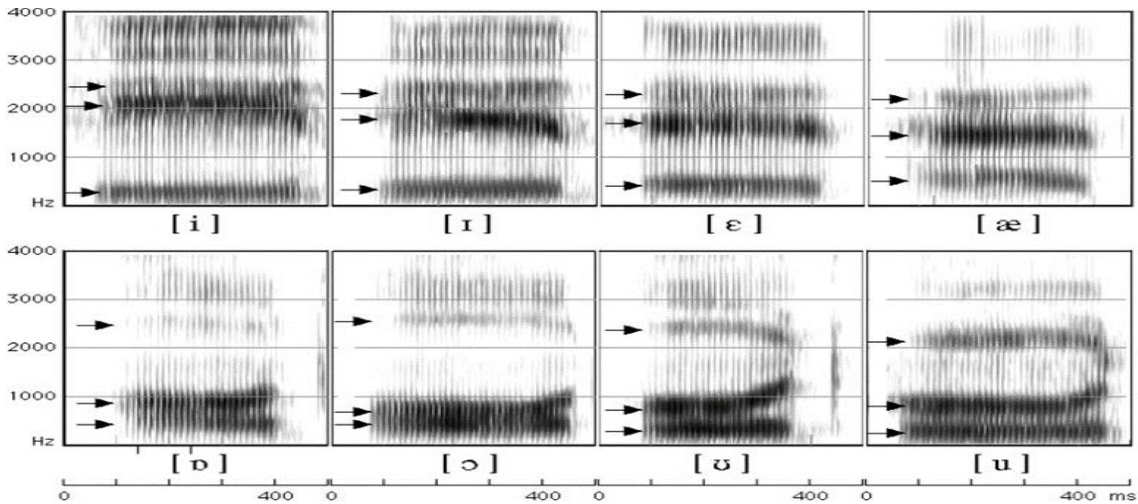
“Here F is a frequency in Hertz, while Z is the frequency in Bark”

DATA ANALYSIS

F1-F2 Frequencies Measurements

The F1 and F2 formant frequencies were collected by visually analyzing the wideband spectrographic view using PRAAT software. The x-axis of the spectrogram represents the duration of the vowel, while the y-axis represents the frequency. The relative darkness of the frequencies on the y-axis indicates the intensity. The figure below illustrates this representation.

Figure 2
Sample Spectrogram of BrE Vowels



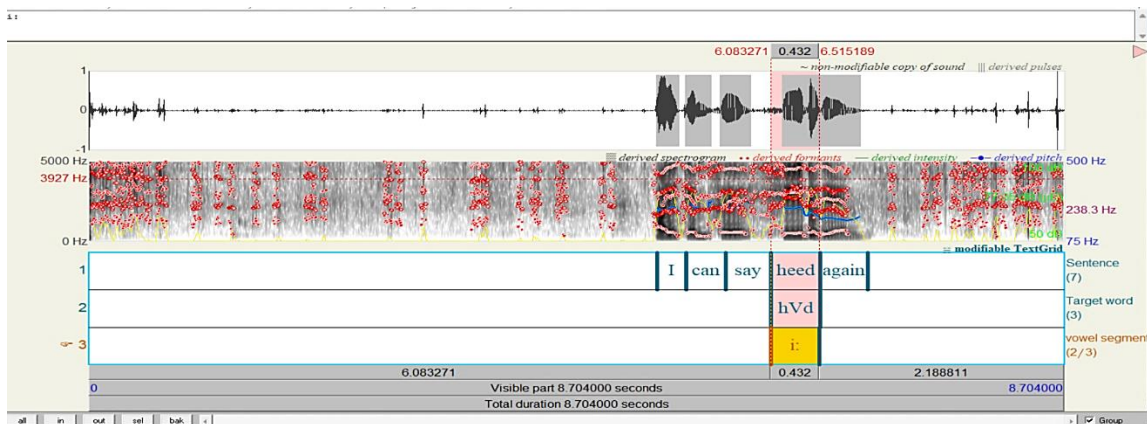
Praat Spectrograms Analysis

The monophthongs in a carrier sentence were analyzed using PRAAT (Boersma & Weenink, 2021) to obtain numerical values in Hz for F1-F2 and duration in milliseconds. The vowels were segmented and spectrographic images of the sounds were also obtained. The formant frequencies of F1-F2 were manually collected from both male and female participants in each age group, and the mid-point of the target word was visually displayed on the formant tracks in PRAAT. The figure below shows a sample of this visual representation.

Figure 3

Sample of Visual Spectrograph of Vowel /i:/

The displayed PRAAT spectrogram includes different tiers representing sound waves and the spectrogram of an audio recording. The vertical axis shows formant frequencies and intensity of vowels in Hz and decibels respectively. The horizontal lines depict the duration of the file and phonemes in milliseconds. The green line signifies the opening of vocal folds during sound articulation. The figure demonstrates differences in vowel articulation among the three age groups. The /i/ sound shows variation in values among speakers. The formant value F1 is 75 Hz. Other vowel sounds also demonstrate significant differences in their F1-F2 values.



Demographic Variable (AGE)

Table 4.1 displays the average values of formant frequencies ("F1 and F2") for Pahari L1 speakers belonging to three distinct age groups. The mean formant frequencies and vowel plots were examined separately for each age group and corresponding figures 4, 5 and 6 were presented.

Table 4
Mean Formant Frequencies ("F1 and F2") categorized by "Age Groups"

	Age 16-20		Age 21-25		Age 26-30	
	F1 (Hz)	F2 (Hz)	F1 (Hz)	F2 (Hz)	F1 (Hz)	F2 (Hz)
i:	388	2520	335	2240	336	2495
ɪ	412	2247	425	2210	445	2319
E	590	2020	575	2006	525	2285
E	523	2222	565	1960	535	2256
Æ	548	2155	560	2022	585	2126
ʌ	522	1175	465	1363	450	1290
u:	412	945	333	1095	440	1277
ʊ	405	1075	425	1085	445	1250
ɔ:	495	1435	725	1445	500	1215
ɑ:	475	1195	530	1175	506	1245

Table 4 displays the mean formant frequencies (F1 and F2) for various vowel sounds of Pahari L1 speakers in three different age groups: 16-20, 21-25, and 26-30. The values for F1 and F2 are given in Hz for each vowel sound.

Figure 4
Mean Formant Plot of Age Group 1 (16-20 years)

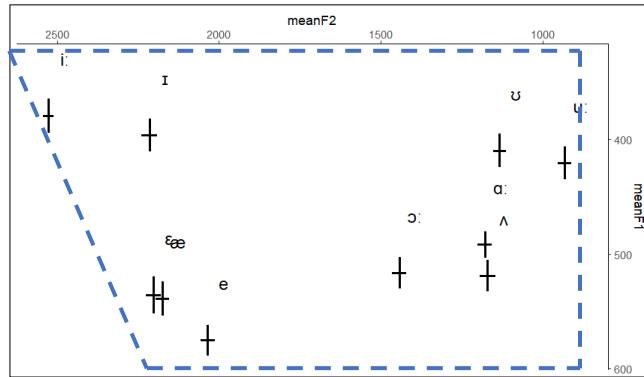


Figure 5
Mean Formant Plot of Age Group 2 (21-25 years)

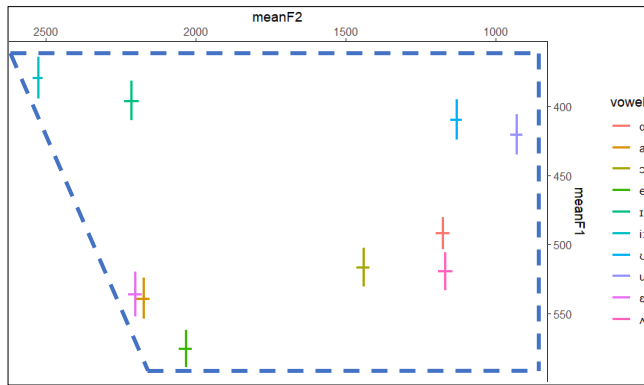
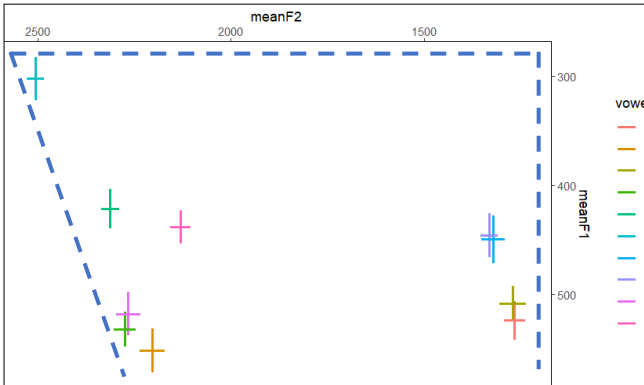


Figure 6
Mean Formant Plot of Age Group 3 (26-30)



Formants Frequencies

The above **Figures 4-6** provide a visual representation of the vowel space for speakers of three different age groups based on the mean values of F1 and F2 formants. The plots show the location of each English vowel produced by a group of speakers, with each vowel length from the

vowel space centroid indicating how peripheral or central the vowel is. It was found that the vowel space of the youngest age group (16-20) was more spread out compared to the other two groups, while the oldest group (26-30) had a more central vowel space.

When comparing the vowel space of the three age groups, it was observed that the front vowels /i:/ and /ɪ/ of age groups 1 and 3 are more fronted than those of age group 2. This indicates a difference in vowel contrast realization among the age groups. The front vowels /e, ɛ, æ/ produced by all three age groups are similar, except that age group 2 shows conflation of these vowels. As a result, the words "hayed," "head," and "had" are produced with similar vowel properties. The vowels /e/ and /ɛ/ also lack contrast in age group 3, while the contrast in vowel /æ/ was observed in age groups 1 and 3.

The back vowels /u:/ and /ʊ/ lacked contrast in age groups 1 and 2, while vowel /ʌ/ was realized with the same vowel approximation by age group 3. The vowels /ɑ:/ and /ʌ/ appeared to be closed for age groups 1 and 3 while further apart for age group 2, with vowel /ʌ/ being produced centrally. A significant difference in the production of the back vowel /ɔ:/ was observed, with it being more central for age groups 1 and 2 than for age group 3.

Overall, the formant plots of F1 and F2 values indicate that the vowel space of the youngest age group is more spread out than that of age groups 2 and 3, with age group 3 having a more central vowel space compared to the other two groups.

The Differences in Vowel Quality for "Age Groups"

This study was conducted to examine how the production of front and back vowel pairs differed among Pahari L1 learners from three different age groups. To achieve this, a paired sample t-test was carried out for each vowel pair within each age group using the F1 and F2 formant values. The results of the t-tests for all the long and short vowel pairs produced by the three age groups are presented below.

Pair-1: /i:/-/ɪ/ (heed)-(hid)

Figures 4-6 illustrate that all three "age groups" of Pahari L1 learners distinguished between the front vowel pair /i:/-/ɪ/ with contrast. However, upon conducting paired sample t-tests, significant differences in the F1 & F2 values for this pair were found only in group 3 ($t(9)=-4.322$, $t(9)=2.526$), while group 2 speakers showed significant differences only in their F1 values ($t(10)=0.24$). In contrast, no significant variations were noticed in group 1's values for this vowel pair ($t(4)=-0.860$ and $t(4)=1.838$).

These results suggest that all three age groups showed difference in the production of the front vowel /i:/-/ɪ/, but the F1-F2 formant values differed significantly. Group 3 speakers showed the greatest degree of contrast, while group 1 speakers exhibited the least difference in their F1 and F2 values. Group 2 participants displayed significant differences only in their F1 values for this vowel pair. **Table 5** shows the summary of the t-test results:

Table 5

T-test Results of Pair-1: /i:/ - /ɪ/

	AG 1 (16-20)		AG 2 (21-25)		AG 3 (26-30)	
	F1	F2	F1	F2	F1	F2
df	4		10	10	9	
T	-0.86*	1.84*	-3.10**	-0.24*	-4.32**	2.53**

"p>0.05" ** "p<0.05"

Pair-2: /e/ - /æ/ (hayed)-(had)

Figures 4-6 indicate that age groups 1 and 3 exhibit contrast in the pronunciation of the “front vowel pair /e - æ/”, while age group 2 does not. The F1 & F2 frequencies of the vowel pair’s t-test findings, however, show that there are significant differences in their average values between the three age groups.

Specifically, group 1 exhibits differences in their F1 values ($t(4) = 2.95, p < 0.05$), while group 3 shows differences in their F2 values ($t(4) = 2.54, p < 0.05$). In contrast, there is no significant difference in the values for F1-F2 for group 2 in the realization of the vowel pair.

The summarized results of the t-tests for the vowel pair /e - æ/ for the three age groups are presented in **Table 6**.

Table 6**T-test Results of Pair-2 /e/ - /æ/**

	AG 1 (16-20)		AG 2 (21-25)		AG 3 (26-30)	
	F1	F2	F1	F2	F1	F2
df	4	4	10	10	9	9
t	2.96**	-1.85*	0.31*	-0.38*	-1.57*	2.54**

**“ $p > 0.05$ ” ** “ $p < 0.05$ ”

The realization of the back "vowel pair" /ɑ:/ - /ʌ/ by three age groups was examined, and the results are illustrated in **figures 4-6**. All three age groups exhibited contrast in the articulation of the vowel pair, with group 1 demonstrating the closest realization. Group 2 speakers pronounced the vowel /ʌ/ towards the centre, while group 3 exhibited dissimilarity in the articulation of this pair. However, the paired t-test results for the F1 averages of the vowel pair did not reveal any significant differences among the three groups. Only the F2 average values of group 2 participants differed significantly ($t(10) = 2.40, p < 0.05$).

The results are summarized in **Table 7**.

Table 7**T-test Results of Pair-3: /ɑ:/ - /ʌ/**

	Age Group 1 (16-20)		Age Group 2 (21-25)		Age Group 3 (26-30)	
	F1	F2	F1	F2	F1	F2
df	4	4	10	10	9	9
t	.55*	-.24*	-1.73*	2.40**	-1.98*	.77*

(*“ $p > 0.05$ ” ** “ $p < 0.05$ ”)

The realisation of the /u:/-/ʊ/ pair was analyzed for three “age groups” using scatter plots, as shown in **figures 4-6**. Only group 1 participants showed distinction in their articulation of the “vowel pair”. The paired “t-test” results for the average values of F1 and F2 frequencies of the “vowel pair” indicate that there is no significant difference in the F1 average values for any of the three “age groups”.

However, there is a significant difference in the F2 average values for group 1 speakers ($t(4) =$

	Age Group 1 (16-20)		Age Group 2 (21-25)		Age Group 3 (26-30)	
	F1	F2	F1	F2	F1	F2
df	4	4	10	10	9	9
t	.18*	-4.84**	1.13*	.18*	-.46*	.35*

-4.84, " $p < 0.05$ ").

□□□

The following **Table 8** presents a summary of the results of the paired "t-test" conducted for the pair /u: - υ/.

Table 8

T-test Results of Pair-4: /ɑ:/ - /ʌ/

The Differences in Vowels Duration (Length) for "Age Groups"

In this section, the researchers discussed the results of the study that examined the duration of vowels produced by speakers from three different age groups. The duration of each vowel was measured in milliseconds by selecting a target word within a carrier sentence.

Additionally, the F1-F2 values of all speakers from the three age groups are available in the appendix. These values were derived from spectrogram analysis and provide important insights into the acoustic properties of vowels and their articulation across different age groups. The mean duration values of monophthong vowels for each age group are presented in **Table 9**.

Table 9

Vowels Duration Mean values for "Age Groups"

Vowel Sounds	Age 16-20	Age 21-25	Age 26-30
	Vowel Duration (ms)	Vowel Duration (ms)	Vowel Duration (ms)
i:	157	145	150
ɪ	95	103	78
e	180	146	148
æ	128	133	145
ɑ:	94	111	116
ʌ	95	166	91
u:	148	140	140
ʊ	113	142	109
ɔ:	144	156	167
ɛ	135	142	132

The results revealed noticeable differences in vowel duration among the three age groups for some vowel pairs, such as /i:-ɪ/ and /æ/-e/. However, for other pairs, such as /ɑ:/, /ʌ/ plus /u:/, /ʊ/, only a marginal difference was observed. The results of t-tests indicated that there was a significant variation in the realization of the length contrast in vowels /i:/, /ɪ/ and /æ/, /e/ among Pahari L1 Learners of all three age groups. However, there was no significant distinction in the realization of the length contrast for the vowel pairs /ɑ: - ʌ/ and /u:-/ʊ/ among speakers of each of the three age groups.

High-Front Vowels: (/i:-ɪ/)

The duration of vowels among Pahari L1 Learners in three different age groups, focusing on **short and long vowels** revealed noticeable differences in vowel duration in the front-high vowels in pair /i:/, /ɪ/. The mean duration of vowel /i:/ was 157ms for group 1 (16-20), 145ms for group 2 (21-25), and 150ms for group 3 (26-30) speakers. Meanwhile, the average duration values for the vowel sound /ɪ/ were 95ms, 103ms, and 78ms for groups 1, 2, and 3, respectively.

These findings suggest that there is only a slight difference in the realization of the vowel /i:/ among speakers of the three age groups, and the same is true for the vowel /ɪ/. However, there is a significant contrast in a realization of the duration contrast between vowel /i:/ (long) and vowel /ɪ/ (short) across all three age groups.

The results of the t-test conducted confirmed that there was a significant difference in the realization of the length contrast in vowels /i:-ɪ/ among Pahari L1 Learners of all three age groups ($t(4) = 3.59$, $t(10) = 2.95$, and $t(9) = 8.97$).

Mid-Front Vowels: /æ/-e/

The study examined the duration of the mid-front "vowel pair" /æ/-e/ among Pahari L1 Learners in three age groups. The results revealed that age group 1 displayed a noticeable difference in the duration of the two vowels, with vowel /e/ lasting 180ms and vowel /æ/ lasting 128ms.

In contrast, age groups 2 and 3 showed only a slight difference in the duration of the "vowel pair", with vowel /e/ lasting 146-148ms and vowel /æ/ lasting 133-145ms.

The paired sampled t-test showed a substantial difference in contrast in length of this vowel pair among all three age groups revealed that only age group 1 showed a significant difference ($t(4) = 3.32$, $p < 0.05$).

Back-Low Vowels: /ɑ: - ʌ/

The study examined the duration of the back "vowel pair" /ɑ: - ʌ/ in Pahari L1 Learners of different age groups and found that there were variations in the realization of this pair across groups. Age group 1 showed no significant distinction in the duration of both vowels, with /ɑ:/ and /ʌ/ having an average duration of 94ms and 95ms, respectively.

In contrast, age group 2 speakers exhibited a clear length contrast, with the long vowel /ɑ:/ being realized shorter in duration (111ms) than the short variant /ʌ/ (166ms). Age group 3 also demonstrated a length contrast, with a duration of 91ms for /ʌ/ and 116ms for /ɑ:/.

However, the results of the t-test indicated that the length contrast in this "vowel pair" was not significant among speakers of the three age groups ($t(4) = 0.46$, $t(10) = 0.995$, $t(9) = 2.104$).

Back High Vowels: /u:-/ʊ/

The duration of the back high "vowel pair" /u:-/ʊ/ was analyzed in Pahari L1 Learners of different "age groups". Results showed that there were differences in the realization of the vowel pair

across groups. Age group 1 demonstrated a significant contrast in duration between the long vowel /u:/ and the short vowel /ʊ/.

Conversely, age group 2 did not show any significant difference in duration between the two vowels, while age group 3 exhibited a contrast in duration. These findings suggest that age group 2 tended to produce the short vowel /ʊ/ in a similar manner to the long vowel /u:/.

Despite the differences, the paired sample t-tests conducted did not reveal any significant contrast in the duration of the two vowels for any of the groups ($t(4) = 2.228, p > 0.05$; $t(10) = -0.71, p > 0.05$; $t(9) = 2.138, p > 0.05$). These results suggest that the difference in duration between the two vowels is not statistically significant.

Vowels: /ɔ:/-/ɛ/

The duration of the "vowel pair" /ɔ:/ and /ɛ/ are nearly equivalent across three "age groups", with the duration of vowel /ɔ:/ ranging from 144ms for age group 1 to 167ms for age group 3, and the duration of vowel /ɛ/ ranging from 132ms for age group 3 to 142ms for age group 2.

A paired sample "t-test" was carried out to establish any "significant difference" in length contrast between the long and short "vowel pair" among the three "age groups," and the outcomes are presented in **Table 10**.

Table 10
Summary of T-test for Vowels Duration

"Age Groups"	/i: - /ɪ/ "t-test"	/æ - /e/ "t-test"	/ɑ: - /ʌ/ "t-test"	/u:/- /ʊ/ "t-test"
1	3.596**	3.323**	.046*	2.228*
2	2.952**	1.255*	.995*	-.071*
3	8.971**	-.516*	2.104*	2.138*

Findings and Discussion

The study's objective was to analyze the quality and duration of vowel formants produced by Pahari speakers and to examine whether the demographic variable "Age" influenced these acoustic features. The results indicate that there are significant differences in the production of vowel sounds based on the demographic factors under investigation. Overall, the study provides insights into the relationship between the demographic variable and the production of vowel sounds in Pahari speakers.

Analysis of **figures 4 to 6** and **tables 5 to 9** revealed that the youngest age group (16-20 years) occupied more vowel space in their average vowel plot through Euclidean distance, with a value of 2.51, compared to the second age group (21-25 years) at 2.39, and the third age group (26-30) at 2.32.

According to Keerio et al., (2014) larger vowel space is one of the features of intelligible speech. This larger vowel space in younger Pahari L1 Learners' English vowel production suggests they may have better intelligibility than the older age groups. However, only age group 3 showed a clear distinction in F1 and F2 values of the pair of the vowel /i:/ and /ɪ/ ($t(9) = -4.322, p < 0.05$; $t(9) = 2.526, p < 0.05$). No categorical distinction was observed in the vowel pairs' F1 and F2 values for all three age groups of Pahari L1 Learners.

Moreover, the difference was observed in the duration of the high front vowel pair /i:/ and /ɪ/ produced by all three age groups of Pahari L1 Learners ($t(4) = 3.59, p < 0.05$; $t(10) = 2.95, p < 0.05$; $t(9) = 8.97, p < 0.05$). The findings indicate that there is no general tendency of variation in the English vowel pairs' contrast in quality and duration in successive age groups of Pahari L1 Learners, which is consistent with (Bilal et al., 2021) study on age group differences in the vowel production of RP (Received Pronunciation) speakers.

This means that the vowels /æ/, /e/, and /ɛ/ were not differentiated sufficiently, resulting in similar-sounding words with varying vowel sounds. Furthermore, the duration of the English vowel sounds produced by the Pahari L1 Learners was lacking contrast because they produced both vowels of various lengths, which are spoken interchangeably, unlike English, where the contrastive quality of vowel sounds is duration. These findings suggest that realizing certain vowels with minimal differences can lead to the realization of comparable words, even though they are intended to be separate words with vowel variations.

Conclusion

The study aimed to analyze the acoustic features of English vowel sounds produced by Pahari L1 Learners and their relationship with demographic factors such as age. The analysis of the data revealed that there are significant differences in the acoustic features of vowel sounds based on age. The study found that younger Pahari L1 Learners tend to have a larger vowel space, which is an important feature of intelligible speech. However, all three age groups of Pahari L1 Learners did not show categorical distinctions in the contrasted vowel pairs.

The findings of this study contribute to a better understanding of the production of English vowel sounds by Pahari L1 Learners and their relationship with demographic factors. The study recommends that English language teachers in Pahari-speaking regions should focus on distinguishing between mid-front vowels and ensuring the correct duration of vowel sounds to enhance their students' intelligibility.

Further research can be conducted to investigate the impact of other factors, such as language background and exposure, on the production of English vowel sounds by Pahari L1 Learners. Moreover, researchers may wish to include additional dimensions, such as F3, F4, and others, to look at additional characteristics of vowel phonemes that are included in a full review of "vowel-specific" and "speaker-specific" information, whereas this study focuses solely on the power generation of English vowel sounds by Pahari L1 Learners. This research makes a valuable contribution to the PakE phonological system and has the potential to benefit future studies in phonetics and speech technologies, particularly in the context of Asian English varieties.

References

- Abbasi, A. M., Arain, A. A., Khokhar, S., & Batool, M. (2022). An Instrumental Study of Speech Variability of English Back-Rounded Vowels Between the English & Karachiites Pnglish: Acoustics of English Back-Rounded Vowels. *Pakistan Journal of Languages and Translation Studies*, 10(2), 40-60.
- Abbasi, M. A., & Rasheed, H. U. (2022). DEVELOPMENTAL STAGE OF ENGLISH COPULA WH-QUESTIONS OF PRESENT TENSE IN MATRIC LEVEL PAHARI SPEAKERS. *PalArch's Journal of Archaeology of Egypt/Egyptology*, 19(1), 444-463.

- Abbasi, M. G., Khattak, Z., Saeed, S. B., & Abbasi, M. (2021). Language At Workplace Setting: A Study of Pahari Usage Among The Employers And Workers In Murree. *LANGUAGE*, 8(02), 2021.
- Behr, N. S. (2022). English Diphthong Characteristics Produced by Thai EFL Learners: Individual Practice Using PRAAT. *Computer Assisted Language Learning*, 23(1), 401-424.
- Bilal, H. A., Azher, M., Ishfaq, M., & Mumtaz, A. (2021). Acoustic Investigation of Back Vowels of Pakistani English. *Review of Education, Administration & Law*, 4(1), 37-52.
- Bilal, H. A., Mahmood, M. A. & Saleem, R. M. (2011a). Acoustic analysis of front vowels of Pakistani English. *International Journal of Academic Research*, 3 (6-I), 20-27. <http://www.ijar.lit.az/pdf/14/2011%2814-4%29.pdf> (December 10, 2011)
- Bilal, H. A., Mahmood, M. A. & Saleem, R. M. (2011b). Merger of /i:/ and /I/ in Pakistani English. *International Journal of Linguistics*, 3 (1), E34. doi:10.5296/ijl.v3i1.1041. <http://dx.doi.org/10.5296/ijl.v3i1.1041>
- Bilal, H. A., Mahmood, M. A. & Saleem, R. M. (2011c). Merger of /e/ and /æ/ in Punjabi English. *International Journal of Academic Research*, 3 (6-II), 407-412. <http://www.ijar.lit.az/pdf/14/2011%2814-69%29.pdf> (December 20, 2011)
- Boersma, P., & Weenink, D. (2021). *Praat: Doing phonetics by computer* [Computer program]. Version 6.1.57, retrieved from <http://www.praat.org>.
- Carlet, A., & Cebrian, J. (2022). The roles of the task, segment type, and attention in L2 perceptual training. *Applied Psycholinguistics*, 43(2), 271-299.
- Cataldo, E., Monteiro, L., & Soize, C. (2021). A novel source-filter stochastic model for voice
- Chen, X., et al. (2009). Assessing Cross-Cultural Competence: A Work-in-Progress Report. In P. S. Goodman & H. S. Ding (Eds.), *Quality Management and Organizational Development* (pp. 535-544). Beijing: Tsinghua University Press Production. *Journal of Voice*.
- De Decker, P., & Nycz, J. (2011). For the record: Which digital media can be used for sociophonetic analysis? *The University of Pennsylvania Working Papers in Linguistics*, 17(2), 7.
- Deterding, D. (2010). English language teaching in East Asia today: Changing policies and practices. In K. Bolton & K. King (Eds.), *Aspects of language education policy in Asia* (pp. 17-36). *Springer*.
- Fang, H. (2022). Second language acquisition of English vowels: A cross-sectional study of Chinese and Korean speakers. *Journal of Phonetics*, 89, 101152.
- Fant, G. (1960). *Acoustic theory of speech production: With calculations based on X-ray studies of Russian articulations*. Mouton
- Faytak, M. (2022). Place uniformity and drift in the Suzhounese fricative and apical vowels. *Linguistics Vanguard*, 8(s5), 569-581.
- Hillenbrand, J., Getty, L. A., Clark, M. J., & Wheeler, K. (1995). Acoustic characteristics of American English vowels. *The Journal of the Acoustical Society of America*, 97(5), 3099-3111.

- Hussain, S., Anjum, U., Safeer, N., & Malik, S. (2022). Acoustic Analysis of English Vowel Sounds Produced by Sindhi Speakers. *Pakistan Journal of Society, Education and Language (PJSEL)*, 9(1), 353-365.
- Keerio, G. R., Abro, M. A., & Raza, S. A. (2014). Acoustic analysis of English vowels by Sindhi speakers. *Journal of Education and Practice*, 5(32), 34-40.
- Khalique, S., Bukhari, N. H., & Jabeen, T. (2022). AA Morpho-Syntactic Analysis of Pahari Pronouns. *The Dialogue*, 17(1), 69-89.
- Khan, A. Q. (2014). An acoustic analysis of Pahari oral vowels. *lingua posnaniensis*, 56(2), 29-39. <https://sciendo.com/downloadpdf/journals/linpo/56/2/article-p29.xml>
- Khan, A. Q., & Bukhari, N. H. (2013). DURATION, FORMANT PATTERNS AND ACOUSTIC SPACE OF PAHARI MONOPHTHONGS. *Kashmir Journal of Language Research*, 16(2).
- Mairano, P., Kaiser, E., Avesani, C., & Dal Lin, C. (2019). Vowel space and phonetic distance in Italian children. *Journal of Speech, Language, and Hearing Research*, 62(7), 2229-2241. https://doi.org/10.1044/2019_JSLHR-S-18-0518
- Mufwene, S., & Escobar, A. M. (Eds.). (2022). *The Cambridge Handbook of Language Contact: Volume 2: Multilingualism in Population Structure*. Cambridge University Press.
- Nagle, J. (2022). *Using English Vowels to Teach Japanese English Pronunciation*. *TESL-EJ*, 25(4), 1-18.
- Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and Policy in Mental Health and Mental Health Services Research*, 42(5), 533-544.
- Perroux, T. A., McElligott, A. G., & Briefer, E. F. (2022). Goat kid recognition of their mothers' calls is not impacted by changes in source-filter parameters. *bioRxiv*, 2022-05.
- Pratiwi, J., Haryanto, E., & Sutopo, H. (2022). The Effect of Phonemic and Phonetic Vowel Length on the Recognition of Indonesian Spoken Words. *Universal Journal of Educational Research*, 10(1), 19-26.
- Riaz, W., Jabeen, T., Afreen, S., & Abbasi, A. S. (2022). ROLE OF SOCIETY IN LANGUAGE CHANGE: A PHONOLOGICAL PERSPECTIVE OF PAHARI LANGUAGE. *PalArch's Journal of Archaeology of Egypt/Egyptology*, 19(3), 360-369.
- Ru, Q. (2016). Age and Language Learning. In *The Handbook of Technology and Second Language Teaching and Learning* (pp. 11-26). *John Wiley & Sons, Inc.* <https://doi.org/10.1002/9781118914069.ch2>
- Tokuda, I. (2021). The source-filter theory of speech. In *Oxford Research Encyclopedia of Linguistics*. The source filter concept in voice production. *STL-QPSR*, 1(1981), 21-37.
- Zwicker, E., & Terhardt, E. (1980). Analytical expressions for critical band rate and critical bandwidth as a function of frequency. *The Journal of the Acoustical Society of America*, 68(5), 1523-1525.