Complex onsets and coda markedness in Persian

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Abstract

This paper argues for the Coda Condition to be a universal set of violable constraints on the basis of new vowel epenthesis data from Persian (Farsi). Vowel insertion in L2 phonology, loanwords, and nonce-words is driven by a strict ban on consonant clusters in syllable onsets. The choice between anaptyxis and prothesis is determined by the Coda Condition. As there is no detectable evidence for a coda condition in the existing Persian lexicon, it would be impossible for speakers of Persian to have acquired the Coda Condition as part of the L1 acquisition process. Moreover, this study contradicts two claims made in the literature: first, that anaptyxis/prothesis splits are always caused by the Syllable Contact Law, and second, that all coda condition effects can be reanalysed with positional faithfulness. Going beyond the Persian data, the paper argues for a formulation of the Coda Condition as positional licensing rather than simple markedness in interaction with positional faithfulness.

Keywords: loanword phonology, syllable phonotactics, Optimality Theory, nonce-word test

1. Introduction

Like many other languages, Persian[1] does not permit complex onsets. Loanwords and nonce-words with initial consonant clusters undergo epenthesis (Fleischhacker 2001, Gouskova 2002, Shademan 2002). The same patterns are observed in Persian-English interlanguage (Boudaoud and Cardoso 2009). The site of epenthesis (preceding or following the first consonant, i.e., prothesis or anaptyxis, respectively) varies according to the quality of the consonants in the cluster. In clusters of three consonants both strategies apply.

In this paper I will first show that, in Persian, the choice of epenthesis site in bi-consonantal clusters is determined by coda markedness: Prothesis is the default and applies when the first consonant is from a restricted set of consonants that are found in syllable codas in other languages, in which some Coda Condition is a surface phonotactic restriction (e.g., Italian, Portuguese, Diola Fogni, or Eastern Ojibwa, which all display different restrictions on codas). Anaptyxis applies when prothesis would result in a violation of the Coda Condition. If the first consonant is not from the set of consonants allowed in codas, the cluster is split and a coda is avoided. Persian prothesis and anaptyxis are illustrated in (1).

(1) *Prothesis and anaptyxis in Persian*[2]

a.	ʔembeki	Mbeki (name; e.g., South African politician Thabo Mbeki)
	ʔesnæk	‘snack’
b.	pelɑstik	‘plastics’
	terɑfik	‘traffic’

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[1] There is a debate on whether the language should be referred to as Persian or Farsi. Most of my informants preferred the label Persian, which is why I use this term rather than the other, which is also often used in linguistic literature.

[2] The data in this study are taken from Windfuhr (1997), Fleischhacker (2001) and my own data from consultations with native speakers. For data elicitation methodology, see also Section 3. All data from the literature were double-checked with my informants. Transcription was adapted to IPA where necessary.

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This is theoretically interesting for three reasons. First, such split epenthesis patterns have been analysed as Syllable Contact effects (Gouskova 2002 on Kirghiz). The default is assumed to be prothesis, and anaptyxis applies only if prothesis would result in rising (or level) sonority in the transition from the coda of the first syllable to the onset of the second (Syllable Contact Law, henceforth SCL; Vennemann 1988). This analysis is not applicable to the Persian pattern, since Persian allows syllable contacts of rising sonority as a result of epenthesis (i.e., obstruent.sonorant, as in [ʔes.læŋg] 'slang'). Second, Beckman (2004) has shown that the cases of vowel epenthesis that Itô (1989) used as additional evidence for the Coda Condition can be analysed as Syllable Contact effects as well. She argues that there is no need to assume an OT constraint CODACOND, since the Coda Condition never causes epenthesis and the restrictions on inventories found in coda position in many languages can be analysed as a positional faithfulness (Beckman 1998, McCarthy and Prince 1999) effect (i.e., faithfulness to onsets, $\text{IDENT}^{\text{Onset}}$, ranked with respect to simple markedness constraints). Third, the Persian pattern is direct evidence for the indispensability of the Coda Condition as a universal OT constraint, or more accurately, constraint set. As there are otherwise almost no phonotactic restrictions on codas in Persian, the Coda Condition effects in cluster resolution are surprising and must be regarded as evidence for the universality of the Coda Condition, since a learner of Persian cannot have generalised the condition from other areas of the existing lexicon or existing phonological alternations. Prince and Smolensky (1993/2004) hypothesize that constraints are universal, i.e., hard-wired in Universal Grammar. Languages are not distinct from others by the constraints present in their grammars, but by the differences in the rankings of the same constraints. There is an ongoing discussion regarding this claim and an increasing number of researchers are convinced that constraints, or phonology in general, are emergent (see, e.g., Boersma 1998 et seq., Hayes and Steriade 2004, or Archangeli and Pulleyblank 2012; 2018), i.e., entirely learned by deduction from the data a learner is exposed to. A constraint that shows an effect only in the integration of loanwords and when speakers of the language learn another language or nonce-words cannot have been learned from primary data and is thus evidence that at least some constraints are universal (Broselow 1993; 1999, Broselow et al. 1998).

The paper is organized as follows. Section 2 gives a brief introduction to the two principles of syllable phonotactics central in this paper, i.e., the Syllable Contact Law and the Coda Condition(s). Section 3 provides the methodology, the results and discusses the data. First, the results of two production experiments with native speakers of Persian are presented, showing clear Coda Condition effects in the choice of cluster resolution strategy in (potential) loanwords as well as nonce-words. Second, data from the existing Persian lexicon are presented that suggest a near-total absence of any Coda Condition, as well as the Syllable Contact Law, in the Persian grammar. Section 4 provides an OT analysis. In Section 5, the problems with analyses using the Syllable Contact Law and an attempt at relying on positional faithfulness are discussed. Section 6 concludes.

2. Background on syllable phonotactics and sonority

In this section I sketch the two phonological phenomena that are central in determining the epenthesis site in Persian. The question is whether the Syllable Contact Law or coda markedness constraints, i.e., the Coda Condition is responsible for the choice of prothesis in some contexts and anaptyxis in others.

2.1 Syllable Contact

The Syllable Contact Law (Vennemann 1988) relies on a hierarchy of consonantal strength which corresponds largely to the stratification of major segment classes in the Sonority Hierarchy (Selkirk 1984, Clements 1990, Zec 1995 and references there). What exactly sonority corresponds to phonetically is a matter of debate, see, e.g., Parker (2002) for debate and a proposal. Obstruents are generally considered to be low in the hierarchy, nasals higher, and the other sonorants higher than nasals. In some hierarchies (e.g., Selkirk 1984), sibilants are not considered obstruents but as comprising a class of their own. Vowels are of high sonority and the degree of openness further determines a vowel's sonority. Here, we are concerned with consonants only.

(2) *The Sonority Hierarchy*

Low						High
Stops	Fricatives	Sibilants	Nasals	Liquids	Glides	Vowels

Recently, syllable contact is usually described in terms of sonority. A syllable contact, i.e., the combination of the last segment of the first of two syllables in a chain and the first segment of the second syllable in this chain, is considered more well-formed the more sonority falls from the first to the second syllable and it is considered more marked the more it rises.

(3) *Syllable Contact ($C) (weak version)*:
Sonority must not rise across a syllable boundary. (Vennemann 1988, Davis 1998, Krämer 2000)

Gouskova quantifies SCL violations and proposes a whole family of constraints of the type *SC*n*, penalising different combinations of consonants at syllable junctures, e.g., *SC+7 (*t.w).

(4) *The Syllable Contact Scale* (Gouskova 2002; 2004:211)

–7	–6	–5	–4	–3	–2	–1	0	+1	+2	+3	+4	+5	+6	+7
w/t	w/s	w/d	w/z	w/n	w/l	w/r	w/w	r/w	l/w	n/w	z/w	d/w	**s/w**	t/w
	r/t	r/s	r/d	r/z	r/n	r/l	r/r	l/r	n/r	z/r	d/r	s/r	**t/r**	
		l/t	l/s	l/d	l/z	l/n	l/l	n/l	z/l	d/l	s/l	t/l		
			n/t	n/s	n/d	n/z	n/n	z/n	d/n	s/n	t/n			
				z/t	z/s	z/d	z/z	d/z	s/z	s/z	t/z			
					d/t	d/s	d/d	s/d	t/d					
						s/t	s/s	t/s						
							t/t							

If Syllable Contact is the driving force behind placement of the epenthetic vowel in or before CC clusters in Persian loanwords and interlanguage, we expect anaptyxis whenever prothesis would create a bad syllable contact, i.e., a sonority plateau or rise.

2.2 Coda Conditions

The syllable coda is generally considered to be a position subject to contrast neutralising constraints (Itô 1988, Zec 1995; 1998). Neutralisation of laryngeal contrasts and the usually regressive nature of voicing assimilation across syllable boundaries led to the postulation of positional faithfulness constraints restricted to onsets (Beckman 1998; 2004, Lombardi 1998).

Neutralization in codas does not only affect laryngeal features. Stops or fricatives other than /s/ and consonants with a place of articulation other than coronal (Itô 1988; cf. Krämer and Zec 2017; in prep. for a detailed survey of the typology of coda manners) are often banned in coda or word-final position. (5) provides some typical cases.

(5) *Examples of Coda Conditions*
  a. Kiribatese coda = nasal (Gilbertese; Piggott 1999)
  b. Japanese coda = nasal or geminate (Itô 1988)
  c. Beijing Chinese coda = non-labial nasal or liquid (Blevins 1995)
  d. Diola Fogni word-internal coda = sonorant (including homorganic nasals) (Sapir 1965, Piggott 1999)
  e. Portuguese (European) coda = sonorants (liquids and (homorganic) nasals) and [ʃ] (Mateus and Andrade 2000)
  f. Italian coda = /s/, (coronal/homorganic) sonorant or geminate (Itô 1988; 1989, Krämer 2009)

g. Eastern Ojibwa word-internal coda = coronal fricative /s, ʃ/, nasal (homorganic with following consonant) (Bloomfield 1957, Piggott 1999)

As can be seen in (5) not all languages with coda conditions impose the same restrictions on this position. They also differ in whether the condition applies across the board, or only word-internally or word-finally. In Japanese and Italian, for example, the coda filter is stricter word-finally than within words. Geminates occur only between vowels, hence not word-finally. In Italian, word-final codas are extremely rare – at least in the native vocabulary. In newer loanwords, however, a much wider array of codas is permitted (see Krämer 2009 and references therein). Eastern Ojibwa and Diola Fogni behave in the opposite manner. While strict limits are set internally, word-final codas display the same freedom as onsets. This is illustrated for Eastern Ojibwa in (6).

(6) *Pre-consonantal and word-final consonants in Eastern Ojibwa* (Piggott 1999)

a.	ombibide:	'it flies up'	b.	bi:ska:bi:	'he returns'
	mindidido	'he is big'		wa:biška:	'it is white'
	baŋgisin	'it falls'		mo:škine:	'it is full'
	ga:nǰibin	'push someone'		ašpa:	'it is high'
c.	a:gam	'snowshoe'	d.	nindib	'my head'
	wa:bimin	'apple'		nizid	'my foot'
	bizindaŋ	'(that) s/he listens'		askig	'seal'
	ne:gaw	'sand'		ninik	'my arm'
	omo:day	'bottle'			

However, since Eastern Ojibwa also has words with a dorsal nasal in final position, as the third item in (c) shows, which is never found in onsets, an analysis of the word-final consonants as codas, rather than onsets, is the more reasonable choice (Piggott 1999). What all these languages have in common is that nasals are welcome in the coda and that there is a preference for coronal consonants. Labial and dorsal consonants are only allowed if they share their place of articulation with the following onset and even in this case they are preferably nasals. Stops, or obstruents, are highly marked coda segments. Liquids and the coronal fricative(s) seem to be somewhere in between these two poles (i.e., homorganic nasals versus obstruents with independent place). For a more detailed discussion of the typology of coda manners cf. Krämer and Zec (2017; in prep.).

(7) *Codas frequently ban:*

a. Labial and dorsal segments,
b. Stops,
c. Obstruents,
d. Non-nasal segments,
e. Non-sonorant segments.

If Persian loanwords are repaired by anaptyxis as a response to coda constraints, we expect prothesis before clusters with a C1 of relatively high sonority, i.e., sonorants and sibilants regardless of the sonority of C2.

3. The data

In this section I first describe the methodology and results of my own fieldwork on the resolution of word-initial consonant clusters in real as well as potential loanwords, and nonce-words. I will then put these new data into context by looking at the distribution of consonants in the existing lexicon of Persian.

3.1 *Cluster resolution in new words*

In this subsection I present two data sets. The first comes from a reading aloud task with three native speakers comprising mostly existing as well as potential loanwords from other languages. The second data source is a nonce/loanword production task with 19 native speakers, run in two groups of ten and nine participants, the second of which was presented with an expanded word list.

The data set in (8) shows a collection of common loans and words elicited from informants. The informants were shown the English words, e.g., *split, snack*, and the personal and group names, such as *Ndebele*, in written form and they were asked how they would pronounce each word in a Persian sentence, for example when discussing foreign politics with a friend. Informants were three females, between 25 and 30 years old. All claimed Persian as their native language, had grown up in Iran and had moved abroad between 6 months and two years before the consultations. All informants hold a B.A. in English from an Iranian university and were studying for an M.A. in English Linguistics at the time of data collection. One informant passed the tasks on to several other Persian speakers, who did not study languages, to obtain their judgements. There was unanimous agreement on the forms among the directly consulted informants as well as those recruited indirectly.

In (8)a, words starting with an obstruent followed by a sonorant are repaired by the insertion of a vowel between the two consonants. (8)b shows that the coronal fricative is an exception to this generalization. Whenever a word starts with a *s*-initial cluster, prothesis is applied. If the first consonant is a nasal, the vowel is inserted after the nasal, as can be seen in (8)a', unless the nasal is followed by a homorganic consonant, as can be seen in (8)b'. In this case, prothesis applies as well. In the attested words with an initial tri-consonantal cluster, the first consonant is always an *s*. As expected, prothesis applies. However, the choice is then whether to avoid a complex coda or onset by inserting yet another vowel. Tri-consonantal clusters are always repaired by double epenthesis and the second vowel is always placed after the second consonant (rather than after the initial *s*), as shown in (8)c.

(8) *Epenthesis in Persian (common loans + elicited forms)*[3]

a.	*Anaptyxis*		b.	*Prothesis*	
	pelɑstik	'plastics'		ʔestɑndɑrd	'standard'
	kelɑs	'class'		ʔeski	'ski'
	berezil	'Brazil'		ʔesnæk	'snack'
	terɑfik	'traffic'		ʔeslæŋg	'slang'
	felæʃ	'flash'			
	firizer	'freezer'	b'.	ʔendebele	Ndebele
				ʔembeki	Mbeki (name)
a'.	melɑditʃ	Mladic (name)			
	merulov	Mrɯl'ov (name)	c.	*Mixed*	
				ʔesteres	'stress'
				ʔespilit	'split'

Prothesis has a side effect—consonant epenthesis. Insertion of the vowel alone is not enough, as this creates a syllable that starts in a vowel. Since syllables have an obligatory consonantal onset in Persian, there is an epenthetic glottal stop preceding the prothetic vowel in (8)b, b' and c. That the glottal stop is indeed the default epenthetic consonant to avoid onsetless syllables can be seen in regular glottal stop/zero alternations at the juncture of stems and prefixes (Naderi and van Oostendorp 2011).[4] This glottal stop epenthesis will play a minor role in the details of the analysis in Section 4.

[3] The epenthetic vowel is not always *e*, as can be seen in the rendition of *split* in (8). For a discussion and analysis of the quality of epenthetic vowels in Persian, see Shademan (2002).

[4] Persian displays several other consonants that can be analysed as epenthetic, as well as glottal stops that do not alternate with zero when preceded by a consonant-final morpheme, and thus have to be analysed as lexical. See Naderi and van Oostendorp (2011) for a detailed description and analysis.

3.1.1 Details of data collection

To ensure the data were reliable and to determine which consonants or consonant sequences trigger prothesis, a production test with more items and more subjects was run.

In the extended production test, a combination of existing words, nonce-words and fillers for both sets was presented in written form to the test participant, with one item visible on the screen at a time. Subjects were asked to produce the word in a natural Persian way in a carrier sentence. They could choose between a colloquial version (a) and a formal one (b).

(9) *Carrier sentence*

a. "Diruz _______-(r)o tu televizjon didæm."

b. "Diruz mæn ______-ra dær televizjon didæm."

'Yesterday, I saw _______ on TV.'

A pilot was run with nine subjects from different regions (south-west, east, and centre-north: Ahvaz (1), Bojnord (2), Isfahan (1), and Tehran (5)). Four of the subjects were male, and five were female. The participants from Tehran were of both genders: two male, three female, as were the two subjects from Bojnord. The informants also came from quite different walks of life, including not only linguistics students, but also two engineers, an attorney, a pizza baker, and a shop assistant in a supermarket. An extended word list was used with a second group of 13 subjects, originating from Annaheim (1), Isfahan (3), Kashan (1), Orumiyeh (1), Shiraz (1), Sacramento (1), Tabriz (1) and Tehran (4). Three of these subjects were bilingual American English/Persian speakers with English as the dominant language and were excluded because they behaved significantly different from the subjects with English as a second or third language. This will be discussed in a different paper.

Subjects were estimated to be between 20 and 40 years old. They varied substantially in how long they had been living abroad. Each subject uses Persian on a daily basis and each of the remaining subjects was certain that Persian was their native and dominant language. Some of the subjects indicated that they speak a local dialect or accent. However, the standard pronunciation is modelled after the accent of Tehran and dialectal variation seems to be neglectable within Iran. Nevertheless, I will briefly discuss the possibility of a regional effect later.

(10) *Combinations by segment class*

	S	F	N	L
S	Ptolemaios ptada	Psammetic		traffic Platon
F	Spartakus ftada	(same as S+S)	snack fnada	slang freezer flapjack Shrek flada
N	Ndebele mpada mkada npada	nfada nvaga nsada		Mladic mrada
L	ldada rdada rtada ltada lbada rgada			rlada lrada

The nonce-words were included for two purposes: to reconfirm results from the real words and to test for additional consonant combinations that had not been covered in the first probe. With the consonant sequences tested we can determine whether sonority or place of articulation (or both), or feature sharing play a role in the choice between prothesis and anaptyxis. Of particular interest are the items with falling sonority, i.e., those with an initial fricative, nasal or liquid, followed by a segment of lower sonority, i.e., a stop or obstruent, respectively (the green cells in 10). These combinations are expected to display prothesis if the constraint enforcing anaptyxis is the Syllable Contact Law. In the cells in (10) labelled N+S (nasal + stop), N+F (N + fricative) and R+S (Liquid + S) we see test words that allow us to detect a feature sharing influence with respect to place features and voicing on the epenthesis site. One could expect that feature sharing would result in prothesis to avoid delinking of association lines between segments. The cells shaded grey are empty because testing these combinations as well would not have provided additional insights regarding Syllable Contact or the Coda Condition.

3.1.2 Results

For existing loanwords, the claims from the literature are confirmed. There is no anaptyxis with sC clusters even if they are of rising sonority and prothesis results in a bad syllable contact, as in *slang* or *snack*, which casts doubt on the Syllable Contact Law analysis (Unfortunately, even steeper sonority rises, as in *sweater* or *swag* were not included. Informal elicitation with one informant yields *sowæg*).

In this discussion I conflate real words and nonce-words. In fact, some subjects were not familiar with some of the real words presented. Clusters with sonorants preceding obstruents were regarded as falling sonority clusters. 40% of realizations of these had a prothetic vowel and 58.9% an anaptyctic vowel.[5] If the SCL is the only factor causing anaptyxis, these 58.9% are surprising. There is a minor difference between nasals that are homorganic with the following consonant and those that are not (54% prothesis versus 40% anaptyxis and 39% vs. 61%, respectively). Once these are factored out, there is no noteworthy difference between nasals and liquids, and we can generalize that sonorants have an unexpected tendency to cause prothesis. Rising sonority clusters of sonorants, such as ML in *Mladic* or MR in *mrada* behave in the same manner as sonorant-obstruent clusters, i.e., 39.3% prothesis and 60.7% anaptyxis for stimulus *mrada*.

(11) *Prothesis and anaptyxis rates for different CC combinations*

	Prothesis in %	**Anaptyxis in %**
Sonorant+Obstruent	40	58.9
Nasal=C	54	40
Nasal≠C	39	61
Nasal+Liquid	39.3	60.7
Liquid+Stop	37.9	61.2
s+Sonorant	70.5	18.2
s+Liquid	52	28
s+Nasal	94.7	0
ʃ+Liquid	10	70
f+C	17.9	69.2
f+Stop	39	53.6
f+Sonorant	6.6	77.6
Stop+Stop	0	84.6

Clusters with an initial labial fricative also show variation independently of the sonority of the following consonant. /f/-initial sequences display 17.9% prothesis. These instances of prothesis are completely unmotivated if the SCL is the driving force deciding the epenthesis site. If we attribute these instances of prothesis to sounding out the letter <f>, it is surprising that literacy takes the upper hand more in clusters with a plateau than in rising sonority clusters. Also, sonorants would be produced as sounded out letters significantly more often than <f> under this hypothesis. We thus have to assume that prothesis with sonorants and the labial fricative is not just interference from literacy. The high prothesis rate with sonorant-

[5] Wherever percentages do not add up to 100, this is because there was the odd case of deletion or a syllabic first consonant. Subjects never changed the consonants discussed here, though they did not all identify letter sequences <sch> and <sh> as /ʃ/. Realizations without a change also occurred occasionally but were not counted.

initial clusters compared to f-initial clusters could be attributed to the Syllable Contact Law if it did not ignore the type of C2. Nasal+liquid clusters receive 39.3% prothesis, despite the bad syllable contact created and Liquid+stop clusters are resolved by anaptyxis in only 61.2% of productions despite the excellent syllable contact that would be created through prothesis.

We can summarize the vowel epenthesis patterns as follows. First of all, prothesis always occurs with initial /s/ and often with sonorants and the voiceless labial fricative, but never with initial stops.

(12) *Generalizations on V epenthesis*
a. Prothesis with initial /s/, and sonorants regardless of following C
b. Prothesis more likely if initial nasal is homorganic with following C
c. Prothesis with /f/-initial clusters more likely with following stops than sonorants
d. Anaptyxis with all other CC combinations

By comparing the different test subjects' behaviour, we can extrapolate a hierarchy of prothesis compatibility for initial consonants. All 19 participants prothesized when /s/ was the initial consonant. 10 did so with homorganic nasals. Six participants produced prothesis with non-homorganic nasals. Prothesis was less frequent with liquid-initial clusters. All subjects who produced prothesis with liquid-initial clusters also did so with nasal-initial clusters. The few subjects who produced prothesis in response to /f/ plus stop clusters also produced prothesis when confronted with nasal- and liquid-initial clusters.

(13) *Nonce-word prothesis preference scale*
VS.C > VN=̣C > VN≠C > VL.C, VR.C > VF.C

3.1.3 Discussion

If prothesis before /sC/ clusters was caused by a constraint demanding falling sonority across syllable junctures, we would not expect this implicational scale. Any speaker that prothesizes before /sC/ should also do so with any other cluster of even more dramatically falling sonority. A further, though minor, problem is the behaviour of /fC/ clusters. For some subjects, initial /f/ causes anaptyxis regardless of the sonority of the following consonant. If obstruents are placed at the same point in the sonority hierarchy, fricative–stop sequences constitute a sonority plateau, which might still be acceptable for the Syllable Contact Law. Nasal plus liquid sequences are of rising sonority. All standard sonority hierarchies place nasals lower than liquids. The syllable contact approach to cluster resolution would thus predict anaptyxis in these clusters. Here, six speakers show prothesis. Moreover, any cluster with an initial liquid and a C2 that is a nasal or obstruent should trigger prothesis, since it would result in an acceptable syllable contact. Thus, these new data corroborate the initial scepticism against a syllable contact analysis, raised by prothesis in words such as *slang*, *snack* and *ldada*.

The set of consonants referred to in (12) and (13) is identical with the consonants that are cross-linguistically preferred in coda position. For our Persian epenthesis patterns, we can now reconfirm the generalization that prothesis is the default strategy and that anaptyxis only applies if prothesis would result in a coda that contains a stop, or labial or dorsal place not licensed in a following onset, or liquids. Persian as spoken by some of the participants in this study displays by and large the same conditions on codas as Italian, Eastern Ojibwa, Portuguese, Chinese (+ /s/) and Kiribatese (+/s/).

Prothesis = default; avoids intrusion inside lexical strings
Anaptyxis = last resort to avoid violation of Ojibwa-style Coda Condition.

Given that anaptyxis only occurs when consonants are too marked to appear in coda position, one expects Persian to display such restrictions on codas in general or at least in some environments. However, as we will now see, this is not the case.

3.2 *The Persian lexicon*

We first examine the consonant inventory of Persian, then compare this with the set of consonants found in word-final, and finally preconsonantal position.

The consonant inventory of Persian is given in (14). The voiceless stops are always aspirated. In final position the voiceless series is aspirated as well, while the voiced stops are devoiced, though not aspirated (Windfuhr 1997). Although Windfuhr lists /q/ as a fricative, as shown in (14), he describes it phonetically as a stop, voiced aspirated in initial position and devoiced and/or spirantized in final position. In intervocalic position it tends to be spirantized. In my own data I observed considerable variation in its realization.

(14) *Persian consonants* (Windfuhr 1997:677)

	Bilabial	Labio-dental	Dental-alveolar	Alveo-palatal	Velar	Post-velar	Glottal
Stops							
Voiceless	p		t		k		ʔ
Voiced	b		d		g		
Affricates							
Voiceless				t͡ʃ			
Voiced				d͡ʒ			
Fricatives							
Voiceless		f	s	ʃ		x	h
Voiced		v	z	ʒ		q	
Liquids			r, l				
Nasals	m		n				
Semi-vowels				j			

In word-final position we find almost all manners and places of articulation, as evidenced in (15). (15)a illustrates stops with different places of articulation, voiced and voiceless (or plain and aspirated). The only restriction on stop places is that velar stops are palatalized. Voiced stops are realized as voiceless, as mentioned previously. (15)b gives examples of different fricatives. The entire inventory of Persian fricatives is attested. (15)c illustrates the word-final inventory of sonorants. Again, all sonorants can be found. (15)d,e,f show complex codas. These can be comprised of up to two segments. As (15)f shows, these clusters can display level sonority, rather than falling sonority, or they can even be of rising sonority. Final sonorants, however, and this happens most consistently in rhotics, are devoiced when preceded by an obstruent.

(15) *Word-final codas*

a.	tʃæp	‘left’ (hand)	b.	sɑf	‘smooth, soft’	c.	ʃekæm	‘belly’
	bæt	‘bad’		guʃ	‘ear’		xun	‘blood’
	xɑkʲ	‘dust’		mix	‘nail’		bɑl	‘wing’
	tʃɑq	‘fat’		kuh	‘mountain’		pær	‘feather’
	tænɑb̥	‘rope’		næv	‘battleship’		mej	‘wine’
	dud̥	‘smoke’		tiz	‘sharp’			
	sæg̊	‘dog’						
d.	poʃt	‘back’	e.	qænd̥	‘cube’	f.	ʃæxs	‘person’
	pust	‘bark, skin’		morq	‘chicken’		sæb̥z̥	‘green’
	xoʃk	‘dry’		sorx	‘red’		ʔæb̥r̥	‘cloud’
				qælb̥	‘heart’		ʔesm̥	‘name’
				solh	‘place’		tæbl	‘big drum’
			e’.	ræŋg̊	‘colour’			
				bɑŋg̊	‘shout’			

The Coda Condition might be enforced word-internally only, as in Eastern Ojibwa. As mentioned above, in this language, word-internal codas are restricted to nasals and (coronal) fricatives while in word-final position the full range of oral obstruents is found as well (Bloomfield 1957, Piggott 1999). Persian may be like Eastern Ojibwa in this respect. Furthermore, if word-final codas enjoy a special status, one could wonder whether they are codas at all, as Piggott did for Eastern Ojibwa. As mentioned above, Piggott argues that Ojibwa word-final consonants are not different from word-internal coda consonants with regard to syllable constituent affiliation.

In Persian, lexical items are usually relatively short. Most lexical morphemes are monosyllabic, and polysyllabic words are usually also polymorphemic, or loanwords. The data in (16) are compounds and derived forms, which show that we do not find a Coda Condition effect word-internally either. Nor do we find any effect of the Syllable Contact Law (Vennemann 1988). The Syllable Contact Law requires falling or level sonority (or rising/level consonantal strength) in the transition from one syllable to the next. The data in (a) and (b) adhere to the Syllable Contact Law: The first consonant in the cluster is of higher sonority than the second (e.g., [n.d]). In (c) both consonants are equal in sonority, while sonority rises from the coda to the onset in (d). (d) is a compound of [toxm̥] 'seed' and [morq] 'chicken' with an intervening *ezafé* vowel. The syllable transition from the fricative to the nasal is thus morpheme-internal. While the nasal is devoiced in the simple form to improve sonority sequencing (roughly: 'sonority rises within a syllable and then falls'), no alternation is observed in the form with the following *ezafé* vowel to improve the syllable juncture between the (low sonority) fricative and the (high sonority) nasal.[6] Given the strict ban on complex onsets, we have to assume that the internal cluster in (e) is spread across two syllables as well, resulting in a voiced coronal stop in a coda, in conflict with the Coda Condition and in a syllable contact of steeply rising sonority. Syllable contacts of even steeper rises in sonority are illustrated in (f) and (g).

(16) *Word-internal consonant clusters*

a.	pærænde	'bird'	c.	ʔeqtesɑd	'economics'
	bærɑjeŋke	'because'	d.	toxmemorq	'egg'
	pærvɑzkærdæn	'to fly'	e.	ʔætlæs	'atlas'
b.	ʃekofdæn	'split'	f.	mædrese	'school'
	xɑkestær̥	'ashes'	g.	ʔætrɑgin	'perfumed'

Internal codas are never complex. We find hardly any words with clusters of more than two consonants. However, besides the observation that both positions allow the same set of segments, there is one neutralization process that further supports an analysis of word-final consonants and consonant clusters as essentially belonging to the same constituent as word-internal pre-consonantal consonants. The dorsal obstruents are velar in onsets and palatalized in word-final as well as pre-consonantal position (and before front vowels).

We can observe a Coda Condition effect in language acquisition, however. Keshavarz and Ingram (2002) report on a bilingual child growing up with English and Persian as his ambient languages. As can be seen by comparison of (17) and (18), the child has a preference for coronal consonants in his English codas and especially does not license labials in this position. In his Persian word-final inventory, stops other than the voiced labial are unattested, and the inventory is almost exclusively restricted to coronals at the age of 20 months. In its near- complete lack of stops and places of articulation other than coronal, this inventory strikingly resembles the coda inventories discussed in 2.2. This impression is reinforced by the child's inventory in word-initial position, which is given in (18).

[6] The devoicing of postconsonantal word-final sonorants (compare the forms for 'seed' and 'egg' and the forms of 'cloud' and 'name' in 15f) can also be considered as evidence that a potential analysis that treats the word-final clusters as coda-onset sequences is quite probably not on the right track. In such an analysis, the final consonant would be followed by an empty nucleus. If this were the case, we would not expect the sonorants to devoice.

(17) *Word-final consonant inventories of a Persian-English bilingual child, 20 months old*

English			*Persian*		
t	tʃ	k			
d			b		
s	ʃ		f	s	ʃ
z				z	
n				n	
l				r	

(Keshavarz and Ingram 2002)

In word-initial position the same child shows a strong preference for stops and a bigger inventory in both languages. The two positional inventories of the child's Persian lexicon are almost mutually exclusive. The word-initial inventory seems to favour consonants from the lower end of the sonority hierarchy and the word-final inventory favours consonants of higher sonority.

(18) *Compared with his word-initial consonant inventories*

	English				*Persian*			
p	t	tʃ	k		p	t	k	ʔ
b	d		g		b	d	g	
f				h				
m	n				m	n		
	l, r							
w		j						

(Keshavarz and Ingram 2002)

Similar coda condition effects are observed in the acquisition of other languages. An extreme case is Norwegian, which is typologically exotic because it has a larger consonant inventory in the coda than in word-initial position, yet children still acquire contrasts in this position later than in onsets (Gram Simonsen 1990). The observation that children display coda condition effects even if they are acquiring languages without restrictions on this position is further support for the claim made here. Such coda filters are part of the universal constraint inventory.

A possible explanation for some of the prothesis beyond sC contexts could be dialectal variation in Persian. Persian is the native language of approximately 60,000,000 people (Ethnologue). My informants stem from eight different cities/regions and claim that they have different dialects/accents. Eight speakers are from Tehran and are thus the only group that is numerous enough to establish whether different prothesis choices are an effect of the local dialect. In this group, however, we find speakers who apply prothesis only with nasals, speakers who apply prothesis for nasal- as well as liquid-initial clusters, and one who does so even with /f/-initial clusters. If the inter-subject differences in our test results result from dialectal variation, the participants that are from the same place should behave identically or be at least very similar. The participants from Tehran clearly show that this is not the case. In addition, 10 of the speakers provided two different renditions for at least one stimulus. The most liberal participant provided two forms for twelve stimuli. This happened exclusively with stimuli featuring sonorant-obstruent sequences. Thus, it must be assumed that we are dealing with free variation. More data would be needed, however, to establish beyond a doubt whether we are dealing with individual differences or free variation.

In conclusion, we can say that the split in the epenthesis pattern is characterized by typical Coda Condition effects even though the language does not display coda neutralization patterns adhering to such filters elsewhere. The Coda Condition thus otherwise plays detectable role in Persian. We now turn to a formalization of these generalizations in an Optimality-Theoretic grammar.

4. OT analysis

Before we turn to explaining the occurrence of the split in the pattern, we must identify the reason for the epenthesis. The constraint *COMPLEX militates against branching or complex onsets and codas. An alternative to epenthesis to avoid violation of this constraint would be the deletion of one of the consonants, as attested in many languages and in acquisition. North Sami, for instance, bans certain onset clusters and adjusts them by deletion of the initial consonant. The north Norwegian city Tromsø, for example, is Romsa in North Sami (Bruce Morén-Duolljá, p.c.), as the initial voiceless stop is dropped. Deletion violates MAX, while insertion violates DEP, which are defined in (19).

(19) *Cluster resolution – Conflicting constraints:*

a. *COMPLEX (*CPLX): No more than one C or V may associate to any syllable position node. (Prince and Smolensky 2004:108)

b. MAX: Every element of S_1 has a correspondent in S_2. Domain $(\Re) = S_1$. (McCarthy and Prince 2004: 92) 'No deletion.'

c. DEP: Every element of S_2 has a correspondent in S_1. Domain $(\Re) = S_2$. (McCarthy and Prince 2004:92) 'No insertion.'

In a grammar that consistently avoids complex onsets and does so by vowel insertion, DEP has to be ranked below the constraints violated by complex syllable constituents and by cluster resolution via deletion. We do not have a ranking argument for the relation between *COMPLEX and MAX so far. If we subscribe to the assumption that, in the initial stage of language acquisition, all markedness constraints are ranked above all faithfulness constraints, it follows that the markedness constraint *COMPLEX outranks the faithfulness constraint MAX, unless a learner is exposed to data that prompt a reranking. Tableau (20) shows the choice of the insertion candidate over a candidate with deletion of a consonant and over the faithful candidate with the offending cluster.

(20) *Complexity avoidance by insertion*

		/snæk/	*CPLX	MAX	DEP
	a.	[snæk]	*!		
	b.	[næk]		*!	
☞	c.	[ʔes.næk]			*

In the previous section, we saw that complex codas are allowed. Thus, the grammar with the very general constraint *COMPLEX is too restrictive since it also bans complex codas. Therefore, the high-ranking markedness constraint has to be $^*\text{COMPLEX}_{\text{ONSET}}$, which militates against complex onsets only (Kager 1999:97). The general constraint *COMPLEX has to be ranked below MAX and DEP to prevent repair of complex codas. Tableau (21) shows how this grammar preserves codas with more than one segment.

(21) **COMPLEX or *$\text{COMPLEX}_{\text{ONSET}}$?*

		/xoʃk/ 'dry'	$^*\text{CPLX}_{\text{ONS}}$	MAX	DEP	*CPLX
☞	a.	[xoʃk]				*
	b.	[xoʃek]			*!	
	c.	[xoʃ]		*!		

As discussed in Section 3.1, prothesis comes with an additional cost. The provision of an onset consonant for the prothesized vowel results in a second violation of DEP. The current grammar would thus always select the anaptyxis candidate (22).

(22) *Why prothesis*

	/snæk/	*CPLX$_{ONS}$	MAX	DEP
☞	a. [senæk]			*
☹	b. [ʔes.næk]			**!

In contrast to anaptyxis, prothesis avoids a violation of CONTIGUITY. This constraint is given in (23).

(23) O-CONTIGUITY: ("No Intrusion")
The portion of S_2 standing in correspondence forms a contiguous string.
Range ($\Re$) is a single contiguous string in S_2. (McCarthy and Prince 2004: 92)

Here our North Sami example *Romsa* 'Tromsø' is instructive again. Even though the obstruent would make a "better" onset than the sonorant, according to Prince and Smolensky's (2004) harmonic scale for syllable margins (the lower sonority the more harmonic as onset consonant), it is deleted to avoid a violation of CONTIGUITY.

In Persian, we run into a ranking paradox here. CONTIGUITY has to outrank DEP for the grammar to select the prothetic candidate (24).

(24) *Prothesis: The relative importance of CONTIGUITY*

	/snæk/	*CPLX$_{ONS}$	ONSET	MAX	CONTIGUITY	DEP
	a. [senæk]				*!	*
☞	b. [ʔes.næk]					**
	c. [es.næk]		*!			*

This, however, excludes anaptyxis in all cases (25).

(25) *Contiguity problem*

	/ klɑs/	*CPLX$_{ONS}$	CONTIGUITY	DEP
☹	a. [ke.lɑs]		*!	*
💣	b. [ʔek.lɑs]			*

In Section 3, we saw that anaptyxis is caused by coda conditions. There are quite a few proposals in the literature on how to formalize coda filters. As mentioned earlier, Beckman (2004) claims that there is no such thing and that coda condition effects are the result of an interaction of positional faithfulness constraints with general markedness constraints. As will be shown in Section 5, this analysis is untenable in light of the Persian data. Another solution is the use of Local Constraint Conjunction (Prince and Smolensky 1993, Alderete 1997, Crowhurst and Hewitt 1997, Downing 1998, Itô and Mester 2003). See, e.g., Itô and Mester (2003), which conjoin the constraint against consonantal codas *CODA with segmental markedness constraints of the type *[+F] ('feature F with positive value is not allowed').

Taking into consideration that, for example, Italian allows geminates of all manners and places of articulation word-internally (e.g., [oṭːo] *otto* 'eight', which stems historically from a medial heterorganic stop cluster [kt] in Latin *octo*) and that codas, especially nasals, cross-linguistically have a tendency to assimilate in place of articulation to following onsets, we can break down the Coda Condition into licensing conditions that require a feature to be associated with a prominent position (as proposed by Zoll 1998; 2004, Walker 2011). A conjunction of *CODA&*F is still violated if feature F is associated to the following onset in addition to its link with a coda. The licensing constraint schema is given in (26).

(26) Generalized Prominence-based Licensing constraint schema (Walker 2011:45): LICENSE(λ, π)
$*\lambda/\neg$LICENSE$(\lambda,\pi)\equiv_{def}$
Let any occurrence of λ, a given type of constituent, in a chain $C_j(\lambda)$ be λ_j and p be an occurrence of π, a given type of prominent position.
Then assign a violation to each λ_j if the following holds
$\exists\ \lambda_j\ [P(\lambda_j)] \wedge \forall\lambda_j\ [\neg\text{Coincide}(\lambda_j,p)]$

Tentative definitions of onset licensing constraints are given in (27). Further typological investigations are under way for a more stringent definition of this constraint family (Krämer and Zec 2017; in prep.). Unfortunately, such an endeavour goes beyond the scope of this paper. However, we will come back to the details of these constraints when discussing individual variation in the experimental data at the end of this section.

(27) *Coda Conditions*

a. LIC([–cont], onset): Assign a violation mark for every stop that is not associated with an onset.
b. LIC([–sonorant], onset): Assign a violation mark for every obstruent that is not associated with an onset.
c. LIC(Lab/Dors, onset): Assign a violation mark for every labial and every dorsal place of articulation that is not associated with an onset.
d. LIC([liquid], onset): Assign a violation mark for every liquid that is not associated with an onset.
e. LIC([–strident], onset): Assign a violation mark for every non-strident that is not associated with an onset.[7, 8]

We first concentrate on the patterns that prefer prothesis before input-initial /s/. This pattern is enforced by the combination of (a) and (c).

In the following tableaux, I will give the offending consonant an exclamation point instead of the usual asterisk in the column under the respective Licensing constraint.

(28) *Contiguity problem solved*

/ klɑs/	*CPLX$_{ONS}$	LIC[–strident]	CONTIGUITY	DEP
☞ a. [ke.lɑs]			*	*
☠ b. [ʔek.lɑs]		k!		*

Since LIC[–strident] is frequently violated in Persian, the ranking of LIC[–strident] above DEP cannot be correct, since this predicts vowel insertion to avoid any coda that violates LIC[–strident]. If we split up DEP into DEP-V, violated only by vowel insertion, and general DEP (or DEP-C), we can leave DEP-V above LIC[–strident] and CONTIGUITY while DEP is bottom-ranked. Codas violating LIC[–strident] are not repaired, as shown in (29).

(29) *The Coda Condition elsewhere in Persian: No impact*

/tʃɑq/ 'fat'	IDENT	MAX	DEP-V	LIC[–strident]
☞ a. [tʃɑq]				q
b. [tʃɑ]		*!		
c. [tʃɑs]	*!			
d. [tʃɑ.qe]			*!	

[7] A reviewer is skeptical of the use of the feature [±strident] in the analysis of Persian. While it distinguishes between the dental fricatives and the sibilants in English, it does not seem to serve any purpose in Persian. I am not aware of any phonological processes in Persian that might justify the use of the feature, but it might serve in distinguishing the affricates from the stops. However, the task at hand is not a detailed featural analysis of the Persian segmental inventory and I consider [±strident] here as a placeholder for the feature that singles out /s/, since the majority of productions of clusters with initial <sh> and <sch>, i.e., intended /ʃ/ in the experiment, were rendered with anaptyxis, i.e., *Schröder* as *Scheroder* (60%/40%). Affricates were not tested.

[8] Many alternative analyses could be discussed for the sC clusters, such as an appendix account or, as suggested by a reviewer, Steriade's (1994) analysis of Mazatec onsets, i.e., Aperture Theory to account for the fact that sC is repaired by prothesis and other clusters by anaptyxis by the assumption that sC clusters are single segments. This proposal ignores two facts: Steriade's analysis of Mazatec onsets was superseded by an alternative analysis by Golston and Kehrein (1998), and Aperture Theory has been abandoned even by Steriade. Additionally, the reviewer also suggests using Steriade's (1995; 1999) Licensing by Cue to account for the difference between sC and TR clusters. The open transition the reviewer refers to, i.e., the release phase of stops, might phonetically favour an excrescent vowel in that position. The mixed behaviour of fC and sonorantC clusters, however, suggests that the phonetics is less important than phonological markedness. Furthermore, the quality of the vowel makes it unlikely that this is an excrescent vowel (Hall 2006).

With the split-up DEP constraints, the additional DEP violation caused by glottal stop epenthesis to provide the obligatory onset of the syllable of the prothetic vowel does not matter, since the higher ranked CONTIGUITY constraint filters out the undesired candidate with anaptyxis; see (30).

(30) *Obligatory onsets – consonants are cheaper than vowels*

/snæk/	*CPLX$_{ONS}$	MAX	DEP-V	LIC[–strident]	CONTIGUITY	DEP-C
a. [se.næk]			*	k	*!	
☞ b. [ʔes.næk]			*	k		*
c. [ʔes.næ.ke]			**!			*

LIC[–strident] filters out all prothetic candidates with an unlicensed consonant, in violation of lower ranked CONTIGUITY, as illustrated in (31) and (32).

(31) *Anaptyxis and the Coda Condition 1*

/klɑs/	*CPLX$_{ONS}$	DEP-V	LIC[–strident]	CONTIGUITY
☞ a. [ke.lɑs]		*		*
b. [ʔek.lɑs]		*	k!	

(32) *Anaptyxis and the Coda Condition 2*

/floridɑ/	*CPLX$_{ONS}$	MAX	DEP-V	LIC[–strident]	CONTIGUITY
☞ a. [fe.lo.ri.dɑ]			*		*
b. [ʔef.lo.ri.dɑ]			*	f!	

A relevant constraint missing here for the moment is the one causing glottal stop epenthesis. The constraint ONSET ('Assign a violation mark for every syllable that does not have a C at the left edge') has to be top-ranked in Persian (see Naderi and van Oostendorp 2011), as in (33).

(33) *Obligatory onsets*

/snæk/	*CPLX$_{ONS}$	ONSET	MAX	DEP-V	LIC[–strident]	CONTIGUITY	DEP-C
a. [es.næk]		*!		*	k		
☞ b. [ʔes.næk]				*	k		*
c. [se.næk]				*	k	*!	

Now we move on to multiple-vowel epenthesis. Clusters of three consonants are repaired by the insertion of two vowels. However, the grammar developed here so far does not allow multiple violations of DEP-V in the respective cases, as Tableau (34) shows.

(34) *Problem with multiple epenthesis*

/stres/	*CPLX$_{ONS}$	MAX	DEP-V	LIC[–strident]	*CPLX$_{CODA}$
a. [stres]	*!				
☹ b. [ʔes.te.res]			**!		
☞ c. [ʔest.res]			*	t	*

As observed in Section 3, codas are maximally binary. Altogether, clusters of three consonants in a row are virtually absent from Persian and complex codas are allowed only word-finally. Since it would exceed the scope of this paper to fully explain this observation, I will simply add the cover constraint *CCC to the grammar (see Kisseberth 1970 for the origins of this constraint).

(35) *CCC: 'Assign a violation mark for every sequence of more than two consonants.'

This constraint has to rank higher than DEP-V to oust the erroneous winner from (34), as shown in (36).

(36) *Prothesis and anaptyxis*

	/stres/	*CPLX$_{ONS}$	*CCC	MAX	DEP-V
☞ a.	[ʔes.te.res]				**
b.	[ʔest.res]		*!		*

However, in triconsonantal clusters the choice between prothesis and anaptyxis shows an interesting aspect of the analysis that was not quite obvious before and poses yet another technical problem. The grammar so far prefers a candidate with one anaptyctic vowel.

(37) *Prothesis and anaptyxis*

	/stres/	*CPLX$_{ONS}$	*CCC	MAX	DEP-V	LIC[–strident]	CONTIGUITY
☹ a.	[ʔes.te.res]				**!		*
☞ b.	[set.res]				*	t	*

The only marked aspect of candidate (b) in Tableau (37) is the stop in a coda, resulting from vowel epenthesis. However, we have seen in Section 3.2 that the lexicon of Persian contains codas with stops in exactly the same environment, as in the word [ʔætrɑgin] 'perfumed', which is most likely syllabified as [ʔæt.rɑ.gin], with a syllable break between the voiceless stop and the rhotic.

While we established that the Coda Condition shows an effect once a vowel is inserted, because the language allows all sorts of consonants in coda position, it was not obvious that vowel epenthesis was a *condition* for the Coda Condition to be activated. This is a typical case of the "avoidance of the worst of the worst" (Prince and Smolensky 1993/2004). Prince and Smolensky proposed the mechanism of constraint conjunction to deal with such effects. Two constraints join forces in a third, new constraint, that is violated only if both constraints are violated in the same local domain.

(38) Local Conjunction DEP-V & LIC(stop) (short, DEP&$_{\sigma}$LIC(stop)):
Assign a violation mark for every instance of an inserted vowel adjacent to a consonant violating the coda condition against stops. Domain: Syllable

Local Constraint conjunction has been used in the analysis of Derived Environments since Lubowicz (2002). The avoidance of a certain type of coda exclusively in an environment created by vowel epenthesis is clearly a derived environment effect.

(39) *Prothesis and anaptyxis*

	/stres/	DEP&$_{\sigma}$LIC(stop)	DEP-V	LIC[–strident]	CONTIGUITY
☞ a.	[ʔes.te.res]		**		*
b.	[set.res]	*!	*	*	*
c.	[ʔe.set.res]	*!	**	*	*

As can be seen from the fate of candidate (c) in Tableau (39), this Local Conjunction also takes care of the position of the second vowel. It could occur either after the first or after the second consonant. The usual location is the former position, which our grammar correctly generates.

The next issue to be discussed is the individual variation encountered in the elicitation task. Recall from Section 3.1 that there was a hierarchy of consonant classes that cause prothesis, with nasals most amenable to prothesis, followed by other sonorants and finally non-strident fricatives. Prothesis was not observed with stop-initial clusters regardless of participants and context.

(40) *Nonce-word prothesis preference scale*

VS.C > VN$\overset{.}{=}$C > VN≠C > VL.C, VR.C > VF.C

Although the number of subjects is quite small, it is nevertheless striking that, as a population, they display an implicational hierarchy of coda tolerance that echoes the impression received from the typological sketch on coda filters in Section 2, summarized in (13) and repeated here as (40) for convenience. We can thus assume that the ranking between the Licensing constraints is more or less stable across speakers.

(41) *Coda Conditions*

a. LIC([–cont], onset): Assign a violation mark for every stop that is not associated with an onset.
b. LIC([–sonorant], onset): Assign a violation mark for every obstruent that is not associated with an onset.
c. LIC(Lab/Dors, onset): Assign a violation mark for every labial and every dorsal place of articulation that is not associated with an onset.
d. LIC([liquid], onset): Assign a violation mark for every liquid that is not associated with an onset.
e. LIC([–strident], onset): Assign a violation mark for every non-strident that is not associated with an onset.

The variation between subjects emerges from the interaction of these constraints with CONTIGUITY, the constraint violated by anaptyxis. Insertion of the vowel after the first consonant avoids violation of LICENSE (x, p) constraints, as this places the first consonant in an onset. The ranking of CONTIGUITY with respect to the different LICENSE(x, p) constraints determines the range of prothesis. Higher ranking of CONTIGUITY results in prothesis with more consonant classes.

Several speakers only display prothesis before initial /s/. Since coda restrictions are the reason to violate O-CONTIGUITY and place the epenthetic vowel between the consonants, these speakers must have LIC[–strident] ranked high, banning any consonant that is not [+strident] from codas derived by epenthesis. Speakers that do not separate nasals homorganic with a following consonant by anaptyxis have LIC[–strident] below CONTIGUITY, and all other Licensing constraints above it.

(42) *Excluding consonants from the coda by onset licensing*

	LIC (stop)	LIC (Lab/Dors)	LIC (nonsonorant)	LIC (liquid)	LIC (nonstrident)	CONTIGUITY
sV.CV						*
Vs.CV						
mV.pV						*
Vm.pV					*	
mV.kV						*
Vm.kV		*			*	
lV.CV						*
Vl.CV				*	*	
fV.CV						*
Vf.CV		*	*		*	
tV.CV						*
Vt.CV	*		*		*	

Once LIC(place) is below CONTIGUITY, together with LIC(non-strident), we see prothesis also with nasals that do not share their place of articulation with the following consonant. If, additionally, LIC(liquid) is below CONTIGUITY, we encounter prothesis also with liquids. If only Lic(liquid) is ranked below CONTIGUITY, but LIC(non-strident) dominates the Faithfulness constraint, we see no liquid-specific effect, since they are still excluded by violating LIC(nonstrident). It also requires the demotion of a fair number of constraints to produce prothesis with fricatives (i.e., /f/ or /ʃ/). The tableau in (42) shows the violations of the respective constraints incurred by the two relevant output candidates for each consonant combination under discussion. With the ranking in (42) prothesis is optimal only with inputs with sC clusters.

In order for /f/ to provoke prothesis, CONTIGUITY has to dominate three Licensing constraints, as shown in (43). This explains the low frequency of prothesis with /fC/ inputs compared to prothesis with sonorant-C inputs.

(43) *Excluding consonants from the coda by onset licensing*

	LIC (liquid)	LIC (stop)	CONTIGUITY	LIC (Lab/Dors)	LIC (nonsonorant)	LIC (nonstrident)
☞ sV.CV						
Vs.CV			*!			
mV.pV			*!			
☞ Vm.pV						*
mV.kV			*!			
☞ Vm.kV				*		*
☞ lV.CV			*			
Vl.CV	*					*!
fV.CV			*!			
☞ *Vf.CV*				*	*	*
☞ tV.CV			*			
Vt.CV		*			*!	*

Tableau (43) shows one of two weaknesses of the account. Some rankings generate prothesis with initial fricatives but anaptyxis with liquid-initial clusters, which was not attested among my participants. Demotion of LIC(stop) also favours prothesis with stops, which is unattested as well. While I am not aware of any language resolving all initial clusters in loanwords by prothesis, I would not be surprised to find one. Future fieldwork on Persian with more informants might fill these gaps.

As discussed in Section 3, dialectal variation with respect to the constraints relevant to this analysis seems to be non-existent, and each subject only produced very few items of each cluster type. We can thus assume that we are not necessarily dealing with interspeaker variation here. Since coda markedness constraints are otherwise irrelevant in the phonology of Persian, it can be assumed that these constraints are demoted during acquisition but remain unranked with respect to each other. Under the assumption that constraint ranking has to be exhaustive under each evaluation, we can describe this free variation as the unranked coda constraints assuming a random ranking under each evaluation, resulting in different outputs produced by the same grammar on different occasions (see Anttila 1997; 2007 for Partially Ordered Constraints as an analysis of free variation)

With this analysis in place, I now discuss why the coda licensing analysis of the Persian split epenthesis pattern is preferable to a Syllable Contact analysis and to a Positional Faithfulness account.

5. Alternatives

Gouskova (2002) examines the typology of prothesis and anaptyxis. She proposes that the default is prothesis, caused by CONTIGUITY (as adopted above; see also Shademan 2002), unless the resulting syllable juncture violates the Syllable Contact Law.

The two tableaux given in (44) show how this analysis accounts for the vowel placement in words like *estop* 'stop' and *ferut* 'fruit', respectively. Prothesis is chosen for *stop* since anaptyxis (candidate b) violates CONTIGUITY. Prothesis does not result in a syllable juncture of rising sonority in this case, since *s* is of higher sonority than the following *t*. Sonority falls from the first to the second syllable. In the failed candidate **ef.rut* with input *frut*, the transition from a fricative to a liquid is a bad syllable contact since the final segment of the first syllable is of much lower sonority than the first consonant of the following syllable. Since $C is ranked higher than CONTIGUITY, this violation of $C is avoided in violation of CONTIGUITY.

(44) *Syllable contact and choice of epenthesis site à la Gouskova (2002)*

		/stop/	*CPLX	DEP	$C	CONTIGUITY
	a.	[stop]	*!			
	b.	[se.top]		*		*!
☞	c.	[es.top]		*	✓	

		/frut/	*CPLX	DEP	$C	CONTIGUITY
☞	b'.	[fe.rut]		*		*
	c'.	[ef.rut]		*	*!	

Some languages do not allow prothesis at all. This is taken care of by an Alignment constraint that matches the left edge of the input with the left edge of a syllable or the prosodic word.

The observation that initial nasals sometimes cause prothesis and sometimes cause anaptyxis, depending on whether they share their place of articulation with the following consonant or not (e*Mbeki* versus *Me*l*adic*) raises doubts for an analysis that explains the choice between prothesis and anaptyxis via $C, though it does not disprove it. However, nonce-words like [me.kæ.dæ] from stimulus *mkada* should not trigger anaptyxis, as the syllable contact in the potential prothetic form *[em.kæ.dæ] is of falling sonority and is thus fine according to $C. The resulting syllable contact in nonce words with initial fricatives followed by stops is quite flat but still falling. 14 of the participants in this study repaired the cluster by anaptyxis and only 4 produced a prothetic vowel. Existing words like *snack*, which have a cluster of rising sonority and which are repaired by prothesis nevertheless, are incompatible with a $C analysis, as shown in (45). (45) displays the two possible rankings of $C and CONTIGUITY. The second one accounts for prothesis in *snack*. This latter ranking, though, cannot handle anaptyxis in *fruit*-type data, as shown in (46).

(45) *The Persian problem part 1: /s/ + sonorant*

i.		/snæk/	$C	CONTIGUITY
💣	a.	[senæk]		*
☹	b.	[esnæk]	*!	

ii.		/snæk/	CONTIGUITY	$C
	a.	[senæk]	*!	
☞	b.	[esnæk]		*

(46) *The Persian problem part 2: Reranking? Not with obstruent + sonorant sequences*

		/frut/	CONTIGUITY	$C
☹	a.	[ferut]	*!	
💣	b.	[efrut]		*

As the tableaux show, *snack*-type words require $C to be ranked above CONTIGUITY, while *fruit*-type words require the reverse ranking. We are faced with a ranking paradox, which is a strong indication that the analysis uses the wrong constraints. As shown above in Section 4, both data can be analysed without such problems if we replace $C by the Coda Condition.

In her analysis of the split epenthesis pattern in Kirghiz, Gouskova (2002) decomposes the $C constraint into a family of constraints along the scale in (4). While /sl/ and /sn/ still trigger prothesis, /sw/, as in *sweater* or *swag* as well as /fr/ in *fruit* trigger anaptyxis. The cut-off point in Persian is thus a syllable contact of +5. Clusters should not have a sonority rise >4. *Dist>+4 is thus the constraint that has to be satisfied, ruling out the mapping /frut/ – **efrut* as well. However, the experimental data presented above show prothesis also with fricative+stop clusters for some subjects.

As noted in the introduction, Beckman (2004) extended the $C analysis to the cases of epenthesis discussed as evidence for the Coda Condition by Itô (1989). Beckman's reasoning runs as follows: the Positional Faithfulness claim is that strong positions enjoy privileged protection rather than that weak positions receive additional pressure to avoid marked structure. In a parsimonious theory we rely on only one mechanism to account for positional asymmetries, such as Coda Condition effects, either Positional Faithfulness or Positional Markedness. Given a grammar that contains the constraints IDENTONSET, *PLACE and

*STOP, parsing an underlying labial stop in an onset rather than in a coda does not improve the violation count. Thus, Positional Faithfulness can account for deletion (47)c and neutralization (47)d, but not for epenthesis as a repair strategy to meet the Coda Condition (47)b. The epenthesis candidate (47)b ties with the faithful candidate that does not avoid marked features in the coda (47)a. If we consider DEP violations as well, the epenthesis candidate turns out to be universally bounded (sub-optimal under any ranking). If vowel epenthesis is a possible Coda Condition effect, i.e., a strategy to avoid violation of coda constraints, then the Positional Faithfulness account of coda neutralization is to be questioned.

(47) *Positional Faithfulness account of Coda Condition effects*

	/apga/	IDENTONSET	*STOP	*PLACE	DEP	MAX	IDENT
a.	ap.ga		**	**			
b.	a.pe.ga		**	**	*		
☜ c.	a.ga		*	*		*	
☜ d.	ag.ga		*	*			*
e.	ap.pa	*	*	*		*	*

Thus, if Itô's epenthesis examples can be reanalysed as being caused by some force other than the Coda Condition, i.e., the Syllable Contact Law, the Coda Condition becomes superfluous, since neutralization and deletion patterns are analysable as interaction of Positional Faithfulness and general Markedness constraints.

As we have seen in the discussion of Gouskova's approach, the Persian vowel anaptyxis pattern is just such a case of epenthesis driven by the Coda Condition that supports Itô's claim of a positional licensing/markedness constraint. Accordingly, whether epenthesis in Axininca Campa or Tamil is a reaction to the Syllable Contact Law or not no longer matters to the discussion of the status of the Coda Condition. However, since Beckman convincingly shows that the Coda Condition alone does not explain the cross-linguistically common asymmetry that coda consonants are often neutralized and assimilate to following onsets rather than encroaching on the following onset to obtain licensing in a prominent position, we have to assume that phonology contains both the Coda Condition, i.e., markedness constraints on codas, as well as positional faithfulness to syllable onsets.

In her analysis of sC clusters in Government Phonology, Goad (2012) proposes that such clusters are coda-onset sequences in most cases, while clusters of rising sonority are branching onsets. Loanwords in languages like Persian are thus repaired by filling the empty vowel position, here indicated by small letter v in vs.C(R)V sequences. The account given here is not just a notational variant of this proposal, since it does not assume that an input /sCV/ is actually analysed as a coda-onset sequence at any stage before the Vs.CV output candidate is chosen as optimal and it does not make any claims about which representation initial sC clusters have in languages that allow them. Goad would also have to explain why this does not happen with all initial clusters. After all, Persian allows syllable contacts of rising sonority word-internally, as discussed in 3.2. **etræfik* would thus not be a bad match for *traffic*, so the Government Phonology equivalent to the Syllable Contact Law should be switched off. The TR onset would have to be represented either as vT.RV or Tv.RV. Since all codas are allowed in Persian, creating a new one should be preferred over breaking up the string.

6. Conclusion

In this paper, new data from Persian have been presented that show that prothesis is the default option to break up consonant clusters in syllable onsets, and that anaptyxis only applies if the initial consonant does not conform to the set of consonants allowed in codas according to cross-linguistically attested coda conditions. This is surprising, since Persian does not show any Coda Condition effects in its lexicon: Almost any consonant can be found in this position. We are thus dealing with a residual effect of otherwise low-ranked constraints, whose presence in the grammar is only expected if constraints are universal.

This has consequences for our understanding of phonological constraints. First, it shows that a constraint (or constraint set) enforcing restrictions on the segment inventories found in codas is necessary, i.e., that such distributional generalizations on neutralization patterns cannot be explained by Positional Faithfulness. Second, since the Coda Condition is not active in Persian phonotactics, the constraint cannot have been learned in first language acquisition. There are no data that would justify regarding the constraint as emergent. While one can in general assume that the Coda Condition is functionally motivated, since phonetic cues for contrastive features in codas are weaker than for consonants followed or surrounded by vowels, Persian speakers do not have any reason to postulate such a constraint when learning the language. Nevertheless, we have seen that it shows effects both in first language acquisition and in loanword adaptation. It thus has to be a member of a universal set of constraints. We can conclude that at least some constraints are not emergent.

Of course, where there is a will there is a way, one might think: To maintain the emergentist hypothesis one could reason that, since Persian children are confronted with the challenge of learning, and learning to produce, a lot of words with all sorts of final contrasts, they figure out early on that these contrasts are difficult to hear and difficult to produce, for the lack of cues (that are provided for initial consonants in the transition to the following vowel). Having experienced these perceptual and articulatory difficulties, they add a corresponding constraint (i.e., the Coda Condition) to their grammar. However, if we apply the same kind of logic to a language with a strictly enforced Coda Condition that does not show alternations, such as Beijing Chinese, we would have to say that native learners of such a language never experience difficulties with coda consonants, since they are never found in the input. Hence, the grammar of Chinese speakers should not contain a Coda Condition, since they lack the relevant data/experience that learners of Persian have to cope with. They have only negative evidence to rely on. If we then try to explain the typical errors committed by Chinese speakers learning a second language, such as English, we cannot say that the typical deletions of final consonants or additions of vowels happen because the learner has a highly ranked Coda Condition in their native grammar. We would have to make reference to lexical statistics instead. English final consonants find no match in the repository of stored exemplars of Chinese words. They are thus unexpected, and the language user is not trained/experienced in their articulation. If we then, for reasons of theoretical parsimony, use lexical statistics to explain the Persian pattern discussed here we run into a problem: Coda consonants of all sorts of places and manners are very common and thus there is no reason to avoid a subset of the inventory in this position in the treatment of loan-/nonce-words or in second language acquisition. The least problematic solution to the dilemma is thus to assume that all constraints are universally present.

The generalizations made in this paper were formalized in Optimality Theory. OT offers a choice to analyse positional distributional asymmetries with either positional faithfulness constraints interacting with general markedness constraints or positional markedness/licensing constraints. A positional faithfulness approach fails, as has been shown in Section 5, since the crucial constraint IDENTOnset(F) is unable to trigger epenthesis. We are then left with the choice between formalising the Coda Condition as positional markedness or positional licensing. A positional markedness constraint simply states that some feature or feature combination is not allowed in a certain position. Such constraints can elegantly be formalized as Local Conjunctions (Smolensky 1995; 2006) of simple constraints, such as *CODA $\&_{seg}$*LABIAL (Smolensky 2006:45 and references cited there), *CODA $\&_{seg}$*DORSAL etc. Constraints of this type, however, do not capture the recurrent phenomenon that features otherwise banned in the coda in a language are allowed nevertheless if they are shared with the following onset (e.g., place of articulation of nasals, and geminate obstruents in Italian and Japanese). Itô, Mester and Padgett (1995) and Crowhurst (2001) offer a more complex formalization of coda conditions as markedness constraints that are violated by certain consonantal features in moraic position if the root node is not affiliated with two syllables. This definition amounts to a licensing statement. A certain feature F or segment class is only allowed if it is in position x—and thereby implicitly banned from all positions ¬x. If F is in position x, it might simultaneously be associated with a position ¬x too. Accordingly, in this paper formalization of CODACOND as a set of licensing constraints was chosen for typological reasons. The Persian data presented here do not allow us to decide between markedness and licensing. However, the exact formalization of the Coda Condition was not at stake in this paper. Further research has to show whether the constraint set it was broken down to here is appropriate for the analysis of cross-linguistic variation of coda segmentism. The more modest aim of this paper was to showcase the unexpected emergence of coda markedness effects in Persian, a language without any coda restrictions, as evidence for the universal status of this set of constraints.

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