Investigation of Back Vowels in Pakistani English Through Acoustic Lens

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Abstract

The examination of distinct features of non-native varieties of English has been the focal point of many research studies. The current study is also a continuation of this query. It intends to observe the acquisition of back vowels /ɒ/, /ʊ/, /ɑ: /, /ʊ: /, /ɔ:/ regarding their spectral (the lowest two Formants) and temporal (duration) aspects in Pakistani English. The data were collected from the female learners of English at middle level (about 15 years old) from a public institute of Pakistan. The target back vowels were embedded into / hvd / syllables in the carrier phrase 'say --- please' as a stimulus. Data comprising of seven hundred and fifty tokens of English back vowels were analyzed using FormantPro (Xu, 2015) software. The results show that the acoustic patterns of back vowels of Pakistani learners of English are not much aligned with those of native speakers. The back vowels /ɑ: / and /ɒ/ are produced as central vowels rather than back vowels on horizontal plane of tongue fronting (corresponding to Formant 2). Likewise, back vowels, particularly /ɒ/ and /ɔ:/, are also displaced on vertical horizon of tongue height (corresponding to F1). The results of the study reflect that vowels of Pakistani English are distinct from the patterns of the English reported by Roach (2004). This distinctness can be linked with discrepancy between phonological and orthographic form of the English language and inter-lingual effects from Urdu/indigenous languages of Pakistan.

Keywords: *Pakistani English, back vowels, distinct variety, acoustic Analysis*

1. Introduction

The current trends of urbanization, digitization, and e-commerce have shown a rapid increase in the use of English which signifies the instrumental use of English in multilingual countries like Pakistan. Although Urdu is the unifying force of the state of Pakistan; however, English plays a vital role in all major domains of power which motivates people, aware of the linguistic utility in socially prestigious networks, to learn it for a better future in the emerging markets (Mansoor, 2005; Haq, 1993; Rahman, 1999).

The growth of English with its one billion non-native (L2) speakers has outnumbered its native speakers, involving 80% use of English among L2 speakers only (Benecke, 1991; Crystal, 2000; 2003). This spread of the English language gave birth to different varieties of the English language which, according to Ladefoged and Johnson (2011), largely differ in their use of vowels rather than the use of consonants. Therefore, it is imperative to observe different patterns of articulation of vowels of different dialects of English so that speakers with diverse language backgrounds may have smooth cross-cultural communication.

According to Botlan (2008), Pakistan is the third largest English-speaking Asian country where about eighteen million population use English as medium of communication. However, investigation of the patterns of Pakistani English yet needs to be made, with exception of a few studies launched in Pakistani context. Mahboob (2004) found that Pakistani speakers adhere to the orthographic system as a guide to English phonology. Rahman (1990) studied PakE comprehensively basing his claims on the conventional continuum of sociolinguistics. Anwar (2007) demonstrated that PakE has its distinctive characteristics due to code-switching at the phrase and clause level. Bilal, Mahmood, and Saleem (2011) focused on front vowels in Pakistani English to find out their patterns of articulation. Kousar (2018) was aimed at observing the effects of consistency of input on acquisition of English short vowels in Pakistan. She came up with the conclusion that consistency of input does have significant effect on the acquisition of English vowels as the experimental group A that received the treatment consistently outperformed the experimental group B that was inconsistently exposed to RP vowels and control group C. Bilal et al. (2012) investigated back vowels in PakE to verify whether Pakistani speakers of English merge back vowels or not like other Asian languages. They took data from the male and female students at a university from the Punjab. The results reflect that PakE has four back vowels where the speakers merged long and short vowel /ɔ: / and /ɒ/.

The back vowels /u/ and /u: / were not merged having their distinct features in the data. This study came up with the findings that PakE is distinct from RP English with five back vowels.

The current study attempts to treat Pakistani English as a recognizable dialect of English with notable influences from British English, Urdu language, and the regional languages. This study focuses on examining English back vowels on scientific grounds i.e., measuring their formant values and duration to observe their distinct features and classify them accordingly.

1.1 Research Objectives

- To observe the F1 values (related to jaw opening) of back vowels in Pakistani English
- To observe the F2 values (related to tongue fronting) of back vowels in Pakistani English
- To observe the Duration values of back vowels in Pakistani English

1.2 Acoustics of Vowels

Acoustically, vowels are described in terms of their spectral and temporal features. The spectral dimension of vowels shows the quality of vowels i.e. relative phonological resonance of the vowel sound (Wang & Heuven, 2006). The temporal aspect of vowels is related to quantity of vowels i.e. phonological distinctive length of the vowel relative to other vowels of similar quality in the language (Behne, Moxnes, & Nyland, 1996). Here, the vowels are described according to their spectral and temporal features.

The spectral features of vowels reflect which part of the tongue is raised to what extent relative to the roof of the mouth (Algeo, 2010). However, some phoneticians (i.e. Heinz, 2011) consider the feature of opening and closure of jaw, rather than tongue height, the second spectral aspect of vowel quality. The third spectral aspect of vowel quality i.e. lip-rounding is closely connected with the first two spectral features of tongue fronting and jaw opening. These spectral features along with pitch and loudness are helpful for distinguishing one vowel from the other (Li, 2004). These three parameters classify the vowels in the following categories.

1.2.1 Front Vowels vs. Back Vowels

The vowel sounds which are produced by placing the front part of the tongue in various positions from the upper incisor to the lower one, are called front vowels (Roach, 2009). But, when the back part of the tongue moves up or down in the velar area, the resultant vowels are called back vowels (Ladefoged & Johnson, 2011). Central vowels are produced when the tongue is in a resting and neutral position in the oral cavity.

1.2.2 Open Vowels vs Closed Vowels

An open vowel (also called low vowel) is articulated when the mandible is depressed with the low position of the tongue (Ladefoged & Johnson, 2011). On the other hand, a closed vowel is produced when the mandible is in relative closed position than the open vowels (Algeo, 2010). There are three other categories of vowels based on the intermediate position of the mandible: open-mid vowels, mid vowels, and close-mid vowels.

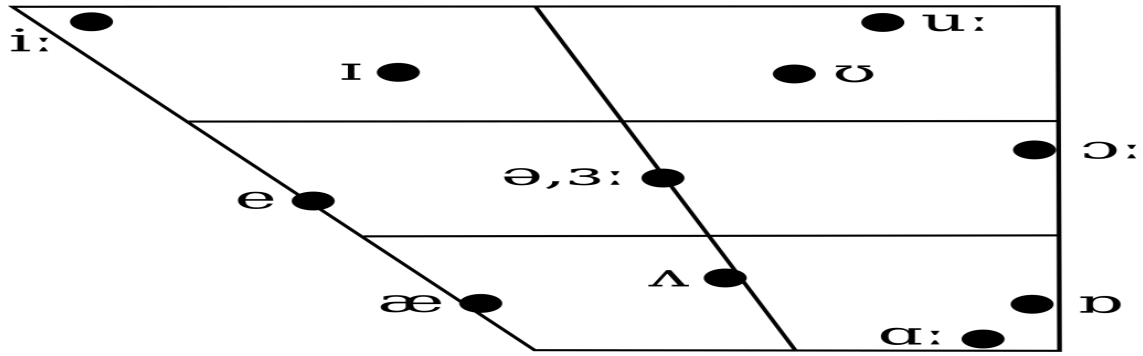

Figure 1.1 English RP Pure Vowels (from Roach, 2004, p. 242)

Temporal aspect of vowels deals with the time during which the vowel signal stays approximately stationary in terms of other precepts (Algeo, 2010). Duration is a distinctive feature of vowels, next to vowel quality (Lin & Wang, 2007). In many languages such as English, duration is even more significant than dimension of vowel quality (Jenner, 1989). However, the greater amount of time spent during a phonologically long vowel may also make its articulation use greater extremes of the vocal space than phonologically short vowels and may also affect the vowel spectrum (Behne et al., 1996). Besides being a distinctive feature of vowels, vowel duration is also a major element of vowel intelligibility (Jenkins, 2000) and paralinguistic feature of speech (Boersma, 2001). There is no exact duration of long vowels and short vowels as vowel duration is relative, not absolute one.

The ‘extrinsic’ duration of vowels is affected by different contextual factors contrary to ‘temporal pattern of formant movements’ (Lehiste, 1976; Peterson & Lehiste, 1960). These non-phonemic influences of the context on the duration of vowels are investigated by various researchers (Ali, 2013; Crystal & House, 1990; Ferguson & Kewley-Port, 2002; Gimson & Cruttenden, 1994; Klatt, 1987; Myers & Hansen, 2005). To indicate relative length of long vowels, the mark of colon is usually used orthographically; however, the doubling of the vowels is also frequent in some languages of the world.

2. Methodology

2.1 Population / Sampling

The target population of the current study comprises of the female learners of English (as L2) at middle level in the Punjab, Pakistan. The researchers took a genuine class group of 30 learners at middle level from a government school for girls in District Sheikhupura, Pakistan. She selected a small representative group of the female learners of English from the population as, according to Milroy and Gordon (2003), the generalizability of the results of the sample depends on the degree of its representativeness of the large population. The average age of the participants of this study was 13 years with standard deviation of 1.69. It indicates that the participants were exposed to English input for roughly eight to nine years. However, the learners were exposed to non-native variety of English language/phonology, rather than to native English.

2.2 Stimuli

The researcher embedded the target back vowels into the /h-v-d/ syllable as stimuli for data elicitation. This CVC structure has the least co-articulatory effects of the neighboring consonants on the target vowels (Bohn, 2004; Cervera, Miralles, & Gonzalez-Alvarez, 2001; Cox, 2006; Hillenbrand et al., 2001; Hillenbrand et al., 1995; Katz & Assmann, 2001; Koenig, 2000; Koenig, Mencl, & Lucero, 2005; Lane et al., 2005; Nearey, 1997; Schiavetti et al., 2004; Steinlen, 2005; Wang & Heuven, 2006; Xue & Hao, 2003). This /h-v-d/ syllable is enormously used due to particular articulatory features of its constituent phonemes. That’s why the discussion on the constituent phonemes of the /h-v-d/ syllable is desirable to examine the effects of their articulation on the adjacent vowels.

If the /h-v-d/ syllable is studied as a unit of co-articulatory effect on the vowel, its phonetic context is called ‘null environment’ (Stevens & House, 1963). The [h] has the quality of

the vowel it precedes because the configuration of the vocal tract during its production is determined by neighboring sounds. That's why the use of [h] in the beginning of syllable supplies a neutral phonetic context (Perry, Ohde, & Ashmead, 2001) to study the articulatory characteristics of speech either preceding or following it. For assessing articulatory behavior of the surrounding phonemes, the articulatory characteristics of [h] are fully appreciable (Robb & Chen, 2009). Likewise, [d] has least anticipatory co-articulatory effect on the vowel followed by [d] except the effect of the pre-boundary (immediately before the end of a word, phrase, or sentence where a pause may occur) voicedness on the length of the preceding vowel (Pickett, 1999). Moreover, the combination of the phonemes [h] and [d] in /h-v-d / syllable assures more standardization of the syllable shape and minimizes intonational as well as co-articulatory influences *(*DeJoy & Barnes, 2011).

The /h-v-d/ syllable in English is very rich in case of production of almost all the vowels of English (Wang & Heuven, 2006). The researcher used the /h-v-d/ stimuli for the back vowels to factor out the co-articulatory effect and acoustic variation determined by information-related phenomena such as linguistic redundancy (Aylett & Turk, 2006; Wright, 2003). The particular focus of the researcher was on the maintenance of the initial /h/ phoneme in all the hvd syllables to minimize the preservatory co-articulatory effect because its open articulation requires minimal amount of movement from the articulators during the transition from the consonant to the vowel (Harrison & Dunkley, 2004; Hillenbrand et al., 2001; Roeder, 2009). The consistent use of the /d/ phoneme at the end of the syllable was intended to control the external factors of the extrinsic length of the vowel. The /hvd / syllables used in the current study were hard, hod, hawed, hood, who'd. Among these /hvd/ syllables, one syllable has post-vocalic /r/.

The /hvd/ syllables were inducted in the carrier phrase 'say hvd please' (Ali, 2013; Bohn, 2004; Cervera et al., 2001; Cox, 2006; Flege, 1992; Hillenbrand et al., 1995; Katz & Assmann, 2001; Kurowski et al., 1996; Lane et al., 2005; McCaffrey & Sussman, 1994; Nearey, 1997; Peterson & Barney, 1952; Schiavetti et al., 2004; Steinlen, 2005; Svirsky & Tobey, 1991; vanWieringen & Wouters, 1999; Xue & Hao, 2003). Although, the reading of the carrier phrase is not representative of the speaker's natural speech like spontaneous/free speech, or reading of a passage, yet the reading of a carrier phrase controls the intonational influences of the speakers; it provides the required number of tokens of each vowel; and this clear speech yields acoustic properties of speech sounds more clearly than the conversational

speech (Al-Hamadi & Ali, 2012). Moreover, the study is concerned with assessment of leaners' English back vowels whether it is limited just to their awareness of RP vowels or their application of this variety of English in their communication too.

2.3 Pilot Testing

Pilot testing ensures high quality of the outcomes of research studies in the specific context. Sudman and Bradburn (I983) even went to the extent of claiming that no research study is conductible if it is not pilot tested. In the pilot testing of the current study, the researchers gave the list of carrier phrases to a few participants of the study for reading and recording. The researchers initially used the carrier phrase 'say hvd again' in the pilot study. But afterwards, they realized that the participants merged the boundaries of /hvd/ and 'again' in the carrier phrase. She changed the phrase 'say hvd again' into 'say hvd please' to mark the lexical boundaries clearer for analysis.

2.4 Data Collection

The data were collected by recording the reading of the 'say hvd please' phrases of the participants. Before formally starting the recording, the participants were directed to read the phrases clearly with a brief gap before and after the 'hvd' syllable as the acoustic properties of speech sounds in conversational speech are different from those in clear speech (Al-Hamadi & Ali, 2012). Each phrase of 'say hvd, please' was digitized at 44100 Hz using PRAAT (Boersma, 2001) on laptop. The average of their syllables was noted as two syllables per second which is classified as slow speech rate (Pickett, 1999). All recordings were made at a sound attenuated place in the school. Each participant read 'say hvd please' phrases 5 times for back vowels to get the average performance of acquisition of RP vowels of the participants rather than random one adding up to seven hundred and fifty tokens of English back vowels (05 ×05 = 25×30=750). The data collected from the participants in form of recordings of 'say hvd please' were ready for acoustic and statistical analysis.

2.5 Ethical Considerations

Ethical considerations are an integral part of experimental research. To fulfill this requirement, the researcher got filled a consent form from the head of the institute, containing the following details (Cohen, Manion, & Morrison, 2000; Creswell, 2003; Johnson & Christensen, 2004):

- An explanation of the objectives of the research and the procedures of the experiment and data collection to be followed.
- A description of the benefits the institute and the participant may receive.
- A statement of the confidentiality of the results.
- An offer to question anything concerning the procedures and to receive a copy of the results.

2.6 Research Validity

Research validity is essential to research to evaluate (a) the meaningfulness of the interpretations that researchers make based on the observations, and (b) the extent to which these interpretations are generalizable beyond the research study (Bachman, 2004a). As it was already mentioned that the current study was launched in language classrooms, the operation of many factors was indispensable in this authentic classroom environment. Though, the researcher tried to control various extraneous factors such as age, gender, language proficiency level, yet tight control of all the factors of the learning process may result in artificial frameworks in laboratory conditions affecting the external validity of the study (Clarke & Kitzinger, 2004). This use of natural and authentic class groups reflects the representativeness of the sample to population. So, the researcher tried to maintain as much internal validity as was safe for external validity of the research.

3. Data Analysis

Acoustic analysis of speech sounds starts from the process of segmentation, followed by the procedure of labelling, and formant extraction. In the current study, the researchers executed these procedures as follows.

3.1 Segmentation

Speech is often segmented into basic phonetic units for recognition and synthesis. Segmentation is "a process where a speech signal is decomposed into smaller acoustic units like words, syllables, and phonemes" (Kaur & Singh, 2010, p. 1). The researchers followed the manual segmentation method segregating the hvd syllable from the rest of the carrier phrase guided by visual cues from the intensity curves of waveform and formant contours of spectrogram (Robb & Chen, 2009). These cues were used to identify likely boundaries between lexical items. The researcher marked the boundary of hvd syllable from the fricative

turbulence of /h/ and after the release of the burst of /d/ preceded by pauses. Phonetic features of [h] appear to be clearer for being syllable initial than syllable-final consonant (Gow et al., 1996; Manuel, 1991; Ohala & Kawasaki, 1984). Identification of word-initial [h] was smooth as the factors that enhance the effect of the acoustic property of phonetic features are mostly at the beginning of words. With respect to identification of syllable-final consonant [d], it is often made with or without a weak burst. In syllable-final [d], devoicing is often achieved by constricting, rather than opening, the glottis.

In cases where the speech rate was very fast, unfortunately, acoustic cues failed to give clues about the word boundaries, particularly when the beginning of a word got merged with the end of the previous word (Prinsloo, 2000). To tackle such situation, the researcher benefitted from auditory and visual cues from waveform and spectrograms to identify the most likely location of the approximant beginning of fricative [h] and closure and burst of [d] in the hvd syllable (Colantoni & Marinescu, 2010; Figueroa & Evans, 2015; Kingston, 2008). After lexical segmentation, formantPro software (Xu, 2015) was utilized to segment the phonemes manually. To marking phonemic boundary, the interval from the approximate onset and offset of the vowel was set (Ali, 2013; Hillenbrand et al., 2001; Wang & Heuven, 2006). The onset of the vowel was the release of the preceding consonant /h/ accompanied by the beginning of vocal fold vibration. At this point, the wave amplitude and complexity began to increase. Following the previous research studies (e.g. Cervera et al., 2001; Nishi & Rogers, 2002; Reuter, 1971; Steinlen, 2005), fricative noise of [h] in form of random pattern and aperiodicity in the waveform (Di Canio, 2015) was not included in the vowel domain. For setting the offset boundary of the vowels, the closure of [d] phoneme was excluded from the domain of vowels by looking for three co-occurring events: a sudden decrease in amplitude and complexity in waveform; a change/loss of energy in higher formants (F2, F3, F4) in spectrogram; the onset of aperiodicity. The researchers focused on the two lowest frequency formants (F1 and F2) for phonemic segmentation because they present the most vital acoustic properties visible in spectrograms, a determiner of vowel quality (Delattre et al., 1955). In cases where the first two formants of monophthongs were not clear, the higher formants were relied on to set the phonemic boundary of vowels. Along with visual cues from spectrogram and waveform, auditory impressions were also utilized as, according to Nicholas (2009), a researcher's auditory impression is the most important qualitative tool in acoustic analysis. However, different criterion of segmentation was applied on rhotacized vowels marked with lowering of the frequency of the third formant (Ladefoged & Johnson,

2011). The part of the vowel dominated by /ɾ/ sound was excluded from the domain of the vowel.

3.2 Labeling

The process of labeling was performed along with the process of phonemic segmentation; yet this process is being discussed separately because a lot of issues are relevant to labeling but not much related to segmentation. All the vowels that had been labeled as monophthongs a priori were treated as such even though they were read alternatively. Moreover, if the participants misread a vowel in all its five tokens in recorded sentences, it was labeled according to the vowel given in the sentences, not the recorded one. However, any mistaken reading of a vowel was ignored by accepting the correct reading of the vowel twice. But it happened in those cases where the mispronunciation occurred once in five readings of a sentence. Additionally, it was also observed that a vowel phoneme was actualized by different phones. In such a case, different realizations of a phoneme were labelled as a single vowel phoneme (Nagarajan, Murthy, & Hegde, 2003; Thangarajan & Natarajan, 2008; Kaur & Singh, 2010). After segmenting and labelling the vowel phonemes, formantpro praat was run for automatically extracting formant values and duration values of the vowels.

3.3 Measurement Reliability

Reliability refers to the "consistencies of data, scores or observations obtained using elicitation instruments administered in educational settings to tasks completed by participants in a research study" (Chalhoub-Deville, Chapelle, & Duff, 2006: p. 2). Measurement reliability shows how much the instruments/procedures generate consistent results in a given population in different circumstances. Following the precedent of acoustic studies (e.g. Cervera et al., 2001; Cox, 2006; Robb & Chen, 2009; van Santen, 1992; van Son, Binnenpoorte, van den Heuvel, & Pols, 2001), reliability of the measurement of data, in present research, was assessed by intra-judge measurement reliability technique by correlating two sets of data at two points of time to calculate their Mean Absolute Deviation. The computation of the mean values of the first and second data sets show that the MAD values of the F1 and F2 of vowels range from 0 to 15.15 Hz from the mean values. This little deviation shows that the measurement of data is within the range of reliability of measurement i.e -+ 60 Hz (Monsen & Engebretson, 1983).

3.4 Data of Vowels

System of FormantPro software (Xu, 2013) generated various files of average values, following the research objectives, the average values of only F1, F2, and Duration were transported to the excel file for computation. Later on, the researchers assembled and calculated average values of the F1, F2, and Duration values of thirty participants in excel sheet. After computing the frequencies of the back vowels in PakE, the plotting of these vowels is discussed with reference to the back vowels plotted in RP English by Roach (2004).

Table 1 Frequency of F1, F2 and Duration of Back Vowels in Pakistan English

Sr. #	Vowel	F1 (Hz)	F2 (Hz)	Duration (ms)
1	/ʊː/	497	1225	205
2	/ʊ/	463	1267	133
3	/ɔː/	668	1311	230
4	/ɒ/	615	1266	186
5	/ɑː/	828	1465	212

ɑ

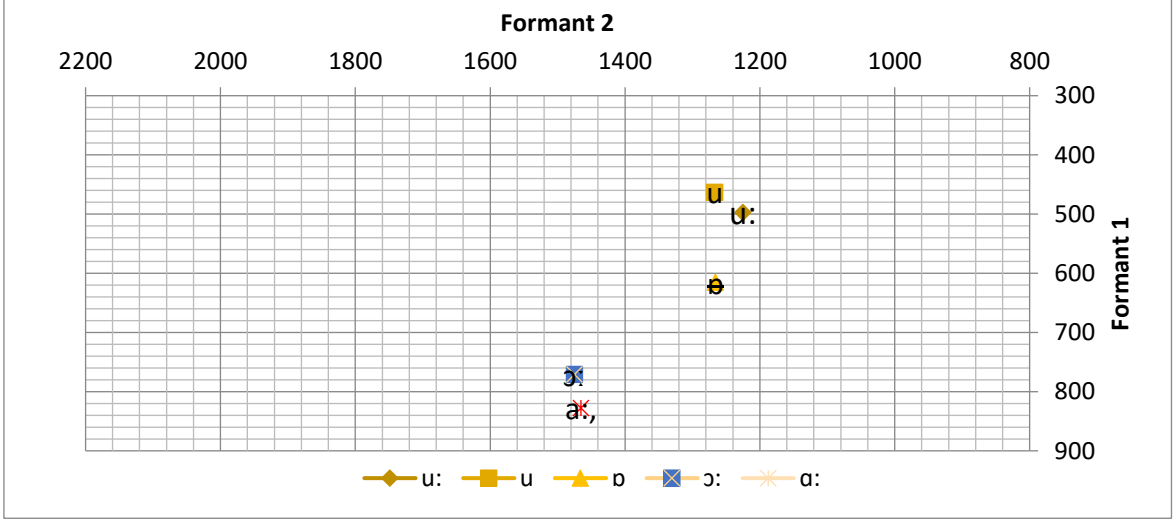

Figure 2.1 Plotting of Pakistani English Back Vowels in vowel Quadrilateral

The tabular and graphical representation of the data of the back vowels makes it clear that the back vowels of the Pakistani learners of English have their own distinct features (for reference Roach, 2004). If we observe the placement of back vowels, it is evident that the back vowels /ɑː/ and /ɔː/ are pronounced as central vowels rather than back vowels. Their place of articulation in vocal tract is almost identical except a little difference in jaw opening.

The remaining back vowels /ɒ/, /ʊ/, /ʊː/ are pronounced as back vowels; however, their pronunciation is marked deviant on the vertical plane of jaw opening/ tongue height. The short vowel /ʊ/ is articulated as the close vowel rather than /ʊː/ on the vertical axis in Figure 2. The same case is found with the long and short variant of vowel 'ɒ'. The Pakistani learners of English articulated the vowel /ɑː / at the point between half-close and half-open in Figure 2. The long vowel /ɔː / is produced close to the open vowel /ɑː /. Hence, the back long vowels in Pakistani English are tilted towards open position of mouth whether these are high vowels or low vowels. However, the back vowel /ɑː / retains its position of open vowel in Pakistani English. If these back vowels are analyzed on x axis related to tongue fronting, the open vowels are tilted to central position of the mouth contrary to RP English where these vowels are located as back vowels. Hence, the findings of this study claim that back vowels in Pakistani English have their own distinct nature with respect to tongue fronting and jaw opening. However, unlike other Asian dialects of English where back vowels /ɒ/ and /ɔː / and /u/ and /uː / are merged (Deterding, 2007; Bilal et al., 2021), Pakistani English does not merge English back vowels.

5. Conclusion

The results of the study lead to the conclusion that Pakistani learners of English feel problem in acquiring English back vowels particularly long vowels. The reason behind this difficulty can be traced to various factors such as interference of learners' L1, lack of direct exposure to native variety of English, and discrepancy between phonological features and orthographic form of English back vowels.

5.1 Recommendations

This study recommends that teaching of English should be assisted by audio aids to provide the learners with direct exposure to native variety of English, to tackle L1 interference, and to overcome discrepancy between orthographic and phonological form of English.

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