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Hiatus Resolution and Its Relation to Vowel Shortening in Persian and Central Kurdish: An Optimality-Theoretic Approach

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Abstract

The present study aimed to investigate vowel hiatus resolution and its relation to vowel shortening in Persian and Central Kurdish within an Optimality-Theoretic framework. The results showed that both Persian and Central Kurdish use glide formation through vowel shortening to resolve hiatus in certain environments. Persian has its own way to resolve vowel hiatus. The two high vowels /i/ and /u/, as a result of glide formation through vowel shortening, are changed into a short vowel and the glides /j/ and /w/, respectively. In Central Kurdish, glide formation occurs in high vowels /iː, uː/ and mid-high vowels /ēː, ōː/. In Persian, glide formation involves a quantitative reduction in the long vowel /iː/ and a quantitative and qualitative alteration in the long vowel /uː/. On the other hand, glide formation in Central Kurdish involves only a quantitative reduction in long vowels. Based on an OT analysis, the main factor in resolving vowel hiatus in both Persian and Central Kurdish is the obligatory presence of onset in the syllable structure. In contexts in which glide formation occurs through vowel shortening, the ranking of the active constraints in Persian and Central Kurdish is: ONSET, AGREE(place) >> MAX, DEP >> IDENT(μ).

Keywords: vowel hiatus, glide formation, vowel shortening, Optimality Theory, Persian, central Kurdish

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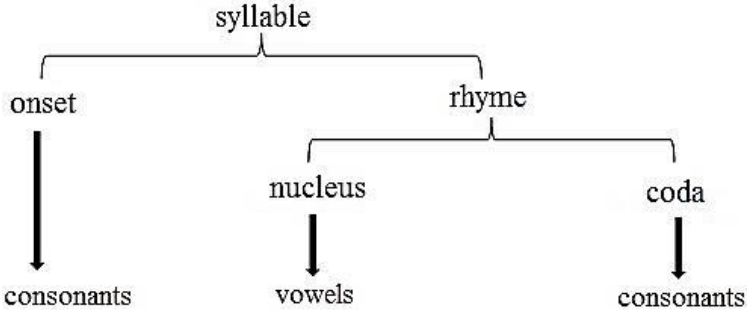
1. Introduction

In languages, when two vowels come into contact with each other without an intervening consonant, the resulting state is called vowel hiatus. In fact, vowel hiatus occurs when in two adjacent syllables, the first syllable has no coda and the second syllable has no onset, as in the syllable structure CV.VC (Davidson & Erker, 2014). In many languages, it is difficult for the speaker to produce consecutive vowels (in hiatus). To solve the problem languages, depending on their syllable structure and phonetic and phonotactic architecture, use different strategies to overcome this difficulty, which is known as the principle of hiatus resolution. In other words, if we consider vowel hiatus as a marked phenomenon, and given that the production of a marked structure is more costly than an unmarked one, it seems logical for languages to use different tools and strategies to resolve vow hiatus. Vowel hiatus in phonological representation occurs in an intermediate stage between phonological and phonetic representations. This phenomenon is expected to exist in any language, but its resolution is only essential in languages in which the presence of onset is necessary (Carr, 2008). It seems that what prevents or resolves vowel hiatus in languages is the preservation of the syllable structure of a language, which is achieved under the rules of phonotactics. "Phonotactics deals with the arrangement of phonological units of a language and yields well-formed words" (Crystal, 2008, p. 366).

According to the following pattern, each syllable is divided into two parts: the onset and the rhyme; and the rhyme in turn has two parts: the nucleus and the coda.

Figure 1

Syllable Structure (adapted from Heinz, 1989, p. 59)



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Each language has its own syllable pattern, and like the number and the type of phonemes which differ from one language to another, patterns of syllable structure also differ from one language to another (Ladefoged & Johnson, 2011).

In Persian, the presence of an onset consonant is obligatory in the beginning of syllables. Therefore, "a syllable in Persian can consist of at least one vowel and one consonant, and at most one vowel and three consonants" (Samareh, 2001, p. 108). Due to the constraints on syllables in Persian, the syllable structure in this language takes the form CV(C)(C). Regarding the syllable structure in Central Kurdish (Sanandaj dialect), Zahedi (2013) argues that the longest syllable in this language has the structural pattern (C)CV(C)(C); that is, a maximum of two consonants can appear in the onset and coda positions. Also, only a vowel can take the nucleus position of a syllable and there is no syllabic consonant in this dialect. The presence of an onset in syllables is obligatory in this dialect; however, the presence of a coda is optional and the syllables CV or CCV are found in abundance in this dialect. Central Kurdish, also called Sorani, is a Kurdish dialect or a language that is spoken in the provinces of Kurdistan, Kermanshah, and West Azerbaijan in western Iran, as well as Iraq, mainly in Iraqi Kurdistan. Sorani is one of the two official languages of Iraq, along with Arabic, and is in administrative documents simply referred to as "Kurdish" (Allison, 2012). All Kurdish dialects spoken in the western regions of Iran, in terms of their phonological systems, have seven syllable structures: (CV), (CCVC), (CVC), (CVCCC), (CVCC), (CCVCC), and (CCV) (Karimi-Doostan, 2006). Due to the constraints on syllables in Central Kurdish, the syllable structure in this language is (C)CV(C)(C).

2. Literature Review

In this section, some of the previous studies that have dealt with the process of glide formation through vowel shortening in both Persian and Kurdish, as well as some other languages, are briefly reviewed.

Although some languages, such as Maori, accept vowel hiatus as an optimal form in their syllable structure, others do not allow vowel hiatus in their syllable structure, and use certain phonological processes to prevent vowel hiatus in specific linguistic contexts. For example, the Sanskrit language, in addition to maintaining vowel hiatus in certain contexts, uses different processes to resolve hiatus in some specific contexts; processes such as the coalescence of two simple identical long

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vowels (/tvā-āgne/ → [tvāgne]); creation of a mid-vowel by combining a low and a high vowel (/rādʒā-indra/ → [rādʒeindra]); deletion of a short vowel (/vane-atra/ → [vanetra]); glide insertion (/si-sri-e/ → [sisrije]); and glide formation (/strī-asja/ → [stryasja]) (Jensen & Jensen, 2012).

Sometimes the process of glide formation is accompanied with vowel shortening. "Vowel shortening is a process in which the length of a vowel is shortened in a specific phonological environment" (Kambuziya, 2017, p. 373). Kambuziya (2019) believes that in Persian, if the long high vowels /uː/ and /iː/ appear at the end of a stem or a word to which the plural suffix [-ɑn] is added, vowel hiatus occurs. In such cases, the vowel /i/ is shortened through glide formation and part of it is turned into the glide /j/. She further argues that vowel shortening leads to a change in syllable quantity. However, sometimes the quality of vowels also changes as a result of shortening.

Esmaeili-Matin et al. (2016) state that in Persian, consonant epenthesis is the most common way to resolve vowel hiatus. They believe that the consonants [j], [ʔ] and [v] occur as the epenthetic consonants in the process of hiatus resolution in the /ɑ-i/ environment at the derivation boundary of words. The presence of the glide [j] and the glottal stop [ʔ] in hiatus resolution is the result of the epenthesis process, and in some words they are floating consonants. The labiodental fricative [v] as an epenthetic consonant in hiatus resolution is seen only in Arabic loanwords, which occurs as a result of the processes of epenthesis and vowel shortening in these words. They argue that in the process of vowel shortening, no consonant is inserted; rather, the presence of an epenthetic consonant is the result of vowel shortening.

In another study, Amirjani et al. (2019) assert that in Persian, after the addition of the progressive prefix /mi-/ to verbs, the glottal consonant /ʔ/ is no longer inserted in informal speech; instead, the shortening of the high front vowel /i/ occurs, realizing as a sequence of a short vowel and a glide [-ej-]. Then, the raising of the mid vowel [e] occurs before the glide [j], resulting in the vowel-glide sequence [-ij-]. However, Jam (2015) believes that in Persian, to resolve vowel hiatus, glide formation does not occur, because to resolve vowel hiatus, glide formation occurs only in the case of the first vowel.

Regarding Kurdish, Sadeghi & Sadeghi (2017) believe that in Sorani Kurdish, the most common phonological pattern to prevent the phonetic realization of vowel hiatus is through the epenthesis of glides [j] and [w]. However, epenthesis does not occur when the suffix vowel – i.e. V2 – is the high front vowel /i/. In this case, /i/ is

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converted to [j] through the process of glide formation, and as a result, the vowel sequence /V + i/ is transformed into a diphtong.

Ahmadi et al. (2019b) believe that in Central Kurdish, the process of glide formation through the shortening of long vowels is less costly compared to other processes such as glide insertion, deletion of one of the vowels, merging of the two vowels, diphthongization, etc., which are commonly used to resolve vowel hiatus. Ahmadi et al. (2019a), in another study, state that the most common strategy used to resolve vowel hiatus in Central Kurdish is the process of glide formation. However, vowel deletion is also used only when two low vowels are placed next to each other. They consider the constraints on glide formation in Central Kurdish to be the following: *OCP » IDENT-F(ROUND) » IDENT.

Jam (2020) discusses the pronunciation of the plural morpheme /-hA/ in Persian. The paper is an attempt to explain idiosyncratic cases in which /h/ fails to delete, even when its conditioning environment is met. These idiosyncrasies included exceptionalities as well as the cases in which the pronunciation of the plural morpheme /-hA/ depended on the interaction between phonology and semantics. In the informal style the /h/ in the plural marker deletes in most of the environments, i.e., when it is attached to words ending in a consonant or in one of the three vowels /i/, /u/ and /o/. Deletion of /h/ results in hiatus which is disallowed in Persian. Therefore, in order to resolve hiatus, intervocalic consonants [j] and [w] are inserted after words ending in /i/ and round vowels /u/ and/o/ respectively.

Since almost the same phonological processes occur in typologically related languages, glide formation through vowel shortening is expected to occur in similar ways in both Persian and Central Kurdish to resolve vowel hiatus in the CV.VC context in these two languages. Accordingly, the present study, adopting an Optimality-Theoretic approach, seeks to compare the type and the ranking of constraints governing the process of glide formation through vowel shortening in the two languages Persian and Central Kurdish.

3. Research Framework

McCarthy (2002) asserts that Optimality Theory made a turning point in linguistic studies, the greatest achievement of which is its new approach to constraints. This theory is based on the view that all areas of language are constraint-based. These

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constraints are universal and are hence rooted in the human's biological and genetic structure. The existence of these constraints explains the commonalities between languages, and the different rankings of these constraints in different languages on the one hand, and their violation on the other hand, justify the differences and diversity between languages. In Optimality Theory, universal constraints are violable. In this theory, constraints fall into two main categories: 1) Faithfulness constraints; and 2) Markedness constraints. Faithfulness constraint are related to the structural changes of a context-specific rule (input and output). According to the correspondence theory, every candidate created by the generator is not just an output, but it also encompasses the relationship between input and output. Markedness constraints govern the structural description of a context-specific rule.

To achieve optimal economy in speech production and comprehension, speakers tend not to favor a marked structure (Derakhshan & Shakki, 2021). Thus, markedness constraints have to do with the violation of the structural description as a marked pattern. Markedness constraints do not have access to the input. In other words, markedness constraints are not able to compare input and output. Optimality Theory is a linguistic model that consists of input, output, generator, and evaluator. According to this theory, then, no part of the model contains rules, but only general constraints. All constraints (phonological, morphological and syntactic) are grouped in one part which is the evaluator. According to Optimality Theory, no constraints are imposed on the input. In OT phonology, instead of "phonetic representation" or "surface representation" used in rule-based phonology, the term "output" is used. The generator is a formal mechanism that links the input to the output and generates all the competing candidates for an underlying form. The evaluator is a one-to-many mathematical function that evaluates the generator's candidates and maps them to an output using faithfulness and markedness constraints.

Optimality Theory is an output-driven theory, meaning that well-formedness constraints only evaluate surface forms. This theory does not hold two basic assumptions of the previous theories. First, the grammar can explain and specify the rules of structural description and structural change by means of the generator in a specific and limited way. The generator offers a wide range of candidates for each input. The important point is that the output in question is within this range, and the grammar's constraint system works very potently to find it. Second, this theory discards the idea that constraints are language-specific. The theory emphasizes the universality of constraints and maintains that these constraints have a language-

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specific ranking and compete with each other (McCarthy, 2002). McCarthy (2002) argues that the markedness constraint *HIATUS has the highest rank in some languages and prevents vowel hiatus. This constraints only applies to a situation in which hiatus occurs between two adjacent syllables; that is, the first syllable has no coda and the second syllable has no onset. This constraint is satisfied when the second syllable in question has an onset. However, for vowel hiatus, another constraint is defined in OT according to which all syllables of words must have an onset, and that is the markedness constraint ONSET.

4. Method

The present study has been conducted within the framework of Optimality Theory phonology and adopts a descriptive-analytical method. To do this, data were collected from spoken and written languages of Persian and Kurdish. For this purpose, in collecting data from the collection of movies, Kurdish and Persian serials broadcasted by the Kurdistan Provincial Network and iFilm Network (20 hours in total), written and spoken texts (1000 pages including several books of poetry and dictionaries), and also the linguistic intuitions of native Persian and Kurdish speakers have been used. The accuracy of the collected data was assessed by five male native speakers of the two languages. In the next step, the cases in which the vowel hiatus occurred were extracted, then the data in which the process of glide formation through vowel shortening had occurred were identified by the researchers in both languages. In the last step, the analysis of the process of glide formation through vowel shortening was performed on the collected data in both Persian and Kurdish languages.

5. Phonological Analysis of Vowel Hiatus in Persian and Central Kurdish

5.1. Persian

The high vowels /u/ and /i/ in Persian are both long. If either of these two vowels is placed at the end of a stem or a word and the plural suffix [-ɑn] is added to that stem or word, vowel hiatus occurs. In such cases, through glide formation, the long vowel /i/ is shortened and a part of it is converted into the glide /j/, as in the examples in (1).

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(1) [bɑ.zɑ.ri:] ‘marketeer’ + plural suffix [-ɑn] → [bɑ.zɑ.ri.jɑn] ‘marketeers’
[se.pɑ.hi:] ‘corps man’ + plural suffix [-ɑn] → [se.pɑ.hi.jɑn] ‘corps men’
[dɑ.neʃ.gɑ.hi:] ‘academic’ + plural suffix [-ɑn] → [dɑ.neʃ.gɑ.hi.jɑn] ‘academics’
[læʃ.kæ.ri:] ‘military man’ + plural suffix [-ɑn] → [læʃ.kæ.ri.jɑn] ‘military men’
[ʔær.teʃi:] ‘army man’ + plural suffix [-ɑn] → [ʔær.te.ʃi.jɑn] ‘army men’
[mɑ.hi:] ‘fish’ + plural suffix [-ɑn] → [mɑ.hi.jɑn] ‘fishes’

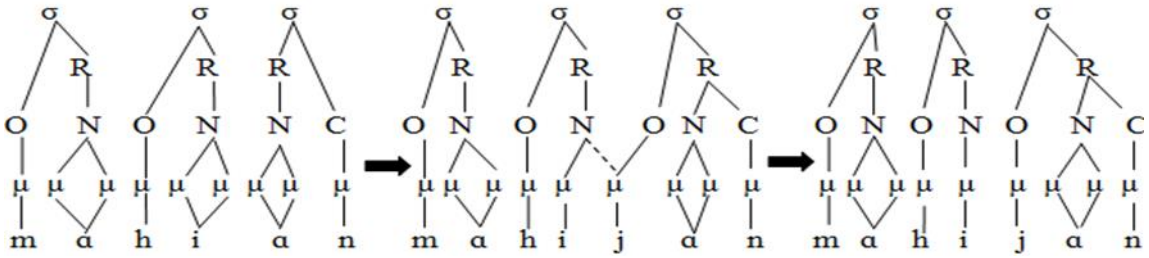
In data in (1), the long vowel /i/ has two moras. With the addition of the plural suffix [-ɑn] to words ending in the long vowel /i/, to avoid vowel hiatus, the long vowel /i:/ loses one of its moras by becoming a shortened vowel /i/ and transfers this mora to the glide /j/. However, by losing a mora which leads to its reduction, the long vowel /i/ does not change qualitatively. In other words, the long vowel /i/ in the words in (1) is not changed into the short vowels /æ, e, o/. Rule 1 can be provided for the above hiatus resolution process:

Rule 1:

/i/ → [i+j] / —{ɑ}

The shortening process of the long vowel /i/ due to glide formation in the hiatus environment /i-ɑ/, and the transferring of one of its moras it to the glide /j/ is shown in Figure 2:

Figure 2
Representation of Glide Formation of the Long Vowel /i/ in [mɑ.hi.jɑn] ‘fish’



According to Figure 2, by transferring a mora from the long vowel /i/ to the glide /j/, the weight of the syllable (CV:) containing the long vowel /i/ decreases to a lighter syllable (CV).

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In Persian, another context in which glide formation is accompanied with vowel shortening is when the plural suffix [-ɑn] is added to words that end in an open syllable containing the long vowel /u:/, as in the examples in (2):

(2) [bɑ.nu:] 'lady' + plural suffix [-ɑn] → [bɑ.no.wɑn] 'ladies'
[ʔɑ.hu:] 'deer' + plural suffix [-ɑn] → [ʔɑ.ho.wɑn] 'deer'
[ʔæb.ru:] 'eyebrow' + plural suffix [-ɑn] → [ʔæb.ro.wɑn] 'eyebrows'
[bɑ.zu:] 'arm' + plural suffix [-ɑn] → [bɑ.zo.wɑn] 'arms'
[gi.su:] 'hair' + plural suffix [-ɑn] → [gi.so.wɑn] 'hair'
[hen.du:] 'Hindu' + plural suffix [-ɑn] → [hen.do.wɑn] 'Hindus'

In the examples in (2), with the addition of the plural suffix [-ɑn] to words ending in the long vowel /u/, to prevent vowel hiatus, the long vowel /u/ is reduced by losing one of its moras and is converted into the short vowel /o/, and the glide /w/ forms as an intermediate phoneme between the two vowels. In fact, the long vowel /u/ goes through a qualitative change and is turned into /o/ by losing one mora which leads to its reduction. Rule 2 can be provided for the above hiatus resolution process:

Rule 2:

/u/ → [o+w] / —{ɑ}

The shortening process of the long vowel /u/ due to glide formation in the hiatus environment /u-ɑ/, and the transferring of one of its moras it to the glide /w/ is shown in Figure 3:

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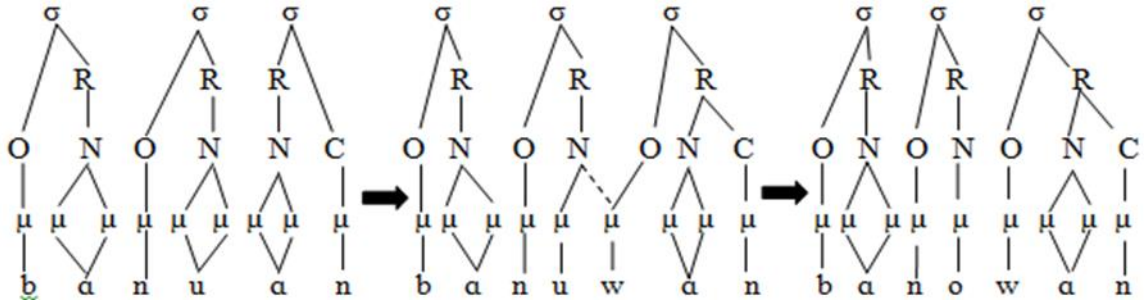
Figure 3

Representation of Glide Formation of the Long Vowel /u/ in [ba.no.wan] 'ladies'



As can be seen in Figure 3, by transferring a mora from the long vowel /u/ to the glide /w/, the vowel is reduce to the short vowel /o/. As a result, the weight of the syllable (CV:) decreases to a lighter syllable (CV).

5.2. Central Kurdish

In Kurdish word-formation process, when the first morpheme ends in a vowel and the second morpheme begins with a vowel, three different corrective strategies, i.e. deletion, consonant epenthesis, and glide formation, are used to prevent vowel hiatus, of which glide formation is the most common (Sadeghi, 2017). The following are some examples of the use of deletion and epenthesis to avoid hiatus:

(3) [sæ.læ] 'basket' + definite singular morpheme [-ækæ] → [sæ.læ.kæ]
[bə.rɑ] 'brother' + definite singular morpheme [-ækæ] → [bə.rɑ.kæ]
[mɑ.si:] 'fish' + definite singular morpheme [-ækæ] → [mɑ.si:.jæ.kæ]
[ʃu:] 'husband' + definite singular morpheme [-ækæ] → [ʃu:.wæ.kæ]

In addition to the above solutions, in Kurdish, when a long vowel is placed next to another vowel at the morpheme boundary, one of the following two conditions occurs:

a) The long vowel is shortened by giving one of its moras to the corresponding glide, which is placed as an intermediate phoneme between the two vowels. This means that one of the moras of the long vowels /i/ or /ē/ is turned into /j/, or, similarly, one of the moras of the long vowels /ō/ or /u/ is turned into /w/, and is therefore attached to the following syllable, as in the examples in (4):

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(4) [si:] 'lung' + definite singular morpheme [-ækæ] → [si.jæ.kæ]
[pē:] 'foot' + definite singular morpheme [-ækæ] → [pē.jæ.kæ]
[dō:] 'yogurt drink' + definite singular morpheme [-ækæ] → [dō.wæ.kæ]
[tu:] 'berry' + definite singular morpheme [-ækæ] → [tu.wæ.kæ]

b) Without shortening the first long vowel, the second vowel is turned into the corresponding glide to the first vowel and is attached to the syllable preceding it, as in the examples in (5):

(5) [si:] 'lung' + genitive morpheme [-i] → [si:j]
[tu:] 'berry' + linking morpheme [-u] → [tu:w]

In the data in (4) the long vowels /i, ē, ō, u/ have two moras. By suffixing the definite singular morpheme [-ækæ] to words ending in long vowels /i, ē, ō, u/, to avoid hiatus, long vowels, through turning into short vowels, lose one of their moras and transfer it to the glides /j/ or /w/. However, the long vowels /i, ē, ō, u / do not change qualitatively by losing a mora which leads to their shortening. Rule 3 can be provided for this hiatus resolution process:

Rule 3:

/i, ē/ → [i+j, ē+j] / —{æ}

/u, ō/ → [u+w, ō+w] / —{æ}

The shortening process of the long vowel /i/ due to glide formation in the hiatus environment, and the transferring of one of its moras to the glide /j/ is shown in Figure 4:

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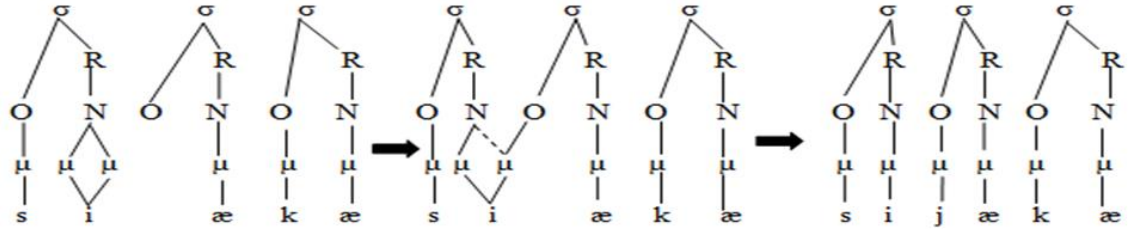
Figure 4

Representation of Glide Formation of the Long Vowel /i/ in the Word [si.jæ.kæ]



According to Figure 4, by transferring a mora from the long vowel /i/ to the glide /j/, the weight of the syllable (CV:) containing the long vowel /i/ decreases to a lighter syllable (CV).

6. OT Analysis

As discussed earlier, in Persian the high vowels /u/ and /i/ are both long. If either of these two vowels is placed at the end of a stem or a word and the plural suffix [-ɑn] is added to that stem or word, vowel hiatus occurs. In such cases, the high vowel at the end of the base is shortened and one of its moras is transferred to the glide which acts as an intermediate consonant between the two vowels. Rosenthal (1994) states that due to the pattern and manner of articulation of the non-high vowels, glide formation of these (non-high) vowels is not an optimal process and occurs only in a few languages. Also, Tanner (2006) and Kadenge and Mudzigwa (2011) assert that in the sequence of two vowels, glide formation occurs only for the first vowel. Persian is also one of the languages in which the process of glide formation of the high vowels /i/ and /u/ takes place in order to prevent vowel hiatus. In Persian, when the plural suffix [-ɑn] is added to words ending in an open syllable with the long vowel /i/, as in the word [ʔær.teʃi:] ‘army man’, in order to prevent vowel hiatus, the long vowel /i:/ is shortened by losing one of its moras and is turned into the shorter vowel /i/ and the glide /w/. In fact, the [+long] feature of the long vowel /i:/ is changed into [−long]. In OT analysis, the generator can generate the following candidates based on the input [ʔær.teʃi:] + [-ɑn]: 1) [ʔær.te.ʃi:.ɑn]; 2) [ʔær.te.ʃi:.n]; 3) [ʔær.te.ʃi:.jɑn]; 4) [ʔær.te.ʃi.wɑn]; and 5) [ʔær.te.ʃi.jɑn].

Persian is one of the languages in which vowel hiatus is not allowed, hence ruling out the first candidate [ʔær.te.ʃi:.ɑn]. Therefore, in OT terms, the markedness constraint ONSET which does not allow vowel hiatus is unviolated:

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ONSET: Vowel hiatus in two adjacent syllables is not allowed (Kager, 1999).

In Persian, the deletion of the vowel in this context is ruled out as a strategy to resolve vowel hiatus. Therefore, in the second candidate [ʔær.te.ʃi:.n], violating the faithfulness constraint MAX is considered a fatal violation. In the glide formation process, there is no epenthesis; rather, the long vowel is transformed into a short vowel and a glide. Hence, the faithfulness constraint DEP does not allow the insertion of a glide in the third candidate [ʔær.te.ʃi:.jɑn]. Regarding the fourth candidate [ʔær.te.ʃi.wɑn], it should be said that in the glide formation process in which a long vowel is shortened and a part of it is turned into a glide, there must be a constraint to create a correspondence between the type of the glide and the vowel; that is, the vowel /i/ must correspond to the glide /j/, and the vowels /u/ and /o/ to the glide /w/. This correspondence is related to the homorganic place of articulation for the vowel and the glide. In this context, if we consider the faithfulness constraint IDENT(round) to watch for the correspondence between the glide and the preceding vowel, the problem arises that the faithfulness constraints control the mapping of input onto output, while in the glide formation process, the glide formed by the long vowel is not present in the input. For this reason, a constraint must ensure the correspondence between the glide and the preceding vowel that is applied only to the output. This constraint is the markedness constraint AGREE(place), which ensures the homogeneity of the place of articulation for the glide and the vowel. Due to this constraint, the fourth candidate [ʔær.te.ʃi.wɑn] cannot be the optimal output despite having glide formation and vowel shortening of /i:/ into /i/, because it has violated the markedness constraint AGREE(place). The fifth candidate [ʔær.te.ʃi.jɑn] is the optimal output because through the glide formation process, the long vowel /i:/ is shortened to /i/ and the corresponding glide to the vowel is added to the final syllable. Nevertheless, the fifth candidate violates the faithfulness constraint IDENT(μ). The justification for this can be found in the ranking of constraints in Persian. Within the given constraints, the markedness constraint ONSET is of the highest rank and inviolable. Then, there is the violable markedness constraint AGREE(place), because in some contexts in Persian this constraint is violated. In the /i-ɑ / environment, the faithfulness constraints DEP and MAX are not violated either, but they are ranked lower than the markedness constraint AGREE(place). However, in most cases, Persian prefers the violation of DEP rather than MAX to resolve vowel hiatus. As a result, MAX is placed higher than DEP.

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The faithfulness constraint IDENT(μ) is ranked lowest. In Persian, the ranking of the constraints governing vowel hiatus resolution in the /i-ɑ/ environment can be represented as below:

(6) ONSET >> AGRRE(place) >> MAX >> DEP >> IDENT(μ)

In Tableau 1, the interaction of constraints in (6) to give the optimal output for the word /ʔær.te.ʃi: + ɑn/ 'army men' can be seen.

Tableau 1

Evaluation Tableau for the Input /ʔær.te.ʃi: + an/

Input: /ʔær.te.ʃi:+ɑn/	**ONSET**	**AGREE (place)**	**MAX**	**DEP**	**IDENT (μ)**
1. ʔær.te.ʃi:.ɑn	*!				
2. ʔær.te.ʃi.wɑn		*!			*
3. ʔær.te.ʃi:.n			*!		*
4. ʔær.te.ʃi:.jɑn				*!	*
☞ **5. ʔær.te.ʃi.jɑn**					*

Tableau 1 shows that candidate 1 violates the markedness constraint ONSET, candidate 2 violates AGREE(place), candidate 3 violates MAX, and candidate 4 violates DEP, and they are hence eliminated from the competition with candidate 5. As can be seen, candidate 5 is the optimal output despite violating the faithfulness constraint IDENT(μ).

In Persian, in addition to the /i-ɑ/ environment, glide formation is also used to resolve vowel hiatus in the /u-ɑ/ environment. In this language, when the plural suffix [-ɑn] is added to words ending in an open syllable with the vowel /u/, such as the word [bɑ.nu] 'lady', in order to prevent hiatus, the long vowel /u/ is reduced by losing one of its moras and is converted into the short vowel /o/ and the glide /w/. In this process, the [+long] and [+high] features of the long vowel /u/ are changed into [−long] and [+mid] and the vowel is shortened. In fact, in this glide formation process, the vowel /u/ undergoes both a quantitative and a qualitative phonetic change and is converted into /o/. In OT analysis, the generator can generate the following candidates on the input [bɑ.nu:] + [-ɑn]: 1) [bɑ.nu:.ɑn]; 2) [bɑ.nu.wɑn]; 3) [bɑ.no.jɑn]; 4) [bɑ.nu.n]; 5) [bɑ.nu.jɑn]; and 6) [bɑ.no.wɑn].

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As mentioned earlier, Persian does not allow vowel hiatus, and in Optimality Theory the markedness constraint ONSET prohibits hiatus. According to this constraint, Persian does not favor the first candidate [bɑ.nu:.ɑn] as the optimal output. The second candidate [bɑ.nu.wɑn] could potentially be an optimal one, as it does not violate the ONSET constraint. However, Persian does not regard the second candidate as the optimal output either because the vowel /u/ before the glide has not undergone a qualitative change, i.e., the change of the high vowel /u/ into the mid /o/, despite going through a quantitative change (reduction of the vowel length). To resolve this, the markedness constraint $V_{high}w$ deals with this situation:

*$V_{high}w$: High vowels are not allowed before the glide /w/.

According to the above markedness constraint, Persian does not allow the second candidate [bɑ.nu.wɑn] to surface as the output, because in the /u-ɑ/ environment the vowel preceding the glide is a high vowel. Regarding the third candidate [bɑ.no.jɑn], it should be noted that in the glide formation process, the markedness constraint AGREE(place), which ensures the place of articulation correspondence between the vowel and the glide, does not favor the third candidate. In this context in Persian, deletion is not one of the solutions to resolve vowel hiatus; therefore, in the fourth candidate [bɑ.nu.n], the faithfulness constraint MAX prevents the deletion of one of the two vowels. As mentioned before, there is no epenthesis in the glide formation process; rather, the long vowel is converted into a short vowel and a glide. Hence, the faithfulness constraint DEP does not allow the insertion of a glide in the fifth candidate [bɑ.nu.jɑn]. The sixth candidate [bɑ.no.wɑn] is the optimal output, because through the glide formation process, the long vowel /u/ is reduced quantitatively and qualitatively to the short vowel /o/ and the corresponding glide is added to the final syllable. Yet, candidate 6 violates the faithfulness constraint IDENT(μ). To justify this situation, the ranking of the constraints must be examined. Within the given constraints, the markedness constraint ONSET has the highest rank because this constraint is never violated in Persian. Then there are the markedness constraints *$V_{high}w$ and AGREE(place). In the /u-ɑ/ environment, the faithfulness constraints DEP and MAX are not violated either. However, in most cases, Persian prefers the violation of DEP rather than MAX to resolve vowel hiatus. Therefore, MAX is ranked higher than DEP. The faithfulness constraint IDENT(μ) is ranked lowest. In

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Persian, the ranking of the constraints on vowel hiatus resolution in the /u-ɑ/ environment can be represented as below:

(7) ONSET >> *V_{high}w, AGREE(place) >> MAX >> DEP >> IDENT(μ)

In Tableau 2, the interaction of constraints in (7) to give the optimal output for the word /bɑ.no + ɑn/ 'ladies' can be seen.

Tableau 2

Evaluation Tableau for the Input /ba.nu: + an/

Input: /bɑ.nu: + ɑn/	ONSET	*V_{high}w	AGREE (place)	MAX	DEP	IDENT (μ)
1. bɑ.nu:.ɑn	*!					
2. bɑ.nu.wɑn		*!				*
3. bɑ.no.jɑn			*!			*
4. bɑ.nu.n				*!		*
5. bɑ.nu.jɑn					*!	*
☞ 6. bɑ.no.wɑn						*

As it is shown in Tableau 2, candidate 1 violates the markedness constraint ONSET, candidate 2 violates *V_{high}w, candidate 3 violates AGREE(place), candidate 4 violates MAX, and candidate 5 violates DEP, and they are hence eliminated from the competition with candidate 6. As can be seen, candidate 6 is the optimal output despite violating the lower-ranked faithfulness constraint IDENT(μ).

In Kurdish, the two high vowels /u/ and /i/ and the two mid-high vowels /ē/ and /ō/ are long. If either of these vowels appears at the end of a stem or a word, and the definite singular suffix [-ækæ] is added to that stem or word, vowel hiatus occurs. In such cases, the long vowel at the end of the base is shortened and one of its moras is turned into the corresponding glide. In Kurdish, when the definite singular suffix [-ækæ] is added to words ending in an open syllable with the long vowels /i:/ or /u:/, in order to prevent hiatus, the long vowels /i:/ and /u:/ are shortened by losing one of their moras and are turned into short vowels /i/ and /u/ and the corresponding glides /j/ and /w/, as in the words [si:] + [-ækæ] → [si.jæ.kæ], or [tu:] + [-ækæ] → [tu. wæ.kæ]. In fact, in the process of glide formation, the [+long] feature of the vowels

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/i:/ and /u:/ is changed into [−long] and the vowels are shortened. In OT analysis, the generator can generate the following candidates on the input [si:] + [-ækæ]: 1) [si:.ækæ]; 2) [si:.jæ.kæ]; 3) [si:.kæ]; 4) [si.wæ.kæ]; and 5) [si.jæ.kæ].

Like in Persian, in Kurdish vowel hiatus is not allowed. Therefore, in Optimality Theory the markedness constraint ONSET prohibits hiatus. According to this constraint, Kurdish does not favor the first candidate [si:.ækæ]. In the second candidate [si:.jæ.kæ], glide insertion has occurred. However, glide insertion is not allowed in the context in question and is not hence a suitable solution to resolve vowel hiatus, and the faithfulness constraint DEP ensures this. In the third candidate [si:.kæ], vowel deletion has occurred, which is banned by the faithfulness constraint MAX. Regarding the fourth candidate [si.wæ.kæ], it should be pointed out that in the glide formation process, the glide must correspond to the preceding vowel. This means that there must be a constraint on the correspondence between the glide and its preceding vowel which guarantees this correspondence. In this case, the constraint that ensures the homogeneity of the place of articulation of the glide and the vowel is the AGREE(place) markedness constraint. Therefore, AGREE(place) does not allow the fourth candidate to surface. The fifth candidate [si.jæ.kæ] violates the faithfulness constraint IDENT(μ). In the ranking of the given constraints, ONSET is ranked highest because this constraint is never violated in Kurdish. Also, the markedness constraint AGREE(place) is inviolable in Kurdish. Thus, AGREE(place) has the same rank as ONSET. The two faithfulness constraints MAX and DEP are violated in some vowel hiatus contexts in Kurdish (examples 3). However, the ranking of these two constraints cannot be determined decidedly. These two constraints are ranked lower than the markedness constraints ONSET and AGREE(place). The IDENT(μ) constraint is ranked lowest, because it is violable in the studied context. In Kurdish, the ranking of constraints on the process of glide formation through vowel shortening in the hiatus environments /ē-æ/, /i-æ/, /u-æ/ and /ō-æ/ can be specified as follows:

(8) ONSET, AGREE(place) >> MAX, DEP >> IDENT (μ)

In Tableau 3, the interaction of constraints in (8) to give the optimal output for the word /si: + ækæ/ can be seen.

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Tableau 3

Evaluation Tableau for the Input /si:+ ækæ /

Input: /si:+ ækæ/	ONSET	AGREE (place)	MAX	DEP	IDENT (μ)
1. si:.ækæ	*!				
2. si.wæ.kæ		*!			*
3. si:.kæ			*!		
4. si:.jæ.kæ				*!	
☞ 5. si.jæ.kæ					*

Tableau 3 shows that the first candidate violates the markedness constraint ONSET, candidate 2 violates AGREE(place), candidate 3 violates MAX, and candidate 4 violates DEP, and they hence lose the competition to candidate 5. As can be seen, candidate 5 is considered the optimal output despite violating the lower-ranked faithfulness constraint IDENT(μ).

7. Conclusion

The present study investigated the issue of hiatus resolution and its relation to vowel shortening in Persian and Central Kurdish within an Optimality-Theoretic framework. Analysis of the data showed that the two typologically related languages, Persian and Central Kurdish, use glide formation through vowel shortening to resolve hiatus in certain environments. Also, according to the pattern and manner of articulation of non-high vowels, according to Rosenthal (1994), glide formation of these (non-high) vowels is not an optimal process and occurs only in a few languages. Consistent with this view, analysis of Persian language data also revealed that, in order to resolve hiatus, the two high vowels /i/ and /u/, as a result of glide formation through vowel shortening, are converted into a short vowel and the glides /j/ and /w/, respectively. In fact, in Persian, glide formation occurs only in high vowels and in the first position of the two environments /i-ɑ/ and /u-ɑ/. In Central Kurdish, however, glide formation occurs in high vowels /iː, uː/ and mid-high vowels /ēː, ōː/. In this process, the long high vowels /iː, uː/ and the long mid-high vowels /ēː, ōː/ are turned into a short vowel and the corresponding glide /j/ or /w/. Another issue that was revealed in data analysis is that glide formation in Persian is done through a quantitative change in the vowel /iː/ and its conversion into /i/, and also a quantitative and qualitative change in the vowel /uː/ and its conversion into the short vowel /o/. However, glide formation in Central Kurdish is

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associated with only a quantitative change in long vowels and their conversion into short vowels. It is remarkable that glide formation of non-high vowels is not an optimal process in languages (Kadenge & Mudzigwa, 2011). The OT analysis also revealed that the main driving factor in resolving hiatus in both Persian and Central Kurdish is the need for the syllable structure to have an onset. This means that the markedness constraint ONSET has the highest rank among the active constraints governing hiatus resolution in both languages. Also, in contexts where glide formation occurs through vowel shortening, the order of active constraints in Persian for the /i-ɑ/ environment is: ONSET >> AGREE(place) >> MAX >> DEP >> IDENT(μ); and for the /u-ɑ/ environment, the order is: ONSET >> *V_{high}w, AGREE(place) >> MAX >> DEP >> IDENT(μ). Also, the ranking of active constraints in Central Kurdish to resolve hiatus through vowel shortening in the environments /ē-æ/, /i-æ/, /u-æ/ and /ō-æ/ is: ONSET, AGREE(place) >> MAX, DEP >> IDENT(μ). There is evidence of glide formation and hiatus resolution in the middle stages of Iranian languages. A historical exploration of this issue and the evolution of this phonetic process is yet to be done in future studies by interested researchers.

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