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Optimality Theoretic Account of Acquisition of Consonant Clusters of English Syllables by Persian EFL Learners*

Dr. Ali Akbar Jabbari**
Leila Arghavan***
Email: jabbari@yazduni.ac.ir

Abstract

This study accounts for the acquisition of the consonant clusters of English syllable structures both in onset and coda positions by Persian EFL learners. Persian syllable structure is "CV(CC)", composed of one consonant at the initial position and two optional consonants at the final position; whereas English syllable structure is "(CCC)V(CCCC)". Therefore, Persian EFL learners need to resolve the conflict between what they know (L1), and what they are learning (L2). Optimality theory (Prince and Smolensky, 1993) claims that the knowledge of language consists of the universal set of structural descriptions and a language-particular ranking of constraints. It provides an explicit account for not only why learners have difficulty with specific EFL structures but also how they resolve it. 40 participants of two levels of English proficiency participated in this study. The data were collected via two tasks. The first task was a sound comprehension test and the second was a production test. The analyzed data revealed that all the learners had difficulties in performing initial consonant clusters in English; however, the lower level learners significantly had more deficiencies. It is worth mentioning that those coda clusters composed of more than two consonants are more difficult than those composed of only two consonants. This study also revealed that epenthesis was more frequent in onset positions while deletion and substitution were more frequent in coda positions. Based on the findings of the study, English instructors and material developers can estimate the degree of difficulty of consonant clusters and provide the needed time and material for teaching them.

Key words: consonant, consonant cluster, onset consonant cluster, coda consonant cluster, syllable, deletion, epenthesis, substitution, Optimality Theory.

*- تاریخ وصول: ۱۳۸۸/۱۰/۲۳ تأیید نهایی: ۱۳۸۹/۵/۲۶
**- Associate Professor of Yazd University
***- M.A Student of Yazd University

1. Introduction

Consonant clusters are a feature of many of the world's languages. In a study of 104 world languages, based on the work of Greenberg (1978), Locke (1983) calculated that 39% had word-initial clusters only, 13% had final clusters only, and the remaining 48% had clusters in both word-initial and word-final position. In English, one third of monosyllables begin with a consonant cluster, and consonant clusters predominate in word-final position (Locke, 1983). This predominance in word-final position is attributable to the addition of the phonemes /s, z, t, d/ to indicate grammatical morphemes. When such morphophonemic clusters are excluded, only 18% of English monosyllables end in consonant clusters. Some languages (such as Italian) have more consonant clusters than English does, and other languages (such as Persian and Turkish) have fewer (Greenberg, 1978; Swan & Smith, 1987). For example, Persian has only consonant clusters word finally. Therefore one of the issues that, for some years, has engaged researchers in the area of second language acquisition is the acquisition of consonant clusters by L2 learners. The present study is an attempt to provide accounts for the acquisition of English consonant clusters both in onset and coda position by Persian EFL learners.

2. Background

Over the past 25 years, research on the acquisition of second language (L2) phonology, especially work on syllable structures such as onsets (consonants at the beginning of syllables) and codas (consonants at the end of syllables), has become one of the most dynamic areas in SLA, yielding important insights into the role of first language (L1) transfer and markedness in the development of a nonnative phonological system. Research in this area has also been characterized by the overall consistency of its findings. For example, it appears that L1 transfer is prominent (Benson, 1988; Broselow, 1984; Hodne, 1985; Major, 1987a, 2001; Sato, 1984; Tarone, 1980, 1987), especially in the early stages of L2 acquisition. L1 transfer appears to be facilitative if there are cross linguistic similarities (Major, 1987a, 1996, 2001) and debilitative if there is cross linguistic divergence (Sato; Tarone, 1980). There seems to be weak evidence for the universal preference for a consonant-vowel (CV) syllable structure (Hodne; Tarone, 1980, 1987); however, shorter syllable structures do appear to be produced more accurately than longer ones (Anderson, 1987; Carlisle, 1997; Hansen, 2001; Major, 1987b). Additionally, longer structures are modified in favor of shorter ones (Anderson; Broselow & Finer, 1991; Carlisle, 1991, 1997, 1998; Eckman, 1987, 1991; Hansen; Sato; Weinberger, 1987). In fact, the acquisition of longer clusters may imply the acquisition of shorter onsets and codas (Carlisle, 1998; Eckman, 1991; Hansen).

The issue of acquisition sequences in L2 phonological development, researched mainly through accuracy orders from one-time data sets, has also yielded a number of interesting findings. One consistent finding is that voiceless obstruents emerge before voiced obstruents (Broselow, Chen, & Wang, 1998; Hancin-Bhatt, 2000; Hansen, 2001; Major, 1987b). However, discrepancies in other orders exist, no doubt due to various L1s being investigated, task variation, and differences in the learners' proficiency level. For example, although Eckman and Iverson (1994) found that their Cantonese, Japanese, and Korean learners were able to produce nasals and fricatives more accurately than stops or liquids, Stockman and Pluut (1999) found that stops had higher accuracy percentages than nasals for their Chinese participants. Both Hansen, working with Mandarin Chinese speakers, and Hancin-Bhatt, in research on Thai speakers, found that the most accurately produced singletons were the voiceless stops and voiceless fricatives; however, whereas Hancin-Bhatt also found that her participants produced nasals with a high degree of accuracy, Hansen found that only 0m0 was produced fairly accurately by the native Mandarin Chinese speakers. Additionally, although Abrahamsson (2001b, on Spanish L1 learners of Swedish), Eckman and Iverson, and Hansen found liquids to be among the most difficult consonants to produce, Tropf (1987) found them the most targetlike for his Spanish L1 learners of German. Tropf explained his findings on the basis of sonority, but the majority of researchers have postulated that L1 transfer may be the most powerful factor governing which consonants emerge first.

Developmental patterns in coda clusters have also been examined, and the findings suggest that codas that meet the Universal Canonical Syllable Structure (UCSS) are produced more accurately (Abrahamsson, 2001b; Carlisle, 1991; Hansen, 2001; Tropf, 1987), although there is contradictory evidence (e.g., Osburne, 1996).

Concerning which clusters emerge first, there are also some inconsistencies in the findings: Research suggests that a CCC onset or coda will not be accurately produced until its constituent CC codas have begun emerging ~see Carlisle, 1997; Eckman, 1991; Hansen), but the lack of longitudinal research makes it difficult to discern whether there is a pattern in emergence if both the CCC and CC codas are present in the data and have similar levels of production accuracy. Research on specific CC codas has also shown a great deal of variation in findings (e.g., Abrahamsson; Bayley, 1996; Hancin-Bhatt, 2000; Hancin-Bhatt & Bhatt, 1997; Major, 1996), which indicates that L1 transfer may be a major influence in the acquisition of these codas by L2 learners.

We are beginning to understand more about developmental patterns in acquisition, although few studies (e.g., Abrahamsson, 1999, 2001a, 2001b; Dickerson , 1975; Hansen, 2001; Hecht & Mulford, 1982; Osburne, 1996; Sato, 1984, 1985) have focused on the longitudinal (e.g., 6 months or longer) Development of the L2 structure(s) under examination. Although research that focuses on a single data set may document the current stage of the learners' L2 phonological development at a given time, it will not necessarily elucidate the actual process or developmental patterns in the acquisition of the structures examined . Second, the majority of the research has focused on a narrow set of syllable onsets, codas, or both, especially voiceless obstruents and nasals, which offers only a limited view of the learner's emerging L2 phonology and therefore may not be truly representative of the learner's actual L2 phonology at the time of the study.

Previous research has focused on production modifications and has tended to generalize them by their subjects across syllable types. For example, Chinese learners of English have been found to favor devoicing (Broselow et al., 1998; Eckman, 1981b; Flege & Davidian, 1984), deletion (Anderson, 1987; Broselow et al.; Weinberger, 1987), and epenthesis (Anderson; Broselow et al.; Weinberger). For Vietnamese learners of English, Sato (1984) found that deletion was the favored strategy. To explain the different results, researchers have proposed such influences as L2 proficiency level (Weinberger), markedness (Broselow et al.; Eckman, 1987; Hancin-Bhatt & Bhatt, 1997), L1 interference (Anderson; Hancin-Bhatt & Bhatt; Tarone, 1987), L1 developmental processes (Eckman, 1981b; Hecht &

Mulford, 1982), linguistic environment (Benson, 1988; Carlisle, 1997), and interlanguage rules (Eckman, 1981a, 1981b, 1987).

Examining production type by onsets and codas in aggregate form, by length, or both (e.g., across C, or across CC or CCC clusters) may obscure individual coda or onset tendencies: There is some indication that production (e.g., with epenthesis or devoicing) is patterned by individual coda or onset type. For example, Broselow and Finer (1991) found that production type for English L2 obstruent1liquid and obstruent1glide onsets were onset-type specific for speakers of L1 Korean and Japanese. Hansen (2001) found that the Mandarin Chinese speakers in her study produced codas with epenthesis and feature change and that their choice of production type was dependent on the coda; Abrahamsson (2001b), in research on native speakers (NSs) of Spanish who were learning Swedish, found that epenthesis was preferred for fricative and stop codas over nasal codas. Few researchers have examined substitution patterns (see Broselow & Finer; Hancin-Bhatt, 2000; Piper, 1984), although the findings indicate that they are also patterned by specific onset or coda type. Even absence, as Osburne (1996) found, may be word specific and not random. 2 In fact, investigating feature change as well as absence and epenthesis and examining production type by each coda is important because they may indicate acquisition processes, especially if examined across time.

Although research on the acquisition of L2 phonology has provided a number of significant findings, particularly regarding transfer and markedness in other languages, few works were done on Persian language and we still lack an understanding of the acquisition of L2 phonology by the native speakers of Persian.

3. Research hypotheses

This study examines the acquisition of English L2 syllable onsets and codas by Persian EFL learners. In light of previous research on the acquisition of English syllable onset and codas by L2 learners, and contrastive analysis of Persian and English syllable structure, this project focuses on four main hypotheses.

1) It seems that Persian EFL Learners have difficulty in comprehending and producing both onset and coda consonant clusters;

2) It seems that Persian EFL Learners have more difficulty in comprehending and producing those coda clusters composed of more than two consonants than those composed of just two consonants;

3) It seems that Persian EFL Learners have more difficulty in comprehending and producing onset clusters than coda clusters;

4) It seems that low level Persian EFL Learners have more difficulty in producing and comprehending both onset and coda clusters than high level Persian EFL Learners.

4. Persian and English Consonant Cluster

Given that the focus of the study is the acquisition of English syllable onset and coda by Persian EFL learners, an overview Persian and English phonology is necessary. There are a total of 39 types of consonant cluster in Persian (shown in appendix 1). All these consonant clusters occur only syllable finally. Let it not remain unsaid that the syllable structure in Persian is cv(cc), as a result only consonant clusters which composed of only two consonants are allowed in Persian.

English syllable structure is more complex. English allows onsets with up to three adjacent consonants and codas with up to four consecutive members, resulting in the following possible syllable structures (Hammond, 1999): V (*I)*, CV (*he*), CCV (*tree*), CCCV (*stray*), VC (*at*), CVC (*bat*), CCVC (*float*), CCCVC (*sprig*), VCC (*apt*), CVCC (*mast*), CCVCC (*blast*), CCCVCC (*sprint*), VCCC (*angst*), CVCCC (*text*), CCVCCC (*sphinx*), CCCVCCC (*strengths*), VCCCC (*angsts*), CVCCCC (*texts*). There are 50 possible consonant clusters in English (shown in appendix 2). Many of the codas ending in the stops /t, d/ and the fricatives /s, z/ may be bimorphemic as the final stop may indicate a past-tense marker and the final fricative may indicate the plural, genitive, or third-person-singular form. In many of the three-member codas and all of the four-member codas, the final consonant is a morphological marker.

5. Methodology

5.1 Participants

Participants in this study were 20 low level and 20 high level Persian EFL Learners enrolled in an intensive English program at Bahar Language Institute in Shiraz. Table 1 gives a summary of the language learning background of the Participants. Appendices I and II provide a more detailed description of each group.

Table 1. EFL Learners' bio-data

(Subjects N=40)	Age	Years studied English	Accuracy on Tasks
Low level (20)	26	1.70	55.50 %
High level (20)	30	4.98	76.95 %

Overall, participants began their English learning in adolescence, so we consider them to be adult learners. The average number of years studying English for the low level group was 1.70 years, and for high level group it was 4.98 years.

5.2 Materials and Procedures

The possible initial and final consonant clusters of English were first studied (Appendices III & IV). Then, all the existing types of English consonant clusters were selected. In order to reduce the effect of pervious exposure to the words, we decided to use English pseudo words in our test. In preparing the appropriate pseudo words for this purpose, an attempt was made to use each word only once in the experiment. For example the pseudo word /smarn/ was used for/ -rn/ (liquid nasal), and /starmz/ for /-rmz/ (liquid nasal fricative).

Having prepared all pseudo words for all types of consonant clusters, we designed two tasks, a comprehension task and a production task. All participants performed two tasks. In task one (comprehension), they were asked to listen to a word (a target pseudo word) and to circle the word that they thought they had heard from a set of five possibilities. One purpose for this task was to expose the participants to the target stimuli before they were asked to produce them. The other purpose was to examine how they heard complex onsets and codas. The participants heard and responded to 50 items, consisting of 50 monosyllabic English pseudo words. 10 items were for onset consonant clusters and 40 items were for coda consonant clusters. The task instructions and examples are given in Appendix V. The items in this task were prerecorded by a male native speaker of American English so that all participants were given the same input and the same amount of time to respond. This task took approximately 15 minutes to complete.

In task two, participants listened to sentence pairs and decided which of the two was grammatically correct. We used a set of sentences to be used in a grammaticality judgement task (Adopted from Hancin- Bhatt and Bhatt, 1997). There were 50 pairs of sentences, each composed of a syntactically correct sentence and one slightly different from the correct sentence that violated one of the following syntactic rules and constraints in English: do support, that trace effects, agreement, case, word order, auxiliary inversion, and adverb placement. For example, a pair that manipulated the case is the following (with target psuedoword):

1. All the pictures were smarn by he.
2. All the pictures were smarn by him.

Additional sample items of each of the other types are given in appendix VI.

The reason for using this type of production task perhaps is that we did not want all participants to simply repeat sentences because that would allow them to ignore meaning and focus their attention on pronunciation, which may not reflect purely natural speech (see Hansin Bhatt 1997 for further discussion). Asking the participants to make grammaticality judgments in this task forced them to attend to meaning to decide which of the sentences was correct, while still getting them to produce the target word.

Each of the sentences contained a target pseudo word. Participants were instructed to repeat the sentence that they thought was grammatically correct, thus ensuring that they would produce the target items. Participants were also allowed to read a written version of the sentences, because of the rapidity of the task. The participants' responses were tape recorded. An example of task two is given in appendix VI. Again, the items in this task were prerecorded by the same native speaker described in task 1 so that all participants were given the same input and the same amount of time to respond. This task took approximately 30 minutes.

After performing the two tasks participants filled out a background questionnaire on their English language learning experience. The questionnaire is given in appendix VII. The entire testing session took approximately 45 minutes and participants participated in this test individually.

The experiment had been designed for individual administration. It was conducted in an educational office in Bahar Language institute in Shiraz. Each participant participated individually in the test. The instruments used for administering the experiment were a Sony tape recorder, a CD and a Sony digital recorder.

In this study, we present the data on participants' comprehension and Production of the consonant clusters together. Their responses for each target word were transcribed in phonetic transcriptions. Errors were then recorded separately, and four main categories of errors in consonant clusters were apparent: Consonant or cluster deletion, vowel epenthesis, consonant or cluster substitution, and consonant addition. A second independent transcriber provided transcriptions of the target items for all participants. A reliability check between the two transcriptions revealed a 90% agreement. This figure was determined by dividing the number of agreements between the investigator and the native transcriber by the number of agreements and disagreements.

5.3 Reliability of the Tests

The reliability of the tests that were used in comprehension and production test are measured

Cranach's Alpha showed 0.813 for comprehension test, and 0.877 for production test. Since these values are larger than 0.7 and are close to 1 it can be concluded that both tests were reliable; that is, if we use them again it is highly probable that the results would be the same as the current results to be reported in the next chapter.

6. Results

Only the onset and coda consonant cluster of each word was the focus of the experiment. To assess the participants' language performance, in addition to the writer, a rater was invited to judge and transcribe the participants' responses to the test items. He was a native speaker of English. For the participant's errors, he also determined the erroneous form of utterances.

The rater was required to determine those items which had not been answered; if there were any. After the data were transcribed by the judge and the writer, we found that some items had been transcribed differently by the judges. To eliminate the differences, another

English native speaker with an American accent was asked to judge the differences.

Each participant responded to 50 items in comprehension test and 50 items in production test. Their responses were either correct or incorrect. For the purpose of scoring, first different types of consonant clusters were determined, i.e. we classified different consonant clusters in #CC, #CCC, CC#, CCC# and CCCC# groups. Then the correct and incorrect responses for each group of consonant clusters were calculated based on the total responses of all participants. For example, for #CC clusters, we had 40 participants and each participant responded to both comprehension and production test; therefore, the number of total responses were 80.

As a result of this type of scoring the number of total correct or incorrect responses could be computed for each consonant cluster type. Since responses were either correct or in correct no real score could be calculated for participants; therefore all collected data were non parametric. Consequently non parametric tests should be used in order to test the hypotheses. Wilcoxon Signed Ranks Test and Mann-Whitney test were those nonparametric tests that were used in this thesis. The former test is exactly the same as paired sample T- test and the latter is exactly the same as independent sample T- test.

6.1 Methods of Data Analysis

For the purpose of analysis, descriptive statistics (frequency table) and inferential statistics (Wilcoxon Signed Ranks Test and Mann- Whitney test) were carried out. Before presenting the results of inferential statistics, we provide the description of data and individual variables.

Table 2 Participants' descriptive statistics

	Frequency	Percent
Valid female	20	50.0
male	20	50.0
Total	40	100.0

Information like frequency and percentage for two groups of male and female participants can be found in table 2. As illustrated in the above table, the number of the members of the male and female groups in the population is the same and equals 20 members for each group.

In order to support or reject the fore-mentioned hypotheses, inferential statistics was used. We used Wilcoxon Signed Ranks Test and Mann-Whitney test for this purpose. In many research studies when the data are nonparametric these tests are used to investigate both the degree and the direction of the changes. The results of the inferential statistics for the first hypothesis are presented below.

6.1.1 Results of the First Hypothesis- Testing

H_1: It seems that Persian EFL learners have difficulty in comprehending and producing both onset and coda consonant clusters. In order to test this hypothesis, Wilcoxon Signed Ranks test was used. The result of the above test for this hypothesis stating whether Persian EFL learners produce and comprehend onset consonant clusters incorrectly or not, were presented below:

Table 3 Descriptive Statistics of correct and incorrect use of onset clusters

	N	Mean	Std. Deviation	Minimum	Maximum
Number of incorrect	20	25.3125	8.88233	13.00	40.00
Number of correct	20	14.6875	8.88233	.00	27.00

Table 4 The ranks table of the number of correct and incorrect use of onset clusters

		N	Mean Rank	Sum of Ranks
Number of correct - number of incorrect	Negative Ranks	12[a]	9.35	93.50
	Positive Ranks	7[b]	5.30	26.50
	Ties	1[c]		
	Total	20		

a. number of correct < number of incorrect
b. number of correct > number of incorrect
c. number of correct = number of incorrect

The value of P and the degree of its significance are – 1.982 and 0.046 respectively. Since the P value equals 0.046 and it is less than 0.05, the hypothesis which claims there is no significant difference between the number of incorrect responses and that of correct responses in onset clusters produced by Persian EFL learners could be rejected. Therefore it can be inferred that there is a significant statistical difference between the number of times Persian EFL learners used the onset consonant clusters correctly and the number of times they used them incorrectly both in comprehension and production tasks.

If we have a look at Table 4, we can realize that the number of times that the equation of number of correct responses minus the number of incorrect responses becomes negative, positive or tie is12, 7 and 1 time respectively. The mean ranks in negative ranks and positive ranks are 9.35 and 5.30 respectively. Therefore it can be concluded that learners used onset consonant clusters incorrectly.

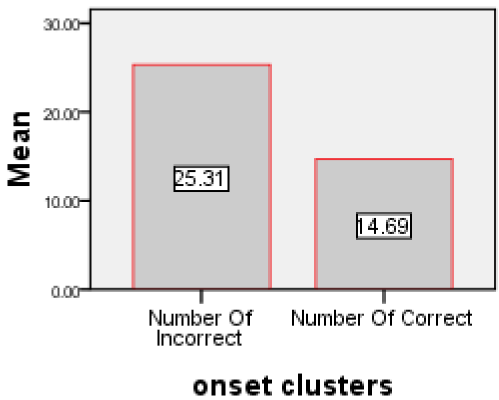

Figure 1. The percentage of correct and incorrect use of onset clusters

In the above figure, the mean number of time, that the learners used onset clusters correctly or incorrectly are illustrated by the bars of the bar-chart. As it was shown, the mean number of time learners used onset clusters correctly and incorrectly are respectively 14.69 and 25.31. This result is a support for the first part of the proposed hypothesis.

The result of Wilcoxon Signed Ranks Test for this part of the hypothesis that claims Persian EFL learners used coda clusters incorrectly were presented in Tables 5 and 6.

Table 5 Descriptive Statistics of correct and incorrect use of coda clusters

	N	Mean	Std. Deviation	Minimum	Maximum
Number of incorrect	80	18.0714	8.99700	3.00	36.00
Number of correct	80	21.9286	8.99700	4.00	37.00

Table 6 Ranks table of correct and incorrect use of coda clusters

		N	Mean Rank	Sum of Ranks
Number of correct – number of incorrect	Negative Ranks	32[a]	17.09	290.50
	Positive Ranks	42[b]	22.25	489.50
	Ties	6[c]		
	Total	80		

a. number of correct < number of incorrect
b. number of correct > number of incorrect
c. number of correct = number of incorrect

The value of the P and its significance level are respectively 1.39 and 0.165. Since P valve equals 0.165 and (P> 0.05), the hypothesis that there no significant statistical difference between the number of correct use and incorrect use of coda clusters cannot be rejected, it means that there is no significant statistical difference between the number of the times Persian EFL Learners used coda clusters correctly and the number of correct responses minus number of times they used them incorrectly. As it was illustrated in the ranks table above, the number of the times the result of the equation of number of correct responses minus incorrect responses becomes negative, positive or tie are 32 times, 42 times and 6 times respectively. The mean Rank in negative and positive Ranks is respectively 17.09 and 22.25.

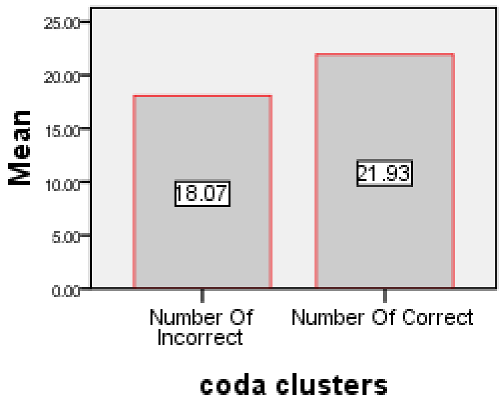

Figure 2. The percentage of correct and incorrect use of coda clusters

In figure 2, the mean number of the times that Persian EFL learners responded to coda clusters correctly or incorrectly is represented by the bars of a bar chart. As illustrated the means for correct responses and incorrect responses are respectively 21.93 and 18.07, which is a support for the rejection of the second part of the first hypothesis.

6.1.2 Results of Second Hypothesis- Testing

H_2: with respect to the difference between Persian and English syllable structures, it seems that Persian EFL learners have more difficulty in using those coda clusters composed of more than two consonants than those composed of only two consonants. Wilcoxon Signed Ranks test is used in order to test this hypothesis. The results of the aforementioned test are presented in Tables 7 and 8.

Table 7 Descriptive Statistics of the comparison of correct and incorrect use of CC# coda clusters and CCC#, CCCC# coda clusters

	N	Mean	Std. Deviation	Minimum	Maximum
More than 2 consonants	40	.5425	.15256	.25	.85
2 consonants	40	.3693	.11924	.14	.68

Table 8 Ranks table of the comparison of correct and incorrect use of CC# coda clusters and CCC#, CCCC# coda clusters

		N	Mean Rank	Sum of Ranks
2 consonants-more than 2 consonants	Negative Ranks	32[a]	23.78	761.00
	Positive Ranks	8[b]	7.38	59.00
	Ties	0[c]		
	Total	40		

a. 2 consonants< more than 2 consonants
b. 2 consonants > more than 2 consonants
c. 2 consonants = more than 2 consonants

The amount of P and its level of significance are -4.718 and 0.000 respectively. Since $p < 0.05$, the hypothesis that claims there is no significant statistical difference between the number of incorrect use of coda clusters composed of more than two consonants and that of coda clusters composed of only two consonants is rejected. Therefore, it can be concluded that there is a significant statistical difference between the number of incorrect responses to those clusters composed of two consonants and that of those composed of more than two consonants ($p < 0.05$).

Now we analyze the rank table. As you can see the number of times that the result of the equation of the number of incorrect responses of coda clusters composted of only two consonants minus the number of incorrect responses of coda clusters composed of more than two consonants becomes negative, positive or tie are respectively 32 times, 8 times and zero times. The mean rank is 23.78 for negative ranks and 7.38 for positive ranks. As a result it can be conclude that Persian EFL learners have more difficulty in using coda clusters composed of more than two consonants than coda clusters composed of only two consonants

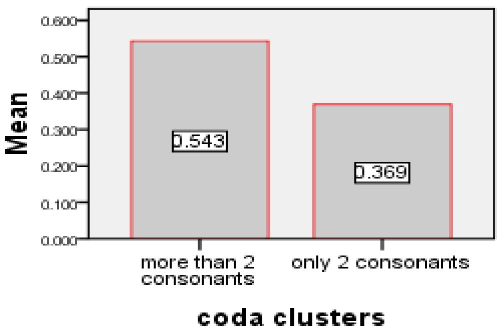

Figure 3. The comparison of correct and incorrect use of CC# coda clusters and CCC#, CCCC# coda clusters

As it is illustrated in Figure 3, the second hypothesis is also proved to be right.

6.1.3 Results of the Third Hypothesis

H_3: It seems that the acquisition of onset clusters is more difficult than coda clusters for Persian EFL learners. That is, learners have more difficulty in using onset clusters than coda clusters. Wilcoxon signed Ranks test is used in order to test this hypothesis. The results of this test are presented in Tables 9 and 10.

Table 9 Descriptive Statistics of the comparison of use of onset clusters and coda clusters

	N	Mean	Std. Deviation	Minimum	Maximum
onset cluster	40	.6328	.14377	.25	.88
coda cluster	40	.4518	.11056	.21	.67

Table 10 Ranks table of the comparison of use of onset clusters and coda clusters

		N	Mean Rank	Sum of Ranks
coda cluster- onset cluster	Negative Ranks	36[a]	21.36	769.00
	Positive Ranks	3[b]	3.67	11.00
	Ties	1[c]		
	Total	40		

a. coda clusters < onset clusters
b. coda clusters > onset clusters
c. coda clusters = onset clusters

The value of P and its significant level are -5.289 and 0.000 respectively. The hypothesis that claims there is no significant statistical difference between the number of incorrect responses of onset clusters and coda clusters can be rejected. Therefore it can be conducted that there is a significant statistical difference between the number of Persian EFL errors in onset clusters and that of coda clusters.

As it is shown in Table 10, the number of times that the result of the equation of the number of in correct responses of coda clusters minus the number of incorrect responses of onset clusters becomes negative, positive or tie are 36 times, 3 times and 1 time respectively, The mean rank is 21.36 for negative Ranks and 3.67 for positive Ranks. Therefore, it can be concluded that Persian EFL learners use more erroneous onset clusters than erroneous coda clusters; in other words, the acquisition of onset clusters is more difficult than that of coda clusters for Persian EFL learners.

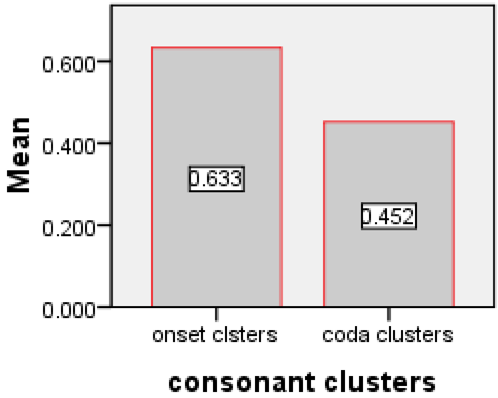

Figure 4. The comparison of use of onset clusters and coda clusters

Figure 4 is a support for our third hypothesis.

6.1.4 The Results of the Fourth Hypothesis- Testing

H_4: It seems that lower level Persian EFL learners have more difficulty both in onset and coda clusters than higher level Persian EFL learners. Mann- Whitney test is used in order to test the above hypothesis. The results of this non- parametric test are presented in Tables 17, 11 and 12.

Table 11 Descriptive Statistics of the comparison of the performance of lower level and upper level learners

	N	Mean	Std .Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
Number Of onset cluster errors	40	10.1250	2.30036	4.00	14.00	8.00	10.00	12.00
Number of coda cluster errors	40	18.9750	4.64365	9.00	2.00	16.00	19.00	22.75
Level	40	1.50	.506	1	2	1.00	1.50	2.00

Table 12 Ranks table of the comparison of the performance of lower level and upper level learners

	Level	N	Mean Rank	Sum of Ranks
Number of onset cluster errors	LOWER	20	26.50	530.00
	UPPER	20	14.50	290.00
	Total	40		
Number of coda cluster errors	LOWER	20	27.28	545.50
	UPPER	20	13.72	274.50
	Total	40		

The significance level of Mann- Whitney U for the comparison of the number of errors in onset clusters that were produced and comprehended by lower level Persian EFL learners and that of higher level Persian EFL learners, equals 0.001 (P value = 0.001). since ($p < 0.05$) the hypothesis that claims there is no significant statistical difference between lower level Persian EFL learners and upper level Persian EFL learners with respect to their number of errors in responding to onset clusters is rejected. Therefore it can be concluded that there is a significant statistical difference between upper and lower Persian EFL learners in the number of their errors in onset clusters.

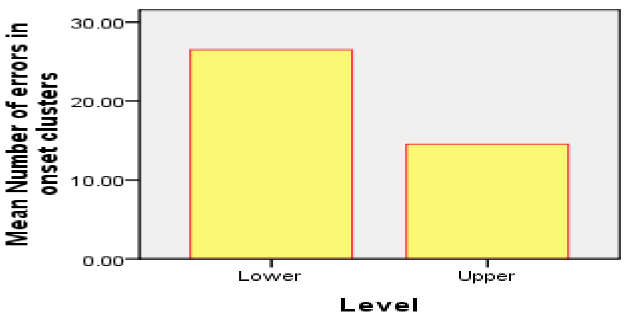

Figure.5. Level and the mean number of errors in onset clusters

The mean Rank of Errors in producing and comprehending onset clusters for lower level and upper level Persian EFL learners are 26.50 and 14.50 respectively for lower and upper level. It means that the mean of lower level Persian EFL learner's errors in responding to onset clusters is more than that of upper level learners.

The valve of Mann-Whitney U for the comparison of the number of errors in coda clusters produced and comprehended by lower level Persian EFL learners and that of higher level learners, equals 0.000 (P = 0.000). Since ($p < 0.05$) the hypothesis that claims there is no significant statistical difference between lower level Persian EFL learners and upper level learners with respect to their number of errors in responding to coda clusters is rejected. Therefore, it can be concluded that there is statistically significant difference between lower level and upper level Persian EFL learners with respect to their performance on coda clusters.

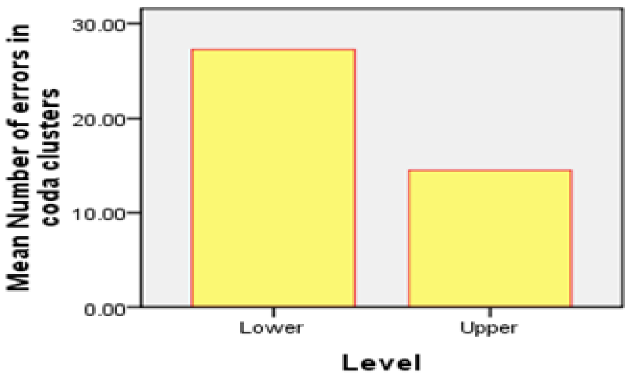

Figure 6. Level and the mean number of errors in coda clusters

The mean rank of errors in producing and comprehending coda clusters for lower level and upper level Persian EFL learners are 27.28 and 13.72 respectively (see Table 6.15). It means that the mean of lower level Persian EFL learners' error in producing and comprehending coda clusters is more than that of upper level learners.

7. Discussion and conclusion

The purpose of this project was to study the acquisition of English consonant clusters by Persian EFL learners. In this chapter some parts of the literature review and previous chapters will be briefly reviewed in order to discuss the results of the data.

The phonology of Persian speakers learning English is known to show deficiencies many of which are argued to be effects of the interference from the grammar of the speaker's first language (L1) i.e. Persian. The simplest effect in this 'interlanguage' phonology is what is known as a transfer effect. This is the application of an obvious L1 rule to L2.

Persian learners of English as a second or foreign language often have difficulty in learning new features of English not present in their first language. One of the features especially problematic in language learners is pronunciation.

In Persian some of the English consonant clusters are nonexistent. For instance, onset clusters present in English syllables are absent in Persian syllables and make some difficulties for these language learners. It is observed that most of the Persian learners of English modify these structures by the insertion of a vowel or deletion of consonant or consonant clusters.

To perform this study two tests were carefully prepared in which pseudo words containing different consonant clusters were introduced to learners. Participants were learners enrolled in the intensive English program at Bahar Language Institute, and their voices were recorded at the time of interview.

After analyzing the data, it was recognized that Persian learners of English continue to modify consonant clusters. The results can be explained more convincingly by Optimality Theory. The acquisition of the consonant clusters may be approached from the constraint based framework of Optimality Theory (OT) (Prince and Smolensky 2004), since OT constraints can account for both universal and transfer processes.

7.1 How Optimality Theory works

Over the last years, a constraint-based approach has been taken to the phonological adjustments. In this approach, demands are put on the surface form, and any form that does not comply with these constraints is rejected in favor of a form that does. The most successful constraint based theory is Optimality Theory (Prince and Smolensky, 1993; McCarthy and Prince 1993a; 1994). This theory holds that constraints are universal. There are two important features of the theory that explain why languages nevertheless have different phonologies. First, languages differ in the importance they attach to various constraints. That is, the phonology of a language is given by the ranking of the set of universal constraints, known as that language's constraint hierarchy. Second, constraints may be contradictory, and thus be violated; if two constraints are contradictory, the one that that is ranked higher will have priority.

Optimality Theory determines what the output form must be. For any given input form, there will initially be an unlimited set of output forms. This free generation of potential output forms is taken care of by a function called GEN (for generator), which is participant only to very general constraints of well-formedness. There are two general forces at work that determine which of these numerous potential output forms is chosen by the language. One of these forces is called faithfulness; it is the force that tries to make the output form identical to the input form. The other force might be said to be the unmarked way of pronouncing things. As Gussenhoven and Jacobs (1998) claim, if this force were allowed to be this way, unchecked by any other force, all words in the language, or indeed in all languages, would end up as something like [ba], or perhaps [tə]; any thing more than this would be more marked in the sense of less common, more complex and more difficult to pronounce (1998). In reality, the outcome is determined by how these two forces interact. Each of the forces is represented by a set of universal constraints, and every language ranks these constraints in its own way. Again, if all the faithfulness constraints are ranked above all the phonological constraints, no phonological adjustments will be made to the input form. However, typically one or more phonological constraints are ranked above one or more faithfulness constraints, which means that in the case of a conflict, the phonological constraint wins. Every constraint that is inspected will thus throw out a number of candidate forms, and this process goes on until there is only one form left. Optimality Theory thus holds that the output form is the optimal form, the form that is left as the only survivor of all candidate forms after an inspection of the constraint hierarchy.

McCarthy and Prince (1995) propose three important constraints to express faithfulness. MAX IO requires that each segment in the input form "I" have a corresponding segment in the output form "O". That is, the input is maximally represented in the output, and the constraint is therefore violated if a segment is deleted. DEP IO requires that each segment in the output form have a corresponding segment in the input form. That is, the output must be entirely dependent on the input, and the constraint is violated by any inserted segment. Thirdly, IDENT requires that every feature of the input segment be identical to every feature in the output segment. That is, this constraint is violated if a segment changes.

(1). MAX IO: Deletion of a segment is prohibited.

(2) DEP IO: Insertion of segments is prohibited.

(3) IDENT: A segment in the input is identical to the corresponding segment in the output.

There are many phonological constraints some of which were mentioned above. It will be clear that the output form will be as close as possible to the input form, and that every deviation must be forced by some higher ranking phonological constraint. There are some further constraints that are relevant to our study. They are Onset Condition, Coda Condition, Complex Coda and Complex Onset. Onset Condition, as stated in Bijan Khan (2006), requires all syllables to have an onset. This constraint is ranked high in languages that have obligatory syllable onset, like Persian, and ranked low in languages that do not have obligatory syllable onset, like English. Complex Onset requires that all syllables have simple onset, that is, no complex onset is allowed. Coda Condition proposes that syllables should not have coda. Finally Complex Coda requires all codas to be simple, that is, all complex codas are prohibited.

(4) Onset Condition: all syllables must have onset.

(5) Complex Onset: not more than one consonant is allowed in the onset position.

(6) no-Coda: syllables should not have a coda.

(7) Complex Coda: not more than one consonant is allowed in the coda position.

Of course there are some other constraints regarding the syllable structure such as αVoice-αVoice, *SibSib and Align-stem which are not relevant to the scope of this study. Analyzing the structure of consonant clusters using these constraints is open to further research. Moreover since this study is concerned with consonant clusters, and both English and Persian have complex codas, we ignore Coda condition constraint in our discussion.

The operation of evaluating the collection of possible output forms is called EVAL (for evaluation). This evaluation is shown in a tableau which is hereafter called table. The constraints are arranged in the columns, and the forms to be evaluated are arranged in rows. An * in a cell indicates that the form of that row breaks the constraint in that column, and *! indicates that such a violation eliminates that form from further consideration. The optimal form, the winner, is marked =>. Shaded cells indicate that the constraint in that column has become irrelevant to the fate of the form in the row concerned. With all these pieces of information in mind, now we can provide our account regarding consonant clusters. As a first step we should determine the constraint hierarchy of Persian and English.

7.2 Optimality Theory Account of English Consonant Clusters in Persian

As mentioned before, Persian is a language that has obligatory onset; therefore this constraint should be ranked at the highest position. Since Persian syllable structure is CVCC again it can be inferred that Complex Onset constraint is important as well, then it can be said that this constraints is located exactly after Onset Condition constraint. So far we understand that the violation of these two constraints is seriously prohibited. On the other hand, English is a language that has optional syllable onset and complex onset is also allowed in this language. As a result these two constraints should not be ranked high. Other related constraints are MAX IO, DEP IO and IDENT respectively. Therefore the ranking hierarchy for Persian and English are as follows:

(8). Persian: Onset Condition >>Complex Onset>> MAX IO, DEP IO, IDENT

(9). English: MAX IO, DEP IO>> Onset Condition, Complex Onset>> IDENT

Since English has complex onset, and speakers of English produce it perfectly, it can be inferred that the faithfulness constraints should be ranked higher. Complex Coda must dominate IDENT; in this way the optimal form without a substitute segment can be distinguished from the candidate with a substitute segment.

The comparison of the production of #CC clusters by Persian speakers of English and native English speakers is illustrated in Tables 13 and 14 below.

Table 13 #CC clusters produced by Persian EFL learners

Candidate	Onset Condition	Complex Onset	Max IO	DEP IO	IDENT
#C1C2V		*!			
#C1□V			*		
# □C2V			*		
#C1<>C2V				*	
#?<>C1.C2V				**	
#C1CxV		*!			*
#CxC2V		*!			*

Symbols such as #, <>, Cx and □ are used in Table 7.1 and the following tables. # represents syllable boundary; symbol <> is used to show an inserted segment. □ represents a deleted segment and finally Cx represents a substituted consonant.

As illustrated in Table 7.1 #C1□V, # □C2V or #C1<>C2V can be optimal candidates for Persian EFL learners, since all of them violate only one constraint and there is no hierarchy between those constraints. That is why some Persian EFL learners use deletion strategy while some others prefer epenthesis strategy in producing #CC clusters. Regarding #?<>C1.C2 structure, we can say that there are two proposed syllable structures for Persian, one with optional onset and the other with obligatory one. There is still debate among the Persian linguists in acceptance of either of the forms. If we believe the syllable structure is obligatory then epenthesis at the beginning of the structure needs another violation of the DEP IO constraint in order to add a glottal stop before the epenthesized vowel. However analyzed data revealed that epenthesis is more frequent than deletion in onset positions (14.04% of the total of 19.93%; see Table 7.10). Another point which is worth mentioning is that according to Jabbari (in press) the epenthesis site in onset clusters is determined by the cluster types. The primary force at work in determining epenthesis site with respect to initial consonant clusters is the goal of achieving the closest possible correspondence between input and output: in the absence of conflicting constraints, epenthetic vowels are located in minimally obtrusive contexts. A Persian speaker treats /sl/ differently from /sr/. /sl/ in a loan word like /eslow/ undergoes prothesis while anaptyxis is triggered in the case of an adopted word like /Serilanka/ for the English words "slow" and "srilanka" respectively. Additionally, sibilant + sonorant shows dual patterning which is governed by the identity of the sonorant. Prothesis occurs when the sonorant is a nasal or /l/, but anaptyxis occurs when the sonorant is /r/ or /w/. Therefore in order to choose the optimal form between #C1<>C2V and #?<>C1.C2 Persian EFL learners resort to the above strategies based on the types of consonant clusters (for further information see Jabbari, in press).

Table 14 #CC clusters produced by English native speakers

Candidate	Max IO	DEP IO	Onset Condition	Complex Onset	IDENT
#C1C2V =>				*	
#C1□V	*!				
# □C2V	*!				
#C1<>C2V		*!			
#?<>C1.C2V		* *!			
#C1CxV				*	*
#CxC2V				*	*

As it is illustrated in Table 14 #C1C2V is the optimal candidate since it violates only Complex Onset constraint only once and this constraint is in low rank.

The comparison of the production of #CCC clusters by Persian speakers of English and native English speakers is illustrated in tables 15 and 16 below.

Table 15 #CCC clusters produced by Persian EFL learners

Candidate	Onset Condition	Complex Onset	Max IO	DEP IO	IDENT
#C1C2C3V		**!			
#C1C2□V		*!	*		
#□ C2C3V		*!	*		
#C1□C3V		*!	*		
#?<>C1.C2<>C3V				* **	
#?<>C1C2.C3V=>				**	
#?<>C1.C2C3V		*!		*	
#C1<>C.C3V				*	
#C1C2CxV		**!			*
#C1CxC3V		**!			*

#CxC2C3V		**!			*

As illustrated in the Table 15, although #C1<>C2.C3V violates DEP IO constraint only once, it is not chosen as the optimal candidate by Persian EFL learners. As mentioned in chapter two, in all #CCC clusters of English C1 is /s/ and C2 is a voiceless stop. Therefore we have sibilant + stop structure. Then according to Jabbari (in Press) Persian speakers of English display prothesis before sibilant + stop. In spite of the fact that #?<>C1C2.C3V violates DEP IO twice, it is the optimal candidate for Persian EFL learners. Since it only violates a low rank constraint.

Table 16 #CCC clusters produced by native speakers of English

Candidate	Max IO	DEP IO	Onset Condition	Complex Onset	IDENT
#C1C2C3V=>				**	
#C1C2□V	*!			*	
#□ C2C3V	*!			*	
#C1□C3V	*!			*	
#?<>C1C2<>C3V		* *!			
#?<>C1.C2C3V		**!		*	
#?<>C1C2.C3V		**!			
#C1<>C2C3V		*!			
#C1C2CxV				**	*
#C1CxC3V				**	*
#CxC2C3V				**	*

In English #C1C2C3V violates Complex Onset constraints twice. This constraint is low rank in English and its violation is not that serious. Therefore it is the optimal candidate. #C1C2□V, #□C2C3V, #C1□C3V, #?<>C1C2<>C3V and #?<>C1C2.C3V have two constraint violations as well, but since they violate the higher rank constraints , they could not be optimal. #C1<>C2C3V has only one violation. Again due to the violation of a high rank constraint, it cannot be optimal candidate.

So far we discussed the production of onset clusters based on optimality theory. Coda clusters can be discussed through this theory as well. As mentioned before both Persian and English have complex coda. Persian allows at most two consonants at coda position and English allows maximally four consonants at coda position. In order to account for coda clusters in addition to MAX IO, DEP IO and IDENT, we need to utilized no- Coda constraint and Complex Coda constraints. Since both Persian and English have complex clusters, we can ignore no- Coda constraint. According to Bijan khan (2006) high frequency of correct production of codas in many languages imply that faithfulness constraints must dominates marked constraints. Therefore the fallowing rank hierarchy can be proposed for coda clusters in English and Persian.

(55). MAX IO, DEP IO>> COMPLEX CODA>> IDENT

However this hierarchy cannot be accepted for Persian, since this hierarchy cannot account for CCC# and CCCC# clusters. Based on the errors of Persian EFL learners in CCC# and CCCC# clusters it can be inferred that another constraint should be introduced. It is Coda Condition constraint which claims that not more than two consonants are allowed at coda position in Persian, and not more than four consonants are allowed in English. Then the following ranking hierarchy is achieved. Since both English and Persian allow coda clusters this constraint should dominate all other constraint.

(10). CODA CONDITION>>MAX IO, DEP IO>>COMPLEX CODA>> IDENT

(11). CODA CONDITION (English): not more than four consonants are allowed in English

(12). CODA CONDITION (Persian): Not more than two consonants are allowed at coda position in Persian

CC#, CCC# and CCCC# clusters will be discussed separately.

The comparison of the production of CC# clusters by Persian speakers of English and native English speakers is illustrated in Table 17 below.

Table 17 CC# clusters produced by native speakers of English and Persian EFL learners.

Candidate	Coda Condition	Max IO	DEP IO	Complex Coda	Ident
VC1C2# =>				*	
C1□#		*!			
V □C2#		*!			
VC1<>C2#			*!		
VC1Cx#				*	*
VCxC2#				*	*

Again VC1C2# is optimal both in English and Persian, since it violates a low rank constraint only once. C1□#, V □C2# and VC1<>C2# violate the high rank constraints, as a result they could not be optimal candidates. VC1Cx# and VCxC2# have two violations; therefore, they cannot be optimal. The comparison of the production of CCC# clusters by Persian speakers of English and native English speakers is illustrated in Tables 18 and 19 below.

Table 18 CCC# clusters produced by Persian EFL learners.

Candidate	Coda condition	Max IO	DEP IO	Complex coda	IDENT
VC1C2C3#	*!			**	
VC1C2□#		*!		*	
VC1□C3#		*!		*	
V□C2C3#		*!		*	
VC1.C2<>C3#=>			*!		
VC1<>C2C3#			*!	*	
VC1<>C2<>C3#			**!		
VC1C2Cx#	*!			**	*
VC1CxC3#	*!			**	*
VCxC2C3#	*!			**	*

As illustrated in table 18 VC1C2C3#, VC1<>C2<>C3#, VC1CxC3# and VCxC2C3# violate the highest rank constraint, as a result they are excluded from the optimal candidates. VC1C2□#, VC1□C3# and V□C2C3# violate the second and third highest rank constraints. Therefore, they cannot be optimal output. Although VC1.C2<>C3# violates the DEP IO, it is optimal since it has the fewest number of constraint violation.

Table 19 CCC# clusters produced by native speakers of English

Candidate	Coda Condition	Max IO	DEP IO	Complex coda	IDENT
VC1C2C3#=>				**	
VC1C2□#		*!		*	
VC1□C3#		*!		*	
V□C2C3#		*!		*	
VC1C2<>C3#			*!		
VC1<>C2C3#			*!	*	
VC1<>C2<>C3#			**!		

VC1C2Cx#				**	*
VC1CxC3#				**	*
VCxC2C3#				**	*

As illustrated in the Table 19, VC1C2□#, VC1□C3#, V□C2C3#, VC1C2<>C3#, VC1<>C2C3#, violate the high rank constraints, as a result they cannot be optimal candidates. VC1C2C3# has the fewest number of violations of low rank constraints. Therefore, it can be the optimal candidate.

The comparison of the production of CCC# clusters by Persian speakers of English and native English speakers is illustrated in tables 20 and 21 below.

Table 20 CCCC# clusters produced by Persian EFL learners

Candidate	Coda Condition	Max IO	DEP IO	Complex Coda	IDENT
VC1C2C3C4#	**!			***	
VC1C2C3□#	*!	*!		**	
VC1C2□C4#	*!	*!		**	
VC1□C3C4#	*!	*!		**	
V□C2C3C4#	*!	*!		**	
VC1<>C2<>C3<>C4#			***!		
VC1C2<>C3C4# =>			*!	*	
VC1<>C2C3C4#	*!		*	**	
VC1C2<>C3<>C4#			**!		
VC1C2C3Cx#	**!			***	*
VC1C2CxC4#	**!			***	*
VC1CxC3C4#	**!			***	*
VCxC2C3C4#	**!			***	*

As illustrated in Table 20 VC1C2C3C4#, VC1C2C3□#, VC1C2□C4#, VC1□C3C4#, V□C2C3C4#, VC1<>C2C3C4#, VC1C2C3Cx#, VC1C2CxC4#, VC1CxC3C4# and VCxC2C3C4# violate coda condition constraint. Therefore they cannot be optimal candidates. VC1<>C2<>C3<>C4#, VC1C2<>C3C4# and VC1C2<>C3<>C4# are the only candidates that do not violate the coda condition constraint. However VC1C2<>C3C4# has the fewest violations of the high rank constraint DEP IO than other candidates. As a result it can be optimal.

Table 21 CCCC# clusters produced by native speakers of English

Candidate	Coda Condition	max IO	dEP IO	Complex Coda	IDENT
VC1C2C3C4# =>				***	
VC1C2C3□#		*!		**	
VC1C2□C4#		*!		**	
VC1□C3C4#		*!		**	
V□C2C3C4#		*!		**	
VC1<>C2<>C3<>C4#			**!		
VC1C2<>C3C4#			*!	*	
VC1<>C2C3C4#			*!	**	
VC1C2<>C3<>C4#			**!		
VC1C2C3Cx#				***	*
VC1C2CxC4#				***	*
VC1CxC3C4#				***	*
VCxC2C3C4#				***	*

As illustrated in table 21 VC1C2C3□#, VC1C2□C4#, VC1□C3C4#, V□C2C3C4#, VC1<>C2<>C3<>C4#, VC1C2<>C3C4#, VC1<>C2C3C4# and VC1C2<>C3<>C4# violate the high rank constraints Max IO and DEP IO; as a result, they cannot be optimal candidates. Among other candidates, VC1C2C3C4# has the fewest number of violations of the low rank constraints. Therefore it can be the optimal candidate.

So far consonant clusters of the syllable structures of Persian and English have been explained. Analyzing the collected data, the percentage of different types of the participants' error is illustrated in table 22.

Table 22 The percentage of different types of the participants' errors

	Total % of the error	Onset error %	Coda error%

Epenthesis	19.93	14.04	5.89
Deletion	24.51	6.27	18.24
Substitution	4.48	0.42	4.06
Addition	1.17	0.0	1.17

As shown in the Table 22, the analyzed data reveals that the most frequent error is consonant deletion (24.51%). Further, this type of error is more frequent in coda clusters (18.24%). The second most frequent error type is epenthesis (19.93%). Unlike deletion which was more common in coda clusters, epenthesis is a process occurring in onset clusters (14.04%).Substitution with the frequency percentage of 4.48% is the third common error. Again it is more common in coda clusters. So far it can be concluded that deletion and substitution are more frequent in coda clusters while epenthesis is the common error in onset clusters. Addition was so rare (1.17%); however, it occurred only in coda clusters. Since this type of error rarely occurs, we neglect it in our discussion and just focus on epenthesis, deletion and substitution.

Optimality Theory can account for the epenthesis in onset clusters. Persian EFL learners adjust the new structure (English onset structure) to their L1 optimal structure by insertion of a vowel. Here, the role of L1 transfer is clear. Participants' errors can be attributed to L1 transfer. However, if we refer to the optimal candidates of coda structure, it is easily recognizable that based on Persian constraint rank hierarchy, all optimal candidates in CCC# and CCCC# coda clusters are those that have epenthesis modifications, whereas our data reveal that deletion and substitution are the most common strategies Persian EFL learners utilized to adjust English coda clusters. Regarding coda cluster modifications OT claims that simpler structures are less marked than more complex structures, as a result CC# is less marked than CCC# and CCC# in turn is less marked than CCCC#. Therefore it can be inferred that the deletion strategy which is favored over epenthesis in coda clusters can be attributed to developmental effects. This is a result of a universal markedness relationship that CC #is less marked than CCC# and CCC #is less marked than CCCC #.

7.3 Conclusions

The results show that almost all Persian EFL learners continue to modify consonant clusters in their normal English speaking. It has been clear that onset clusters are more difficult for Persian EFL learners. In addition it turns out to be true that low level Persian EFL learners have more difficulty both in onset and coda clusters (see table 6.15 & 6.16). Further, analyzed data reveal that CCC# and CCCC# clusters are more difficult than CC# clusters. As a result we can have the following order for the acquisition of consonant clusters:

(13). CC#< CCC#<CCCC#<#CC< #CCC

Less difficult<-------->most difficult

Optimality Theory is an answer to the problem of consonant cluster adjustments of Persian EFL learners. In the case of onset clusters, OT reveals that the adjustments and modification is due to L1 transfer. Regarding coda cluster modifications OT claims that simpler structures are less marked than more complex structures, as a result CC# is less marked than CCC# and CCC# in turn is less marked than CCCC#. Therefore it can be inferred that deletion strategy which is favored over epenthesis in coda clusters can be attributed to developmental effects. This is a result of a universal markedness relationship that CC# is less marked than CCC# and CCC# is less marked than CCCC#.

7.4 Implications and Concluding Remarks

7.4.1 Theoretical Significance

Theoretically, the present research has studied optimality theory about the acquisition of consonant clusters. This theory answers some questions about the ultimate attainment in the acquisition of phonology.

The role of UG and its principles in first language acquisition is not questionable, but in L2 and especially on L2 phonological acquisition there are a lot of unanswered questions. This research has tried to find some answers to a trivial part of these questions.

7.4.2 Pedagogical Significance

This study can be applied pedagogically, because teachers, syllable designers and material producers in teaching phonology are greatly concerned with the learners' pronunciation. The result of this study, specially its findings on different modification patterns can help syllabus designers and material developers in providing appropriate syllabi and texts for teaching phonology.

The teachers can use the results of this study in providing right and ordered input as well as appropriate amount of time in teaching phonology, because as the findings show a little change in the input can have significant effects on the acquisition of phonology by language learners. At last, this study provides some information for SL and FL researchers or linguists specially applied linguists to have some follow-up studies

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Appendix I. Profile of ESL participants: lower level

Participant	level	age	Native teacher	Years studied English	Living in the US or UK	Pronunciation class	International exams	Normal hearing	Performance accuracy
1	3	18	no	2 years	no	no	no	yes	%36
2	2	21	no	8 months	no	no	no	yes	%27
3	1	21	no	1 year	no	no	no	yes	%36
4	1	24	no	1 month	no	no	no	yes	%54
5	3	21	no	4 months	no	no	no	yes	%45
6	4	26	no	9 months	no	no	no	yes	%36
7	4	33	no	3 years	no	no	no	yes	%45
8	1	31	no	1 month	no	no	no	yes	%54
9	2	27	no	2 months	no	no	no	yes	%45
10	4	25	no	3 years	no	yes	no	yes	%63
11	1	23	no	2 years	no	no	no	yes	%54
12	6	49	no	2 years	no	no	no	yes	%54
13	5	23	no	6 months	1month	no	no	yes	%75
14	6	32	no	3 years	1month	no	no	yes	%63
15	6	23	no	3 years	no	no	no	yes	%81
16	5	27	no	4 months	no	no	no	yes	%72
17	6	30	no	6 months	no	no	no	yes	%81
18	5	24	no	4 months	no	no	no	yes	%54
19	5	20	no	5 years	no	no	no	yes	%45
20	6	23	no	2 years	no	yes	no	yes	%90
mean of low level	--	26	----	1.7 years	---------	-------	-------	------	%55.5

Appendix II. Profile of ESL participants: upper level

Participant	level	age	Native teacher	Years studied English	Living in the US or UK	Pronunciation class	International exams	Normal hearing	Performance accuracy
21	7	29	no	1 year	no	no	no	yes	% 90
22	7	27	no	1 year	no	no	no	yes	% 72
23	8	25	no	2 years	no	no	no	yes	% 81
24	7	29	no	5 months	no	no	no	yes	% 72
25	7	42	no	6 months	1 year	no	no	yes	% 81
26	10	28	no	13 years	no	yes	IELTS 8	yes	% 72
27	8	32	no	7 months	no	no	no	yes	% 90
28	9	22	no	7 years	no	no	no	yes	% 81
29	8	35	no	8 months	no	no	no	yes	% 54
30	7	24	no	10 years	no	no	no	yes	%72
31	10	25	no	1 year	no	no	no	yes	% 72
32	10	23	no	1 year	no	no	no	yes	% 72
33	11	23	no	2 years	no	no	no	yes	% 81
34	12	43	no	2 years	no	no	no	yes	% 90
35	12	22	no	4 years	no	no	no	yes	% 63
36	12	33	no	10 years	no	no	no	yes	% 81
37	11	25	no	15 years	no	no	no	yes	% 72
38	12	50	no	25 years	no	no	no	yes	% 72
39	11	27	no	2 years	no	no	no	yes	% 90
40	10	34	no	2 years	no	no	no	yes	% 81
mean of upper level	----	30	----	4..9 years	--------	------	-----------	----	% 76.95

Appendix III. Possible English consonant cluster

1	#CC	Stop+ glide	26	CCC#	Nasal+ stop+ fricative
2	#CC	Stop+ liquid	27	CCC#	Nasal+ fricative+ fricative
3	#CC	Stop+ nasal	28	CCC#	Liquid+ stop +fricative
4	#CC	Fricative+ glide	29	CCC#	Liquid+ fricative +fricative
5	#CC	Fricative+ liquid	30	CCC#	Fricative+ stop +fricative
6	#CC	Fricative+ nasal	31	CCC#	Stop+ fricative+ stop
7	#CC	Fricative+ fricative	32	CCC#	Nasal+ fricative+ stop
8	#CC	Nasal+ glide	33	CCC#	Nasal+ stop+ stop
9	#CC	liquid+ glide	34	CCC#	Nasal+ affricate+ stop
10	#CCC	Fricative+ stop+ liquid	35	CCC#	Liquid+ stop+ stop
11	CC#	Stop+ stop	36	CCC#	Liquid+ fricative+ stop
12	CC#	Stop+ fricative	37	CCC#	Fricative+ stop+ stop
13	CC#	Affricate+ stop	38	CCC#	Liquid+ nasal+ fricative
14	CC#	Fricative+ stop	39	CCC#	Stop+ nasal+ stop
15	CC#	Fricative+ fricative	40	CCC#	Liquid+ nasal+ stop
16	CC#	Nasal+ stop	41	CCC#	Liquid+ affricate+ stop
17	CC#	Nasal+ fricative	42	CCC#	Liquid+ liquid+ fricative
18	CC#	Nasal+ affricate	43	CCCC#	Nasal+ stop+ fricative+ stop
19	CC#	Liquid+ stop	44	CCCC#	Liquid+ stop+ stop+ fricative
20	CC#	Liquid+ fricative	45	CCCC#	Liquid+ fricative+ fricative+ fricative
21	CC#	Liquid+ nasal	46	CCCC#	Stop+ fricative+ stop+ fricative
22	CC#	Liquid+ affricate	47	CCCC#	Nasal+ stop+ fricative+ fricative
23	CC#	Liquid+ liquid	48	CCCC#	Stop+ fricative+ fricative+ fricative
24	CCC#	Stop+ fricative+ fricative	49	CCCC#	Nasal+ stop+ stop+ fricative
25	CCC#	Stop+ stop+ fricative	50	CCCC#	Liquid+ fricative+ stop+ fricative

Appendix IV. Possible Persian consonant clusters

1	CC#	Stop+ stop	21	CC#	Nasal+ nasal
2	CC#	Stop+ fricative	22	CC#	Nasal+ liquid
3	CC#	Stop+ nasal	23	CC#	Nasal+ glottal
4	CC#	Stop+ liquid	24	CC#	Liquid+ stop
5	CC#	Stop+ glide	25	CC#	Liquid+ fricative
6	CC#	Stop+ glottal	26	CC#	Liquid+ affricate
7	CC#	Fricative+ stop	27	CC#	Liquid+ nasal
8	CC#	Fricative+ fricative	28	CC#	Liquid+ glide
9	CC#	Fricative+ nasal	29	CC#	Liquid+ glottal
10	CC#	Fricative+ liquid	30	CC#	Glide+ stop
11	CC#	Fricative+ glide	31	CC#	Glide+ fricative
12	CC#	Fricative+ glottal	32	CC#	Glide+ affricate
13	CC#	Affricate+ stop	33	CC#	Glide+ nasal
14	CC#	Affricate+ fricative	34	CC#	Glide+ liquid
15	CC#	Affricate+ liquid	35	CC#	Glottal+ stop
16	CC#	Affricate+ glide	36	CC#	Glottal+ fricative
17	CC#	Affricate+ glottal	37	CC#	Glottal+ nasal
18	CC#	Nasal+ stop	38	CC#	Glottal+ liquid
19	CC#	Nasal+ fricative	39	CC#	Glottal+ glide
20	CC#	Nasal+ affricate			

Appendix V. Sample of Comprehension test

In this test you will listen to words which sound like English words. You will be given a list of possible spelling correspondence of the word on this sheet. Listen to each word and identify what you hear by circling one word in appropriate set on this sheet. Try to be as fast as you can. If you are not sure which word you heard, make your best guess. Please do not leave any numbers unanswered. You cannot listen to any item over again.

1.	a. celar	b. car	c. lar	d. clar	e. crar
2.	a. sefer	b. esfer	c. sfer	d. fer	e. ser
3.	a. ferum	b. frum	c. rum	d. fum	e. fnum
4.	a. eswab	b. sowab	c. swab	d. sab	e. wab
5.	a. estek	b. sek	c. stek	d. tek	e. espek
6.	a. snil	b. sil	c. nil	d. esnil	e. spil
7.	a. piyun	b. pyun	c. pun	d. yun	e. piwun
8.	a. estrim	b. estirim	c. srim	d. trim	e. strim
9.	a. mel	b. mech	c. melech	d. melch	e. melge
10.	a. rolt	b. rot	c. rol	d. rolet	e. ront

Appendix VI . Sample of Production test

In this task, you will hear 2 sentences spoken for each number. One is a good English sentence, the other is not good. After listening to the 2 sentences, decide which one is good and repeat that sentence as fast and as loudly as you can. You may not know all of the words in the sentence, but you should answer question as best as you can. You may use this sheet to read the sentences that are being said. This task goes fast, so please try to answer as quickly as you can. Please respond to every number. You may not listen to any item over again.

1. A. Only dogs are allowed in the Spelch Park after dark.
   B. Only dogs is allowed in the Spelch Park after dark.
2. A. All the pictures were smarn by he.
   B. All the pictures were smarn by him.
3. A. Everyone likes Mary who Rosa is talking to in the starms.
   B. Everyone likes Mary who Rosa talking to in the starms.
4. A. Mary hopes they are ready to fulm today.