CHAPTER 4

FINDINGS AND DISCUSSION

This chapter presents and discusses the findings from this study. The findings are divided into two main sections. The first section discusses the results of the English monophthongs produced by the Persian subjects in this study, and the second section discusses their production of English diphthongs, which addresses the first research question (see Chapter 1). Comparisons between male and females subjects are presented as are comparisons with British English in order to address questions 2 and 3 (see Chapter 1).

4.1 Monophthongs

The results for monophthongs will be presented by looking at vowel quality, vowel contrast of particular vowel pairs in relation to British English and the influence of Persian language on the production of English vowels by Persian speakers of English.

4.1.1 Vowel Quality

As explained in Chapter 3, the F1 and F2 frequencies were measured at the midpoint of each vowel using the linear predictive coding (LPC) tracker overlaid on a wide-band spectrogram. The Euclidean distance (ED) between the F1 and F2 values for the centroid for both female and male Persian speakers in the word list context (WLC) and informal speech context (ISC) were calculated and are shown in Table 4.1 and 4.2 to enable comparisons of how the vowels are spread out in the vowel space in the different speaking contexts. The F1, F2 and durational values for the vowels produced by the individual subjects are shown in Appendix C.

Table 4.1: Average Values for F1 and F2 and Euclidean Distance of English Monophthong Vowels Produced by Female and Male Persian Speakers in WLC

Target Vowels	Female					Male				
	F1 (Hz)	F2 (Hz)	F1 (Bark)	F2 (Bark)	Euclidean Distance(Bark)	F1 (Hz)	F2 (Hz)	F1 (Bark)	F2 (Bark)	Euclidean Distance(Bark)
iː	423	2489	4.06	14.48	3.19	311	2384	3.02	14.22	3.70
ɪ	449	2438	4.29	14.36	2.96	322	2363	3.13	14.16	3.58
e	675	2112	6.19	13.45	1.64	504	2094	4.77	13.40	1.90
æ	985	1845	8.42	12.58	2.66	761	1762	6.85	12.28	1.08
ʌ	738	1376	6.68	10.62	1.48	664	1172	6.10	9.54	2.32
ɑː	788	1417	7.06	10.82	1.58	597	1048	5.56	8.81	3.06
ɒ	790	1426	7.07	10.86	1.56	631	1130	5.84	9.30	2.55
ɔː	612	1379	5.68	10.63	1.23	455	898	4.34	7.83	4.30
ʊ	585	1384	5.46	10.66	1.26	391	1141	3.77	9.37	3.25
uː	437	1206	4.18	9.74	2.70	335	1000	3.25	8.51	4.24
ɜː	584	1733	5.45	12.16	(0.52)	449	1696	4.29	12.02	(1.58)
Average	642	1709	5.87	11.85	2.03	493	1517	4.63	10.86	2.62

Table 4. 2: Average Values for F1 and F2 and Euclidean Distance of English Monophthong Vowels Produced by Female and Male Persian Speakers in ISC

Target Vowels	Female					Male				
	F1 (Hz)	F2 (Hz)	F1 (Bark)	F2 (Bark)	Euclidean Distance(Bark)	F1 (Hz)	F2 (Hz)	F1 (Bark)	F2 (Bark)	Euclidean Distance(Bark)
iː	422	2244	4.04	13.84	2.69	287	2065	2.80	13.31	3.39
ɪ	428	1933	4.10	12.88	2.04	328	2067	3.19	13.32	3.05
e	641	2049	5.92	13.26	1.41	430	1764	4.12	12.28	1.80
æ	872	1842	7.66	12.57	1.93	594	1696	5.54	12.02	0.37
ʌ	694	1896	6.34	12.76	1.03	495	1468	4.69	11.05	1.41
ɑː	772	1596	6.93	11.62	1.10	650	1396	5.99	10.72	1.14
ɒ	790	1426	7.07	10.86	1.56	498	1239	4.72	9.91	2.25
ɔː	766	1529	6.89	11.33	1.15	500	1295	4.74	10.21	1.99
ʊ	511	1493	4.83	11.17	1.23	357	1146	3.45	9.40	3.44
uː	442	1452	4.23	10.98	1.85	311	1454	3.03	10.99	2.96
ɜː	510	1718	4.82	12.11	(1.07)	466	1507	4.44	11.23	(1.55)
Average	576	1587	5.27	11.02	1.60	405	1417	3.84	10.29	2.76

As mentioned in Chapter 2, section 2.3 the frequencies of F1 and F2 are related to vowel height and fronting/retraction; as any increase in F1 frequency corresponds to tongue lowering and jaw opening, while an increase in F2 frequency corresponds to tongue fronting (Ladefoged and Harshman, 1979). This is reflected in the vowel charts in Figure 4.1, where it can be seen that the vowels with lower F1 value are placed high in the vowel charts (e.g. /iː/, /ɪ/, and /uː/). The vowels with higher F2 value are placed

towards the front (left) of the vowel charts (e.g. /iː/, /ɪ/, /e/, and /æ/). Based on the measurements of the Euclidean distance of the vowels from the centroid, the vowels produced by the female Persian subjects in the WLC (2.03 Bark) were less peripheral compared to the ones produced by the males (2.62 Bark) in the same speaking context. This is unexpected because the tendency is usually for females to be more peripheral (e.g. Deterding, 1997; Tan & Low, 2010). The same result is repeated in the ISC for both females and males Persian speakers as females produced less peripheral vowels (1.60 Bark for females and 2.76 Bark for males) compared to the male respondents. Despite this unexpected result, the average distances from the centroid for female and male Persian English in the WLC, are smaller compared to British English vowels produced in citation form reported in Deterding (1997, p. 53), that is, 2.90 Bark for female British English speakers and 2.57 Bark for male British English speakers. The results suggest that British English vowels are more peripheral and spread out compared to Persian English vowels. Thus, it appears that the monophthong vowels produced by Persian speakers occupy a smaller vowel space compared to British English vowels (see Deterding, 1997). This is similar to findings on other non-native varieties of English (e.g. Hubais and Pillai, 2010; Pillai, Mohd. Don, Knowles & Tang, 2010; Salbrina, 2006).

However, the measurements of the Euclidean distance of the vowels from the centroid for the female Persian English in WLC is higher (2.03 Bark) than for the same females in ISC (1.60 Bark), suggesting that female Persian speakers produced more peripheral vowels in WLC than ISC. This is to be expected as speakers would tend to be more careful with their pronunciation when reading a word list compared to speaking spontaneously. A correlated sample *t*-test comparing the average Euclidean distances between the WLC and ISC for Persian female speakers showed that the difference is

significant (t (9) =3.94, p <0.01). A similar finding was reported for female British speakers, (Deterding, 1997, p. 53), that is Citation Form = 2.90 Bark compared to Connected Speech = 2.81 Bark. In both the Persian and British English contexts, the vowels produced in citation form are more peripheral than in connected speech, and this, as mentioned earlier, is because speakers will tend to be more careful with their pronunciation in read speech.

In contrast, the vowels of the male Persian speakers were more peripheral from the centroid in the ISC (2.76 Bark) than the WLC (2.62 Bark). However, a correlated samples t-test indicated that the difference between the average Euclidean distances for male Persian subjects in both speaking contexts is not significant (t (9) =0.3, p >0.01).

A comparison between the male and female Persian subjects in the current study shows that the vowels produced by the males are more peripheral than the ones produced by the females. This finding is in a way unexpected as females tend to be more careful with their pronunciation (e.g. Deterding, 1997; Tan & Low, 2010). Compared to vowels produced by British English males (Deterding, 1997, p.53), the vowels were produced more peripherally by the male Persian subjects in both speaking contexts (British English males: Citation Form = 2.57 Bark; Connected Speech = 2.04 Bark). It should be noted that the comparison with British English need to be treated with caution as the data are not derived from the same word list for the citation form, and the number of vowels extracted from the connected speech are also not the same.

As can be seen in Figure 4.1, the vowel pairs /ɪ/-/iː/, /ʌ/-/ɑː/ and /ɒ/-/ɔː/ are produced close to each other. The vowels /iː/ and /ɪ/ are produced very close together and overlap suggesting that they are realized in a similar manner. For the male subjects, this vowel

pair is realized closer than for the female subjects in both the WLC and ISC. The vowel

pair /ʊ/-/uː/ among male subjects is produced more fronted than female ones although,

the vowel /ʊ/ among female subjects is produced very close to the vowel /ɔː/ in both the
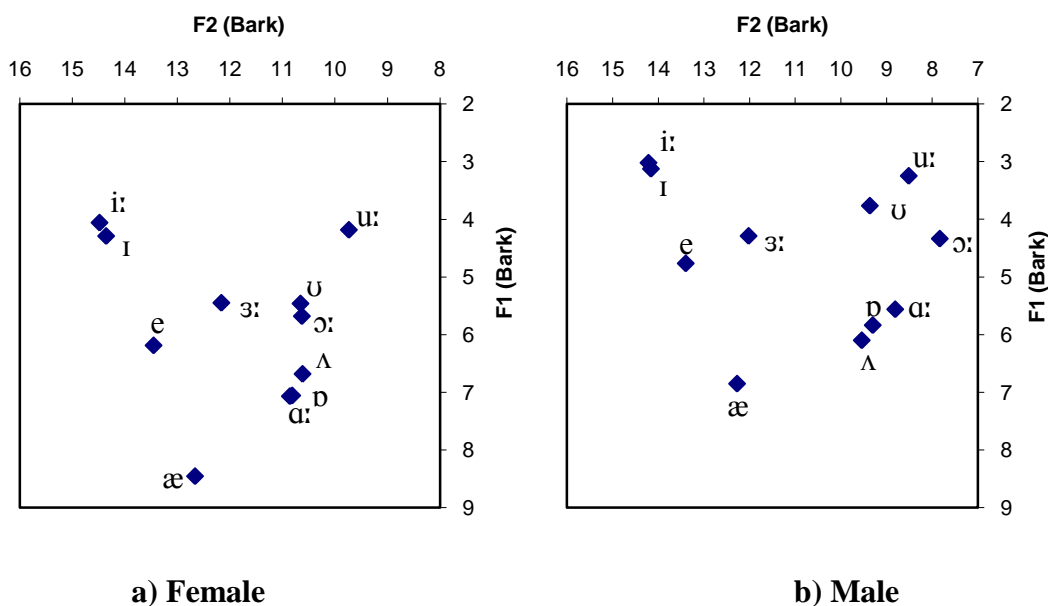
WLC and ISC.

a) Female   b) Male

Figure 4.1: Vowel Chart for English Monophthongs Vowels Produced by a) Female and b) Male Persian
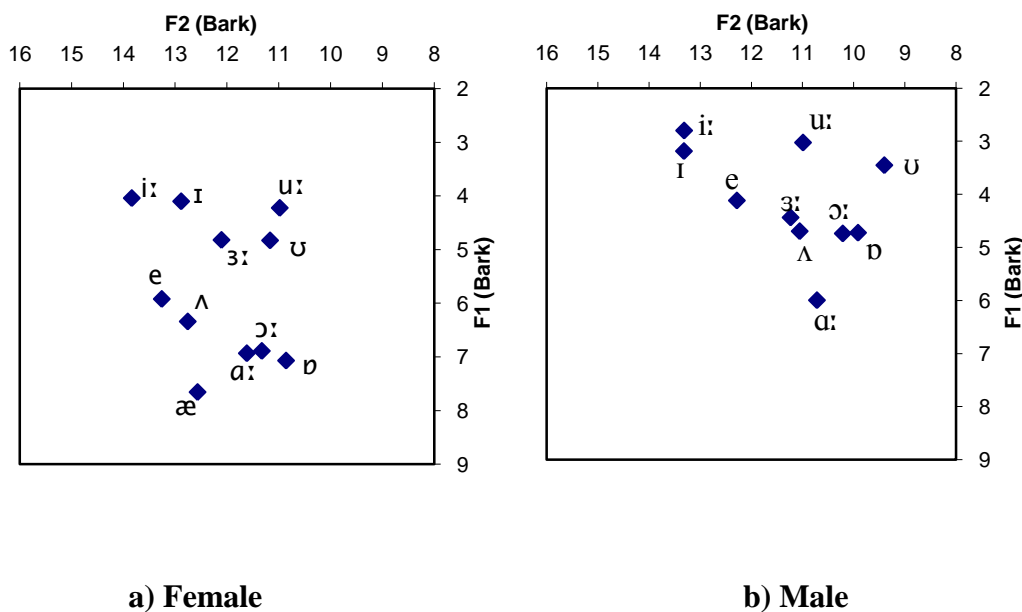   Speakers (WLC)

a) Female   b) Male

Figure 4.2: Vowel Chart for English Monophthongs Vowels Produced by a) Female and b) Male Persian
        Speakers (ISC)

The vowel charts in Figure 4.3 show that both male and female speakers produced the vowels /ɑː/, /ɒ/ and /ʌ/ similarly in the WLC. Thus, the word *hard*, *hod* and *hud* are produced similarly. However, for both females and males in the ISC, these vowels seem to be produced more peripheral than in WLC. The observed lack of lip rounding among the subjects during the recording process may be why /ɒ/ to be produced close to /ɑː/ and /ʌ/. As Hayward (2000) opines, the lack of lip rounding for English back vowels can affect on the F2 value. The conflation of the three vowels may be also due to the absence of /ɑː/ and /ʌ/ in Persian. Moreover, most of the subjects realized the word *hard* as /hɑːrd/ instead of /hɑːd/. Although, English language education in Iran is based on the British system, the realization of /r/ after the target vowels in the words *hard*, *horde* and *heard*, may be indicative of a more Americanised pronunciation among Iranian students or a tendency for students to pronounce the *r* in the spelling of the word. A perception test was used to verify if these vowels were being produced similarly where 10 speakers of English (six Malaysian students and four international students) were asked to listen to recordings of the target vowels in the words *hard*, *hod* and *hud*. Seven out of 10 students perceived the sounds as similar as the above mentioned findings of the present study. Findings from the ISC (Figure 4.4) also show a conflation of the three vowels, although these results need to be treated with caution given the small number of tokens used in the analysis (/ʌ/ = 35, /ɑː/= 5, /ɒ/ =24 for females and /ʌ/ = 20, /ɑː/= 4, /ɒ/ =10 for males) (See Appendix A).
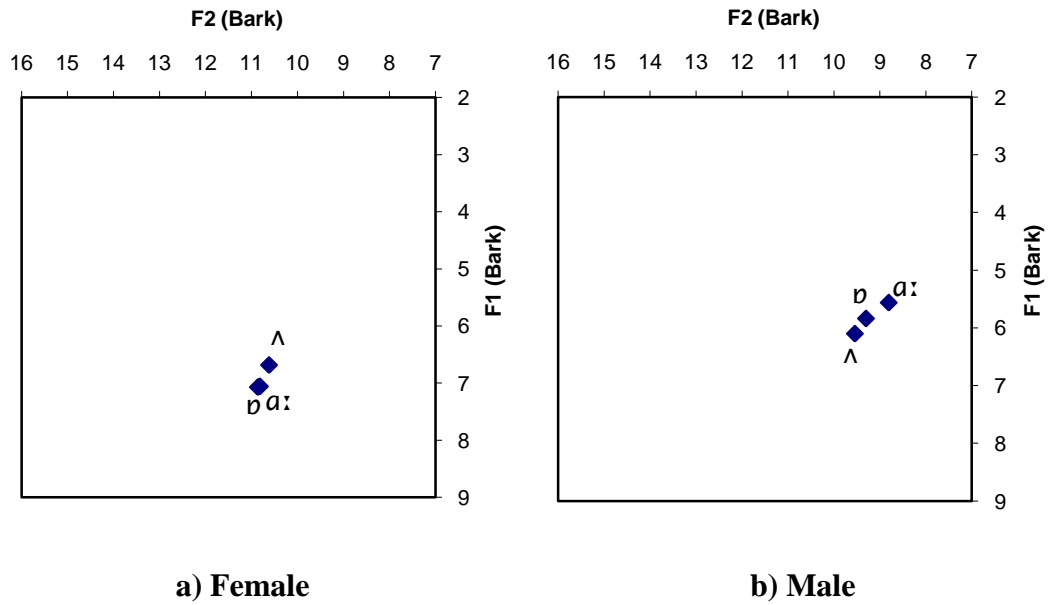
a) Female   **b) Male**

Figure 4.3: Vowel Charts of /ʌ/, /ɑː/, /ɒ/ for a) Female and b) Male Persian Speakers in WLC

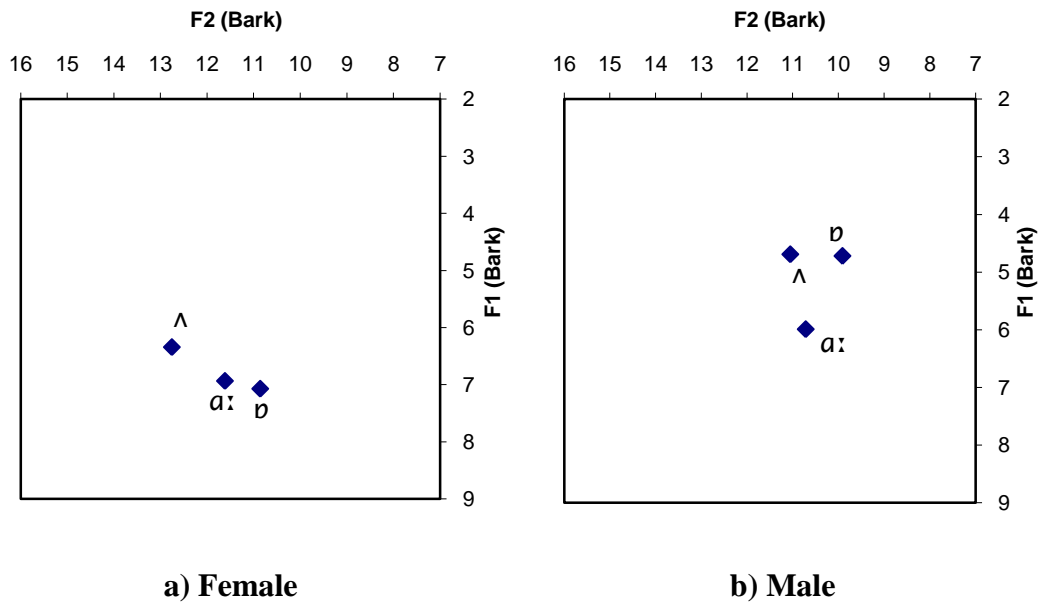**a) Female**   **b) Male**

Figure 4.4: Vowel Charts of /ʌ/, /ɑː/, /ɒ/ for a) Female and b) Male Persian Speakers in ISC

4.1.2   Vowel Contrast

To obtain a better clear picture on the extent to which particular vowel pairs were

contrasted, plots based on the average F1 and F2 measurements of /ɪ/-/iː/, /ʌ/-/ɑː/, /ɒ/-

/ɔː/, /ʊ/-/uː/ and /e/-/æ/ were generated. The average duration of these vowels, except for

/e/-/æ/ were also compared to examine if length contrast was maintained between the

pairs. The /e/-/æ/ pair was not included in the analysis for length contrast as this pair

does not typically contrast for length in English.

4.1.2.1 Length Contrast

The comparison of average duration between long and short vowel pairs produced by

female and male Persian English speakers is shown in Table 4.3.

Table 4.3: Comparison of the Average Duration between Long and Short Vowel Pairs by Female and Male Persian Speakers (in msec)

Vowel Pairs	/iː/-/ɪ/		/ɑː/-/ʌ/		/ɔː/-/ɒ/		/uː/-/ʊ/	
Female	heed	hid	hard	hud	horde	hod	who'd	hood
(WLC)	184	162	216	156	217	155	191	146
Male	heed	hid	hard	hud	horde	hod	who'd	hood
(WLC)	153	133	187	134	188	171	161	133
Female	/iː/	/ɪ/	/ɑː/	/ʌ/	/ɔː/	/ɒ/	/uː/	/ʊ/
(ISC)	104	97	91	99	132	140	170	117
Male	/iː/	/ɪ/	/ɑː/	/ʌ/	/ɔː/	/ɒ/	/uː/	/ʊ/
(ISC)	122	91	148	101	107	132	151	131

The results for the vowel pair /e/-/æ/ are not included in Table 4.3 as typically there is

not expected to be contrast in terms of duration between this vowel pair in English. In

relation to the vowel length contrast, a comparison of the average duration of each

vowel pair for female and male subjects in both speech contexts are shown in Figures

4.5 to 4.8. Female Persian speakers show less contrast between the vowel pairs /iː/-/ɪ/,

/ɑː/-/ʌ/, and /ɔː/-/ɒ/ in WLC and ISC. In contrast, the results for male Persian subjects

show more length contrasts between the vowel pairs in both WLC and ISC.
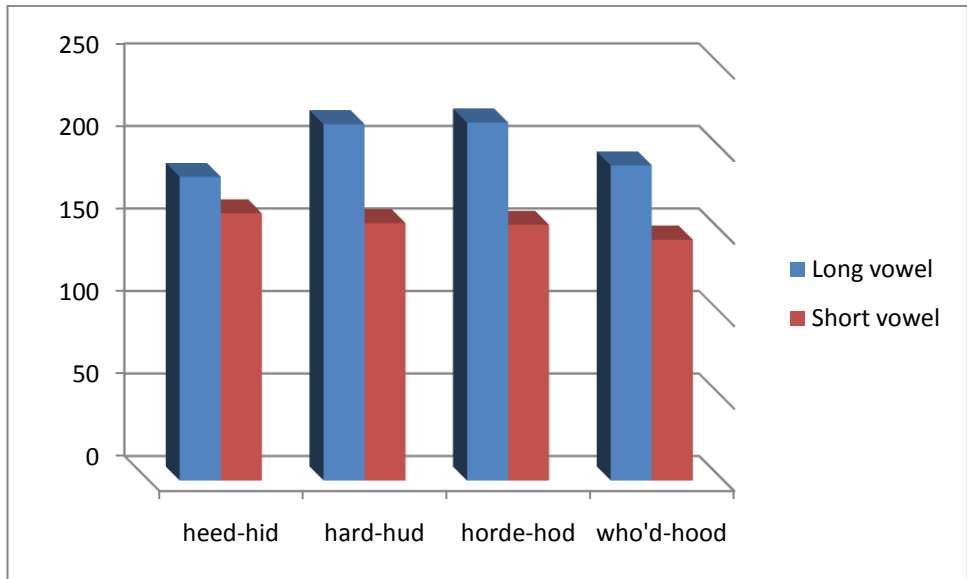
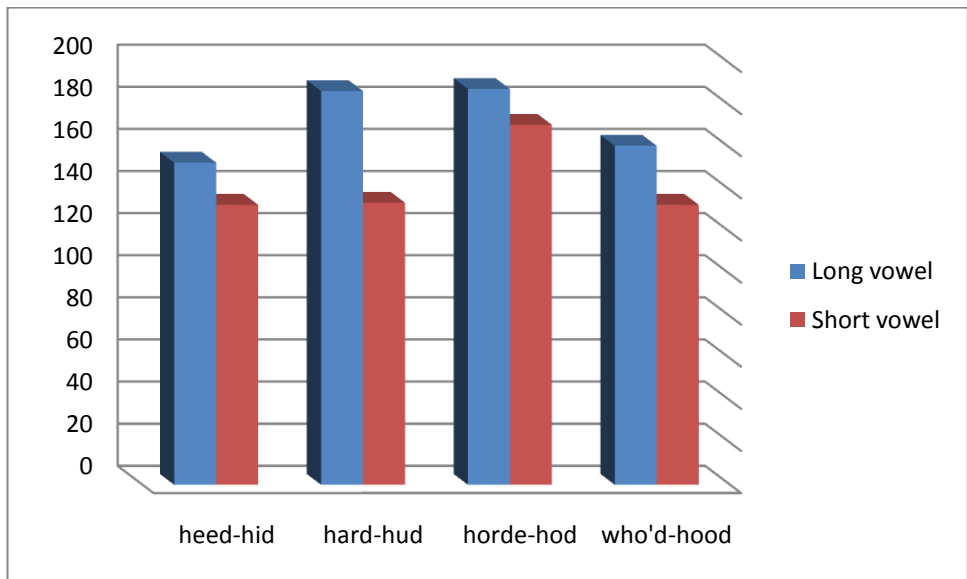Figure 4.5: Length Contrast -Female Persian Speakers in WLC

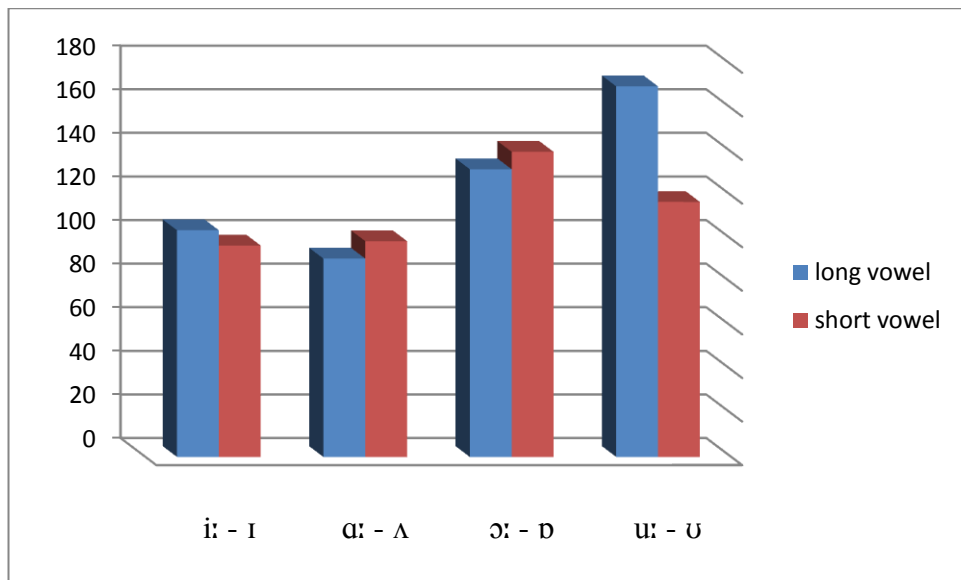Figure 4.6: Length Contrast -Male Persian Speakers in WLC

Figure 4.7: Length Contrast -Female Persian Speakers in ISC

Note: Phonetic symbols are used for ISC as the vowels were extracted from different words (see Appendix A)
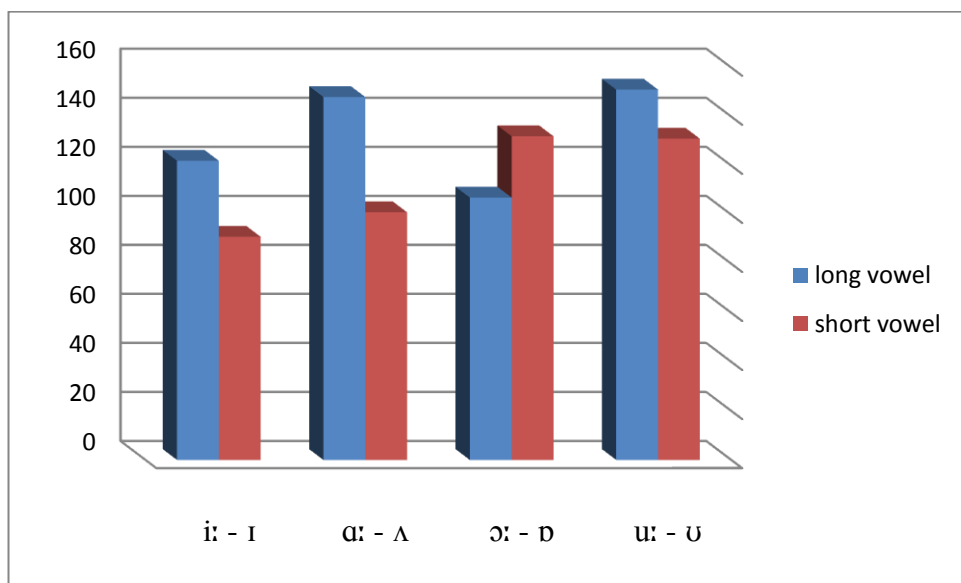

Figure 4.8: Length Contrast -Male Persian Speakers ISC

The difference in average durations and the short to long ratios in milliseconds (msec) for the vowel pairs were calculated and are shown in Table 4.4. However, these results need to be considered with caution because as Cox (2006, p. 149) explains, "[t]he difference [in vowel length] is relative rather than absolute as contextual and prosodic factors affect the ultimate length of the vowel".

Table 4.4: Length Differences (Dif) and Ratios (Rat) for English Vowel Pairs Produced by Persian Subjects

Vowel Pairs	/iː/-/ɪ/		/ɑː/-/ʌ/		/ɔː/-/ɒ/		/uː/-/ʊ/	
Female (WL)	**Dif**	**Rat**	**Dif**	**Rat**	**Dif**	**Rat**	**Dif**	**Rat**
	22	0.88	60	0.72	62	0.71	45	0.76
Male (WL)	**Dif**	**Rat**	**Dif**	**Rat**	**Dif**	**Rat**	**Dif**	**Rat**
	20	0.86	53	0.71	17	0.90	28	0.82

The findings from the ISC were not used for length contrast comparison because the number of useable vowel pairs (see Table 3.5) was small as for the vowels /ɑː/ and /ɔː/ the number of token was less than ten.

The results for the differences in duration for the vowel pairs taken from the WLC are illustrated in Table 4.4. As can be seen, the ratios for the female subjects range from .71 to .88 msec and for male subjects also range from .71 to .90 msec. For the male subjects the highest ratio is for /ɒ/-/ɔː/ (.90 msec) suggesting that length is not discriminated between the vowel pair /ɒ/-/ɔː/ among male Persian speakers. A correlated samples *t*-test indicated that length differences among female Persian speakers between the vowel pair /ɒ/-/ɔː/ is significant (t (13) =10.7, p <0.001), while, the difference between the two vowels for male Persian speakers (t (11) =1.97, p >0.01) is not significant. The vowel pair /ɪ/-/iː/ for both female and male subjects had similar ratios; for female .88 msec and for male .86 msec. Thus, as expected, a correlated samples *t*-test found that there was no significant difference between the average lengths for the vowel pair /ɪ/-/iː/ for the female Persian (t (13) =1.81, p >0.01) and for male Persian speakers (t (11) =1.81, p >0.01). The vowel pair /ʌ/-/ɑː/ also had similar ratios for both female and male Persian subjects; .72 msec for the female and .71 msec for the male subjects. This vowel pair

/ʌ/-/ɑː/ had the biggest length difference among the vowel pairs. The average length difference between the vowel pair /ʌ/-/ɑː/ for both female (t (13) =5.79, p < 0.001) and male subjects (t (11) =4.21, p < 0.01) is significant. Since there is no /ɑː/ in the Persian language, this vowel may have not been differentiated in terms of length with /ʌ/. For the vowel pair /ʊ/-/uː/ a significant length difference was found for female subjects (t (13) =4.85, p < 0.001) but not for male subjects (t (11) =2.42, p > 0.01). In general, the results suggest that length contrast was maintained by Persian female and male speakers for most vowel pairs.

4.1.2.2   Vowel Contrast between /ɪ/ and /iː/

In order to further examine the extent to which particular vowel pairs were contrasted in Persian English, and visually represent the distribution of the vowels, scatter plots of vowel pairs produced by the female and male Persian English speakers are shown in Figures 4.9 to 4.18. Scatter plots were generated for the following vowel pairs /ɪ/-/iː/, /ʌ/-/ɑː/, /ɒ/-/ɔː/, /ʊ/-/uː/ and /e/-/æ/ for both WLC and ISC. Figures 4.9 and 4.10 show the scatter plots for the vowel pair /ɪ/ and /iː/ for the female and male subjects. There is an obvious lack of contrast in terms of quality between /ɪ/ and /iː/, especially among male subjects as there is considerable overlap between these two vowels. As can be seen in Figure 4.9 and 4.10, the results for ISC shows more contrast, and these vowels are produced more spread out than in WLC, although it would have been expected that speakers will be more careful when they are reading sentences compared to when they are speaking spontaneously (e.g. Deterding 1997; Pillai, forthcoming). The bigger contrast could be due to the different words in which the two vowels occurred in the two

speaking contexts. A correlated samples *t*-test between the F1 and F2 for female subjects in WLC showed that there is no significant difference for the vowel pairs /ɪ/-/iː/ (F1: *t* (13) = 0.9, *p* > 0.01; F2: *t* (13) = 0.24, *p* > 0.01), and the same result is found for male subjects (F1: *t* (11) =1.14, *p* > 0.01; F2: *t* (11)= 0.99, *p* > 0.01). The result of an independent sample *t*-test for ISC also showed that there is no significant difference between the F1 and F2 for female subjects (F1: *t* (48) = 0.23, *p* > 0.01; F2: *t* (48) = 1.9, *p* > 0.01) and male subjects (F1: *t* (46) = 1.89, *p* > 0.01; F2: *t* (46) = 0.02, *p* > 0.01). Such merging among this vowel pair has also been reported in other varieties of English (e.g. Deterding, 2003; Pillai, Mohd. Don, Knowles & Tang, 2010; Tan & Low, 2010 Tsukada, 1999). However, the British English vowel pair /ɪ/-/iː/ is contrasted (Deterding, 1997; Salbrina, 2006).
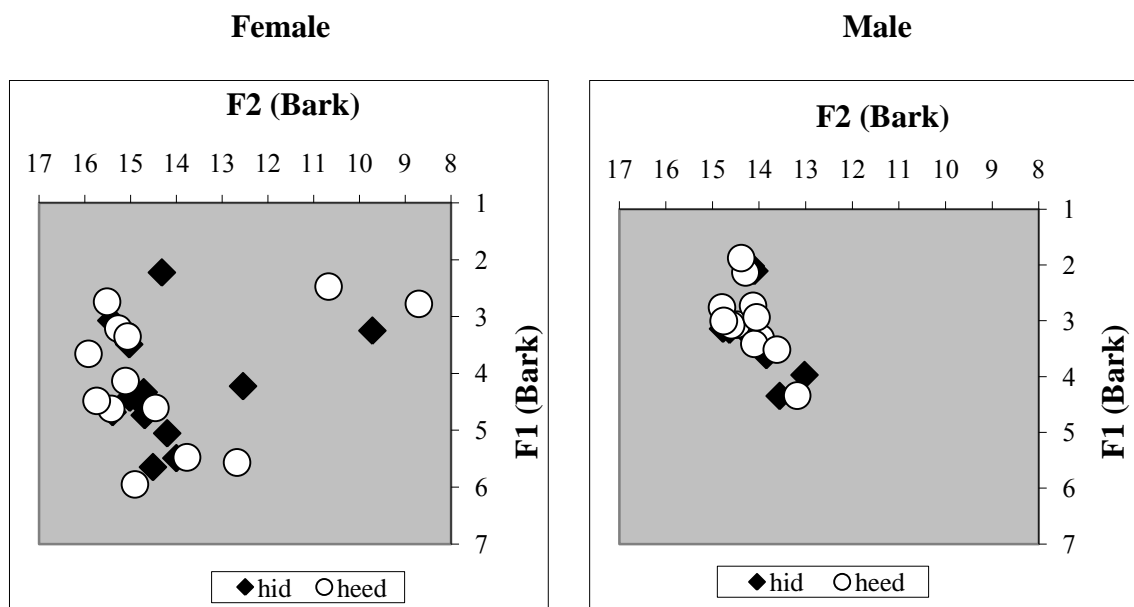
Female **Male**

Figure 4.9: Distribution of /ɪ/-/iː/ for Female and Male Persian Speakers in WLC

Female   **Male**
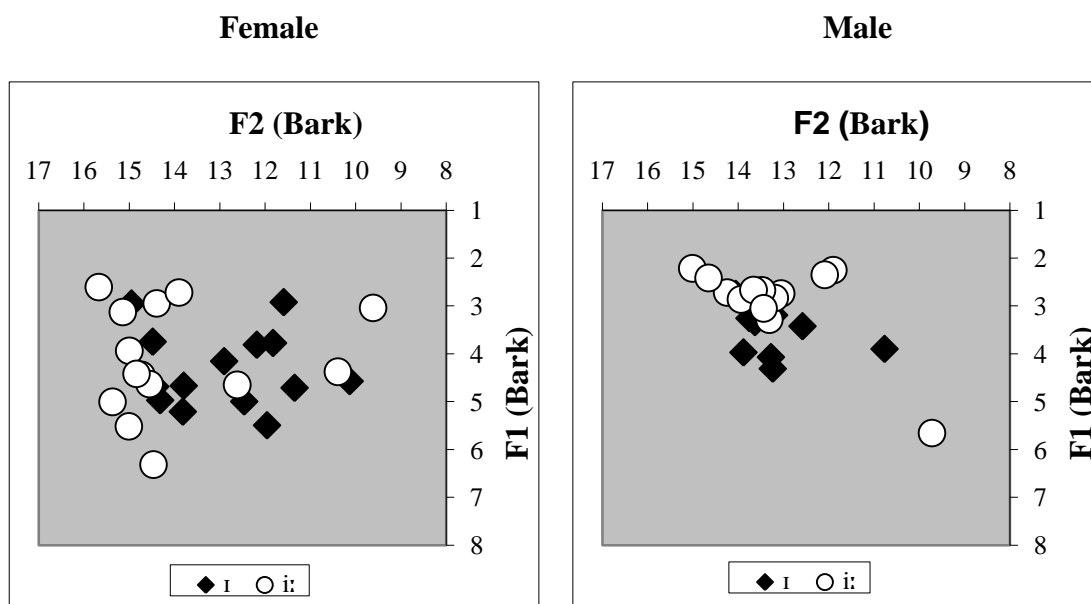

Figure 4.10: Distribution of /ɪ/-/iː/ for Female and Male Persian Speakers in ISC

Note: Phonetic symbols are used for ISC as the vowels were extracted from different words (see Appendix A)

4.1.2.3   Vowel Contrast between /ʌ/ and /ɑː/

Based on the distribution of /ʌ/ and /ɑː/ can be said that there is a tendency for these two vowels to overlap in terms of vowel quality. These vowels are generally produced as homophones. A correlated samples *t*-test between F1 and F2 for female subjects in the WLC (F1: t (13) = 1.29, $p >$ 0.01; F2: t (13) = 0.56, $p >$ 0.01) indicates that the differences are not significant but the results for the male subjects (F1: t (11) = 4.59, $p <$ 0.01; F1: t (11) =5.01, $p <$ 0.01) in the WLC indicates significant difference in production of the vowels /ʌ/ and /ɑː/. The small number of words for the vowel /ɑː/ in the ISC, five token for females and four token for males, means that no statistical conclusions can be made about these vowels in the ISC for both female and male subjects. The scatter plots for the vowel pair /ʌ/ and /ɑː/ are shown in Figures 4.11 and 4.12. A comparison between the F1 and F2 values is shown in Table 4.1 and 4.2

indicates that F1 for /ʌ/ for female subjects (738Hz) is lower than for /ɑː/ (788Hz) while

F1 for /ʌ/ for male (664Hz) is higher than /ɑː/ (597Hz). The results from female and

male British English speakers (Deterding, 1997) indicate that the vowel /ʌ/ was

produced with a higher F1 and F2 than /ɑː/ thus; British English /ʌ/ is produced more

open and fronted. However, the British English vowel pair /ʌ/-/ɑː/ in Deterding's study

(1997) was one of the least contrasted vowel pairs compared to other pairs. The F2

value for /ʌ/ (1376Hz) for female Persian subjects is also lower than for the vowel /ɑː/

(1417Hz) and for male Persian subjects F2 value for /ʌ/ (1172Hz) and for /ɑː/ (1048Hz)

indicates that male subjects produced /ʌ/ more fronted and open than female ones. In the

ISC, the F1 values taken from male and female subjects had a lower F1 for /ʌ/ and
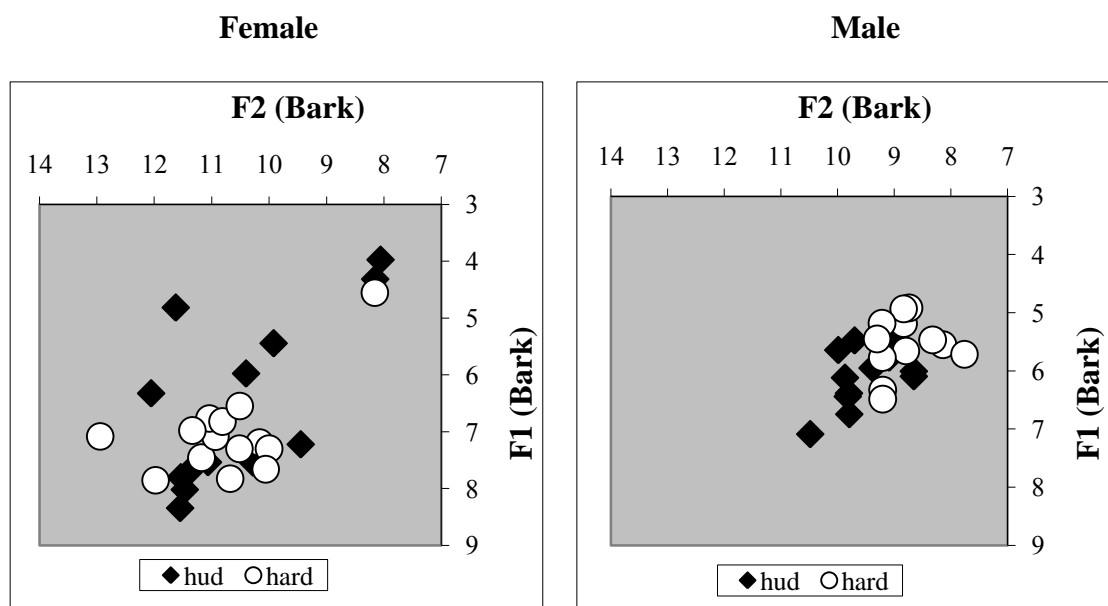
higher F2 for /ɑː/.

Female   **Male**

Figure4.11: Distribution of /ʌ/-/ɑː/ for Female and Male Persian Speakers in WLC

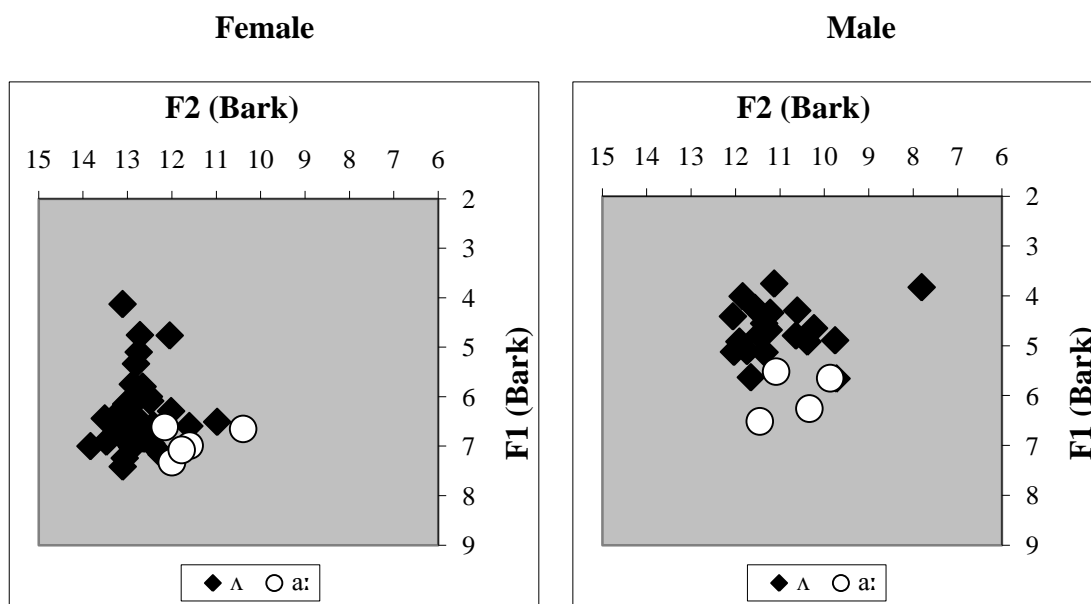**Female**   **Male**

Figure4.12: Distribution of /ʌ/-/ɑ:/ for Female and Male Persian Speakers in ISC

4.1.2.4   Vowel Contrast between /ɒ/ and /ɔ:/

The distribution of the vowel pair /ɒ/-/ɔ:/ is shown in Figure 4.13 and 4.14. Although

compared to the distribution of /ʌ/-/ɑ:/, there is more contrast for /ɒ/-/ɔ:/; the pattern of

distribution is still inconsistent. This is possibly due to the difficulty the subjects had

with pronouncing the words *hod* and *hud* even after being giving the rhyming clues (see

Table 3.3). There was a tendency for /ɑ:/ to be produced more frequently than /ɒ/ in the

word *hard*. Thus the results pertaining to this vowel pair need to be treated with caution.

The average F1 and F2 values for /ɑ:/ among female subjects in the WLC (F1=788 Hz

and F2=1417 Hz) are shown in Table 4.1, which are similar to the results for /ɒ/:

(F1=790Hz and F2=1426Hz). As mentioned in section 4.1.1, the lack of lip rounding

which was observed during the recording process might have an effect on the

production of /ɒ/. Similar to findings on Pillai (forthcoming) it seems that the back

vowels displayed less overlaps compared to the other vowel pairs. Pillai (forthcoming)

implies that "[t]here is of course variability in the realisation of the back vowels, mostly due to the problems associated with measuring the formants of back vowels and the effect of lip rounding on the F2, and thus these results need to be treated with caution". The results from a correlated samples t-test between F1 and F2 in WLC for female subjects were as follows: F1: t (13) = 3.92, $p < 0.01$; F2: t (13) = 0.59, $p > 0.01$, and for males: F1: t (11) = 7.13, $p < 0.001$; F2: t (11) = 5.89, $p < 0.001$ where there was no significant difference only for the average F2 value for females in the vowel pair /ɒ/-/ɔː/. In other words this vowel pair appears to be contrasted. For ISC, No t-test was carried out due to the small number of samples for the vowel /ɔː/ (five token for females and one token for males) in this speaking context for both the female and male subjects.
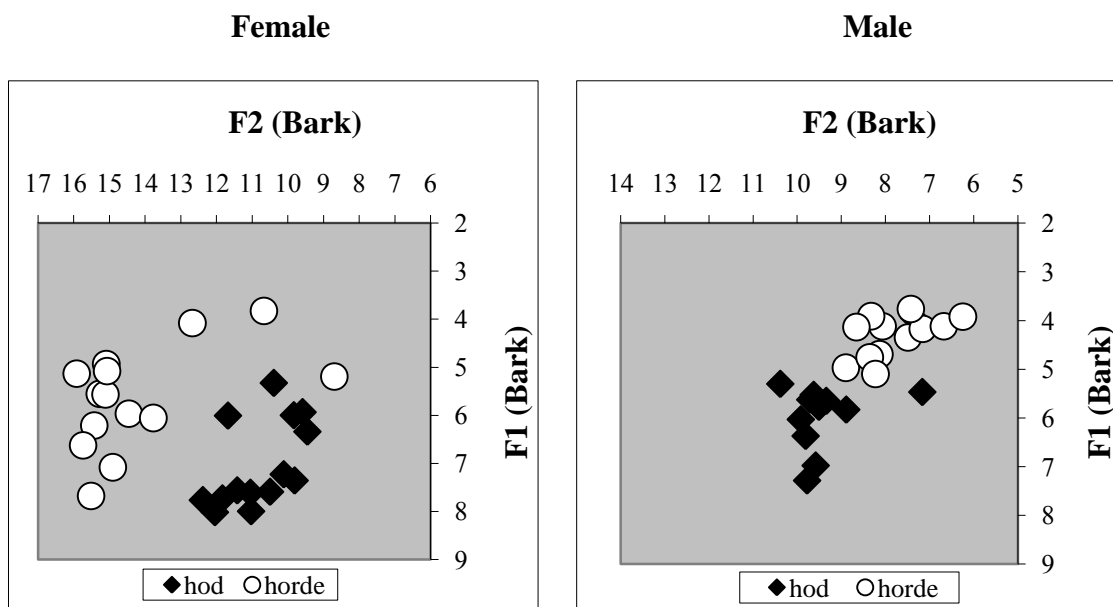
Female   **Male**

Figure4.13: Distribution of /ɒ/-/ɔː/ for Female and Male Persian Speakers in WLC

Female   **Male**

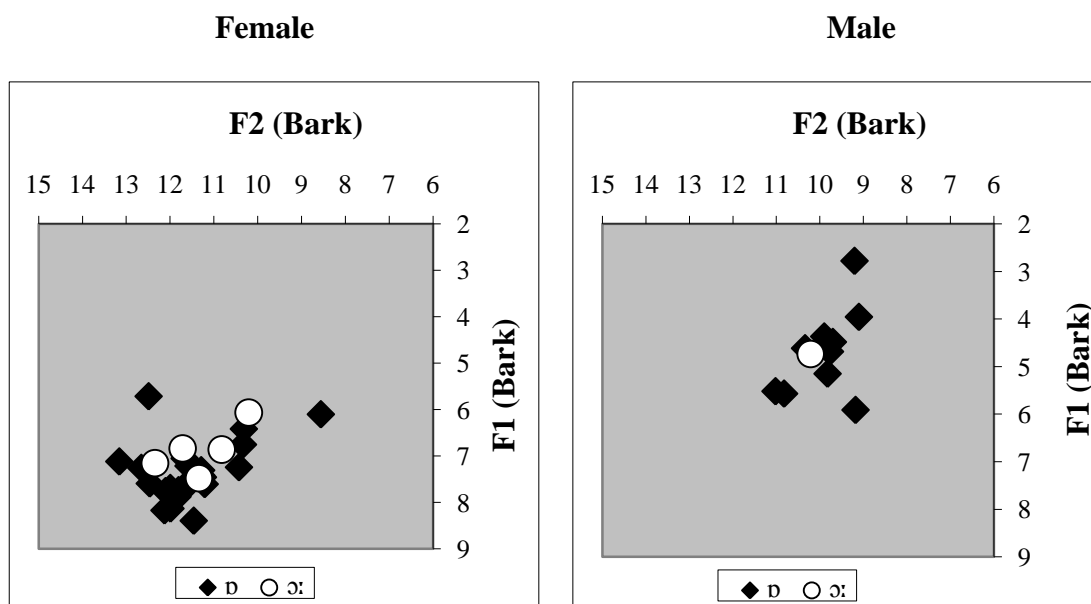Figure4.14: Distribution of /ɒ/-/ɔː/ for Female and Male Persian Speakers in ISC

4.1.2.5   Vowel Contrast between /ʊ/ and /uː/

The scatter plots for the vowel pair /ʊ/-/uː/ are illustrated in Figures 4.15 and 4.16. As can be seen in the scatter plots, there is a lack of contrast between the /ʊ/ and /uː/ for male and female subjects. Furthermore, the findings showed that there is certain amount of overlap between these two vowels for both female and male subjects in WLC and ISC, where vowel quality is concerned. The contrast between these vowels in the WLC can also be seen in a comparison between the F1/F2 values, where the F1 for /ʊ/ for female subjects (585Hz) is higher than for /uː/ (437Hz) and is also higher than what male subjects produced where the F1 is (511Hz) and F2 is (442Hz). Thus, this comparison indicates that the vowel /ʊ/ was generally produced higher and more fronted by male subjects. The F2 value for /ʊ/ (1384Hz) is higher than for /uː / (1206Hz) among the female subjects, and the same thing can be observed for the male subjects as F2 for /ʊ/ (1141Hz) and for /uː/ (1000Hz) indicating that /ʊ/ is more open and fronted. A

similar finding was reported in citation form in Deterding (1997, p. 52-53) for British English vowels as the F1 value for /ʊ/ was higher than /uː/ while F2 values was higher for /uː/. The same result is shown for the ISC for F1 values but for F2 values, both female and male subjects showed higher F2 values and produced a more fronted vowel /uː/. An independent sample t-test for the ISC between the F1 and F2 showed that there is no significant difference for both female (F1: t (28) = 1.6, $p >$ 0.01; F2: t (28) = 0.47, $p > 0.01$) and male subjects (F1: t (20) = 2.42, p = 0.01; F2: t (20) = 2.04, $p >$ 0.01). However, a correlated sample t-test for Female subjects in WLC showed that there is a significant difference in the average of F1 (t (13) = 3.63, $p <$ 0.01) and no significant difference in the average of F2 (t (13) = 1.69, $p >$ 0.01). The results for male subjects in WLC showed that the differences are not significant (F1: t (11) = 2.46, p = 0.01; F2: t (11) = 2.42, p = 0.01).
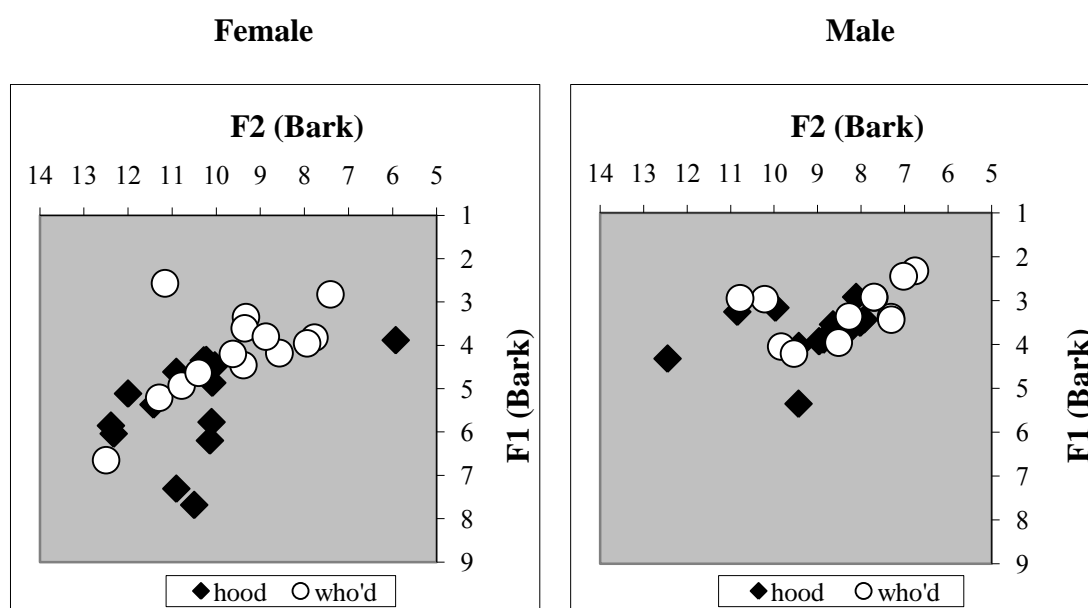
Female **Male**

Figure 4.15: Distribution of /ʊ/-/uː/ for Female and Male Persian Speakers in WLC

Female

Male
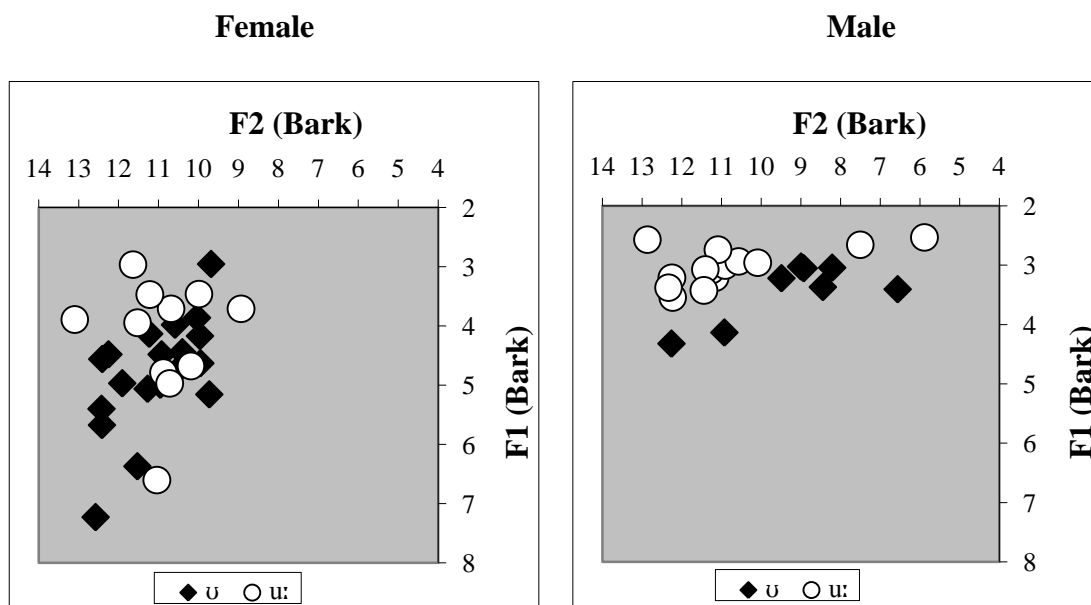

Figure 4.16: Distribution of /ʊ/-/uː/ for Female and Male Persian Speakers in ISC

4.1.2.6   Vowel Contrast between /e/ and /æ/

The results for vowel pair /e/-/æ/ indicate that in the WLC there is hardly any merger of

the vowels in this pair of /e/ and /æ/, while in the ISC a slight overlap can be seen

(Figure 4.17 and 4.18). A significant difference was found between the average F1 and

F2 for female and male subjects in WLC for the /e/-/æ/ pair: (Females, F1: t (13) =

12.98, $p < 0.001$; F2: t (13) = 6.01, $p < 0.001$; Males, (F1: t (11) = 9.12, $p < 0.001$; F2: t

(11) = 9.88, $p < 0.001$). An independent t-test for the average F1 and F2 for females in

the ISC indicates that there is significant difference for the vowel pair /e/-/æ/ (F1: t (62)

= 9.54, $p < 0.001$); F2: t (62) = 4.87, $p < 0.001$) while, for the male subjects only the

average of F1 shows significant difference but not for F2 (t (45) = 5.63, $p < 0.001$; t (45)

= 1.17, $p > 0.01$). The F1 and F2 values for the female and male subjects in both WLC

and ISC (see Table 4.1 and 4.2), indicates that both female and male Persian subjects

produced lower F1 and higher F2 for /e/ compared to vowel /æ/. Thus, they produced
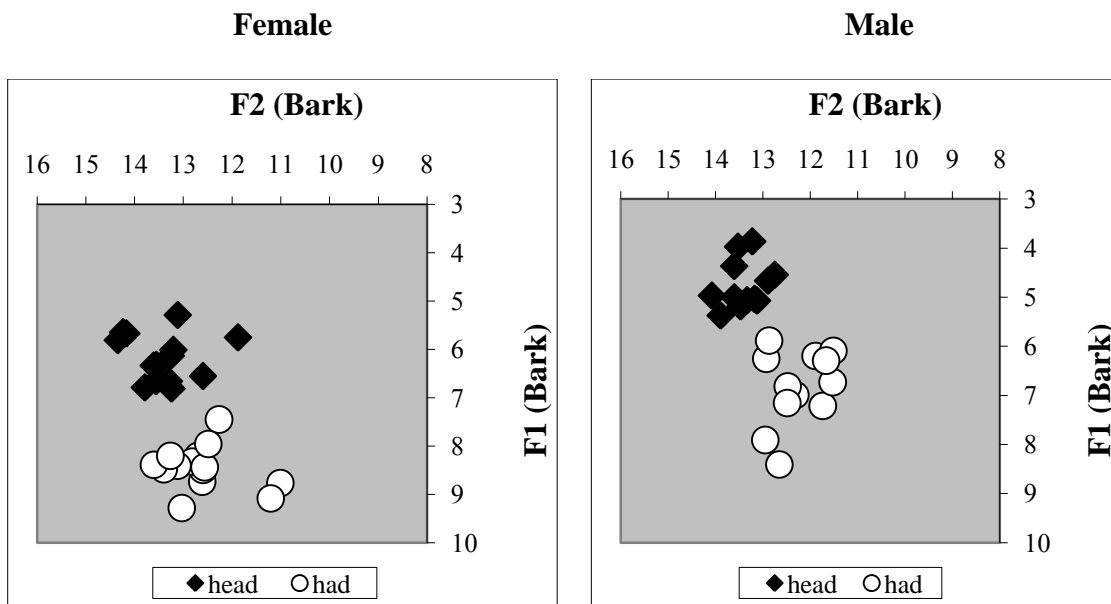
the vowel /e/, closer and more fronted than /æ/.

Female   **Male**

Figure 4.17: Distribution of /e/-/æ/ for Female and Male Persian Speakers in WLC

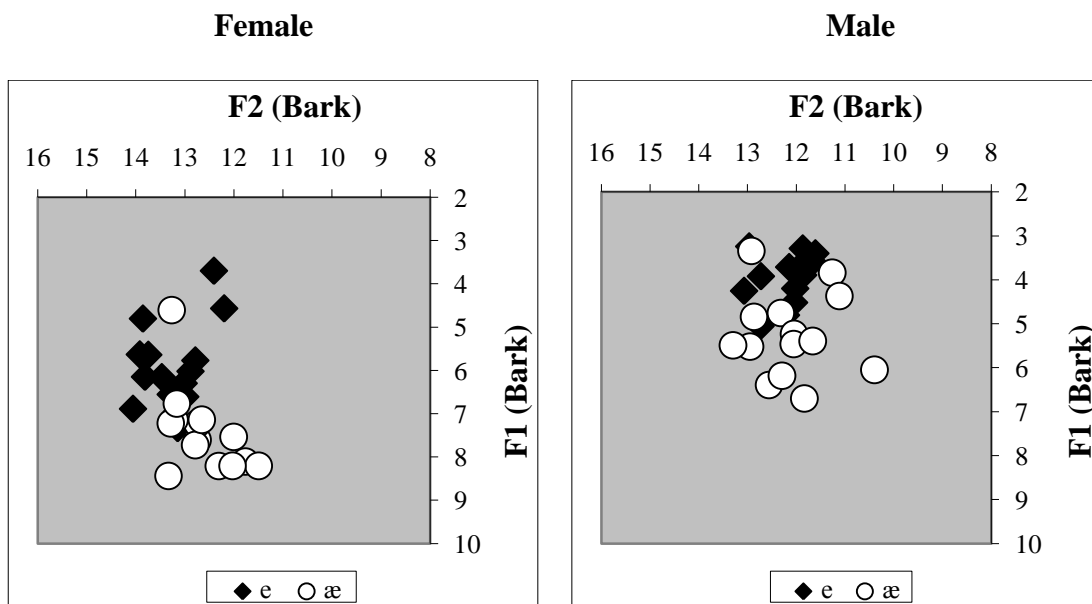**Female**   **Male**

Figure 4.18: Distribution of /e/-/æ/ for Female and Male Persian Speakers in ISC

4.1.3   Comparison with Standard British English Vowels

This section compares the findings from the present study with similar findings from British English. This comparison aims to determine to what extent the vowels produced by the Persian subjects are similar or different from a native variety like British English which is the teaching model used in Iran. A comparison between data of this study and published data on British English suggests that the quality of Persian English vowels differ from British English (Deterding, 1997). As mentioned in section 4.2, the monophthong vowels produced by Persian speakers occupy a smaller vowel space compared to British English. The data for British English was compared with Persian English was obtained from citation in Deterding, (1997, p. 50-53). The F1/F2 vowel plots from Deterding's study suggest that British male subjects produced more fronted and back vowels than female subjects. In general, the British male subjects produced more peripheral vowels than female ones (see Deterding, 1997, p. 50-51). The British male and female subjects contrasted the all the vowel pairs, with /ɪ/-/iː/, /e/-/æ/, and /ɒ/-/ɔː/ exhibiting the most contrast (see Figure 1 and 2 in Deterding, 1997, p. 50-51). In comparison, the Persian speakers in this study showed a distinct lack of contrast between /ɪ/-/iː/, in both speaking contexts. However, /e/-/æ/ were contrasted similar to the British speakers in Deterding's (1997) study. There was also a lack of contrast between /ʊ/-/uː/ among the Persian subjects, a phenomenon also evident in Deterding's study (1997).

A comparison of the vowel charts for British and Persian female subjects showed that the vowels /iː/, /ɒ/, /ɔː/, /ʊ/ and /uː/ are produced lower in the vowel space by the female Persian subjects while the vowels /ʌ/ and /ɜː/ are produced slightly higher than females

British English. The front vowels /ɪ/, /e/, /æ/ and /ɑː/ in both varieties appear to be produced quite similarly where vowel height is concerned while a comparison of the vowel charts for male Persian speakers shows more similarities than female Persian subjects with British English. As male Persian subjects produced the vowels /iː/, /æ/, /ʌ/, /ɒ/, /ɔː/, /ʊ/ and /uː/ quite similar to male British subjects on Deterding's (1997) study but the male Persian subjects produced more fronted vowels than male British English with the exception of /ʌ/, /uː/, /ɪ/, and /iː/. However, these comparisons must be treated with caution given the different nature of both studies.

.

4.1.4   Comparison with General American English Vowels

As mentioned in Chapter 1, Standard British English is the prescribed model for teaching English at schools in Iran, but the results suggest that students may be influenced by American English. Thus, a comparison was also carried out to gauge how similar the English vowels produced by the subjects were to those of General American English. The findings from the production of the vowel /ɜː/ show that this vowel appears to be produced differently from British English among Persian speakers of English but it is produced more similar to American English. A comparison was done between findings from British English (Deterding, 1997), American English (Hillenbrand et al., 1995), and the present study (Persian English) on the values of F1 and F2 for the vowel /ɜː/. Table 4.5 presents the F1 and F2 values for both female and male speakers of English.

As shown in Table 4.5, the average value of F1 for Persian speakers of English indicates more similarity to American English than British English. However, the values of F2 are quite different from both British and American English. Thus, Persian English speakers appear to produce closer and more fronted /ɜː/ compared to British and American English. The speakers of this study pronounced the postvocalic /r/ after /ɜː/ in word *heard* which pronunciation of /r/ could affect the quality of the preceding vowel /ɜː/, the same realisation as American English in word *bird*. However, given that the data were derived from different sources (e.g. in terms of speaker profiles, speaking contexts and type of measurements), the comparison of the data across the three varieties of English are only meant to provide an exploratory impression of the possible differences in vowel quality and distribution among these varieties and are not meant to be definitive conclusions.

Table 4.5: Average Values of F1 and F2 for British, American and Persian English /ɜː/

/ɜː/	Female		Male	
	F1(Hz)	F2 (Hz)	F1 (Hz)	F2 (Hz)
British Eng	650	1593	513	1377
American Eng	523	1588	474	1379
Persian Eng	584	1733	449	1696

A comparison of the vowel charts for American English (Hillenbrand et al., 1995, p. 3103) and Persian English showed that the female Persian subjects produced more fronted vowels /ɒ/, /ɔː/, /ʊ/, /uː/, /ɜː/ and more back vowels /iː/, /e/, /æ/ compared to female American subjects. The vowel /ɑː/ is slightly more back for female Persian English. The result for the vowels /ɪ/ and /ʌ/ show that production of these two vowels is similar in both varieties for the female subjects. Compared to female Persian subjects,

the male Persian ones show similarities in the production of the vowels /iː/, /e/, /ʌ/, /ɔː/, /ʊ/, and /uː/ with male American English. The male Persian subjects produced more fronted vowels /ɪ/, /ɜː/, /ɒ/ (the vowel /ɒ/ produced slightly more fronted) and more back vowels /æ/ and /ɑː/ compared to their male American counterparts. Overall, the vowels produced by the Persian subjects in this study are not totally akin to American vowels. However, they are perhaps perceived to be Americanised because of the tendency to realise /r/ in post vocalic contexts (although this is not consistently done), and the production of a less rounded /ɒ/.

4.2   Diphthongs

As mentioned in chapter two and three about the procedures for measuring diphthongs, the present study measured diphthongs using the formula for the rate of change (ROC) of first and second formants (F1 and F2) as an approximate estimate for the quality of diphthongs. The ROC for each diphthong and for each speaker, taken from the WLC is shown in Tables 4.5 to 4.12 (see Appendix E) to compare the average ROC for female and male Persian speakers of English and for determining the extent to which the vowels were produced as diphthongs. For ISC only the ROC for /eɪ/ and /əʊ/ is reported as there were less than 15 tokens for each of the other diphthongs in this speaking context. Although this study follows Deterding (2000) in measuring the diphthongs, Deterding examined only the closing diphthongs /eɪ/ and /əʊ/, where the measurement of ROC of F1 is sufficient to indicate the diphthongal movement. The present study measured the ROC for eight diphthongs including those which are classified as centring

diphthongs: /ɪə/, /ʊə/, /eə/ and closing diphthongs /eɪ/, /ɑɪ/, /ɔɪ/, /əʊ/, /ɑʊ/. However for the centring diphthongs, the measurement of ROC of F1 and subsequently, vowel height changes might be insignificant (Lee and Lim, 2002). Thus, the ROC of both F1 and F2 are calculated to indicate the changes for both the front and back dimensions for the centring diphthongs. The F2 ROC was also calculated for the other diphthongs in the WLC.

Usually a positive result is expected for centring diphthongs as the movement for these diphthongs is towards a more central vowel and should be from a higher target (/ɪ/, /ʊ/, /e/) to a lower one, that is, /ə/. On the other hand, a negative result means that the diphthong is rising (from a lower target to a higher one). The findings for the present study shows a negative average value for the F1 and F2 ROC values of /eə/ (see Appendix D for details on the average ROC for centring diphthongs produced by Persian speakers). The positive F1 ROC values for /ʊə/ and /ɪə/ show a downward trajectory from the higher target vowels /ʊ/ and /ɪ/ towards /ə/ (lower target) whereas a negative result for /eə/ shows a rising trajectory from the lower target vowel /ə/ to a higher one that is the vowel /e/ (Pillai, forthcoming). Table 4.6 shows the average ROC values for centring diphthongs for both female and male Persian subjects in WLC.

Table 4.6: Average Rate of Change (ROC) Values in Hz/Sec for Female and Male Persian English Centring Diphthongs in WLC

Female				Male			
Word	Diphthong	F1 ROC	F2 ROC	Word	Diphthong	F1 ROC	F2 ROC
hered	/ɪə/	326	-1034	hered	/ɪə/	448	-2078
haired	/eə/	-370	-961	haired	/eə/	-393	-1382
hoar	/ʊə/	50	469	hoar	/ʊə/	31	932

As can be seen in Table 4.6, the centring diphthongs except /eə/ have positive F1 ROC values. This is because for /eə/, the vowel is moving to a higher target. The average F1 ROC for /eə/ among the female subjects is smaller for the ones produced male ones, although the difference between them is small. An independent *t*-test of the average F1 ROC values of /eə/ for females and males subjects (*t* (24) = 0.16, *p* > 0.01) indicates that the difference is not significant. The F2 ROC for this vowel indicates some degree of retraction in the vowel space. For /ɪə/ as well, there is more front-to-back than centring movement as indicated in the average F2 ROC value. For both male and female speakers, /ʊə/ has very little diphthongal movement as indicated by the low ROC values for F1 and F2 The formant trajectories of these three diphthongs are plotted on F1/F2 charts (see Figures 4.19 and 4.20). A comparison between Figure 4.19 and 4.20 show similar realisations of these diphthongs for both female and male Persian speakers.
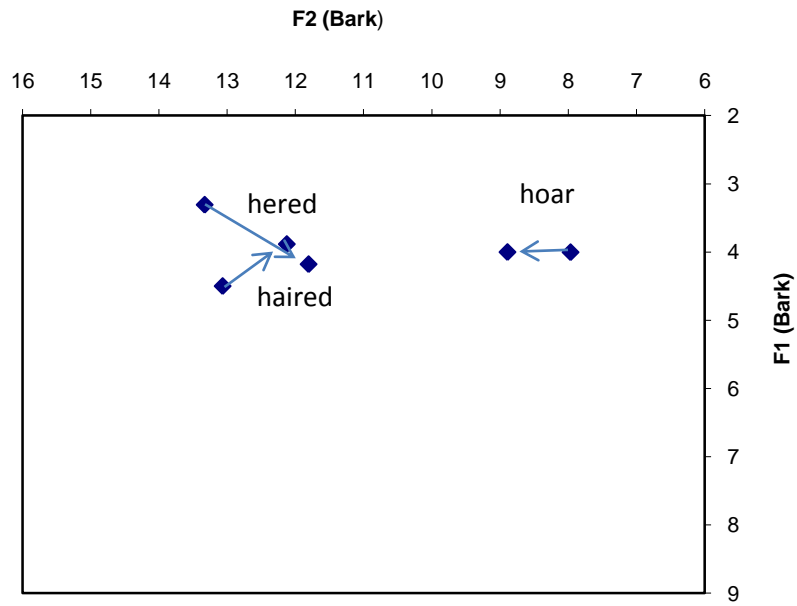
Figure 4.19: Formant Trajectories for Female Persian English *hered*, *haired* and *hoar*
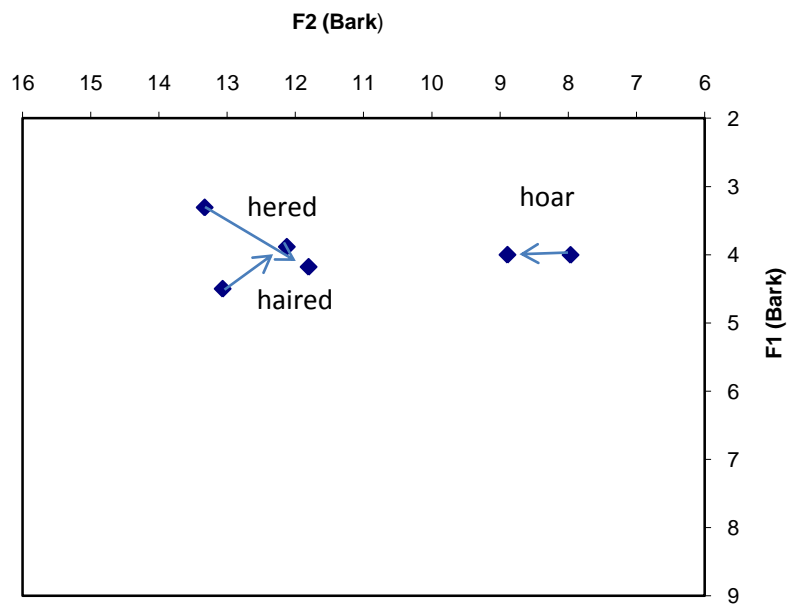
Figure 4.20: Formant Trajectories for Male Persian English *hered*, *haired* and *hoar*

Compared to centring diphthongs in Standard British English, Cruttenden (1994) says

that the diphthong /eə/ is realized as a long monophthong /ɜː/, and /ɔː/ is commonly used

instead of /ʊə/. Similar descriptions are given by Roach et al., 2006 (see 2.2.2). The

finding of present study also shows the realization of /ɔː/ and /ɜː/ in place of /ʊə/ and /eə/

in the words *hoar* and *haired*. In the word *hered*, all the subjects pronounced the vowel as /ɪər/ except for one of the male subjects who pronounced it as /ɜː/ followed by /r/.

Table 4.7 shows the average ROC F1 and F2 values for closing diphthongs for both female and male Persian subjects in WLC (see Table 4.8 to 4.12 in Appendix E for the average F1 and F2 ROC for closing diphthongs that produced by Persian English speakers). For the closing diphthongs, the average F1 ROC value is higher for the female subjects than the male ones, except for the diphthong /əʊ/, which for the males is -462 Hz/second while for females, -444 Hz/second. This is mirrored in ISC where the average F1 ROC for females is -188 and -375 for the males for /əʊ/. However, the result from an independent *t*-test of the average F1 ROC values of /əʊ/ between the female and male subjects (*t* (24) = 0.07, *p* > 0.01) confirms that the difference between the average ROC values is not significant. The bigger F1 ROC values for the female subjects indicate that their closing diphthongs have more diphthongal movement than the ones produced by the males. This is with the exception of /əʊ/, where that male subject showed more diphthongal movement than the female ones. The diphthong /əʊ/ showed the least movement from onset to offset.

Table 4.7: Average Rate of Change (ROC) Values in Hz/Sec for Female and Male Persian English Closing Diphthongs

Female				Male			
Word	Diphthong	F1 ROC	F2 ROC	Word	Diphthong	F1 ROC	F2 ROC
hide	/ɑɪ/	-1618	4197	hide	/ɑɪ/	-1325	4210
hoyed	/ɔɪ/	-899	3423	hoyed	/ɔɪ/	-420	5248
hayed	/eɪ/	-1190	-719	hayed	/eɪ/	-864	731
how'd	/ɑʊ/	-2057	-566	how'd	/ɑʊ/	-1358	135
hoed	/əʊ/	-444	609	hoed	/əʊ/	-462	1587

However, the results based on the average F1 ROC for both female and male Persian subjects show less diphthongal movement than the corresponding vowels in Standard British English (Deterding, 2000, p. 97). Deterding's findings (2000) for the diphthongs /eɪ/ and /əʊ/ reports bigger negative F1 ROC values for British English suggesting that Persian subjects produced these diphthongs with less diphthongal movement diphthongal

Similar to the centring diphthongs, the formant trajectories for the closing diphthongs are also plotted on an F1/F2 chart based on their F1 and F2 measurements taken at the onset and offset of these five diphthongs (see Figure 4.21 and 4.22). As is illustrated in Figure 4.21 and 4.22, the diphthong /əʊ/ has less diphthongal movement for the female subjects and is more back compared to the ones produced by the males while for /ɑʊ/, there is more diphthongal movement for male subjects. However, a comparison between the average F1 ROC values for the female and male Persian English speakers suggests that the closing diphthongs produced by the females were more diphthongal than the ones produced by the males. As with the centring diphthongs, there is less diphthongal

movement for Persian English diphthongs compared to Standard British English (Deterding, 2000).

As mentioned in section 2.2.2, the diphthongs /ɑɪ/, /eɪ/ and /əʊ/ are present in Persian. The findings from the present study are similar to that of Tsukada's (2008) where although these diphthongs exist in Persian, they are not produced in exactly the same way as in British English. Perhaps, this could be due to the Persian speakers producing the diphthongs more like the equivalent Persian ones, which supports Flege's theory (1995), that similarities between the L1 and L2 phonetic categories is not a factor for a native-like pronunciation.
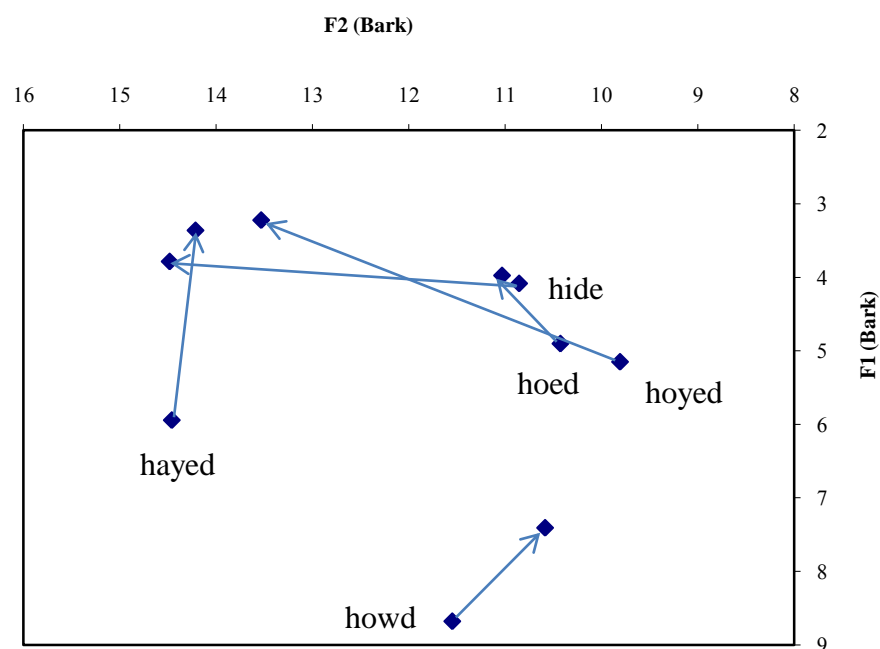

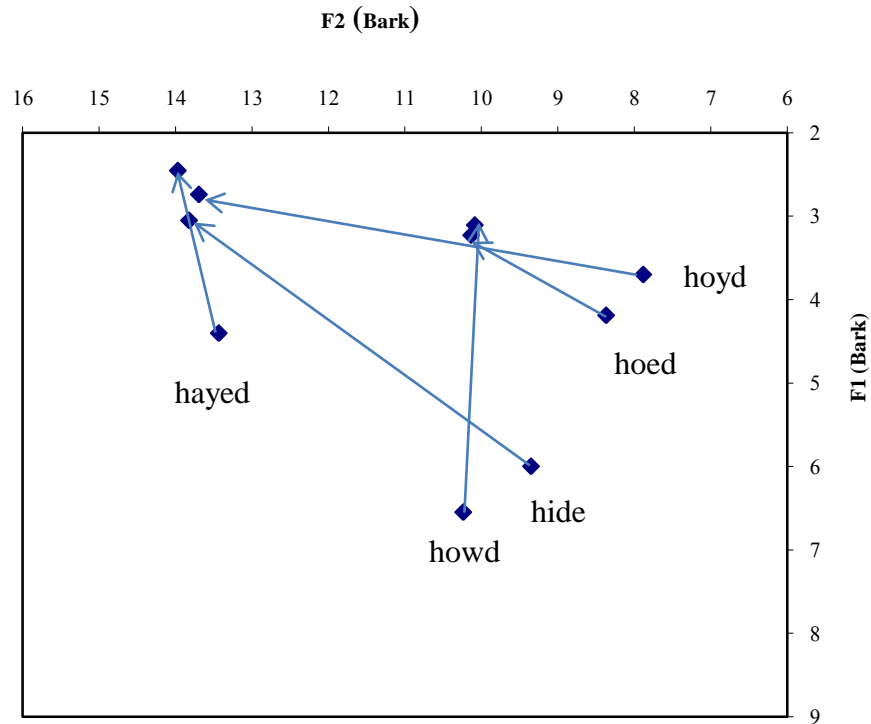Figure 4.21: Formant Trajectories for Female Persian English Rising Diphthongs

F2 (Bark)

Figure 4.22: Formant Trajectories for Male Persian English Rising Diphthongs

4.3 Summary

The results from the analysis of the English monophthongs and diphthongs produced by Persian speakers show particular characteristics of these Persian English vowels. These include the maintaining of vowel length contrast in typical vowel pairs, but a lack of quality contrast between the pairs especially for /ɪ/ and /iː/ and the conflation of /ʌ/, /ɑː/ and /ɒ/. This kind of contrast has been found in other varieties of English (e.g. Deterding, 2003; Pillai, Mohd. Don, Knowles & Tang, 2010; Tsukada, 1999). The merger between these vowels would reduce the vowel inventory for Persian English to nine (/i/, /e/, /æ/, /ɑ/, /ɜː/, /ɔː/, /ʊ/, /uː/, /ə/) instead of 12 monophthongs with of the inclusion of the schwa. There is also a tendency to produce the diphthongs /eə/ and /ʊə/

as monophthongs, but these also tend to be produced as monophthongs in Standard British English.

It was discussed in 2.1 that similar phonetic categories could actually cause difficulties in second or foreign language (Flege, 1987). On the other hand, sounds with dissimilar categories are considered more likely to be produced with native like pronunciation because of learners noticing the differences (Flege, 1995). Although this study did not investigate similar/dissimilar phonemic categories between English and Persian, and the extent to which learners attend to these similarities/dissimilarities, the findings suggest that learners are able to produce sounds and categories which are not in their native language. For example the Persian speakers in this study could produce vowels /ɪ/, /ʌ/,

/ʊ/, /ɑː/, /ɜː/, /ɔɪ/, and /ɑʊ/ which are not present in Persian. However, the quality of this

production is not exactly similar to British or American English but the findings from sections 4.1.3- 4.2, showed the evidence that there are similarities between Persian English vowels and other varieties like British or American English. Persian speakers of English also maintained phonemic length contrast among most of the vowel pairs, a feature which is not present in Persian. This lends support to Flege's Speech Learning Model (see 2.1) that dissimilarities between first and second languages are easier to learn.