The Phonological Opacity of Local Compensatory Lengthening in Modern Colloquial Persian: A Stratal Optimality Theoretic Approach

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This study applies Stratal Optimality Theory (OT) to illuminate the phonological opacity of local Compensatory Lengthening (CL) in Modern Colloquial Persian, which targets moraic glottal consonants /h/ and /ʔ/ in the postvocalic position. It concludes that moraic structure is built before segmental changes through Weight-by-Position (WBP), which applies before consonant deletion or vowel lengthening. This order of application ensures that moras are assigned to coda consonants before their deletion to facilitate the affiliation of floating moras to preceding stem vowels. This opaque phonological derivation involves consonant deletion counterbleeding WBP. Unlike Standard OT, Stratal OT is shown to be capable of accounting for counterbleeding through strata with different sets of OT constraints; the first stratum guarantees building moraic structure prior to segment deletion or lengthening, while the secBond stratum guarantees counterbleeding to account for CL.

Keywords: *Modern Colloquial Persian; Local CL; Counterbleeding; Stratal OT*

1. Introduction

Compensatory lengthening (CL) refers to vowel lengthening that results from the affiliation of moras of deleted consonants as weight-bearing segments (Hayes 1989; Shaw 2007; Samko 2011; Kavitskaya 2017). Accounting for CL is considered problematic in declarative phonological analysis, especially OT, since it embodies a sequence of processes that is impossible in two-level OT (i.e., where only input and surface are available) (Shaw 2007; Topintzi 2012). According to Kiparsky (1973: 79), phonological opacity arises from *counterfeeding* and *counterbleeding* interactions, as shown in (1).

(1) Opacity definition (Kiparsky 1973: 79)
A phonological Rule *P* of the form *A*→*B*/ *C*______*D* is opaque if there are surface structures with any of the following characteristics:
a. instances of *A* in the environment *C*________*D*,
b. instances of *B* derived by *P* that occurs in the environments other than *C*_____*D*.

Based on the definition of opacity in (1), the statement (1. a) is characterized as counterfeeding, also known as *underapplication opacity*, while (1. b) is characterized as counterbleeding, termed as *overapplication opacity*. Baković (2011) demonstrates that counterfeeding and counterbleeding are inverses of two transparent rule interactions, *feeding* and *bleeding*. Accordingly, counterfeeding would be feeding if rules B and A were reversed, while counterbleeding would be bleeding if rules B and A were reversed. Accordingly, the derivational versions of OT will be addressed in Section 6 to determine which version of OT is suitable to address opacity and why.

CL in Persian has long aroused the interest of scholars, most recently including Darzi (1991), Lazard (1992), Kambuziya (2007), and Aldaghi & Tavakoli (2011). Darzi (1991) describes CL in Colloquial Tehrani Farsi as the consequence of two phonological processes: the deletion of glottal consonants in coda position plus lengthening of the preceding vowel. Consider the examples in (2):

(2) I) Glottal consonants that precede word-final consonants within a syllable

	Input	Output	Gloss
a.	/ɢæʔr/	[ɢæ:r]	‘bottom’
b.	/læʔn/	[læ:n]	‘cursing’
c.	/ʃæʔn/	[ʃæ:n]	‘dignity’
d.	/roʔb/	[ro:b]	‘terror’
e.	/ræhn/	[ræ:n]	‘mortgage’
f.	/boʔd/	[bo:d]	‘dimension’

II) Glottal consonants that occur in the syllable-final position within a word

	Input	Output	Gloss
a.	/tæʔmir/	[tæ:mir]	‘repair’
b.	/næʔnɑ/	[næ:nɑ]	‘mint’
c.	/zæhrɑ/	[zæ:rɑ]	‘proper name’
d.	/væhʃi/	[væ:ʃi]	‘wild’
e.	/ʔeʔzɑm/[1]	[ʔe:zɑm]	‘dispatch’
f.	/mæhmud/	[mæ:mud]	‘a proper name’
g.	/tohfe/	[to:fe]	‘present’

Lazard (1992) states that the deletion of a preconsonantal glottal fricative in a coda and word-internally yields CL in Colloquial Persian, as demonstrated in (3):

(3)

		Standard Persian	Colloquial Persian	Gloss
I)	a.	fæh.mi.di	fæ:.mi.di	‘you have uunderstood’
	b.	ʔeh.te.rɑm	ʔe:.te.rɑm	‘respect’
II)	a.	ʃæhr	ʃæ:r	‘city’
	b.	fohʃ	fo:ʃ	‘abusive language’

[1] Darzi (1991) observes that glottals in word-initial position are immune to deletion.

Kambuziya (2007) scrutinizes CL in Persian using rule-based phonology as a framework, and presents rule (4) to describe the deletion of glottal consonants:

(4) /ʔ, h/→Ø / V__C#
VC__#

Aldaghi & Tavakoli (2011), who work on major phonetic processes in the Sabzevari dialect of Persian, a vernacular spoken in Northeast Iran, reveal CL in this dialect as in (5):

(5) CL in Sabzevari dialect

		Input	Output	Gloss
I)	a.	/jæʔ.ni/	[jæ:.ni]	'That is'
	b.	/beh.tær/	[be:.tær]	'better'
II)	a.	/mohr/	[mo:r]	'seal'
	b.	/mehr/	[me:r]	'affection'

The scholars cited above have addressed CL in Persian varieties and they have obtained the same observational findings. However, the phonological derivation behind this phenomenon has yet to be investigated in terms of a Stratal OT approach. Therefore, this research is intended to clarify how Stratal OT is superior to previous analyses when accounting for the phonological derivation behind local CL. To do so, two questions must be considered: First, what type of phonological derivation is behind local CL in Modern Colloquial Persian? Second, how can phonological derivation in local CL in Modern Colloquial Persian be accounted for using Stratal OT?

Section 2 provides the background knowledge about the phonology of Modern Colloquial Persian. Section 3 presents the local CL data. Then, Section 4 presents the autosegmental/metrical analysis of local CL data. The versions of OT are addressed in Section 5. Next, Section 6 is dedicated to a Stratal OT approach as an analytical framework in this study. Section 7 summarizes this paper and its findings.

2. Phonology of Modern Colloquial Persian

2.1 *Consonant inventory of Modern Colloquial Persian*

Modern Colloquial Persian has 23 consonants, which are presented in Table 1 in the conventional arrangement according to place and manner of articulation as per Windfuhr (1987), Mahootian (1997), and Hosseini (2014).

Table 1: Manners and places of articulation of the consonants of Modern Colloquial Persian (Windfuhr 1987; Mahootian 1997; Samareh 1999; Hosseini 2014)

	Bilabial	Labio-dental	Dental	Alveolar	Post-alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosives	p b		t d				c ɟ	ɢ		ʔ
Nasals	m			n						
Trills				r						
Fricatives		f v		s z	ʃ ʒ			χ		h
Affricates					ʧ ʤ					
Laterals				l						
Glides						j				

2.2 *Vowel inventory of Modern Colloquial Persian*

Modern Colloquial Persian has three short vowels of the [-long] feature, /e/, /æ/, and /o/, plus three long counterparts of the [+long] feature, /i/, /u/, and /ɑ/ (Miller 2013; Aronow et al. 2017; Kambuziya et al. 2017).[2] The vowel chart of short and long vowels is shown in Table 2.

Table 2: Vowel chart of Modern Colloquial Persian (Miller 2013; Aronow et al. 2017; Kambuziya et al. 2017)

	Front	Mid	Back
High	i [+long]		u [+long]
Mid-High	e [-long]		o [-long]
Mid-Low			
Low	æ [-long]		ɑ [+long]

Considering Table 2, short vowels of the [-long] feature can be derivationally lengthened through CL, which is addressed later on in this study. On the contrary, Kambuziya et al. (2017) report that long vowels /i/, /u/, and /ɑ/ undergo vowel shortening to become [e], [o], and [æ] in the cases presented in (6).

[2] Based on the development of the contemporary Iranian Persian, Miller (2013) indicates the occurrence of emergers in the vowel system, which have resulted in sets of words with distinct vowels in Early New Persian and identical vowels in Contemporary Persian, i.e., /eː, iː/→ /i/, /oː, uː/→ /u/.

(6) Cases of vowel shortening in Modern Colloquial Persian:

I. Long vowels are liable to shortening when they are followed by nasal consonants within the same syllable.

e.g., /pirɑh**ɑ**n/→[pi.rɑ.h**æ**n] ‘shirt’, /peh**i**n/→ [pe.h**e**n] ‘dung’, /t**u**m**ɑ**n/→ [t**o**.m**æ**n] ‘currency’

II. Long vowels before a glottal fricative /h/ within the same syllable are subject to shortening.

e.g., /sep**ɑ**h/→ [sep**æ**h] ‘corps’

III. Vowel shortening of long vowels occurs before liquids.

e.g., /l, r/, e.g., /j**u**reʃ/→ [j**o**.reʃ] ‘raid’, /s**u**rme/→ [s**o**r.me] ‘kohl’

The types of syllable structures permitted in Modern Colloquial Persian are demonstrated in the next subsection.

2.3 *Syllable structure of Modern Colloquial Persian*

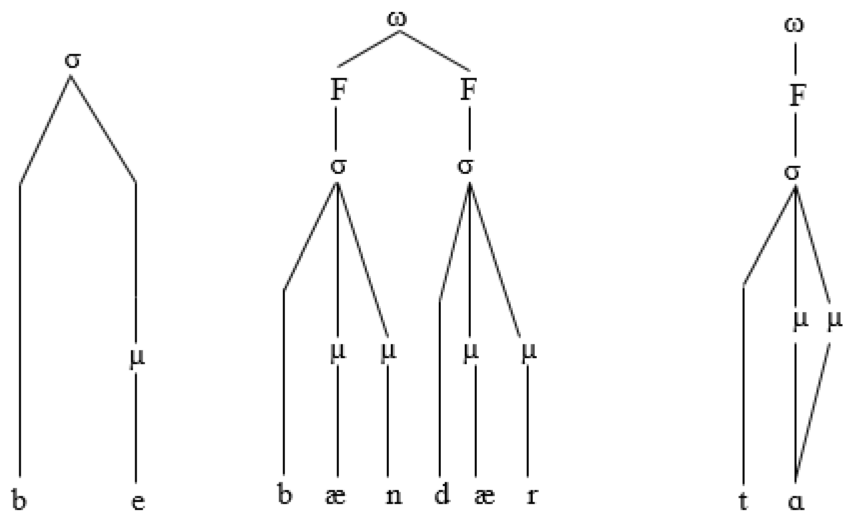
The syllable structure of Modern Colloquial Persian has been addressed by scholars; namely, Elwell-Sutton (1976), Hayes (1979), Windfuhr (1979), Darzi (1991), Amini (1997), Bijankhan (2000), Hall (2007), Rahbar (2012), and Heidarizadi (2014), among others. According to them, six syllable structures are found in Modern Colloquial Persian: CV, CV̄, CVC, CV̄C, and CVCC, as shown in Table 3.

Table 3: Syllable structure in Modern Colloquial Persian

S.No.	Syllable Structure	Example	Gloss
a.	CV	[be]	‘to’
b.	CVC	[bæn.dær]	‘port’
c.	CV̄	[tɑ]	‘till’
d.	CV̄C	[ʃɑd]	‘happy’
e.	CVCC	[dæst]	‘hand’

According to Table 3, syllable weight and restriction must be considered when accounting for the syllable structure of Modern Colloquial Persian. We note that CV̄ syllables are derived from CVC and is the result of local CL. Similarly, CV̄C derives from CVCC syllables and is achieved through the same process, local CL. These derived syllables are important to the analysis of CL in the sections that follow. CV is the only light syllable. The heavy syllables are CV̄ and CVC, which are bimoraic. Consider the representations of light and heavy syllables in (7) (Note that ω stands for a prosodic word, and F stands for a foot).

(7) a. CV b. CVC c. CV̄

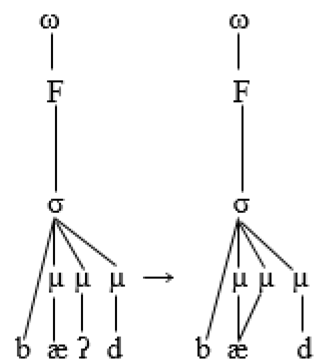


The existence of trimoraic syllables in number of different languages including Old English, Persian, German, Danish dialects, Finnish, and Estonian has been argued by Hayes (1989). He states the existence of trimoraic syllables can be indirectly established by patterns of CL, and quantitative metrics, and can be directly established by the existence of three-way or ternary long contrasts. Referring to Hayes's (1989) argument above, trimoraic syllables in Persian can be established by CL and quantitative metrics, as he proposes 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 (CV̄C 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).*

However, Darzi (1991) states that the three moraic slots are more highly restricted in Persian to syllables that contain glottals in coda position with reference to colloquial Tehrani Farsi, i.e. moraicity of consonants is a language specific phenomenon. The data in (8) show the preservation of the mora through CL despite deletion of the glottal consonant:

(8) /bæ$^{\mu}$ʔ$^{\mu}$d$^{\mu}$/→ [bæː$^{\mu\mu}$d$^{\mu}$] ‘after’

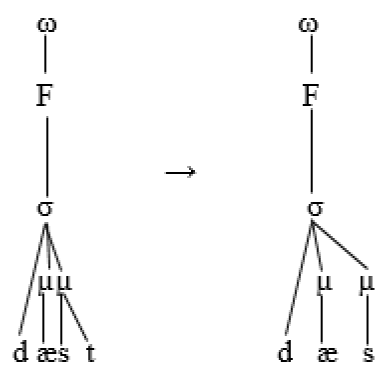


On the other hand, Darzi (1991) posits that the three moraic slots are not found in syllables with non-glottal coda consonants since vowel lengthening does not result from the deletion of non-glottal consonants in coda position:

(9) a. /dæ$^{\mu}$s$^{\mu}$t/→ [dæ$^{\mu}$s$^{\mu}$]/ *[dæː$^{\mu\mu}$s$^{\mu}$] ‘hand’
b. /lo$^{\mu}$χ$^{\mu}$t/→ [lo$^{\mu}$χ$^{\mu}$]/ *[loː$^{\mu\mu}$χ$^{\mu}$] ‘naked’
c. /ɢæ$^{\mu}$n$^{\mu}$d/→ [ɢæ$^{\mu}$n$^{\mu}$]/ *[ɢæː$^{\mu\mu}$n$^{\mu}$] ‘sugar’

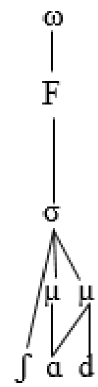
Darzi (1991) hypothesizes that the word-final consonants in (10) are not assigned as extrasyllabic since they are linked to the preceding mora, as shown in the representation below:

(10)



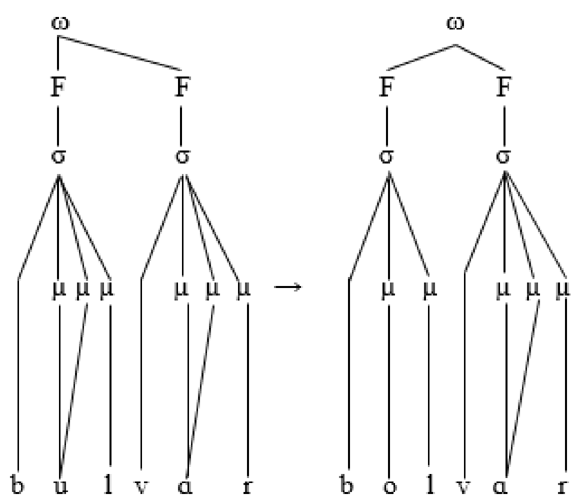
Likewise, the final C$\bar{V}$C is considered to be heavy since the word-final consonant is linked to the preceding mora, as shown in the representation of [ʃɑd] ‘happy’ below:

(11)



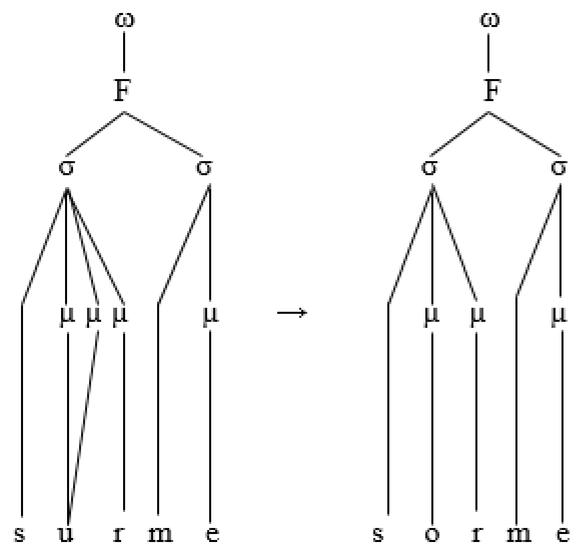
According to Kambuziya et al. (2017), if a word in Persian has two superheavy syllables of the CV̄C form, the first syllable becomes heavy (bimoraic) due to long vowel shortening while the final syllable remains superheavy (trimoraic). Consider the following presentations of [bol.vɑr] 'boulevard'.

(12) /bulvɑr/→ [bol.vɑr] 'boulevard'



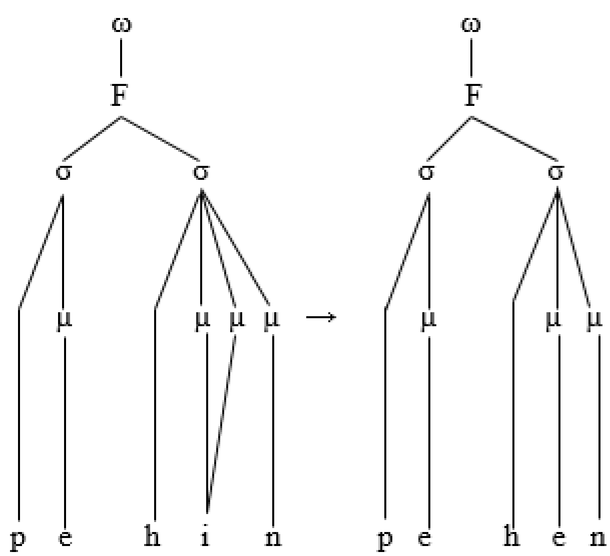
The above rule of long vowel shortening is mentioned by Kambuziya et al. (2017), who note that long vowels followed by liquids /l, r/ undergo vowel shortening. Consider the following representation of [s**o**r.me] 'kohl'.

(13) /s**u**rme/→ [s**o**r.me] ‘kohl’



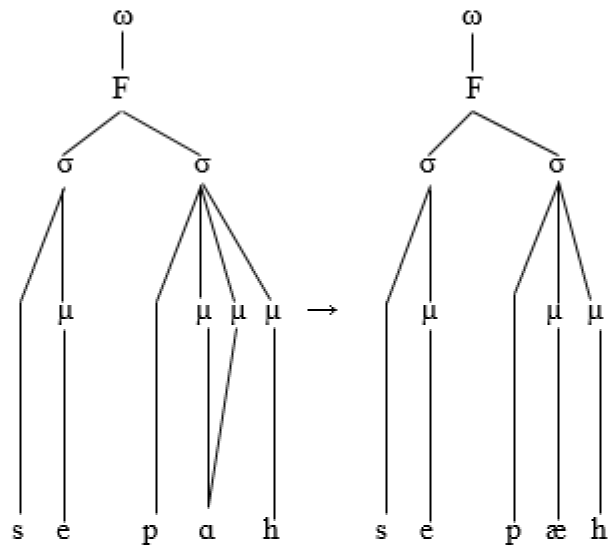
Moreover, Kambuziya et al. (2017) agree that a long vowel in the superheavy syllable (CV̅C) is prone to shortening when it is followed by a nasal consonant, as shown in the representation of [pe.hen] ‘dung’ below:

(14) /pehin/ → [pe.hen] ‘dung’



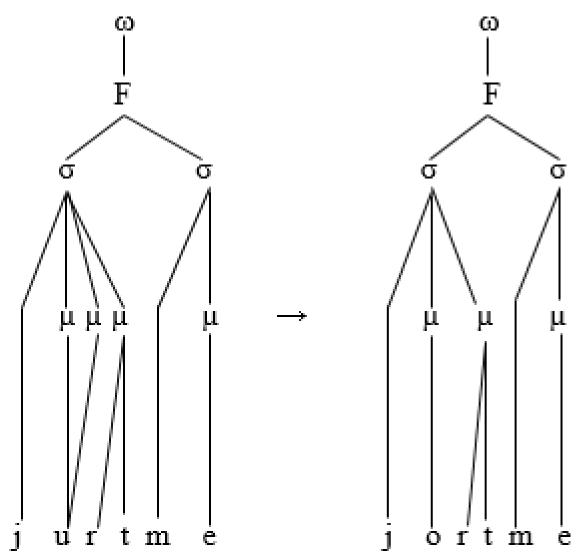
Similarly, according to Kambuziya et al. (2017), a long vowel in the superheavy (CV̅C) is liable to shortening when it is followed by a glottal fricative. Consider the representation of [se.p**æ**h] ‘corps’ below:

(15)



Kambuziya et al. (2017) state that CVCC is found in non-final position as the reduced syllable of CV̄CC due to vowel shortening. For instance, a long vowel in /ju̲rtme/ ‘trot’ undergoes vowel shortening before /r/ as a liquid, i.e. /ju̲rtme/→ [jort.me] ‘tort’. Consider the following representation:

(16) /ju̲rtme/→ [jort.me] ‘tort’



To summarize, syllable weight in Modern Colloquial Persian is divided into light, heavy, and superheavy, depending on the number of moras found in each syllable types. For instance, CV is light since it is monomraic while two moras are found in heavy syllables of the forms CV̄ and CVC. The trimoraic syllables are highly restricted in Modern Colloquial Persian since moraicity of consonants is a language specific phenomenon. The long vowel in CV̄C syllable undergoes vowel shortening if it is followed by any one of coda consonants /l, r, n, m, ʔ, h/. CV̄C syllables of which word-final consonants are other than /l, r, n, m, ʔ, h/ are considered to be heavy (bimoraic) since word-final consonants are linked to the preceding mora. CVCC syllables of which word-final consonant are non-glottal are deemed heavy since word-final consonants are linked to the preceding moras. The same syllable type (i.e. CVCC) may be derived from CV̄CC that is attached to a consonant-initial suffix through vowel shortening if the word-final consonant in CV̄CC is either one of coda consonants /l, r, n, m, ʔ, h/. Section 3 is devoted to elucidating the data of this study.

3. Modern Colloquial Persian Data

The data of this study were extracted from existing literature particular to local CL in Persian varieties, including books, articles, and theses. Some native Persian speakers were consulted to verify the data gained from the literature when necessary.

CL in Modern Colloquial Persian targets glottal consonants /h, ʔ/ following stem vowels, that is, short vowels. In other words, CL in this variety of Persian is restrained because it is limited to glottal consonants that follow short vowels. Furthermore, this process never applies to the same consonants in coda position that follow long vowels. Otherwise, syllables with trimoraic vowels would be created, e.g. /se$^{\mu}$pɑ$^{\mu\mu}$h$^{\mu}$/→ *[se$^{\mu}$pɑ$^{\mu\mu\mu}$] ‘corps’. The possible examples of local CL in Modern Colloquial Persian are shown in (17).

(17) Examples of CL in Modern Colloquial Persian

		Input	Output	Gloss
I)	a.	/behtær/	[be:.tær]	‘better’
	b.	/tæh/	[tæ:]	‘bottom of something’
	c.	/dæh/	[dæ:]	‘ten’
	d.	/deh/	[de:]	‘village’
	e.	/leh/	[le:]	‘crushed’
	f.	/kohne/	[ko:.ne]	‘old’
	g.	/ʔehterɑm/	[ʔe:terɑm]	‘respect’
II)	a.	/mehr/	[me:r]	‘affection’
	b.	/mohr/	[mo:r]	‘seal’
	c.	/fæhr/	[fæ:r]	‘city’
	d.	/fohʃ/	[fo:ʃ]	‘abusive language’
	e.	/sehr/	[se:r]	‘magic’

	f. /zæhr/	[zæ:r]	‘poison’
	g. /sæhm/	[sæ:m]	‘share’
	h. /bæhs/	[bæ:s]	‘discussion’
	i. /mæhr/	[mæ:r]	‘portion’
	j. /zehn/	[ze:n]	‘mind’
	k. /mæhz/	[mæ:z]	‘mere, pure’
III)	a. /jæʔni/	[jæ:.ni]	‘That is’
	b. /ʃoʔbe/	[ʃo:.be]	‘branch’
	c. /mæʔni/	[mæ:.ni]	‘meaning’
IV)	a. /bæʔd/	[bæ:d]	‘after’
	b. /sæʔd/	[sæ:d]	‘prosperity’
	c. /roʔb/	[ro:b]	‘horror’

Referring to the examples in (17), the question here is: Why is CL in Modern Colloquial Persian restricted to the deletion of glottal consonants? To answer this question, it is crucial to shed light on the allophony of glottals in Persian varieties. The realization of glottals in Modern Colloquial Persian has been previously investigated by Samareh (1977), Windfuhr (1979, 1997), Darzi (1991), Kavitskaya (2001, 2002), and Sadeghi (2011, 2014) based on their phonological environments and complementary distribution. In word-initial position, the glottal consonants /ʔ/ and /h/, according to Samareh (1977), are treated as strong allophones, exhibiting the blockage of vowel lengthening and deletion (e.g., /ʔensɑn/→ [ʔen.sɑn] ‘human’ and /hælɑl/→ [hæ.lɑl] ‘halal’). Additionally, Windfuhr (1979, 1997) posits the realization of the glottal stop /ʔ/ in word-initial position with stricture in careful speech, whereas the chance of realization of the glottal stop in the same position as a weak variant is far-fetched; namely, word-initial position is where both glottal deletion and CL are blocked. Darzi (1991), who studied CL in Modern Colloquial Tehrani Farsi, reports that glottals in the word-initial position are preserved and are non-moraic. Consider the examples in (18).

(18)

	Input	Output	Gloss
a.	/ʔensɑn/	[ʔen.sɑn]	‘human’
b.	/hælɑl/	[hæ.lɑl]	‘halal’
c.	/ʔɑzɑd/	[ʔɑ.zɑd]	‘free’

Similarly, Windfuhr (1997: 683) argues that the glottals /ʔ/ and /h/ tend to be articulated fleetingly in the intervocalic position. In spite of Windfuhr’s (1997) argument, Samareh (1977) posits that the glottal stop /ʔ/ in the intervocalic position is a strong variant that does not lead to CL, even though it might undergo deletion in specific cases where the deletion of /h/ in the same position is unattested. The notion that a glottal stop in the intervocalic position triggers deletion without lengthening is supported by Darzi (1991), since a glottal stop in this case occupies the syllableinitial position and is therefore non-moraic. Furthermore, Sadeghi (2011, 2014) infers that a glottal stop in the Vowel-Consonant-Vowel context is prone to deletion since its realization provokes neither creaky nor breathy phonation on adjacent vowels. Rather, in the denoted context, this consonant demonstrates normal voicing that is sustainable through the glottal constriction gesture. Consider the examples in (19).

(19)	Input	Output	Gloss
	a. /næhɑr/	[næ.hɑr]	'lunch'
	b. /ʃæhɑdæt/	[ʃæ.hɑ.dæt]	'testimony'

However, the glottals /ʔ/ and /h/ in the postvocalic position in the coda are realized as creaky and breathy glottal approximants as in (20) below. This statement is supported by Kavitskaya (2001, 2002), who argues that glottal consonants provoking CL are always approximant-like while a true phonetic glottal stop that is solely subject to deletion never triggers vowel lengthening. Moreover, based on Kavitskaya's (2001, 2002) observation, the glottal consonants /h/ and /ʔ/ are realized as approximants in Tehrani Farsi. Therefore, moraicity assignment to these sounds is plausible, depending on sonority.[3,4,5] Consider the examples in (20).

(20)	Input	Output	Gloss
	a. /jæʔni/	[jæ:ni]	'That is'
	b. /ʃæhr/	[ʃæ:r]	'city'

The next section examines the autosegmental or metrical approach to CL in Modern Colloquial Persian.

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[3] Hayes (1989) observes that a glottal stop that motivates deletion only is weightless while glottal approximants, which synchronically yield CL, are predicted to be moraic.

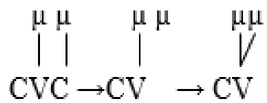
[4] Kavitskaya (2001) refers to Ladefoged & Maddieson's (1996) study conducted on glottals (ʔ and *) that are phonologically contrastive in Gimi. She deduces that these consonants are either phonologically stops or approximants, which are predictably in contrast in some languages.

[5] Kavitskaya (2001) declares the predictability of a glottal stop in occupying different places in the sonority hierarchy in different languages if a variety of possible phonetic realizations of glottal stops is potentially correspondent to different phonological representations in terms of their moraicity status. According to her, with regard to the distribution of glottal stops, this prediction finds support in cross-linguistic observations; this type of consonant is considered an obstruent, a true stop, in some languages (e.g., Kwakwala), while it is classified as a sonorant since it is an approximant in some languages (e.g., Karok). In contrast to Kwakwala, Hayes (1995) reports that glottalised sonorants and obstruents in Cahuilla and Mam languages, for instance, are the most marked codas occurred in stressed environments, whereas other coda consonants are unstressed. This is why CVC syllables are light while CV and C$\bar{V}$ syllables are heavy. To rephrase it, Hayes (1995) states that vowel-plus-glottal stop sequences in some languages, including Cahuilla and Mam, are counted as heavy compared to other VC rimes.

4. Autosegmental or Metrical Analysis of CL in Modern Colloquial Persian

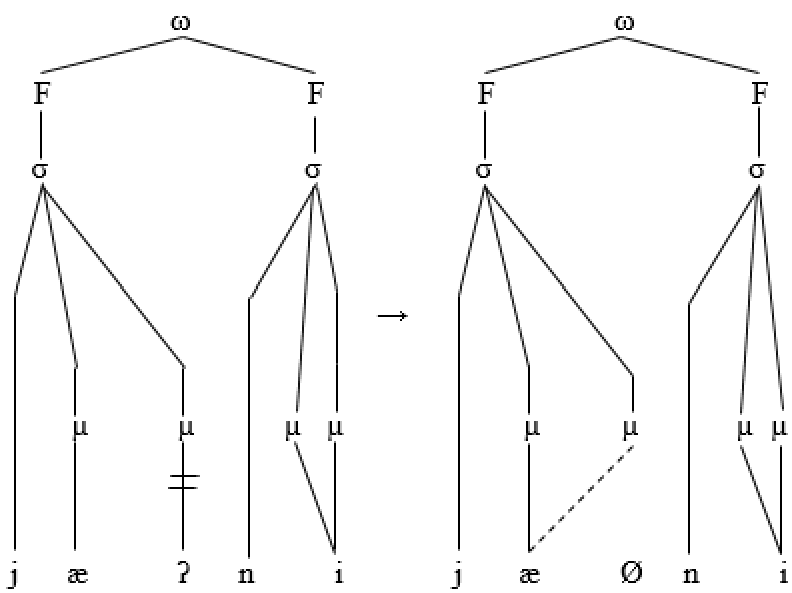
According to Hayes (1989), the autosegmental or metrical approach to CL is derivational since it comprises two steps; the first step is peculiar to the deletion of a consonant associated with a mora, resulting in an unassociated mora with any segment (i.e., the floating mora). The second step, known as reassociation, functionally links the floating mora with the preceding vowel, yielding vowel lengthening. The CL steps are schematized in (21).

(21)

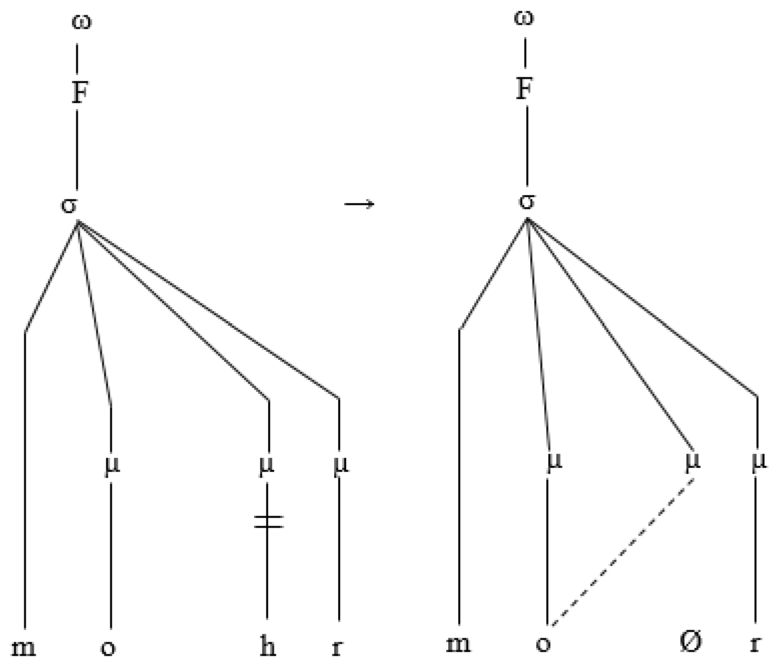


Turning to Modern Colloquial Persian, CL is a twofold process, which targets glottals in the postvocalic position in the coda. The first process is the deletion of a glottal consonant associated with a mora, resulting in the floating mora. In the second process, a mora unassociated with any segment, i.e. a floating mora, is linked with the preceding vowel. Consider the examples of CL in (22).

(22) a. /jæʔni/→ [jæ:ni] 'That is'



b. /mohr/→[mo:r] ‘seal’



The derived syllables C$\bar{V}$ and C$\bar{V}$C result from CL in accordance with the representations in (22). C$\bar{V}$ results from CL applying to the glottal stop in /jaʔni/, while C$\bar{V}$C results from CL applying to glottals in postvocalic position as in /mohr/.

CL in Modern Colloquial Persian is an opaque rule interaction preceded by the implementation of Weight-by-Position (WBP), since coda consonant deletion could block WBP.[6] In other words, CL in Modern Colloquial Persian is opaque and involves the overapplication of WBP; that is, the moraicity of coda consonants is assigned prior to coda consonant deletion. This type of opaque rule interaction is known as counterbleeding; coda consonant deletion counterbleeds WBP, as shown in (23).

(23) Counterbleeding order in Modern Colloquial Persian:

Underlying	a. /mo$^{\mu}$hr/	b. /jæ$^{\mu}$ʔni$^{\mu\mu}$/
WBP:	mo$^{\mu}$h$^{\mu}$r$^{\mu}$	ja$^{\mu}$ʔ$^{\mu}$.ni$^{\mu\mu}$
Deletion of glottal consonant:	mo$^{\mu}$ $^{\mu}$r$^{\mu}$	ja$^{\mu}$ $^{\mu}$.ni$^{\mu\mu}$
Vowel Lengthening:	mo$^{\mu\mu}$ r$^{\mu}$	ja$^{\mu\mu}$.ni$^{\mu\mu}$
Surface	[mo$^{\mu\mu}$r$^{\mu}$]	[ja$^{\mu\mu}$.ni$^{\mu\mu}$]

[6] CL is restricted to the context of Weight-by-Position (codas are moraic) (Samko 2011).

Counterbleeding, the phonological opacity shown in (23), will be accounted for using Stratal OT. Before proceeding, it is necessary to investigate how OT models address this opacity to show the capability of Stratal OT in accounting for such opacity. To this end, Section 5 offers an analysis of derivational versions of OT.

5. The derivational versions of OT

Parallel OT does not easily handle the phonological opacity presented in Section 4, i.e., counterbleeding as well as counterfeeding according to the following scholars: Idsardi (1997, 2000), Kager (1999), McCarthy (1999), and Kiparsky (2000, 2003). McCarthy (1999: 2) reports:

> *As OT is currently understood, though, constraint ranking and violation cannot explain all instances of opacity. Unless further refinements are introduced, OT cannot contend successfully with any non-surface-apparent generalizations nor with a residue of non-surface-true generalizations.*

Correspondence Theory, as an output-output faithfulness model, has been criticised by McCarthy (1999) and Kiparsky (2000, 2003) due to its handling of counterbleeding. McCarthy (1999) states that this model is incapable of accounting for counterbleeding in Tiberian Hebrew since it does not provide a complete solution to counterbleeding as the opacity problem.

McCarthy (1999) introduced an OT model known as Sympathy Theory, which could be the ad hoc solution to the problem of opacity. This model, however, has been criticized by Idsardi (1997, 2000), Kiparsky (2000), and Itô & Mester (2003). According to Kiparsky (2000), for instance, the opaque interaction of stress and vowel epenthesis in Palestinian Arabic cannot be appropriately analyzed by this model; hence, every different opaque process demands a different sympathy constraint, referring to the *same* Selector, which gives rise to chaos in the Palestinian Arabic system.

Another attempt to solve the problem of opacity is pertinent to the introduction of Harmonic Serialism by McCarthy (2007), which is an inherently derivational variant of Classic OT. According to McCarthy (2007) and Samko (2011), this model involves the input-making multiple passes through the same constraint ranking, whereby the winner candidate of each pass serves as the input to the following stage until the winning of the faithful candidate and the coverage of the derivation. McCarthy (2007: 37), its primary developer, criticizes this model: "Wherever classic OT has a problem with counterbleeding opacity, harmonic serialism will too, since harmonic serialism is just classic OT, iterated". Samko (2011), who worked on CL in Harmonic Serialism, reports that this model concomitant with the concept of the Fully Faithful Candidate plus Candidate Chains (OT-CC) (McCarthy 2007) can possibly account for counterbleeding, as an opaque rule interaction. However, Samko's (2011) findings show that Harmonic Serialism only accounts for counterbleeding, while she never mentions whether this model is capable of accounting for counterfeeding or not. In other words, it is not appropriate to rely on an OT model whose ability to account for opaque processes is limited; hence, this argument is supported by McCarthy (2007) and Elfner (2016), who agree on the inability of Harmonic Serialism to account for counterfeeding opacity.

The current study crucially relies on an OT model, known as Stratal OT, which can account for both counterbleeding and counterfeeding, according to Kiparsky (1997a, 1997b, 2000, 2003), Bermúdez-Otero (1999, 2008), McCarthy (1999), and Staroverov (2014). To put it simply, this model allows us to account for otherwise opaque rules. Kager (1999: 381–385) discusses the difference between standard OT, where the input is directly mapped onto the output, and a stratal approach, where the stages between input and output have different sets of OT constraints (i.e., the set of OT constraints is not unified). The representation in (24) illustrates how Stratal OT works.

(24) Stratal OT (Kager 1999: 382)

Input

↓

Stratum 1 Gen_1 $Eval_1$

↓

Stratum n Gen_n $Eval_n$

↓

Output

The output of *Stratum 1* in (24) is employed as the input of the following *Stratum n*. Section 6 accounts for counterbleeding stemming from local CL in Modern Colloquial Persian using Stratal OT.

6. Stratal OT Approach to CL in Modern Colloquial Persian

While the groundwork for Stratal OT has been described in Section 5, this section demonstrates how this model is capable of accounting for counterbleeding with reference to CL in Modern Colloquial Persian. The most important step is to ensure moraic structures are built before segmental changes. In other words, glottals in the postvocalic position must be assigned with moras as the first step, before these consonants are deleted. To do so, the first step at the stem level (Stratum 1) is to build moraic structure prior to consonant deletion. This optimal output in this step serves as the input for the following step at the word level (Stratum 2), where the derivation is covered. These strata are established with reference to Persian morphology. Before analyzing this process, consider the relevant OT constraints on the derivation in (25).

(25) Relevant constraints:

a. WBP (Hayes 1989)
Assign a violation for each coda consonant that is not moraic.

b. MAX[μ] (McCarthy 1997)
Assign a violation for each mora in the input that is not present in the output.

c. MAX (McCarthy & Prince 1995)
Assign a violation for each segment in the input that is not present in the output.

d. *Coda-Glottal (Davis 1997)
Glottals are prohibited from coda position.

e.DEP (McCarthy & Prince 1995):
Every segment of S_2 has a correspondent in S_1 (S_2 is "dependent on" S_1).

f. DEP[μ] (McCarthy 1997)
Assign a violation for each mora in the output that is not present in the input.

g. *FLOAT (Samko 2011: 29)
Assign a violation for each mora in the output that is not associated with a segment.

Given these constraints, the following tableaux account for the counterbleeding order with reference to the input /bæ$^{\mu}$ʔd/ 'after':

Table 4: Stratum (1) (Stem level):
WBP>> MAX>>DEP>>*Coda-Glottal >>*FLOAT>> MAX[μ]>> DEP[μ]

/bæ$^{\mu}$ʔd/		WBP	MAX	DEP	*Coda-Glottal	*FLOAT	MAX[μ]	DEP[μ]
a.	bæ$^{\mu}$ʔd	*!*			*			
b.	☞bæ$^{\mu}$ʔ$^{\mu}$d$^{\mu}$				*			**
c.	bæ$^{\mu}$d$^{\mu}$		*!					*
d.	bæ$^{\mu}$ʔ$^{\mu}$		*!		*			*
e.	bæ$^{\mu}$ʔ$^{\mu}$d	*!			*			*
f.	bæ$^{\mu}$ʔæ$^{\mu}$d$^{\mu}$			*!				*

In Stratum (1) above, the WBP constraint is fatally violated by candidates (a) and (e), which are initially eliminated, compared to the rest of candidates. For instance, candidates (c) and (d) avoid the violation of WBP, but they fail to be optimal due to the violation of MAX, since both candidates allow consonant deletion. Candidate (f) satisfies both WBP and MAX constraints, but it is not chosen as optimal due to the violation of DEP. Consequently, candidate (b), as the desired output, is distinguished as optimal and serves as the input in Tableau (5) (i.e., Stratum 2).

Table 5: Stratum (2) (Word level):
WBP>>*Coda-Glottal >> DEP>> MAX[μ]>>*FLOAT>>MAX >> DEP[μ]

/ bæ^{μ}ʔ^{μ}d^{μ} /	WBP	*Coda-Glottal	DEP	MAX[μ]	*FLOAT	MAX	DEP[μ]
a. bæ^{μ}ʔ^{μ}d^{μ}		*!					
b. bæ^{μ}d^{μ}				*!		*	
c. bæ^{μ} ^{μ} d^{μ}					*!	*	
d. bæ^{μ}d	*!			*		*	
e. ☞bæ^{μμ}d^{μ}						*	

In Stratum (2), the phonological derivation, or counterbleeding, is over, resulting in candidate (e) with lengthened vowel being determined as optimal since it avoids the violation of WBP, *Coda-Glottal, MAX[μ], and *FLOAT constraints. Unlike the optimal candidate (e), candidate (d) is eliminated due to the violation of WBP, while the rest of candidates avoid violating the same constraint. For instance, candidate (a), which is the most faithful output to the input /bæ^{μ}ʔ^{μ}d^{μ}/, satisfies WBP due to a moraic glottal stop, which, on the contrary, violates *Coda-Glottal. As a result, this candidate fails to be optimal. The floating mora in candidate (c) incurs the fatal violation of *FLOAT; this is why candidate (c) is not optimal. Mora deletion in candidate (b) yields the fatal violation of MAX[μ]. The sets of constraints in Strata 1 and 2 above are to deal with the counterbleeding order with reference to the input /jæ^{μ}ʔni^{μμ}/ ‘That is’.

Table 6: Stratum (1) (Stem level):
WBP>> MAX>> DEP >>*Coda-Glottal >>*FLOAT>> MAX[μ]>> DEP[μ]

/jæ^{μ}ʔni^{μμ}/	WBP	MAX	DEP	*Coda-Glottal	*FLOAT	MAX[μ]	DEP[μ]
a. jæ^{μ}ʔ.ni^{μμ}	*!			*			
b. ☞jæ^{μ}ʔ^{μ}. ni^{μμ}				*			*
c. jæ^{μ}. ni^{μμ}		*!				*	

Candidates (a) and (c) are eliminated in Tableau (6) due to the violation of WBP and MAX constraints, while the same constraints are satisfied by candidate (b), which is chosen as optimal.

In other words, candidate (b) in Stratum (1) above, which is discriminated as optimal, is employed as the input in Tableau 7 (i.e., Stratum 2), where the phonological derivation is covered.

Table 7: Stratum (2) (Word level):
WBP>>*Coda-Glottal >> DEP >> MAX[μ]>>*FLOAT>>MAX >> DEP [μ]

/jæ^{μ}ʔ^{μ}. ni^{μμ}/	WBP	*Coda-Glottal	DEP	MAX[μ]	*FLOAT	MAX	DEP[μ]
a. jæ^{μ}ʔ^{μ}. ni^{μμ}		*!					
b. jæ^{μ} ^{μ}.ni^{μμ}					*!	*	
c. jæ^{μ}.ni^{μμ}				*!		*	
d. ☞jæ^{μμ}.ni^{μμ}						*	

The coverage of phonological derivation, or counterbleeding, in Stratum (2) is accomplished, yielding the optimality of candidate (d) with lengthened vowel because it does not violate *Coda-Glottal, MAX[μ], and *FLOAT constraints. Candidate (a), on the other hand, violates *Coda-Glottal, since the moraic glottal stop in the same candidate is immune to deletion while the same glottal stop has deleted in candidate (b) to satisfy *Coda-Glottal. However, the floating mora in candidate (b) incurs the violation of *FLOAT. Candidate (c) avoids the violation of *Coda-Glottal and *FLOAT by deleting a glottal stop with its mora, but this deletion leads to the fatal violation of MAX[μ] and to another violation of MAX.

To summarize, this section shows how Stratal OT is superior to previous analyses when accounting for counterbleeding as the phonological opacity, with reference to local CL in Modern Colloquial Persian. The strata in this model are established on the basis of Persian morphology. In Stratum 1, building the moraic structure is achieved prior to CL, which takes place in Stratum 2 of which a phonological derivation is over.

7. Conclusion

This study has addressed the phonological opacity of local CL in Modern Colloquial Persian in light of Stratal OT. Local CL in Modern Colloquial Persian applies to moraic glottal consonants /h/ and /ʔ/ in coda position. The assignment of moras to coda consonants is crucial to the application of CL, indicating that moraic structure is built before deletion or lengthening applies. This means that WBP applies before CL to ensure that coda consonants are assigned with moras such that the deletion of these consonants gives an opportunity for the floating moras to be affiliated to the preceding stem vowels. This opaque phonological derivation is a form of counterbleeding such that WBP counterbleeds consonant deletion. Stratal OT reveals that this OT as a framework is capable of accounting for counterbleeding as regards local CL, compared to other analyses. Strata in this model, which are established on the basis of Persian morphology, are with different sets of OT constraints used for each step; hence, Stratum 1 ensures building the moraic structure before CL occurs in Stratum (2) (i.e., the end of a phonological derivation). The results of this research acknowledge the need for future research specific to the phonological derivation of non-local CL in Modern Colloquial Persian in light of Stratal OT.

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