An Acoustic Analysis of Modern Persian Vowels

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ABSTRACT
Determining the acoustic properties of the sounds of any language is assumed to be the initial step in pedagogical or linguistic studies. No attempt to study Persian vowels’ acoustic properties has been reported yet according to our knowledge. With the help of spectrographic and F1 and F2 comparison of Persian vowels this paper attempts to do a computer-based acoustic analysis of Persian vowels, and provides a digitized and authentic chart of Persian vowels. As a result, based on the formant values, a vowel space plot of Persian vowels was developed. Also, the theory of efficiency of these three vowels /i, a, u/ as the major means of communication in the majority of languages of the world is supported by the results. Furthermore, the analysis of distributional occurrence of these vowels in the vowels space and their relative distance from one another suggest that the pressure to form pattern has made Persian language to develop a vowel system which could be described in a triangular auditory space. In addition to these constrictions, Persian language has developed three other intermediate vowels /e, æ, o/ to create a symmetrically distributed vowel system to cater the communicative needs of the language users. In general, in a descriptive method the acoustic properties of Persian vowels /i, e, æ, a, o, u/ are examined and illustrated in this paper.

Key words: acoustic properties, Persian vowels, formant analysis.

1 INTRODUCTION:
Acoustic analysis of speech sounds has been carried out with different goals. Among the various goals, according to the literature available, we can refer to Mirza’s (1986, 357-369) aim in preparing a simple phonetic guide which was devised for those who wished to learn English as foreign language. In his paper he talks of a computer guide which helps “a learner to adjust his tongue hump position and the constriction in his vocal cavity so that he can accurately pronounce any English vowel.” He demonstrates how a software deduces the first two formant frequencies and “marks a corresponding square [grid] displayed on the computer screen” and by watching the squares marked for the pronounced vowel a learner could easily adjust his tongue position so that he could pronounce the vowel accurately and mark the ideal square, which is considered to be an indication of accurate pronunciation. With a different practical application, addressing the deaf Hebrew-speaking implanted patients, Aronson and et al. (1996, 283) worked on 5 Hebrew vowels in isolation comparing male and female formant values. Their results showed significant differences in terms of gender difference. Yet in another study Kewley-Port and et al. (1996) worked on intelligibility of American English vowels produced by Japanese speakers. Their experiment demonstrated that vowel intelligibility may vary significantly depending on the vowels present in the native language.

The need to understand the acoustic properties of the vowels on one hand and the lack of any account of Persian vowels prompted the author to undertake the present study. The review of the literature shows that there is no report of any study to account for the acoustic properties of Persian sound in general and Persian vowels in particular. Of course in the available literature there are graphs representing the place of articulation of the vowels. However, no explanation has ever been given as to where from and based on what kind of acoustic studies these places of articulation have been attributed to Persian vowels. One interpretation is that they have been established only based on non-acoustic and subjective comparisons of the location of these vowels with the English ones. See Samareh (1985), Yarmohammadi (1985), Hagshenas (1976) for details.

In the empirical studies, different methods have been used to normalize the data. In order to normalize the vowel qualities of different speakers, Yang (1996) suggests removal of the “…anatomical differences in vocal tract length or the ratio of pharynx to the mouth cavity…” In line with this, we collected the data from a homogenous group. Furthermore, 1) to discard the biological differences among the informants, 2) to measure tongue position in the production of vowels, and consequently 3) to create an appropriate vowel plot, Ladefoged (2001, 39, 2003) suggests measuring the average values of the informants. So, in this study 10 readings of every single waveform of every individual were taken, and then the average values were calculated for further analysis. However, Clark and Yallop (1990, 225) believe that “…absolute values of the formant frequencies are not crucial, but their relationships are…”

In the production of vowels, theoretically it has been established that repetitive closure of vocal folds sets the different volumes of air in throat and mouth into vibration, and as such a sound wave is produced. The resonances of vocal tract which are called formants are decisive means of determining the qualities of sound waves of a language. The vibration of air depends on the altering size and shape of the vocal tract. For a vowel the relevant shape is the tube formed by the mouth and throat, which is known as the vocal tract. “Because the vocal tract has a complex shape the air within it will vibrate in more than one way. Often we can consider the
body of air behind the raised tongue (i.e. in the throat) to be vibrating in one way, and the air in front of it (i.e. in the mouth) to be vibrating in another. In the vowel heed the air behind the tongue will vibrate at 250 Hz, and the air in front of it at about 2100 Hz”, Ladefoged (2001, 33). The resonance which is lower in pitch is called the first formant, and the latter one is called the second formant.

As indicated above, physical representation of vowel sounds of the languages is basic and vital step in the above mentioned as well as any other theoretical or empirical study. Being conscious about the above mentioned practical goals, the present study attempts to launch the query into the acoustic properties of Persian vowels.

2 METHODOLOGY:
2.1 Subjects:
The participants in the study were twelve undergraduate young female Persian speakers studying English as major at Tabriz University in Iran.

2.2 INSTRUMENT:
The instrument consisted of six Persian words each containing a vowel in middle environment. That is, all words started with the phoneme /h/ and ended with the phoneme /d/. In other words, the environment was h_d.

2.3 PROCEDURE:
The subjects were asked to read out the words, each containing a Persian vowel. Each word was repeated three times and the best recording was selected for the analysis. The data were directly recorded on a computer and later on analyzed by speech analysis programs on a computer.

3 FINDINGS AND DISCUSSION:
The recorded sound waves were analyzed by the speech analysis software Praat and Speech Analyzer. In doing so, the average of ten readings of each sound wave was calculated and the results as shown in Table 1 are derived. The table represents the mean values of the first and second formants for each vowel. For example, /i/ has the formant-one value of 365, and formant-two value of 2508. Furthermore, the sample spectrograms of each vowel are shown in the figures 3 through figure 8.

The relationship between the first and second formants is mainly summarized in a vowel space plot. Here this was done by matching grid references of first and second formants of each vowel. Thus, as shown in Figure 1, based on the formant frequency values, a vowel space plot of Persian vowels was developed. The resultant plot shown in Figure 1 is not what we normally encounter in phonetic textbooks. So it was inverted to achieve the common way of the presentation which is called inverted and reversed model. In this graph the X axis, which is based on second formant values, starts with the lowest frequency and ends with the highest, and the Y axis starts with the lowest and goes up in terms of frequency values. Refer to Figure 2 for more details.

As indicated in the figures 1 and 2, distribution of the three vowels /i, a, u/ in the vowel space supports the idea of sufficiency of these three vowels as the major means of communication in the majority of the languages of the world in general and in Persian in particular. That is, in majority of the languages, including Persian, these vowels are present and they are the basic vowels. The graphic investigation of the place of occurrence of these vowels in the plot shows that, in Persian, they happen to occur at the corners of this plot. The relative and symmetrical distance of these vowels from one another, which creates a triangular shape in the vowel space, is an indication of a kind of pressure to form a systematic pattern in the vowel system of Persian language. In addition to these cornering vowels, Persian language has developed three other intermediate vowels /e, ã, o/ to create a symmetrically distributed vowel system to cater the communicative needs of the language users.

![Fig. 1 Persian vowels plot](image1)

![Fig. 2 Persian vowel plot (inverted and reversed presentation)](image2)

<table>
<thead>
<tr>
<th>Vowels</th>
<th>F1</th>
<th>F2</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>365</td>
<td>2508</td>
</tr>
<tr>
<td>e</td>
<td>644</td>
<td>2115</td>
</tr>
<tr>
<td>ã</td>
<td>990</td>
<td>1722</td>
</tr>
<tr>
<td>a</td>
<td>750</td>
<td>1251</td>
</tr>
<tr>
<td>o</td>
<td>558</td>
<td>1102</td>
</tr>
<tr>
<td>u</td>
<td>423</td>
<td>1065</td>
</tr>
</tbody>
</table>
Fig. 3  Spectrogram of the Persian Vowel /i/

Fig. 4  Spectrogram of the Persian Vowel /e/

Fig. 5  Spectrogram of the Persian Vowel /æ/

Fig. 6  Spectrogram of the Persian Vowel /a/

Fig. 7  Spectrogram of the Persian Vowel /o/

Fig. 8  Spectrogram of the Persian Vowel /u/
4 CONCLUSION:
As the primary objective of the study a phonetic chart of Persian vowels is developed. As regards to Persian language this chart is believed to be the first authentic chart which has ever been developed on acoustic grounds. The findings indicate the presence of six vowels distributed symmetrically in the vowel space plot. The findings further lend support to the idea of efficiency of the three vowels /i, a, u/ as the major means of communication in the majority of languages of the world. In Persian these vowels appear to occur at the corners of this vowel space. Furthermore, the results suggest that the pressure to form pattern has made Persian language to develop a vowel system which could be described in a triangular auditory space. In addition to these cornering vowels, Persian language has developed three other intermediate vowels /e, æ, o/ to create a symmetrically distributed vowel system to cater the communicative needs of the language. In general, all six vowels of Persian i.e. /i, e, a, æ, o, u/ are examined acoustically, then their relevant and exact places of articulation, which are reflections of the approximate tongue positions, are plotted in a scaled format which is traditionally called as vowel chart.

The findings and results of the present study could be utilized in linguistic studies such as dialectology, or practical studies like developing a computer based devise aiming at helping the foreign language learners to improve their pronunciation.

Finally it is suggested that future studies incorporate data related to male speakers to investigate the differences across gender.

REFERENCES: