

Avoidance of Association Line Crossing in Prosodic Structure: An Examination of Non-Local Compensatory Lengthening in Colloquial Persian

Mufleh Salem M. Alqahtani*

Department of Linguistics and Translation Studies, King Saud University, Saudi Arabia

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Abstract

This study examines how association line crossing in prosodic structure, as well as a bad sonority contour triggered by a glottal approximant in postconsonantal position, is avoided by non-local Compensatory Lengthening (CL) that invokes the double flop operation concerning Colloquial Persian. The study concludes that non-local CL in Colloquial Persian relies on Flop and Spread. After the deletion of a glottal consonant in the postconsonantal position that conforms to Weight-By-Position (WBP), the remaining postvocalic consonant is delinked from its mora and flops to the floating mora of the deleted glottal stop. The stem vowel would have an opportunity to spread to the adjacent mora to lengthen. This study also shows that the framework of Optimality Theory (OT) can support the double flop operation in non-local CL.

Keywords: Colloquial Persian; Non-local CL; Crossing association lines; Spread and Flop; OT.

Introduction

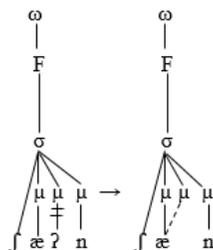
This study explains the avoidance of association line crossing in prosodic structure when dealing with non-local compensatory lengthening (CL) in Colloquial Persian to fulfill well-formedness in Universal Grammar (UG). Before stepping into any further analysis, it is crucial to tell the reader from where association line crossing originates and which phonological phenomenon represents association line crossing. Association line crossing is derived from the overlapping relation in time (Williams 1971; Goldsmith 1976; Pulleyblank 1983; Archangeli 1984; Nespor and Vogel 1986; Sagey 1986). In fact, as per Goldsmith (1976) and Nespor and Vogel (1986), two conditions are obligatorily met to accomplish well-formedness in UG; all prosodic units must be associated with at least one segment, and no association line can be crossed. Meeting the second condition is easily achieved when dealing with the local CL in Colloquial Persian. Consider the following representation:

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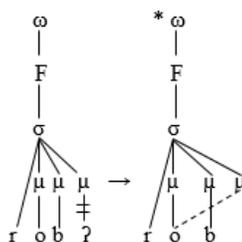
* Corresponding Author: mqahtani1@ksu.edu.sa

(1) /ʃæʔn/ → [ʃæ:n] ‘dignity’



The representation in (1) shows no association line crossing since the stem vowel spreads to the adjacent mora of the deleted consonant. On the other hand, dealing with the non-local CL in Colloquial Persian is a different story; hence, the second condition is considered a challenge when coping with non-local CL, as shown in the following representation:

(2) /rɒbʔ/ → [rɒ:b] ‘quarter’



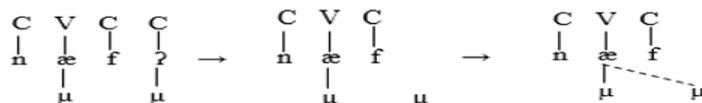
The non-local CL in Colloquial Persian is addressed by Darzi (1991), Sumner (1999), and Samko (2011). Darzi (1991), who worked on CL in colloquial Tehrani Farsi, stated that the deletion of the postconsonantal glottals results in vowel lengthening whereby the left moraic nodes of the deleted glottal consonants are linked to vowels.

(3) Non-local CL in Colloquial Tehrani Farsi (Darzi 1991):

a. /qætʔ/	[qæ:t] ¹	“cut (noun)”
b. /næfʔ/	[næ:f]	“benefit”
c. /solh/	[so:l]	“peace”
d. /rɒbʔ/	[rɒ:b]	“quarter”
e. /ʃejʔ/	[ʃe:j]	“object”

Darzi (1991) observed that the crossing of association lines as per Goldsmith (1976) and Hayes (1989) is the consequence of non-local CL in Colloquial Tehrani Farsi. Therefore, he proposed a CV and moraic tiers where vowels can freely associate with a standard mora, as shown in the following diagrams:

(4) CV and moraic tiers (Darzi 1991:35)



In the moraic representation in (4), one of the two moras is linked to a postconsonantal glottal. Since the CV and moraic tiers are separate, the vowel can freely associate with the left mora of the deleted glottal stop.

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Sumner (1999) rejected Darzi's (1991) solution for forming separate CV and moraic tiers. First, unlimited long-distance CL was allowable by this type of representation. Second, the success of this analysis relied on the idea that glottal consonants are moraic, while other consonants are not. However, this would cause a problem when considering the sonority of glottal consonants versus other consonants (Sumner 1999). Zec (1995:107) argued that "if obstruents appear in WBP, this implies that the remaining segments in the inventory are also members of the moraic set." Kavitskaya (2002) addressed the problem of assigning moras to glottal consonants, which are realized as approximants in intervocalic and postconsonantal position in Tehrani Farsi based on both phonological and phonetic evidence, as discussed in Section 2. Turning to criticism on Darzi's (1991) solution, Kavitskaya (2002) states that Darzi's (1991) model is problematic for two reasons; first, since there are no association lines to prevent the spreading, Darzi's (1991) model predicts that the loss of coda consonant may cause lengthening of the vowel in the following syllable. The second reason is peculiar to matching the standard prosodic hierarchy; hence, Kavitskaya (2002: 31) reports that:

Under Darzi's (1991) account, syllables represent groupings of segmental material, but do not constitute a higher level of prosodic hierarchy with respect to moras. This understanding of syllables is in conflict with standard insights of various works on syllable-related phenomena and syllable typology.

Samko (2011) demonstrated the crossing of association lines regarding non-local CL in Tehrani Farsi through the analysis of harmonic serialism as an OT model. She followed Kavitskaya's (2002) statement that glottals in postvocalic and postconsonantal position that are approximants are moraic. She stated that the final glottal with the preceding consonant is shared with one mora to prepare an environment in which the occurrence of mora sharing does not cross the association line. However, as per Samko's (2011) study, four comments on her study should be specified. First, her analysis targets one example of a postconsonantal glottal stop while neglecting to address a postconsonantal glottal fricative, e.g., /ro^ubʔ^u/ → [ro:^ub] "quarter". Second, there is crucial and plausible evidence of the contrast between glottal consonants as approximants synchronically motivating CL and as obstruents which are immune to deletion in the onset position. This evidence has not yet been examined and constitutes the basis of this study. The third comment on Samko's (2011) study pertains to her finding, i.e., [ro:^ub], of which a word-final consonant becomes non-moraic that consequently violates WBP. Finally, she never discussed how the double flop operation serves as a repair strategy for repairing a bad sonority contour, stemming from the sonority of glottals in postconsonantal position as well as the importance of the same strategy for avoiding association line crossing. These comments are taken into consideration in the current study which aims to clarify how the avoidance of crossing association that results from non-local CL in Colloquial Persian is achieved by the process of Flop and Spread, respectively with the utility of OT, as a framework. To do so, the questions that must be addressed are how can the process of Flop and Spread be used to avoid the crossing of association lines found in non-local CL in Colloquial Persian? How can the process of Flop and Spread to avoid the crossing of association lines in non-local CL in Colloquial Persian be accounted for using OT? The next section explains the allophony of glottals in Colloquial Persian to show how the glottal deletion

in postvocalic and postconsonantal position yields vowel lengthening compared to the deletion of other consonants in the same environment.

2. The Allophony of Glottals in Colloquial Persian

The glottal consonants /ʔ/ and /h/ are realized as strong allophones in word-initial position that resist glottal deletion or vowel lengthening, e.g., /hæ.læ.zun/ → [hæ.læ.zon] “snail” and /ʔin.sən/ → [ʔin.sæn] “human” (Samareh 1977). Similarly, Windfur (1979, 1997) postulates that the glottal stop /ʔ/ in word-initial position is realized with stricture in careful speech, while its chances of being realized as a weak allophone in the same position are highly unlikely. Alternatively, both glottal deletion and CL are excluded in the word-initial position. Darzi (1991) focuses on CL in Tehrani Farsi, stating that glottals in the onset position are retained and preserved as non-moraic as well as other consonants in the same position. Consider the following examples:

(5)

Input	Output	Gloss
a. /hæ.læ.zun/	[hæ.læ.zon]	“snail”
b. /ʔin.sən/	[ʔin.sæn]	“human”
c. /hæ.ləl/	[hæ.læl]	“halal”
d. /hu.sain/	[hu.sain]	“proper name”
e. /ʔa.zad/	[ʔa.zad]	“free”

Windfur (1997) argued that the glottals /ʔ/ and /h/ tend to be articulated fleetingly in the intervocalic and word-initial positions.² However, Windfur’s (1997) statement was disproved by Samareh (1977), Darzi (1991), and Sadeghi (2011, 2014). Samareh (1977) wrote that the glottal stop /ʔ/ in the intervocalic position is a strong variant that does not trigger CL despite it is possibly prone to deletion in specific cases where the deletion of /h/ in the same position is unattested. Darzi (1991) agreed with the statement that a glottal stop in intervocalic position triggers deletion without invoking lengthening because it occupies the syllable-initial position without being moraic. Moreover, Sadeghi (2011, 2014) has explained that a glottal stop undergoes deletion without CL in the intervocalic context as it is realized, showing neither creaky nor breathy phonation on adjacent vowels.³ Rather, this consonant in the denoted context demonstrates normal voicing, which is sustainable via the glottal constriction gesture. Consider the following examples:

(6)

Input	Output	Gloss
a. /næ.hær/	[næ.hær]	“lunch”
b. /ʃæ.hæ.dæt/	[ʃæ.hæ.dæt]	“certificate”
c. /pæ.hen/	[pæ.hen]	“wide”

The glottals /ʔ/ and /h/ are realized respectively as creaky and breathy glottal approximants in both the postvocalic and postconsonantal positions prone to CL, as discussed in the next sections later on. Consider the following examples:

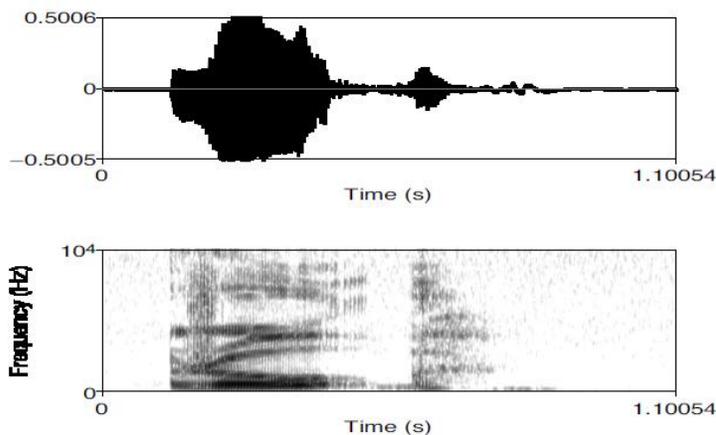
(7)

Input	Standard Persian output	Colloquial Persian output	Gloss
a. /roʔb/	[roʔb]	[ro:b]	‘terror’
b. /næfʔ/	[næfʔ]	[næ:f]	‘benefit’

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The moraicity of glottal approximants in both the postvocalic and postconsonantal position originates from phonetic and phonological evidence. For instance, Kavitskaya (2002) presents her phonetic evidence of a glottal consonant being phonologically approximant, which stems from the recording of two speakers producing glottal stops word-finally. She finds that the phonetic data from the two speakers recorded for her study confirms that glottals in Farsi are vocalized and realized phonetically as approximants even in careful pronunciation. She notes that the glottal segment is indeed vocalized even in formal speech as per the standard pronunciation of [roʔb] “terror”; i.e., the pronunciation of a glottal consonant shows no silent closure as would be expected for a true “glottal stop”.

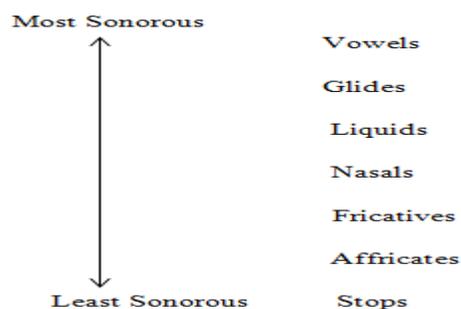
(8) Tehrani Farsi: [roʔb] ‘terror’ (formal speech) (Kavitskaya 2002:84)



Referring to the standard pronunciation of [roʔb] “terror” in the formal speech, Kavitskaya (2002) observed that the shape of the vocal tract in a glottal approximant is that of a preceding vowel but with the laryngealization on the vowel, i.e., this is parallel to what has been observed for the glottal fricative *h*. This similarity is addressed by Pierrehumbert and Talkin (1992: 93), who reported that “both /h/ and /ʔ/ are produced by a laryngeal gesture. They make no demands on the vocal-tract configuration, which is therefore determined by the adjacent segments.” Kavitskaya (2002:85) states that “the noise after the vowel can be interpreted as the vowel itself, so the vowel is reanalyzed as phonologically long due to the additional phonetic length contributed by the laryngealized part.” Moreover, glottal “stop” in the grammars of Persian was considerably described as a glottal stricture (Matthews 1956), a pharyngeal voiced strident glide (Giunashvili 1965), or just a glide (Windfur 1979). The glottal segment in Farsi is described as a phonetic and phonological approximant since it does not have a stop-like character (Kavitskaya 2002).

The phonological evidence is germane to the sonority value of glottal approximants. Based on the Persian sonority scale, Mobaraki (2013) presents the sonority hierarchy pertinent to Persian as follows:

(9) Sonority Hierarchy of Persian (Mobaraki 2013, 115)



Concerning Mobaraki's (2013) finding, glottal approximants are not shown in his sonority hierarchy above. In fact, Kavitskaya (2001) reported that a glottal consonant is predictable in occupying different places in the sonority hierarchy in different languages. This occurs if a variety of possible phonetic realizations of glottals are potentially correspondent to different phonological representations as per their moraicity status.⁴ According to her, this prediction finds support in cross-linguistic observations regarding the distribution of a glottal; this type of consonant is classified as a sonorant since it is an approximant in some languages (e.g., Karok), and is considered an obstruent, a true stop, in other languages (e.g., Kwakwala). Unlike Kwakwala, Hayes (1995) stated that some other languages, Cahuilla and Mam, for instance, have glottalised sonorants and obstruents, as the most marked codas occurred in stressed environments compared to other consonants. Cross-linguistically, glottals often pattern not only with sonorants but straightforwardly with vowels. For instance, in nasal vowel-consonant harmony, there is a universal scale (vowels, laryngeals >> glides >> liquids >> fricatives >> stops) in which segments are arranged in such a way that if any natural class blocks nasal harmony, all natural classes lower on the scale block harmony as well (Walker 1998, Flemming 2004). Furthermore, complete vowel harmony or vowel copy epenthesis often occurs only across laryngeal consonants (Kawahara 2007, Rose and Walker 2011). The aforementioned finding is also supported by Almashaqaba (2015) who discusses a phonological process known as 'guttural vowel epenthesis' in some Bedouin Arabic dialects where the epenthetic vowel [a] is motivated by the constraint against the primary gutturals (/χ, ʁ, ħ, ʕ, h, ʔ/) in the coda position. Consider the following examples:

(10)

a. /sahl/	→	[sa.h <u>al</u>]	'plain'
b. /ʔaʕma/	→	[ʔa.ʕ <u>a</u> .ma]	'blind'
c. /taχt/	→	[ta.χ <u>at</u>]	'bed'

Accordingly, the sonority scale of Persian has been modified as follows:

(11)



With regard to the modified sonority scale (11), glottal approximants become more sonorous than glides. This is why the existence of trimoraic syllables in Colloquial Persian is restricted to syllables containing glottals in both postvocalic and postconsonantal positions (Hayes 1989; Darzi 1991), as will be discussed in the next section.

To extrapolate, Kavitskaya (2002) argued that a true phonetic glottal stop that is solely subject to deletion never triggers vowel lengthening, whereas glottal consonants prone to CL are always vocalic or approximant-like. More so, she observed that the glottal consonants /h, ʔ/ are realized as approximants in Farsi in postvocalic and postconsonantal positions and are moraic through phonetic and phonological evidence based on sonority.

In summary, this section has shown the complementary distribution of glottal allophones in Colloquial Persian that are both articulated in the syllable-initial position and immune to deletion (Samareh 1977; Windfur 1979, 1997; Darzi 1991). However, the realisation of these consonants in the intervocalic position is the subject of disagreement among scholars, including Samareh (1977), Windfur (1997), Darzi (1991), and Sadeghi (2011, 2014). Windfur (1997) argued that these consonants are not deleted, while Samareh (1977), Darzi (1991), and Sadeghi (2011, 2014) agreed that a glottal stop only undergoes deletion without CL, whereas the deletion of the intervocalic /h/ is unattested. I believe that the treatment of these consonants in intervocalic position depends on ‘register’ as a sociolinguistic variation; hence, these consonants are retained intervocalically in the formal speech whilst being liable to deletion without CL in the colloquial speech. In the word-final position, both glottals are realized as approximants. That is why they are both moraic based on phonetic and phonological evidence, i.e., sonority, and are eventually targeted by CL (Kavitskaya 2002). Regarding the moraicity of segments, it is essential to explore the syllable structure of Colloquial Persian addressed in Section 3.

3. The Syllable Structure of Colloquial Persian

The syllable structure of Colloquial Persian has been taken into consideration by scholars; namely, Elwell-Sutton (1976), Hayes (1979), Windfuhr (1979), Darzi (1991), Amini (1997), Bijankhan (2000), Hall (2007), Rahbar (2012), Heidarizadi (2014), Rahmani (2019), and Alqahtani (2020). According to them, the five-syllable structures observed in Colloquial Persian are given below (Table 1):

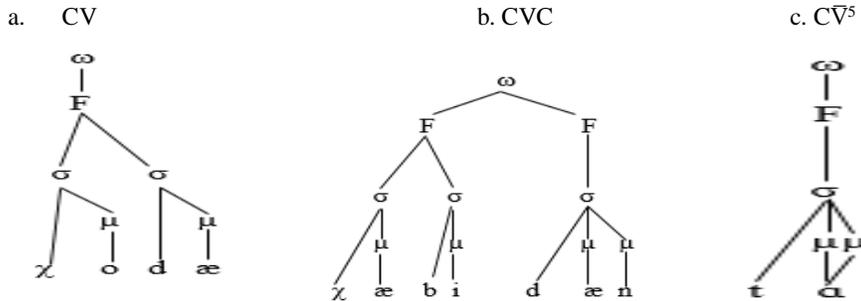
Table 1: Syllable structure in Colloquial Persian

Syllable Structure	Example	Gloss
a. CV	[χo.dæ]	“god”
b. CVC	[χæ.bi.dæ̃n]	“to sleep”
c. C \bar{V}	[tɑ]	“till”
d. C \bar{V} C	[tɑb]	“swing”
e. CVCC	[jort.me]	“tort”

As per Table 1, two crucial points pertaining to the syllable structure of Colloquial Persian are discussed in this section, i.e., syllable weight and constraints. Notably, C \bar{V} C is derived from CVCC

syllables through CL, which is considered in the following section, CV is the only light syllable, and the heavy syllables are $C\bar{V}$ and CVC that are bimoraic. Consider the following representations of light and heavy syllables (Note that ω stands for a prosodic word, and F stands for a foot):

(12)



$C\bar{V}$ can also be derived from CL that targets glottals in the postvocalic position in CVC syllables as shown in the following examples:

(13)

- a. /næ^μʔ^μna^μ/ → [næ:^{μμ}. na^μ] ‘mint’
 b. /zæ^μh^μra^μ/ → [zæ:^{μμ}. ra^μ] ‘proper noun’
 c. /fo^μʔ^μbe^μ/ → [fo:^{μμ}. be^μ] ‘branch’
 d. /zo^μh^μre^μ/ → [zo:^{μμ}. re^μ] ‘proper noun’

Hayes (1989) strongly argued for the existence of trimoraic syllables in different languages, including Old English, Farsi, German, Danish dialects, Finnish, and Estonian. According to him, the existence of trimoraic syllables can be indirectly established by patterns of CL and quantitative metrics. Also, trimoraic syllables can be directly established by the existence of three-way contrasts. Based on Hayes’s (1989) justification of trimoraicity in different languages above, syllables in Persian may be trimoraic due to CL and quantitative metrics, as he proposed below:

In this system, the light syllables correspond to a short metric position (/˘/) and heavy syllables to either a long metrical position (/—/) or two shorts (/˘˘/). Superheavy syllables (CVVC and CVCC) are scanned as (/—˘/). If we make the usual assumptions for quantitative (/—/ corresponds to two moras, /˘/ to one), then the superheavy syllables must count as trimoraic.” (Hayes 1989, 292).

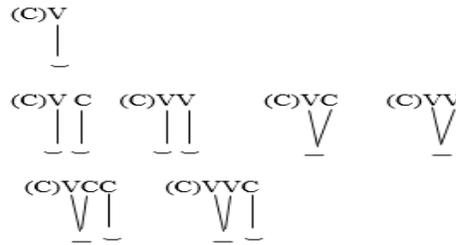
The above generalizations of quantitative metrics are based on the Persian correspondence rules (Hayes 1979, 196-197):

- a. Ignore all syllable-initial consonants.
- b. Every breve (/˘/) of the pattern must correspond to a single phonological segment of the line.
- c. Every macron (/—/) of the pattern must correspond to the syllable of the first two segments of a syllable of the line (not counting initial consonants).

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The rules of Persian correspondences are shown in the following representations:

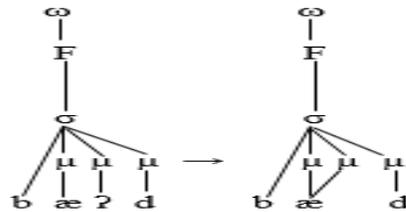
(14)



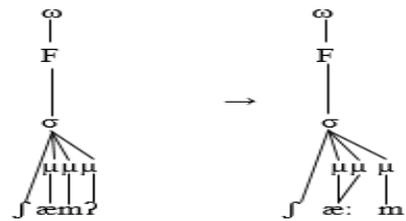
However, Darzi (1991) stated that the assignment of the three moraic slots is more highly restricted in Persian to syllables containing glottals in both postvocalic and postconsonantal positions as per colloquial Tehrani Farsi, i.e., moraicity of consonants is a language-specific phenomenon. This is seen through the deletion of glottals in postvocalic position in colloquial Tehrani Farsi which results in vowel lengthening, as shown below:

(15)

a. /bæ^μʔ^μd^μ/ → [bæ:^{μμ}d^μ] ‘after’⁶



b. /ʃæ^μm^μʔ^μ/ → [ʃæ:^{μμ}m^μ] ‘candle’⁷

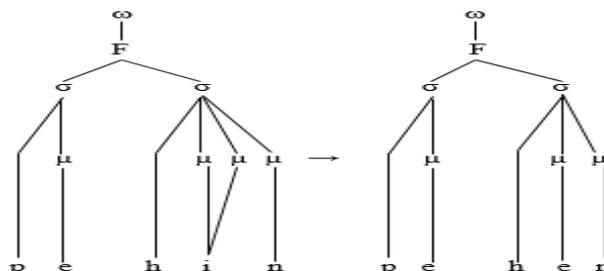


Differently, Darzi (1991) noted that the assignment of the three moraic slots is unobservable in syllables containing other consonants in postconsonantal position since the deletion of these consonants gives no vowel lengthening:

(16)

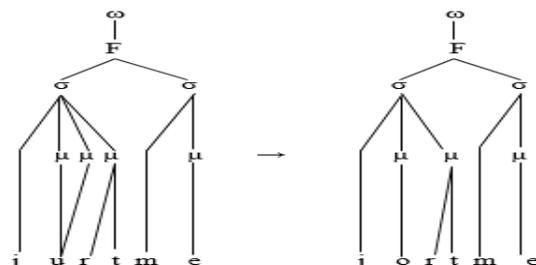
- a. /dæ^μs^μt/ → [dæ^μs^μ] * [dæ^μs^μ μ] ‘hand’
- b. /lo^μχ^μt/ → [lo^μχ^μ] * [lo^μχ^μ μ] ‘naked’
- c. /qæ^μn^μd/ → [qæ^μn^μ] * [qæ^μn^μ μ] ‘sugar’
- d. /fe^μk^μr/ → [fe^μk^μ] * [fe^μk^μ μ] ‘thought’
- e. /ko^μn^μd/ → [ko^μn^μ] * [ko^μn^μ μ] ‘slow’

(20) /pehin/ → [pe.hen] ‘dung’



Kambuzia et al. (2017) stated the exceptional case where CVCC is in a non-final position as the reduced syllable of C \bar{V} CC due to vowel shortening despite the restriction on CVCC syllable. For instance, a long vowel in / \underline{j} urt-me/ ‘tort’ undergoes vowel shortening before /r/ as a liquid, i.e., / \underline{j} urtme/ → [jort.me] ‘tort’. Consider the following representation:

(21) / \underline{j} urtme/ → [jort.me] ‘tort’



In summary, the weight of syllables in Colloquial Persian is divided into light, heavy, and superheavy, depending on the number of moras observed in each syllable type. For instance, CV is light since it is monomoraic, while two moras are found in heavy syllables of the forms C \bar{V} and CVC. The trimoraic syllables have a highly restricted distribution in Colloquial Persian. The long vowel in C \bar{V} C syllable undergoes vowel shortening if followed by either one of the consonants /l,r,n,m,ʔ,h/. C \bar{V} C syllables of which word-final consonants are other than /l,r,n,m,ʔ,h/ are considered heavy (bimoraic) since word-final consonants are linked to the preceding moras. CVCC syllables of which word-final consonants are non-glottal are considered heavy since word-final consonants are linked to the preceding moras. The same syllable type (i.e., CVCC) may be obtained from C \bar{V} CC that is attached to a consonant-initial suffix through vowel shortening if the word-final consonant in C \bar{V} CC is either one of the consonants /l,r,n,m,ʔ,h/. After demonstrating the moraicity of segments, including glottals in both postvocalic and postconsonantal positions, the following section is devoted to present data collection and analysis in the current study.

4. Data Collection and Analysis

Data in this study were obtained from the existing literature on non-local CL in Persian, including books, articles, and theses. Also, several native Persian speakers were consulted to verify the data derived from the extant literature, depending on their intuition.¹⁰

As discussed earlier, non-local CL targets glottal consonants as peripherals (postconsonantals). Why do glottals in this position motivate vowel lengthening compared to other consonants? This question has been answered previously. Section 2 represents the allophony of glottals in cases where they are realized as approximants in postvocalic and post consonantal positions (Kavitskaya 2002). Based on sonority, as phonological evidence, these consonants become moraic. More so, Kavitskaya (2002) in Section 2 provides phonetic evidence of glottals in postvocalic and postconsonantal positions as approximants, originating from the phonetic data gathered from two native speakers of Persian. In Section 3, Darzi (1991) stated that consonants in the same positions, excluding glottals, are linked to the preceding moras since the deletion of them does not lead to vowel lengthening. This is why not all CVCC and CVC syllables in Persian are trimoraic. Differently, as per Darzi (1991), the assignment of the three moraic slots is limited to syllables with glottal in the word-final positions, either postvocalic or postconsonantal, based on the cross-linguistic markedness of trimoraic syllable. The examples below show that glottals non-adjacent to vowels are subject to CL:

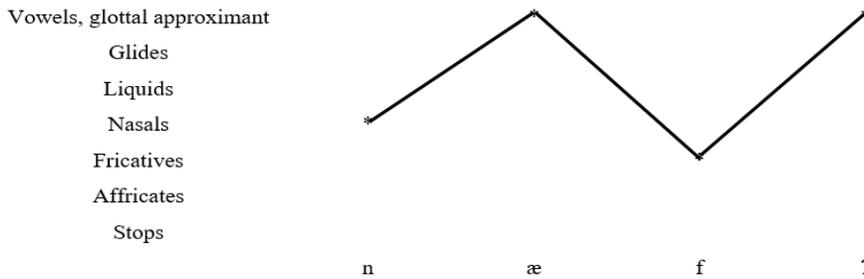
(22)

Input	Output	Gloss
a. /to ^μ b ^μ ʔ ^μ /		“nature”
	[to: ^μ b ^μ]	
b. /mæ ^μ n ^μ ʔ ^μ /	[mæ ^μ :n ^μ]	“prevention”
c. /ro ^μ b ^μ ʔ ^μ /		“quarter”
	[ro: ^μ b ^μ]	
d. /tæ ^μ r ^μ h ^μ /		“project”
	[tæ: ^μ r ^μ]	
e. /ʃæ ^μ r ^μ h ^μ /	[ʃæ: ^μ r ^μ]	“explanation”
f. /sæ ^μ r ^μ ʔ ^μ /	[sæ: ^μ r ^μ]	“epilepsy”
g. /qæ ^μ t ^μ ʔ ^μ /	[qæ: ^μ t ^μ]	“rescission”
h. /ʃæ ^μ m ^μ ʔ ^μ /	[ʃæ: ^μ m ^μ]	“candle”
i. /væ ^μ z ^μ ʔ ^μ /	[væ: ^μ z ^μ]	“situation”
j. /so ^μ b ^μ h ^μ /	[so: ^μ b ^μ]	“morning”
k. /so ^μ h ^μ /	[so: ^μ h ^μ]	“peace”
l. /ʃe ^μ j ^μ ʔ ^μ /	[ʃe: ^μ j ^μ]	“object”
m. /ʃæ ^μ r ^μ ʔ ^μ /	[ʃæ: ^μ r ^μ]	“religious law”
n. /qæ ^μ l ^μ ʔ ^μ /	[qæ: ^μ l ^μ]	“tin”
o. /næ ^μ f ^μ ʔ ^μ /	[næ: ^μ f ^μ]	“benefit”
p. /fæ ^μ r ^μ ʔ ^μ /	[fæ: ^μ r ^μ]	“branch”

Considering the modified sonority scale of Persian in section 2, a falling-rising sonority contour in the syllable’s rhyme in the examples above, which is formed by approximant glottals in postconsonantal position, yields a bad sonority contour, i.e., sonority reversal. Let us consider the representation of /næfʔ/.

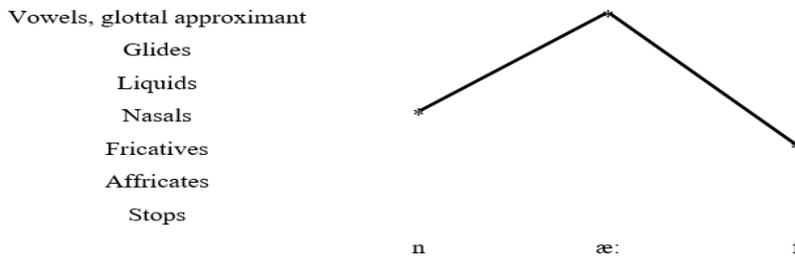
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(23) The sonority representation of the input /næfʔ/ ‘benefit’



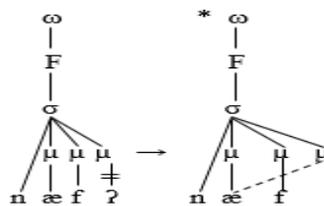
A falling-rising sonority contour in the syllable’s rhyme in (23), which is formed by the approximant glottals in the postconsonantal position, is avoided by CL as a strategy for repairing such bad sonority contour, as shown in the following representation:

(24) The sonority representation of the output [næ:f] ‘benefit’



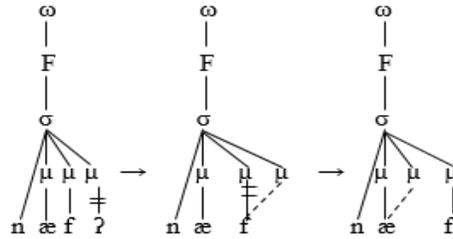
Although the non-local CL is used as a strategy for repairing bad sonority contour which results from glottal approximants in postvocalic position, it leads to the crossing of the association line without invoking the double flop operation; hence, the crossing of the association line is formed by the spreading of stem vowels to the floating moras of the non-adjacent deleted glottal consonants, resulting in irredeemably ill-formed syllables. Consider the following representation:

(25) ill-formed syllable by association line crossing



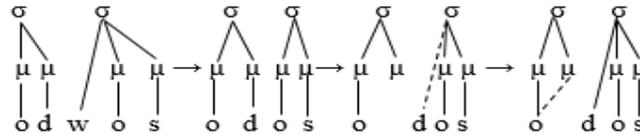
However, non-local CL in Colloquial Persian is achieved by Flop and Spread, i.e., double flop, after the deletion of glottal consonants without crossing the association line. The first step is by deleting a glottal consonant in postconsonantal position. The preceding consonant flops to a floating mora of the deleted glottal consonant, as the second step, while the same spreading consonant is delinked from its mora. The final step is the spreading of the stem vowel to the adjacent floating mora to be lengthened. As per the moraic model, non-local CL is autosegmentally shown in the presentation of the outputs of /næ^μfʔ^μ/ ‘benefit’:

(26) /næ^μf^μ?^μ/ → [næ:^μf^μ] ‘candle’



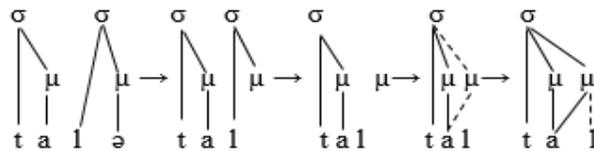
In fact, double flop is not an isolated phenomenon found in Colloquial Persian while it is utilized to deal with non-local CL in Ancient Greek and Middle English (Hayes 1989). Considering the output [o:dos] ‘threshold’ of the input /odwos/ in Ancient Greek, Hayes (1989) states that /d/ would receive WBP due to CVC being heavy in Greek. The same consonant, i.e., /d/, is resyllabified to the following syllable after the deletion of /w/, resulting in a floating mora. The preceding vowel flops to a floating mora to lengthening, as shown in the following representation:

(27) The output [o:dos] ‘threshold’ in Ancient Greek, Hayes (1989:266)



According to Hayes (1989), non-local CL in Middle English relies on the assumption that the principle of *Parasitic Delinking*, which states the loss of syllable structure when the syllable contains no overt nucleus segment. To put it simply, the delinking of a vowel segment yields the deletion of syllable structure. Considering the output [ta:l] ‘Modern English *tale*’ of the input /talə/, Parasitic Delinking after Schwa Drop incurs the loss of syllable structure; hence, a floating mora is linked to the preceding vowel melody, and the stranded [l] is resyllabified to the preceding syllable, as shown in the following representation:

(28) The output [ta:l] ‘Modern English *tale*’ (Hayes 1989: 286-269)



To summarize, the non-local CL accomplished by the double flop operation can solve the problem of a bad sonority contour and the association line crossing in Colloquial Persian, coping with glottal approximants in postconsonantal position. The next subsection is devoted to account for the aforementioned phenomenon using OT as a framework.

4.1 OT analysis of non-local CL in Colloquial Persian

The non-local CL, achieved by the double flop operation, as a repair strategy for a bad sonority contour, as well as the avoidance of association line crossing discussed earlier, can also be supported by the further analysis of the OT framework. To do so, the following OT constraints are used to evaluate the

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candidates of the input /næ^μf^μʔ^μ/ → [næ:^μf^μ] “benefit” in the following table. Consider the following OT constraints:

(29) OT constraints:

- a. WFC (b) (Byrd and Sandell 2015:4)
Association lines do not cross. Assign one violation for each crossed association line.
- b. WBP (Hayes 1989:258)
Assign a violation for each coda consonant that is not moraic.
- c. *FLOAT (Samko 2011: 29)
Assign a violation for each mora in the output that is not associated with a segment.
- d. LINEARITY “No metathesis” (McCarthy and Prince 1995: 123):
S₂ is consistent with the precedence structure of S₁, and vice versa.
- e. MAX[μ] (McCarthy 2008:290)
Assign a violation for each mora in the input that is absent in the output.
- f. Sonority Sequencing Principle (SSP) (Selkirk 1984:116):
Sonority increases towards the syllable peak and decreases towards the syllable margins.
- g. *SHARED (Samko 2011:29)
Assign a violation for each mora that dominates more than one segment in the output.
- h. DEP (McCarthy and Prince 1995:122):
Every segment of S₂ has a correspondent in S₁ (S₂ is “dependent on” S₁). (No epenthesis).
- i. MAX (McCarthy and Prince 1995:122)
Assign a violation for each segment in the input that is absent in the output.

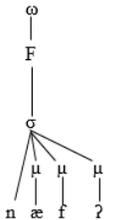
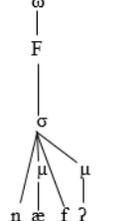
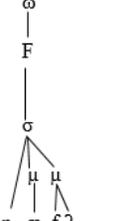
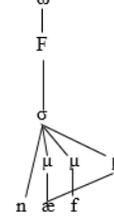
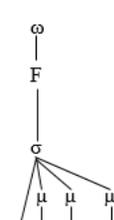
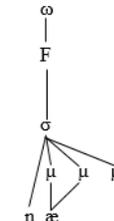
WFC(b), WBP, and *FLOAT equally outrank other constraints to eliminate candidates with crossing association lines, unmoraic word-final consonants, and floating moras. MAX[μ], LINEARITY, and SSP are ranked higher than *SHARED to militate against candidates with the deleted moras, metathesized segments, and sonority violation. *SHARED outranks MAX and DEP as faithfulness constraints to be against candidates with mora sharing. DEP is ranked higher than MAX to eliminate candidates that permit vowel epenthesis to avoid sonority violation. Consider the following set of ranking constraints:

(30)

WFC(b), WBP, *FLOAT >> MAX[μ], LINEARITY, SSP >> *SHARED >> DEP >> MAX

The above set of ranking constraints is used to evaluate the candidates of the input /næ^μf^μʔ^μ/ “benefit” in the tableau below:

Table 2: WFC(b), WBP, *FLOAT>>MAX[μ], LINEARITY, SSP>>*SHARED>>DEP>>MAX

	WFC (b)	WBP	*FLOAT	MAX [μ]	LINEARITY	SSP	*SHARED	DEP	MAX
 <p>a.</p>		*!		*		*			
 <p>b.</p>				*!		*	*		
 <p>c.</p>	*!								*
 <p>d.</p>						*!			
 <p>e.</p>									*

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<p>f.</p>			*!		*	*		
<p>g.</p>		*!						*
<p>h.</p>			*!					
<p>i.</p>							*!	
<p>j.</p>								*

The tableau (2) fails to identify one of the candidates, including candidate (f) as the desired output, as optimal. WFC (b), as one of the most highly ranked constraints, is fatally violated by the candidate (c) due to the crossing of association line, while the rest of the candidates concur with the same constraint. Although the candidate (a) is immune to the crossing of association line, this candidate is eliminated due to the fatal violation of WBP constraint. Unlike the candidate (a), WBP is satisfied by the candidate (b) while the fatal

violation of MAX[μ] by the same candidate yields the failure of optimality. Similarly, the candidate (f) incurs the fatal violation of MAX[μ] and thus not the optimal. Contrastingly, the candidate (g) retains the number of moras to satisfy MAX[μ], but the floating mora in the same candidate leads to fatal violation of *FLOAT. The candidate (d) incurs a fatal violation of SSP; thus, it is not optimal. On the other hand, the same constraint, i.e., SSP, is satisfied by candidate (h) due to the metathesis of the members of word-final cluster, but the same candidate consequently violates LINEARITY. The epenthetic vowel [æ] to avoid the violation of SSP in candidate (i) leads to the violation of DEP. The candidates (e) and (j) are not optimal since they equally violate MAX. To make candidate (e) optimal, it is necessary to add a constraint to eliminate candidate (j) as the most challenging outputs. It is clear that the difference between candidate (e) and (j) is peculiar to the existence of the glottal in word-final position. Accordingly, the following constraint acts against the word-final glottal:

(31)

***Coda-Glottal (Davis 1997:251)**

Assign one violation for each consonant that is dominated by more than one mora.

The above constraint outranks MAX to eliminate candidate (j), as shown in the following tableau:

Table 3: WFC(b), WBP, *FLOAT>>MAX[μ], LINEARITY, SSP>>*SHARED>>DEP>> *Coda-Glottal >>MAX

	WFC (b)	WBP	*FLOAT	MAX [μ]	LINEARITY	SSP	*SHARED	DEP	*Coda-Glottal	MAX
<p>a.</p>		*!		*		*			*	
<p>b.</p>				*!		*	*		*	

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<p>c.</p>	*!									*
<p>d.</p>				*!					*	
<p>e.</p>										*
<p>f.</p>			*!	*	*			*		
<p>g.</p>		*!								*
<p>h.</p>				*!						

<p>i.</p>							*!		
<p>j.</p>							*!	*!	*

The tableau above successfully determines candidate (e) as optimal through the satisfaction of the *Coda-Glottal constraint, which is, however, prone to fatal violation by candidate (j).

Conclusively, this section has revealed the non-local CL, invoking the double flop operation, is used to avoid association line crossing in prosodic structure as well as the bad sonority contour triggered by glottal approximants in postconsonantal position; hence, Flop and Spread are invoked after the deletion of glottal consonants to ensure that the association line must not cross and to comply with WBP. The remaining postvocalic consonant flops to the floating mora of the deleted glottal consonant and is delinked from its mora to prepare an environment for the stem vowel to spread to the adjacent mora where vowel lengthening is achieved. The further OT analysis has also shown how the double flop operation involved the non-local CL is capable of dealing with the association of line crossing, which is triggered by spreading the stem vowel to the non-adjacent mora of the deleted glottal consonant.

5. Conclusion

This study has examined the role of the double flop operation involved in non-local CL in Colloquial Persian in the avoidance of the association line crossing in prosodic structure, which results from the spreading of the stem vowel to the non-adjacent mora of the deleted glottal consonant as well as a bad sonority contour yielded by a glottal approximant in postconsonantal position. Such avoidance is achieved by Flop and Spread along with the deletion of glottal consonant in postconsonantal position. The preceding consonant, which is delinked from its mora flops to the floating mora of the deleting glottal consonant, and this would facilitate the spreading of stem vowel to the adjacent mora where vowel lengthening is achieved. Remarkably, the avoidance of association line crossing addressed in this study considers WBP unlike Darzi (1991) and Samko's (2011) approaches to avoid association line crossing; thus, their approaches incur the violation of WBP. The OT framework additionally supports the double flop operation in non-local CL as an approach to avoid the association line crossing and a bad sonority contour. The results of this study open up a discussion peculiar to the nature of the phonological derivation of non-local CL considering OT and should be meditated for future studies.

تجنب تقاطع خطوط الربط في البنية النغمية: تحليل الإطالة التعويضية الغير المحلية
في اللهجة الفارسية العامية

مفلح سالم القحطاني

قسم اللسانيات ودراسات الترجمة، جامعة الملك سعود، المملكة العربية السعودية

الملخص

تبحث هذه الدراسة كيفية تجنب تقاطع خطوط الربط في البنية النغمية والمنحنى السيء لتنغيم الجهوية الناجم عن التقارب الحنجري في موضع بعد الحرف الساكن اللاحق عن طريق الإطالة التعويضية غير المحلية التي تستدعي عملية التقليل المزدوج فيما يتعلق بالفارسية العامية. وخلصت الدراسة إلى أن الإطالة التعويضية غير المحلية في اللغة الفارسية العامية تعتمد على التقليل والانتشار. فبعد حذف الحرف الساكن الحنجري في موضع ما بعد الحرف الساكن الذي يتوافق مع قاعدة "الوزن حسب الموضع" باحتوائه على المجتزأ أو المورا (mora)، حيث يبقى المجتزأ أو المورا عائمة و ينقلب إليها الحرف الساكن ما بعد الصائتي بعد فك ارتباطه من المجتزأ أو المورا وعليه سيكون لحرف العلة الأصيل فرصة الانتشار إلى المورا المجاورة ليستطيل. كما تظهر هذه الدراسة أن إطار النظرية التفاضلية يمكن أن تدعم عملية التقليل المزدوج في الإطالة التعويضية غير المحلية. الكلمات المفتاحية: اللهجة الفارسية العامية، الإطالة التعويضية غير المحلية، تقاطع خطوط الربط، التقليل والانتشار، النظرية التفاضلية.

Endnotes

¹ [ː] mark indicates a long vowel.

² /ʔ/ and /h/ are the only glottals in Colloquial Persian and they are gutturals as well as the voiced uvular stop /g/ and a voiceless uvular fricative /χ/ (Windfuhr 1987; Mahootian 1997; Hosseini 2014).

³ The realisation of ʔ with an incomplete closure in intervocalic position or with a creaky voice superimposed on the vocalic stream is well-documented cross-linguistically (Ladefoged and Maddieson 1996: 75).

⁴ This statement is addressed in the following sections.

⁵ This representation is cited from Alqahtani (2020, 8).

⁶ This representation is cited from Alqahtani (2020, 9).

⁷ This phenomenon will be addressed in the two following sections.

⁸ This representation is cited from Darzi (1991, 9).

⁹ This representation is cited from Darzi (1991, 34).

¹⁰ Native speakers whom I consulted are not specialised in linguistics to avoid linguistic awareness.

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