

An Acoustic Analysis of Pashto Vowels

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Key Words

- Pashto
- Yousafzai Dialect
- Pure Vowels
- Formants
- Vowel Duration

Abstract

The present paper explores Pashto monophthongs focusing on a point of disagreement regarding Pashto vocalic inventory found in a number of studies (e.g., Penzl, 1954, 1961; Miran 1969; Tegey & Robson, 1996; Rehman, 2009 and among others). By analyzing data from (the standard) Yousafzai dialect, the study provides a detailed insight into the nine pure vowels of the language in the light of both traditional (by using minimal sets qualitatively) and latest experimental techniques using Praat 6.4.01. The qualitative part of the study included minimal sets and the recording and phonemic transcription of the International Phonetic Association (IPA) story, i.e., The North Wind and the Sun. The experimental part of the study also included the recording of a selected list of minimal set consisting nine words from 10 informants with the rural monolingual background. The informants were required to speak out the given words (three times each) in isolation in a soundproof room. Finally, the averages of their responses ($10 \times 3 = 30$) for the first two formants (F1 and F2) and length duration (in MS) for each sound were calculated and were subsequently plotted on a chart to show their spectral features. The findings of the study show that the actual number of Pashto vowels are nine (i.e., /u:, ʊ, v, i:, ɪ, a: ə, a, e/) in the standard (Yousafzai) dialect of the language.

1. Introduction

Pashto links to the Indo-Iranian family of languages. It traces back to the Iranian branch of the Indo-European family of languages. The nearer languages with it are Persian, Kurdish, Tajik, and Ossetian (Tegey & Robson, 1996). Pashto belongs to Indo-Iranian (Kahn, 2012). It is spoken natively by approximately half of Afghanistan's population, 7.5 million, and 90% of the population of Khyber Pakhtunkhwa, 14 million speakers in Pakistan's Baluchistan province, and two million in Karachi (Tegey & Robson, 1996). Pashto is also spoken natively by thousands of people in India, the United Arab Emirates, and other parts of the Gulf. It is now spoken by approximately 50 million people (Khan, 2012). Moreover, people in Tajikistan, Iran, India, Iran, the United Arab Emirates, and the United Kingdom also speak it (Aslamzai & Saad, 2015).

Pashto is spoken in the districts of Kohat, Bannu, Dera Ismail Khan, Peshawar, Hazara, Swabi, Mardan, Charsada, Bajaur, Buner, and Swat in the Khyber Pakhtunkhwa. It is also spoken in Northeastern Baluchistan and in Punjab near Mianwali and Attock. Pashto speakers can be found in Afghanistan's south, southwest, and east (Hallberg, 1992). The majority of Pashto speakers live in a single geographical area: southern Afghanistan and northeastern Pakistan (Tegey & Robson, 1996). According to Shahedkhel (2019), some phonetic symbols of Pashto are similar to those of other Indo-European languages because it belongs to the Indo-European family after being linked to Indo-Iranian.

This study is highly significant in terms of a vital contribution to Pashto phonology as it analyzes the Pashto vocalic phonemes. This might be very fruitful for the upcoming researchers, teachers and for the student as well. Furthermore, this study is limited only to the exploration of Pashto vocalic phonemes. It was based on minimal sets, pairs, and IPA recommended story. For doing this, the data was collected from male speakers of Yousafzai dialect.

2. Literature Review

Pashto is an Eastern Iranian language. It has great dominance in the area of Southern Afghanistan and most parts of Baluchistan and Khyber Pakhtunkhwa. Pashto phonology has been a focus of many studies. Most of the books, articles and thesis have been carried out on various interesting features of Pashto phonology. Penzl's (1954) investigation focuses on the orthography and spelling of the Pashto language, specifically the Kandahari dialect. In addition to delineating the phonemics of modern Pashto, he dedicates a portion of his study to the analysis of vowels. Based on his findings, Pashto comprises nine vowels: /a, e, i, u, ii (i), uu (u), aa, ee, oo/. Furthermore, Penzl (1961) delves into loan words from other languages integrated into Pashto, providing a concise overview of vowels in this context. The author identifies the following vowels in loan words: /i, a, ə, ā, ē, i, ī, ō, u, ū/. He distinguishes long vowels with a bar over them, including /ē, ā, ō, ī, and ū/. Notably, /ē/ is a mid-front vowel, /ā/ is a low central unrounded or low back rounded vowel, /ō/ is mid-back rounded with raised allophones, /ī/ is high front, and /ū/ is a high back long vowel. Miran's study (1969) primarily focuses on contrasting the Dari and Pashto languages while highlighting the challenges faced by speakers of these languages. He systematically presents Pashto vowels as /i, e, æ, ə, a, o, u/. The first three front vowels /i, e, æ/ are categorized as unrounded vowels, with /e/ occurring in the middle and final

positions but not at the beginning. Similarly, the central vowel /ə/ is found in the middle and final positions but is absent at the beginning. The last three vowels /a, o, u/ are classified as back vowels, with /a/ being unrounded and /o, u/ being rounded. Similarly, Bashir's (1991) contrastive analysis of Pashto and Urdu includes a focus on the Yousafzai dialect and identifies seven vowels: /i, e, a, ɜ, ā, o, u/. In her research, she clarifies that /a/ is a short vowel, while /ā/ is long. Additionally, /e/ is a front central vowel, /i/ is short, /o/ is a back central vowel, and /u/ is a lower-high back vowel. Bashir also notes the presence of the mid-central vowel /ɜ/ in the vowel inventory of the Yousafzai dialect.

Tegey and Robson's (1996) study provides a comprehensive overview of a specific Pashto dialect, focusing on the Kabul/central dialect. Their work, centered on Pashto grammar, aims to fulfill the essential requirements for language learning, especially for instructing Pashto to foreign learners. Within the context of the central dialect, the study delves into historical aspects, encompassing grammatical forms, phonology and pronunciation, word stock, and loan words. A notable segment of this analysis is dedicated to the examination of vowels. They identified nine vowels in the central dialect of Pashto: /i, ɪ, e, ə, a, ā, o, ʊ, u/. The authors provide insights into Pashto vowels based on tongue and lip postures, highlighting the restriction that vowels /ɪ, e, o, and u/ do not appear at the beginning of words. Henderson's (1998) work is rooted in the Kandahari dialect, where he elucidates syntactic structures, prestige, and literary traditions inherent to this specific Pashto dialect. He posits six Pashto vowels for the Kandahari dialect: /i, e, a, ə, o, u/. In his examination of Pashto vowels, he categorizes /i/ as high, /a/ as low, /o/ as back round, and /u/ as high back round. Additionally, he notes that /e/ and /o/ are extra-long, particularly in unstressed syllables, while /i/ and /u/ are short, with elongated forms in Arabic and Persian loanwords. Furthermore, Roberts (2000) contributes to the understanding of Pashto by elucidating its phrase structure and explaining various sentence features. Within this linguistic exploration, Roberts investigates Pashto vowels, identifying /i, ee, a, e, aa, o, u/. The researcher also briefly touches upon the mid vowels /ee and o/, as well as the raised high vowels /i and u/, particularly when the subsequent syllable contains a high vowel.

Mirdehghan and Jahangiri (2005) research is confined to the description of phonological ergative of three languages; Hindi/Urdu, Balochi and Pashto. It gives an explanation of variation in the said languages. The inventory further elucidates the Pashto vowels /i, e, æ, a, aa, o, u/. Ijaz (as cited by Shierani, 2009) is basically related to new names entities into media in the form of personal names and organization. He spells out the above issue that it is a problem in translation. He investigates the present techniques to develop bilingual English-Pashto proper nouns lexicon for the web. He asserts further that English and Pashto have got different rules. In his study, he explores the phonemic inventory of Pashto and suggests that Pashto has ten vowels, /i, ɪ, e, a:, a, ə, ɐ, o, u, u:/. Among them, there are seven short vowels /a, e, i, ə, ɐ, o, u/ and three long vowels /a:, u:, i:/.

Din and Rahman (2011) is based on the acoustic analysis of Pashto vowels. Their inventory shows a vowel chart, nine in number /i, ɪ, e, ə, u, ʊ, æ, ɑ, o/. Ali (2013) deals with the difference between Pakistani English and Singaporean English vowels. The author points out eleven vowels in Pashto /i, ɪ, e, æ, ʌ, a:, ɐ, ɔ:, ʊ, ɜ:, u:/. He further claims that there is no difference between the above two varieties. However, the slight difference is highlighted only in the F1 for the sounds /ɔ:/ and /ɜ:/. Another difference in F2 for the sounds /ɐ/ and /ɔ:/ is also mentioned. In the last, he suggests that the above-mentioned languages are the different varieties of English language.

Miller (2014) is cramped to the Waziri dialect of Pashto language. He demonstrates the vowel shift of the mentioned dialect to other dialects. He raises a point on vowels that Waziri has the same vowels as other standard varieties. He declares that there are seven vowels in Pashto /i, e, a, ə, ā, o, u/. Here, he explains the vowel shift from its position to another. Waziri long vowel /ā/, its quality reaches to /a/, short vowel /a/, and reaches to /ʌ/. In this shift /ā/ rises to /o/. Back vowels move to the front. Waziri vowel /u/, changes to front vowel /i/. Back vowel /o/ changes to front /e/.

2.1. Similarities and Differences in the above Cited Studies

The existing reviews on Pashto show similarities and differences in the following inventories. The authors included the phonemes /i/ and /e/ in their inventories which are given below: Penzl (1954) and (1961), Miran (1969), Bashir (1991), Tegey and Robson (1996), Henderson (1998), Robert (200), Mirdehgan and Jahangiri (2005), Shierani (2009), Din and Rahman (2011), Ali (2013) and Miller (2014). The phoneme /ə/ is also found in the above works, except Penzl (1954), Bashir (1991) Robert (2000), and Ali (2013). The phoneme /ɪ/ pinpointed in these studies: Penzl (1961), Tegey and Robson (1996), Shierani (2009), Din and Rahman (1996) and Ali (2013).

The phonemes /a/, /o/ and /u/ found in the inventories given below: Penzl (1954) and (1961), Miran (1969), Tegey and Robson (1996), Henderson (1998), Robert (2000), Midehgan and Jahangiri (2005), Shierani (2009), Din and Rahman (2011), Ali (2013) and Miller (2014). The vowel /æ/ existed in the following works: Miran (1969), Din and Rahman (2011) and Ali (2013) and the phoneme /ʊ/ also included in the above studies except for Miran (1969) but the /ʊ/ sound found in the work of Tegey and Robson (1996). The schwa /ə/ phoneme searched out in these studies: Penzl (1961), Tegey and Robson (1996), Henderson (1998), Shierani (2009), Din and Rahman (2011), and Miller (2014). The phonemes /ɒ/, /ʌ/, and /ɜ:/ found only in the work of Ali (2013).

2.2. Total Number and Symbols of Pure Vowels in Secondary Data

The following phonetic symbols for pure vowels were collected from the existing reviews on Pashto. The list is given bellow for the existing pure vowels in Pashto: /i, ɪ, e, a, aa, ee, oo, ə, ā, ē, ī, ō, u, ū, æ, o, ɜ, ʊ, a:, u:, α, ʌ, ɒ, ɔ:, ɜ:/. These twenty-five different pure vowels (symbols) were found in the above-cited studies based on Pashto.

As discussed above, there is no agreement among the scholars who conducted various research on Pashto language about the number of vowels. However, this study is going to discuss this issue in greater detail, providing data from everyday language of the selected dialect (Yousafzai) of Pashto spoken in Pakistan. The collection of the above-cited works clarifies that there is big ambiguity in the number of Pashto vocalic phonemes. Many studies have been done but different opinions have been raised, regarding the number of vowels. The purpose of this study is to fill up this gap by exploring Pashto vocalic phonemes traditionally and acoustically. The main concern of this study is to highlight the acoustic analysis of the vocalic phonemes of Pashto.

2.3. Vowels in Human Languages

Roach (1991) claims that a vowel is a sound in which there is no obstruction of airflow from the lungs to the lips. The articulators are separated, allowing the airflow to exit freely.

The frontness and backness of the tongue, as well as the rounding of the lips, are used to define vowel sounds. Davenport (2005) states that a fixed vowel sound is known as a pure vowel and will be represented by a single vowel symbol. Similarly, Ladefoged (2006) opines that producing vowel sounds, the articulators do not come together, and the passage of air is relatively unobstructed. Ogden (2009) has the view that monophthongs are pure, and they do not change in their voices.

Natural languages have flexible number of vowels. There are languages that have up to 17 vowels such as Urdu (Hussain, 2005). Spanish has a set of five vowels /i, e, a, o, u/ and Japanese also has only five /i, e, a, o, u/ (Ladefoged, 2005). English has twenty vowels /i, ɪ, e, æ, ʌ, ɜː, ə, ɑː, ʊ, uː, ɪə, eə, ʊə, eɪ, aɪ, ɔɪ, əʊ, aʊ/ (Roach 1991; Ladefoged, 2005). Kono has seven vowel system /i, e, ɛ, a, ɔ, o, u/ (Komba, 1983) and Latin has five vowels (Tench, 2011). This detail clarifies that each human language has its own vowels due to its different vocabulary and pronunciation. As languages have got contrasting grammatical features and rules, same is the case with vowels. In the above-mentioned languages that only Spanish and Japan have the same number in vowels, other don't have similarities in vowels. That's why; Pashto also needs an effort for finding its vocalic phonemes, to explain them qualitatively and acoustically, because it has also got different rules, pronunciation and grammar.

2.4. Acoustic Analysis of Vowels in Other Studies

Low (2019) conducted research on 'kinematic and acoustic vowel changes in adult bite block speech'. The focus remained on the acoustic analysis of phonemes by analyzing the formants and their changing frequencies, sided by side kinematic analysis of articulators was done. For doing this research, data were collected from twenty speakers, divided equally, 10 males and 10 females involved. The stimuli used in the study 'the blue spot is on the black key again'. In this stimulus, the word blue was taken for high back vowel, the word spot for low back vowel; black for low front vowel; and key for high front vowel.

Phakkahn (2018) introduced the vowels of Yoy. It has 18 vowels in which nine are short and nine are long /i, e, æ, a, ʊ, ɪ, o, ɔ/ and /iː, eː, æː, aː, ʊː, ɪː, uː, oː, ɔː/. A word list was provided to participants in Thai script. It was recorded from the informants. The input of the informants was broken into words. All these words tagged, transcribed and glossed and the data was analyzed through Praat. Formants 1 and 2 were taken and showed the actual places of all vowels on tongue. He has the view that long and short vowels don't have any distinctive feature in open final syllable, but they are clearly distinct in closed final syllables.

Nolan (2014) says that Lekwungen has five vowels and thirty-five consonants. These vowels were introduced acoustically. The data was collected in CV and CVC structures. All words were recorded twice and analyzed through Praat. Vowels were determined after observing stress effects, duration, pitch and amplitude. F1, F2 and F3 were checked of all target vowels. Words were divided into segments and textgrid tier were used for writing separate vowels and their duration. Measurements were exported to Microsoft Excel and then to R (R Core Team), then analysis and plotting were done.

Roesler conducted a study in 2013, on 'acoustic characteristics of tense and lax vowels across sentence position in clear speech'. He analyzed vowel duration, vowel space dispersion, space area, and vowel peripheralization in clear and conversational speech. For

doing this, he collected the data from 12 monolingual speakers in spoken form and analyzed through PRAAT software. Vowel space was represented through F1 and F2. Another feature of acoustic analysis showed that vowel durations were greater in clear speech than the conversation style. Tense vowel had greater space and longer duration than lax vowels. Vowels occurred in the sentence-final position had longer vowel durations and great vowel space areas than those vowels that occurred in sentence-medial position.

Bailey (2012) provided an acoustic analysis of Brazilian Portuguese nasal and oral monophthongs, produced by native and non-native speakers both. The data for this study was collected from ten speakers, six native speakers of Brazilian Portuguese and four native speakers of Spanish. All these participants were university students at the time of research and data recording. Praat software was used for data analysis measuring vowel durations, first two formants and anti-resonances. The study compares Brazilian Portuguese and Spanish speakers using ANOVA. The analysis revealed that all participants had a significantly higher F1 for /a/ than /ẽ/. For females, F1 of nasal and oral vowels remained higher than their male counterparts. The analysis also revealed higher F1 for nasal vowels than oral vowels for /e/ and /u/ for males. The analysis showed interesting findings for Spanish L1 informants producing higher F1 values than Portuguese L1 informants. Based on these lines, the current study describes the acoustic features of Pashto vowels using Praat software.

3. Research Methodology

The nature of this study is a blend of both qualitative and quantitative methodologies exploring various features of the vocalic sounds in Pashto. A written standard list of selected vocabulary was chosen which was designed as minimal sets having nine words from the Yousafzai dialect, followed by IPA recommended story, i.e., *The North Wind and the Sun*. For the acoustic analysis, the utterances of the subjects of the selected vocabulary items were recorded. The first attempt was made; each sound in collected data for the study was recorded in isolation for better analysis of vocalic sounds. For further precaution, other speakers of the same language were asked to listen to the recorded sounds and then the recorded data was analyzed on Praat.

Fant (1960) introduced the Source-Filter Theory which was taken as a theoretical framework for this study. This theory forms the basis for speech analysis with respect to the articulation of vowel sounds. According to this concept, the vocal cords are considered the source of sound, which is subsequently shaped by the vocal tract or filter. For vowels, this filtering effect is let's say the most important, which helps determining the formant frequencies of the vowels which in turn helps in analyzing and categorizing vowels in a cross linguistic perspective. Fant's model can aid researchers in studying vocal tract modifications and their impact on the acoustic properties of vowels, particularly the manner and interpretation of formant frequencies (F1, F2, etc.), which, in turn, help in vowel categorization.

3.1. Sampling Techniques and Procedures

Ten NORMS (non-mobile, old, rural, males) were randomly selected from different areas-as adopted Trudgill (1987) method for the participants. They all belonged to Malakand division of Khyber Pakhtunkhwa. These subjects were aging 40+.

As part of the descriptive study, Praat software (6.4.01) was used for the acoustic analysis of the vowel sounds. For each single segment, the duration and first three formants along with other related properties were checked. Each word having vowel had the same process for the purpose to be analyzed and finalized for plotting on quadrilateral shape at the end.

This systematic process recording was conducted in a comfortable soundproof room. First, the selected word list containing nine words was given to the participants and they were directed to read them in a natural way. They were directed to read each word three times, and they were recorded by using Zoom H6. This process was repeated with each participant. In the last, all recordings were saved in the laptop in audio form (WAV file). Subsequently, this data was used for measuring the duration, formants, and frequencies for the purpose.

4. Data Analysis & Discussion

Before deciding the number of monophthongs, Pashto phonemes were explored using many sets. For these segments, certain minimal sets in CVC context were explored for their inclusion in the study. After this detailed procedure, the following set given in Table 1 was finally selected for this study that has nine words.

Table 1

Selected set of stimuli for Pashto monophthongs and their measurement

Vowels	Transcription	Pashto	Glossary	Duration	F1	F2	F3
u:	tu:k	توک (توکمار)	Thickly woven	148	369	955	2455
ʊ	tʊk	ټک	Piece	93	400	1032	2468
ɒ	tɒk	ټوک	Cutting tool	218	502	979	2554
i:	tʲi:k	ټیک	Right	130	380	2070	2671
ɪ	tɪk	ټک	As in rest	87	376	2013	2556
ɑ:	tɑ:k	ټاک	Marked	230	694	1238	2473
ə	tək	ټک(ټکي)	As in word	92	639	1456	2296
a	tak	ټک	Drip-drip	99	637	1491	2385
e	tɛk	ټیک	Support	201	440	1958	2572

The recorded data were analyzed using Praat. The data covered the required specific notions of sound analysis such as duration, F1, F2, and F3. The duration of each phoneme and three formants are the results of thirty responses as there were ten informants and each of them uttered the sound thrice (10 speakers x 3 responses = 30 tokens). First, the average of three responses of every speaker was taken, then the average was taken of all ten informants. The duration, F1, F2, and F3 values are the grand average of all thirty responses. When the final average was taken, then the data was exported to Microsoft Excel. The values for vowel duration and the first three formants are given in Figure-1.

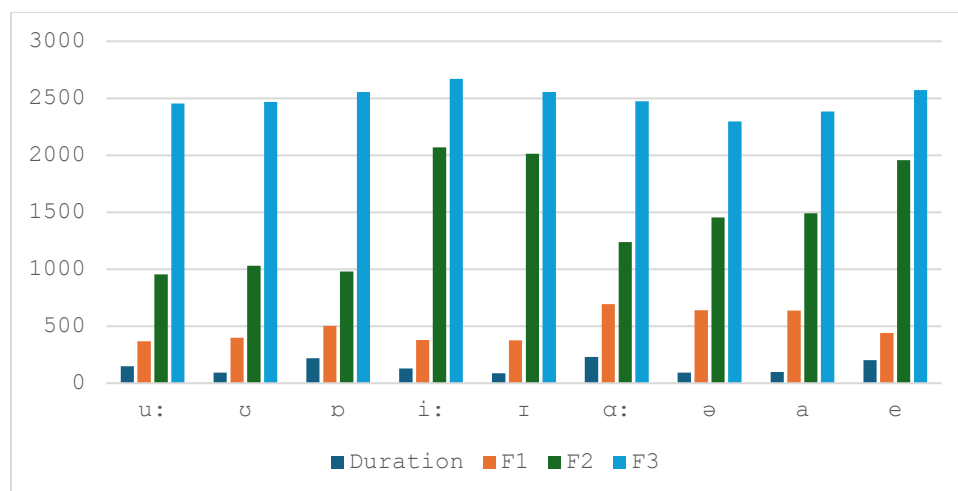


Figure 1: Pashto monophthongs and their measurement

The values for the first three formants and durations were taken systematically using Praat and were put respectively. The chart design used was created through Microsoft ExcelSheet. For spectrographic illustrations, individual segments for all nine vowels were processed and measured through Praat. For example, Figure-2 shows the spectrogram for /u:/ vowel sound.

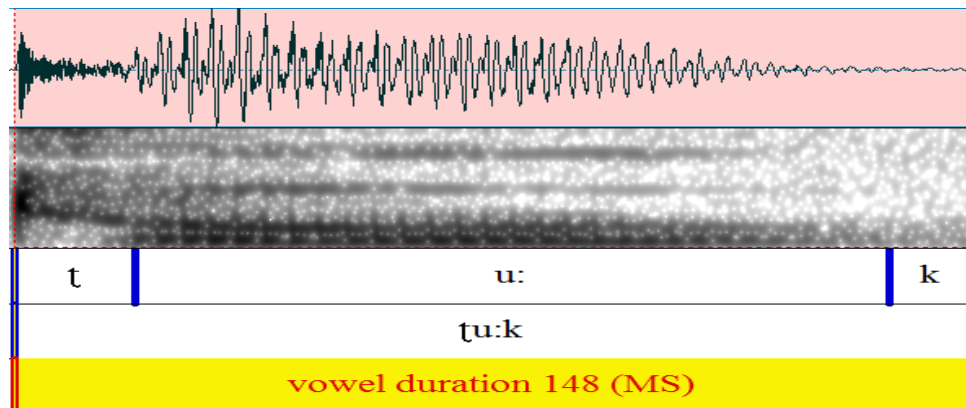


Figure 2: Spectrogram for /u:/

Figure-2 presents the spectrogram of the vowel /u:/. It provides a detailed visualization of the vowel's characteristics. At the top, it features the waveform, followed by the spectrogram itself. Below these, three tiers display different linguistic details: the first tier represents the phonemic transcription, the second shows the word in which the vowel appears, and the third indicates the vowel's duration, measured in milliseconds. This structured representation offers a comprehensive insight into the acoustic properties of the vowel.

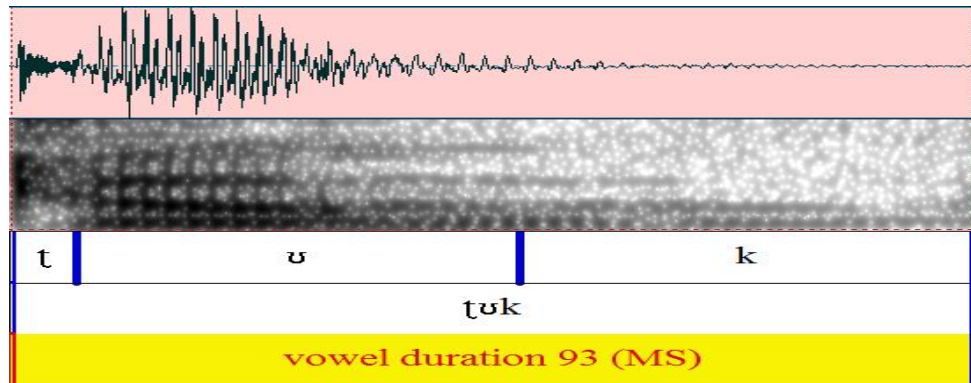


Figure 3: Spectrogram for /ʊ/

Figure-3 illustrates the spectrogram of the vowel /ʊ/, which serves as the short counterpart of /u:/. The spectrogram provides a multi-layered representation of the vowel and shows all the features of the phonemes such as waveform, spectrographic representation, phonemic transcription, and duration (93) in milliseconds.

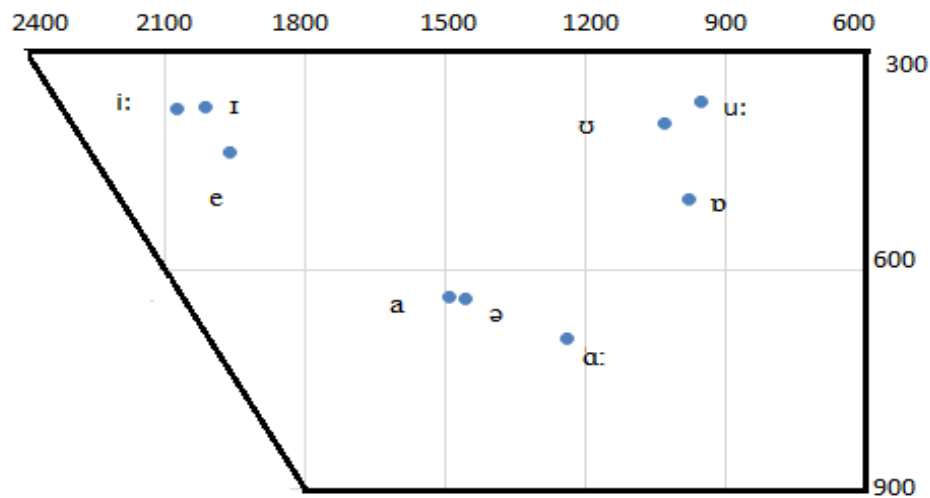


Figure 4: Pashto Vowel Grid

Figure-4 was created following an acoustic analysis of the stimuli presented in Table 1. This table contains nine Pashto root words, each featuring a single vocalic phoneme. Native speakers carefully pronounced these words, which were then recorded, analyzed, and segmented. The extracted values were used to generate this figure, which visually represents all nine vowels along with their corresponding symbols. The figure was produced using the first two formants, F1 and F2.

4.1. Vowel Height

Pashto vowels were put under the binary features as Chomsky and Hall (1968) used for vowel height. Pashto vowels were described with (+high) and (-high), also with other terms as (+back) and (-back) as given in Table 2.

Table 2

Pashto Vowel Height Features

Vowel Height	-back	+back
+high, -mid	i:, ɪ	u: ʊ
+high, +mid	e	ɒ
-high, +mid	a, ə	ɑ:

In this broad description, six vowels were included in (+high) portion and three were (-high); and for further clarification (-back) marked out five vowels and (+back) covered four vowels.

Feature Chart

The above results and discussion on Pashto vowels were summarized by the feature chart as given below in Table 3.

Table 3

Feature Chart for Pashto Vowels

Features	u:	ʊ	ɒ	i:	ɪ	ɑ:	ə	a	e
Consonant	-	-	-	-	-	-	-	-	-
High	+	+	-	+	+	-	-	-	-
Mid	-	-	+	-	-	+	+	+	+
Front	-	-	-	+	+	-	+	+	+
Back	+	+	+	-	-	+	-	-	-
Round	+	+	+	-	-	+	-	-	-

The above chart made clear distinguishing features of each vocalic phoneme. It also mentioned that each phoneme has considerable existence and phonological properties in the language. These features were highlighted in the light of vowel grid (Figure 4) that was generated based on grand average. After all these processes, the final touch was given through descriptive statistics.

4.2. Descriptive Statistics

The grand average of all nine vowels put in Table 1 was exported to SPSS for statistical purpose. All vowels were taken as variable and the following results obtained given in Table 4.

Table 4

Summary Statistics, using the obtained results of 9 Vowels for the variables: Duration, F1, F2, and F3

Variable	Mean	Median	Minimum	Maximum
Duration	144.222	130.000	87.0000	230.000
F1	493.000	440.000	369.000	694.000
F2	1465.78	1456.00	955.000	2070.00
F3	2492.22	2473.00	2296.00	2671.00
Variable	Std. Dev.			
Duration	57.9995			
F1	130.301			
F2	453.520			
F3	110.991			

The results related to duration, F1, F2, and F3 were given to SPSS where the mean, median, minimum and maximum were derived. In statistics analysis, the mean of all duration was obtained 144.2 where the median 130, minimum value was 87 and maximum was 230. The Standard deviation of duration is 57.9.

The results related to F1 shows that mean is 493 and median is 440, and the minimum value is 87 and maximum is 694. The standard deviation of F1 is 130.3. The values of grand average of F2 were given and results obtained in which mean is 1465, median 1456, minimum value 955 and maximum 2070. The standard deviation of F2 is 453. The last obtained results were regarding the roundness of all vowels. The grand average of all them shows in Table 1. The same value was put in statistical tool which gave these results. The mean of F3 is 2492.2, median is 2473, minimum is 2296 and maximum value is 2671. The standard deviation of the F3 is 110.

4.1. Discussion

Most studies on Pashto vowels have focused on their analysis, identifying varying numbers of vowels. Notable differences exist among these studies. The present study shares similarities with other studies, such as Penzl (1954), Tegey and Robson (1996), and Din and Rahman (2011) in terms of the number of vowels. However, some vowels identified in these studies differ from those found in the present study. As Din and Rahman (2011) conducted an acoustic analysis of Pashto vowels, presenting an inventory of nine vowels: /i, ɪ, e, ə, u, ʊ, æ, ɑ, o/. Their inventory closely aligns with the present study, as both identify nine vowels. The key difference between the two lies in the presence of the vocalic sounds /æ/ and /o/, which are not found in the present study.

The existing review on Pashto vowels also shows similarities and differences in the following inventories. The studies carried the phonemes /i/ and /e/ are given below: Penzl (1954) and (1961), Miran (1969), Bashir (1991), Tegey and Robson (1996), Henderson (1998), Robert (200), Mirdehgan and Jahangiri (2005), Shierani (2009), Din and Rahman

(2011), Ali (2013) and Miller (2014). The above mentioned two vowels are also the part of the present study and found in day-to-day routinely words. The phoneme /ə/ also found in the above studies, except Penzl (1954), Bashir (1991) Robert (2000), and Ali (2013). The phoneme /ɪ/ pinpointed in the studies of Penzl (1961), Tegey and Robson (1996), Shierani (2009), Din and Rahman (1996) and Ali (2013). The above listed two phonemes /ɪ, ə/ are also the part of present study and have got their existence in roots.

Moreover, the phonemes /a/, /o/ and /u/ found in the inventories such as Penzl (1954) and (1961), Miran (1969), Tegey and Robson (1996), Henderson (1998), Robert (2000), Midehgan and Jahangiri (2005), Shierani (2009), Din and Rahman (2011), Ali (2013) and Miller (2014). In these three morphemes /a, o, u/ only /a and u/ are found in the present study but /o/ is not the part of it. Furthermore, the vowel /æ/ existed in the following studies: Miran (1969), Din and Rahman (2011) and Ali (2013) and the phoneme /ʊ/ also included in the above studies except for Miran (1969) but the /ʊ/ sound found only in the work of Tegey and Robson (1996). The phoneme /ʊ/ is also found in the present study that is frequently used in roots. However, the vowel /æ/ was found in many studies as mentioned above, but it is lacking in the present study.

The schwa /ə/ phoneme searched out in these studies: Penzl (1961), Tegey and Robson (1996), Henderson (1998), Shierani (2009), Din and Rahman (2011), and Miller (2014). The phonemes /ɒ/, /ʌ/, and /ɜ:/ found only in the work of Ali (2013). Similarly, the phonemes /ə and ɒ/ are found in the present but the last two are not the part of it, because these are not present in Yousafzai dialect. Moreover, the present study also carries the phonemes /ɑ:/ which was not found in the above literature.

5. Conclusion

The main objectives of the current study were to find out the vocalic phonemes in Pashto and to explore their acoustic properties. For addressing these objectives, the data were collected from the native speakers and then made different minimal sets and pairs having CVC context. The data discussed many times with experts and native speakers of the language. Then, the native speakers were invited to a comfortable room and guided them to utter the words in the list in a natural tone. All the participants were agreed and had no stress on them during data collection. All of the ten speakers uttered the word list thrice and recorded respectively using Zoom H6. The data were then transferred to a laptop and saved in WAV file. After finalizing the process of recording, the data was analyzed acoustically using Praat. In the acoustics process, the boundaries of vowels were carefully identified and marked, and spectrograms were taken. The durations and values of F1, F2 and F3 were taken for generating quadrilateral shape of the tongue. The results showed that there are some similarities and dissimilarities with other existing studies regarding the vowels. Some vowels are found in the secondary sources as well as in the current study and some are missing. The results also showed that there is a total of nine monophthongs in Pashto. All of them have existence in root words and the minimal set of these nine words was given in Table 1. It was finally concluded that Pashto has nine monophthongs which are given here /u:, ʊ, ɒ, i:, ɪ, ɑ: ə, a, e/.

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