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Isomorphism between orthography and underlying forms in the syllabification of the Armenian schwa

Hossep Dolatian*

Stony Brook University – hossep.dolatian@alumni.stonybrook.edu

Orthographic representations are often derived from phonological analyses or representations, and can even lead to claims about phonological representations (Sproat 2000). In Armenian, many strings of orthographic consonants are broken up by schwas in pronunciation. As a grammatical process, this spelling-pronunciation mismatch is sensitive to a host of phonological, morphological, and morphophonological factors. I systematically catalog these factors, and this systematicity reinforces previous generative arguments that the orthographic form (without schwas) matches the underlying form (without schwas) (Vaux 1998). As for these factors, I argue that, phonologically, the epenthesis is triggered by directional syllabification and other syllabification-based constraints, including constraints on sibilant-stop contiguity (Itô 1989). Morphologically, epenthesis respects morpheme boundaries even when the boundary is semantically opaque, whether from prefixation, compounding, reduplication, or pseudo-reduplication. And from the morphophonology, there is evidence that epenthesis is simultaneously a phonological rule. It is an early lexical rule and it interacts opaquely with allomorphy and strata. Thus, this paper argues for a tight integration of orthographic, phonological, and morphological structures (cf. Boersma 2011; Hamann & Colombo 2017).

Keywords: orthography; underlying representation; directional syllabification; orthography-phonology; schwa epenthesis

1 Introduction

Cross-linguistically, there is ample documentation of vowel epenthesis processes that are sensitive to phonological and morphological factors (Itô 1986; Kenstowicz 1994; Côté 2000; Hall 2011; Silverman 2011). This paper discusses schwa epenthesis in Armenian. We first treat epenthesis as a process that transforms orthographic representations to surface pronunciation forms. The near-perfect systematicity of this process is then a strong argument that schwa epenthesis likewise operates from underlying forms to surface forms, such that the orthographic and underlying representations are isomorphic. The orthography is thus a proxy for the underlying form.

Armenian is an Indo-European language with two standard varieties: Western and Eastern. Eastern Armenian is the official language of the Republic of Armenia, and it's spoken in Georgia, Iran, and Russia (essentially in areas that were part of the Russian and Persian empires), as well as diaspora communities elsewhere in the globe. In contrast, Western Armenian developed as a koine in the Ottoman Empire. After the Armenian Genocide, Western Armenian became a diasporic language spoken in the Middle East, Europe,

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Americas, and elsewhere. I focus on Western but the generalizations extend to Eastern.

Armenian is primarily a CjVCC language, but the orthography contains large sequences of consonant clusters (Table 1). Many of these orthographic clusters are pronounced with one or more unwritten schwas: <mnal>→[mə.nɑl] 'to stay'. We argue that orthographic forms (<mnal>) by default mirror the underlying forms (/mnɑl/) by lacking these schwas. This paper provides a near-complete catalog of the different contexts for schwa epenthesis as a productive and psychologically real rule at the interface of orthography, phonology, and morphology (Hamann & Colombo 2017). A sample is shown in Table 1.

Table 1: Representative sample of root-initial clusters

1C	2C	3C	4C		5C		6C
<dal>	<mnal>	<krban>	<p'ndṙel>	<mgrdel>	<d͡ʒmṙt'gel>	<hrmʃdug>	<k'rt'mnt͡ʃel>
/d-ɑl/	/mn-ɑl/	/k^{h}ɾbɑn/	/p^{h}ndɾ-el/	/mgɾd-el/	/d͡ʒmɾtk-el/	/hɾmʃtug/	/k^{h}ɾt^{h}mnt͡ʃ-el/
[d-ɑl]	[mə.n-ɑl]	[k^{h}əɾ.bɑn]	[p^{h}ənd.ɾel]	[mə.gəɾ.del]	[d͡ʒə.məɾt.k^{h}el]	[həɾ.məʃ.tug]	[k^{h}əɾt^{h}.mən.t͡ʃel]
'to give'	'to stay'	'pocket'	'to seek'	'to baptize'	'to wrinkle'	'jostling'	'to murmur'

The overarching analysis is that schwa epenthesis is governed by right-to-left directional syllabification. Mismatches between schwa location and directionality arise from the interaction of phonotactic and morphological constraints whether word-initially or word-medially. These constraints include contiguity constraints in sibilant-stop clusters, syllable alignment to morpheme left-boundaries, and alignment in (pseudo-)reduplicative structures. Schwa epenthesis is a productive and psychologically real rule that applies from the orthography to surface forms. Based on this systematicity, we argue that this rule simultaneously applies from underlying forms to surface forms. The generated schwas are phonologically visible, inserted early in the derivation, feed allomorphy, and interact opaquely with late post-lexical processes. Thus, for words with epenthetic schwas, the orthographic forms are essentially the same as the underlying forms (Vaux 1998:ch3).

The take-away from this paper is thus to document the existence of a systematic process at the interface between orthography, lexical representations, and morphophonology. This process interacts with directional syllabification, phonotactics, morphological structure, and derivational strata. This paper is organized as follows. §2 provides background on Armenian orthography and syllable structure, with a focus on the role of schwas. §3 catalogs the distribution of orthographic clusters and epenthetic schwas in small and large consonant clusters. This distribution is predicted from right-to-left syllabification. §4 catalogs deviations in the placement of schwas, i.e., when a schwa is placed in a location that's not predicted by directional syllabification. These deviations are caused by phonotactic constraints on sibilant-stop clusters, and on left-alignment to morpheme boundaries. §5 discuses the psychological reality of schwa epenthesis as an orthographic and phonological rule, both diachronically and synchronically. §6 teases apart schwa epenthesis from vowel reduction. Conclusions are in §7. The appendix discusses an alternative analysis of schwa epenthesis by Vaux (1998) (Appendix A), and an alternative complete analysis for vowel reduction (Appendix B).

Data is collected from published grammars and dictionaries, published both in English and in Armenian. Data is verified against my native Western intuitions and double-checked on English/Armenian Wiktionary. The supplementary materials provide transliteration software and complete OT tableaux with URs and all our constraints, verified with OT-Help (Staubs, Becker, Potts, Pratt, McCarthy & Pater 2010).[1] Such tableaux may be useful as pedagogical problem sets.

2 Background on orthography and syllable structure

This section provides background information on Armenian orthography, specifically how schwas show mismatches in their written vs. pronounced forms (§2.1). §2.2 clarifies my methodology and the relationship

[1] https://osf.io/jx9wa/

between this paper and the wide body of work on Armenian schwas. §2.3 then discusses Armenian syllable structure, and how Armenian is largely a strict C(j)VCC language with constraints on licit complex codas.

2.1 Orthography of schwas

Armenian utilizes its own script, the Armenian script. The script was invented in around the 5th century for Classical Armenian, the oldest attested written variety of Armenian (Sanjian 1996). The script has continued to be used for the modern standard lects: Western and Eastern Armenian. In the 20th century, there was a series of spelling reforms in Soviet Armenia (Dum-Tragut 2009). These reforms affected the spelling of words for Eastern Armenian in Armenia, but not for Eastern communities in Iran nor for Western Armenian in the diaspora. For this paper, we utilize the reformed spelling of words because it is closer to the surface pronunciation of words. Transcriptions however are in Western Armenian. We use the transliteration scheme in Table 2.

Table 2: Transliteration system

Grapheme	ա	բ	գ	դ	ե	զ	է	ը	թ	ժ	ի	լ	խ	ծ	կ	հ	ձ	ղ	ճ	մ
Transliteration	a	p	k	t	e	z	ē	ə	t'	ʒ	i	l	x	d͡z	g	h	t͡s	ɣ	d͡ʒ	m
Pronunciation	ɑ	p^h	k^h	t^h	e	z	e	ə	t^h	ʒ	i	l	χ	d͡z	g	h	t͡s^h	ʁ	d͡ʒ	m
Grapheme	յ	ն	շ	ո	չ	պ	ջ	ռ	ս	վ	տ	ր	ց	ւ	փ	ք	օ	ֆ	ու	և
Transliteration	y	n	ʃ	o	t͡ʃ'	b	t͡ʃ	ṙ	s	v	d	r	t͡s'	w	p'	k'	ō	f	u	ev
Pronunciation	j	n	ʃ	o	t͡ʃ^h	b	t͡ʃ^h	ɾ	s	v	d	ɾ	t͡s^h	v	p^h	k^h	o	f	u	ev

Some pairs of graphemes are homophonous in Western Armenian. To maintain a one-to-one correspondence, we disambiguate these homophonous graphemes via diacritics. Some graphemes have multiple surface pronunciations based on context, including devoicing and post-fricative deaspiration processes in consonant clusters: <aɣp>→/ɑχp^h/→[ɑχp] 'trash'. These complications do not affect our analysis and we don't discuss them. The nasal /n/ becomes [ŋ] before velars.

We place transliterations in angles <>, underlying forms in slashes //, intermediate representations in double slashes // //, and surface pronunciations are either unbracketed or get []. We place morpheme boundaries in our representations, when useful.

The orthography captures all phonemic contrasts. It is relatively predictable to go from the orthographic representations (ORs) to the pronunciation or surface representations (SRs). The vowel inventory consists of /ɑ,u,i,e,o,ə/. Each vowel has its own grapheme, set of graphemes, or digraphs. The schwa has its own grapheme ը <ə>. But, not all surface schwas are written down in the orthography. Based on the correspondence between the ORs and SRs of schwas, we arrive at three categories, shown in Table 3 (Baronian 2017; cf. similar classifications in Dutch: van Oostendorp 2014).

Table 3: Categories of schwas in orthography vs. pronunciation

	Present	Inserted	Reduced	
OR:	<ənger>	<mnal>	<kir>	<krel>
UR:	/ənger/	/mnɑl/	/k^{h}iɾ/	/k^{h}iɾel/
SR:	[əŋgéɾ]	[mənɑ́l]	[k^{h}íɾ]	[k^{h}əɾél]
	'friend'	'to stay'	'writing'	'to write'

Some schwas are present in both ORs and SRs: <ənger> ∼ [əŋgeɾ] 'friend'. We call these 'present' or underlying schwas. Most schwas in the SR are absent in the OR. We call these 'inserted' schwas: <mnal> ∼ [mənɑl] 'to stay'. A special case of schwas corresponds to deleted or reduced high vowels. These high vowels are pronounced when stressed: <kir> ∼ [kʰíɾ] ‘writing’. But they are deleted or reduced to a schwa in certain morphological contexts when they are unstressed: <krel> ∼ [kʰəɾ-él] ‘to write’.

Cross-linguistically, there is little work on formalizing the derivational relationship between orthography and linguistic structure (Aronoff 1985; Dresher 1994). For the derivational relationship between ORs and SRs, the largest work to my knowledge is Sproat (2000), who argues that ORs represent a level of representation that, depending on the language, can match either the UR, SR, an intermediate representation, or even a much deeper representation than the UR. As for how to derive SRs from ORs, there is some pre-existing work (Giegerich 1999; Wiese 2004; Song & Wiese 2010; Neef 2012; Hamann & Colombo 2017; Hamann 2020), mostly for Germanic languages.

For Armenian, it is commonly argued that the orthography reflects the presence or absence of schwas in the underlying representation (UR) (Vaux 1998). I ultimately argue for this position as well, but I first establish the systematic correspondence of ORs and SRs. I utilize constraints from Hamann & Colombo (2017) for the OR-to-SR mapping, couched within Bidirectional Phonetics and Phonology (BiPhon: Boersma 2011). Given that ORs and SRs are systematically related, I then argue that this systematicity means that URs essentially match ORs (§5.2; Nevins & Vaux 2008). We focus on the case of ‘inserted’ or epenthetic schwas because they are the most complex, and later briefly discuss the other categories of schwas (§5.2.1, §6, Appendix B). We ultimately argue that the three categories of schwa display different phonological behavior.

2.2 Methodological problems in Armenian

For Armenian schwa insertion, there have been different proposed analyses to predict the location of these epenthetic schwas, given either the UR or OR as input. Traditional grammars simply list different contexts and locations where these schwas appear without any overarching prediction (Thomson 1989; Bardakjian & Thomson 1977; Bardakjian & Vaux 2001; Սուքիասյան 2004; Dum-Tragut 2009). There is some Soviet Armenian work on predicting the location of schwa epenthesis (Гулакян 1965; Ղարագյուլյան 1974, 1979; Թոխմախյան 1988). Khachaturian (1985) provides a summary of Soviet work. In generative phonology, Armenian schwa epenthesis has been analyzed with left-to-right syllabification (Levin 1985), simultaneous rules (Schwink 1994), left-alignment (Orgun 2000), markedness constraints based on vowel-consonant adjacency (Khanjian n.d.), and right-alignment (Vu 2014). These various analyses are however incomplete and look at only small subsets of the Armenian data. Vaux (1998) is the most developed algorithm or analysis. His system is inspired by sonority-based syllabification of syllabic consonants in Berber (Dell & Elmedlaoui 1985).

Because the data is quite complicated and relatively unknown (outside of Armenology), this paper starts from the data first and incrementally builds up an analysis. This paper acts as an typologically-oriented meta-analysis, a standalone theoretical analysis, and as an empirical catalog of the individual variables involved in schwa epenthesis. We emphasize the empirical nature because there are methodological issues in past work, which we try to address. These issues are UR Construction, Reduction-Epenthesis Conflation, and Factorization.

For UR Construction, most generative work on schwa epenthesis aims to directly model schwa epenthesis as a process that occurs from URs to SRs. To do so, these analyses implicitly adopt the following premises: a) given the OR, it is predictable to know how to pronounce schwas in the SR, b) the UR should lack predictable information, thus c) the UR should match the OR. Although we ultimately argue that (c) is true, that there is near-identity between the UR and OR (= the OR is a proxy for the UR), this argumentation has to first establish the truth of premise (a).

Furthermore, URs are an abstract representation that one has to explicitly argue for, and not take for granted. Depending on the language, the UR can either match or mis-match the OR. In contrast, the ORs and SRs are given non-abstract representations. Thus, it is a methodologically simpler task to first establish that there is a systematic relationship between ORs and SRs. After doing so, we argue that the OR is a proxy for the UR such that UR matches the OR. By doing so, we reduce the problem of abstraction, and we increase the replicability or psychological reality of our analysis.

As a reviewer points out, the analysis opens the issue of how URs and schwa epenthesis would be acquired by literate vs. non-literate speakers. The mental grammar of literate speakers would necessarily have a transformation/mapping of ORs and URs to SRs. Such speakers would get the most obvious evidence for needing a schwa epenthesis rule; for them, the OR acts as a proxy to the UR by default. In contrast, the mental grammar of illiterate or pre-literate speakers would only have a UR-to-SR mapping. For both literate and illiterate speakers to acquire schwa epenthesis from URs to SRs, they would need to exploit the predictability of this rule (§3–4) and its morphophonological behavior (§5) in order to treat these epenthetic schwas as absent from the UR.

For Reduction-Epenthesis Conflation, most work on schwa epenthesis tends to argue for a single monolithic analysis of the distribution of inserted and reduced schwas. The problem with this approach is that it presumes that the exact same generalizations apply to both types of schwas. In this paper, we tease apart this conflation. We at first focus strictly on the behavior of inserted schwas. By establishing the generalizations that govern inserted schwas, we then find that reduced schwas display subtle differences that merit a separate analysis, which we explore briefly in §6 and in-depth in Appendix B.

For Factorization, schwa epenthesis is a quite convoluted process that affects a wide range of the Armenian lexicon. It can thus be difficult to isolate the individual generalizations that govern schwa epenthesis. Such individual generalizations are tantamount to epiphenomenal generalizations that arise from our formal grammar. For example, most grammars or analyses of schwa epenthesis provide catalogs of inserted schwas based on the size of the consonant cluster. However, these catalogs don't disentangle or isolate a) the presence of morpheme boundaries, b) the possible presence of reduced schwas, c) and the historic role of vowel syncope. This paper resolves this issue by methodologically cataloging the different contexts for schwas, and by focusing on one individual parameter at a time. The end result is a relatively clearer sense of what are the basic patterns in schwa epenthesis: right-to-left syllabification (avoiding medial Cə syllables), morpheme alignment, and other factors such as the effects of syncope and vowel reduction.

When we do the above three methodological finesses, we end up with two positive outcomes. One is a clearer sense of what is schwa epenthesis in its own terms. The second is a yardstick to evaluate the empirical coverage and theoretical elegance of an analysis. As we discuss later, we find that Vaux (1998)'s analysis has impressive empirical coverage, but that there are two corners of the grammar where it has problems: #CCCCV clusters (Appendix A) and disentangling vowel reduction (§6). This doesn't mean that we reject Vaux's analysis, but it encourages future work to see how pre-existing analyses can be augmented.

2.3 Syllable structure

Armenian has relatively simple syllable structure (Table 4). The maximal syllable is CjVCC. Complex onsets are generally avoided except for C+j sequences, which are arguably complex segments (Vaux 1998:81). Complex codas generally need falling sonority.

Table 4: Syllable structure of Armenian

V	VC	CV	CVC	CVCC	CjVCC
<ē>	<ov>	<pu>	<pan>	<sird>	<gyank'>
[e]	[ov]	[p^hu]	[p^hɑn]	[siɾd]	[gjɑŋk^h]
'is'	'who'	'owl'	'thing'	'heart'	'life'

Some falling-sonority consonant clusters are not licit complex codas, and they can trigger schwa epenthesis. For example, the lateral /l/ can be the second member of a complex coda in native words (Table 5), but it cannot be the first *k^halt*. Word-finally, /ɾm/ is a licit complex coda, but /ɾn/ can variably trigger schwa epenthesis for some speakers. Word-medially, /ɾm/ can form a complex coda in native words, while /ɾn/ cannot. Word-medially, /ns/ triggers epenthesis for some speakers.[2] For /mC/ complex codas, the C has to be a homorganic stop (Vaux 1998:103); otherwise we get epenthesis.[3]

Table 5: Some falling-sonority clusters that are not syllabifiable

GL,*LX	ɾm#	*ɾn#	...ɾm...	*...ɾn...	(*)...ns...	mC	
<kayl> [k^{h}ɑjl] 'wolf'	<t͡ʃerm> [t͡ʃeɾm] 'warm'	<xaṙn> [χɑɾ(ə)n] 'mixed'	<garmranal> [gɑɾm(ə)ɾɑnɑl] 'to redden'	<gornkan> [goɾəŋk^{h}ɑn] 'honey-lotus'	<ōrenstir> [oɾen(ə)stiɾ] 'legislator'	<amt͡ʃ'god> [ɑmət͡ʃkot] 'shy'	<amb> [ɑmb] 'cloud'

Many of these constraints are inactive for non-nativized loanwords like [volt^{h}] 'volt', [ɾomɑns-neɾ] 'romance-PL'. I set aside loanwords because such words often maintain the source language's syllable structure at the expense of native constraints.

For most types of licit complex codas, these codas can be licensed either by full vowels or schwas. Both full vowels and schwas can host a complex coda (Table 6) that is a homorganic nasal-stop cluster, homorganic nasal-affricate, fricative-stop cluster, rhotic-stop cluster, or a rhotic-affricate cluster. Word-medially-medially, neither can host [ɾn].

Table 6: Complex codas licensed by both full vowels and schwas

nasal + stop	nasal + affricate	fricative + stop	rhotic + stop	rhotic + affricate	*...ɾn...
<ambrob> [ɑmb.ɾob] 'storm'	<hant͡snel> [hɑnt͡s.nel] 'to surrender'	<asdvad͡z> [ast.vɑd͡z] 'God'	<arpʃiṙ> [ɑɾp.ʃiɾ] 'tipsy'	<gard͡ʒnal> [gɑɾd͡ʒ.nɑl] 'to get short'	<gornt͡ʃ'il> [go.ɾən.t͡ʃil] 'to perish'
<ʃmprot͡s'> [ʃəmp^{h}.ɾot͡s] 'knapsack'	<t'nd͡zgal> [t^{h}ənd͡z.gɑl] 'to yelp'	<sgzpnagan> [əs.kəsp.nɑ.gɑn] 'initial'	<grg.nel> [gərg.nel] 'to repeat'	<t'ṙt͡ʃ'nig> [t^{h}əɾt͡ʃ.nig] 'birdie'	<pṙnt͡ʃ'i> [p^{h}ə.ɾən.t͡ʃi] 'nettle tree'

However in native words, there are some clusters that can be licensed by full vowels, but generally not schwas. Full vowels can host [ɾm] and rhotic-sibilants, while schwas generally don't (Table 7). I do not provide an analysis for these asymmetries but take them as given.

Table 7: Complex codas licensed by full vowels but not schwas

[ɾm]		rhotic + sibilant		
<t͡ʃermnagan> [t͡ʃeɾm.nɑ.gɑn] 'feverish'	<sermnager> [seɾm.nɑ.geɾ] 'seed-eater'	<harsnik'> [hɑɾs.nik^{h}] 'wedding'	<garʃneɣ> [gɑɾʃ.neʁ] 'nervous	<marzban> [mɑɾz.bɑn] 'marquis'
<trmpal> [t^{h}ə.ɾəm.p^{h}ɑl] *tərm.pɑl 'to thump'	<xṙmp'al> [χə.ɾəm.p^{h}ɑl] *χəɾm.pɑl 'to snore'	<bṙsdel> [bə.ɾəs.tel] *bəɾs.tel 'to wrinkle'	<p'ṙʃdal> [p^{h}ə.ɾəʃ.tɑl] *p^{h}əɾʃ.tɑl 'to sneeze'	<srsgel> [sə.ɾəs.kel] *səɾs.kel 'to sprinkle'

[2] Besides *s*, other nasal-sibilant clusters are vanishingly rare, but the examples that I found suggest that [nʃ] can form a complex coda: <d͡ʒnʃman> → [d͡ʒənʃ.m-ɑn] 'pressure-GEN'; while [mʃ] cannot: <lmʃtot͡s'> [lə.məʃ.tot͡s, *ləmʃ.tot͡s] 'cradle'.

[3] An exception is stem-final *ms* clusters like *doms* 'ticket'. The *s* is analyzed as an appendix (Vaux 1998:84).

Besides complex codas, Armenian licenses a limited set of extrasyllabic appendix consonants. These appendixes are added at the edges of syllables or words, while violating sonority laws. For example the nominalizer suffix -k^h can be added after complex codas: *bartk*^{h} 'debt'. This appendix -k^h is limited to the end of stems (Vaux 1998; Vaux & Wolfe 2009; Dolatian 2020). Other final appendixes exist but are rare, including /s,χ,ʃ/. These appendixes do not interact with schwa epenthesis, so we do not discuss them in depth.[4]

Throughout this paper, I assume a shorthand constraint *CC_σ which encompasses all the above restrictions on licit onsets and codas (1). The exact formulation of this constraint is tangential. A fruitful approach would be to use nuanced projection constraints (van Oostendorp 2011). But for this paper, what matters is knowing what counts as a well-formed syllable.

(1) *General constraint on syllabification*

*CC_σ	Do not have a syllable margin more complex than what is allowed by the phonotactics of the language.

3 Distribution of schwas in clusters

Despite the relatively restricted syllable structure, the orthography displays many cases of consonants clusters in ORs that are broken up by schwas in the SR. These clusters are especially common root-initially. I go through a catalog of these clusters as they are found root/word-initially (§3.1), root/word-medially (§3.2), and root/word-finally (§3.3). A common analysis across of all these cases is right-to-left syllabification.

Note that as explained in §2.2, we at first treat the OR as the input to syllabification/phonology. But since the OR is a proxy for the UR (= the OR and UR match), the schwa-less OR inputs in subsequent tableaux can be equivalently replaced with schwa-less URs. For convenience, I also provide the OR-based URs in the tableaux.

3.1 Root-initial and word-initial clusters

Root-initially, there are ORs that show long clusters of consonants. But most of these clusters are broken up by one or more schwas in pronunciation. These root-initial clusters range in size from 2 to 6 (Table 1). In this section, the words that we focus on are either monomorphemic roots like <krban>→[kʰərbɑn] 'pocket', or consist of a bound root and some category-forming suffix like <mnal>→[mən-ɑl] 'to stay'. These words are not derived from roots which surface with a high vowel. That is, it is not the case that the schwa in *mən-al* is derived from the high vowel of a morpheme like **min*. The schwas in forms thus are non-alternating.

By focusing on these words, we remove any confounds from vowel reduction.[5] We argue that in the transformation of ORs to SRs, these schwas are inserted via directional syllabification.

3.1.1 2C and 3C clusters

The simplest types of root-initial clusters are 2C or 3C clusters. For both types of clusters, a schwa is pronounced after the first consonant. We provide a sample of 2C clusters in Table 8. The data is organized to illustrate how pervasive these clusters are. The first consonant ranges over all possible consonants, while the second consonant is either a plosive, fricative, or sonorant. Complications arise when cluster is sibilant-stop, discussed in §4.1.

[4] The nasal *m* seems to have appendix-like behavior, and it can follow fricatives: *goʁm* 'side', *baderazm* 'war', and *tʰəroʃm* 'stamp.'

[5] Some of these words possibly were multimorphemic in an earlier stage of the language, e.g., *hərməʃtug* 'jostling' might be derived diachronically from *hər-el* 'to push'. But such knowledge would be unknown to most contemporary speakers.

Table 8: Epenthesis in initial 2-consonant clusters: <CCV> → [Cə.CV]

C + plosive			C + fricative			C + sonorant		
<pt͡ʃit͡ʃ> [pʰə.t͡ʃit͡ʃ] 'cell'	<ttum> [tʰə.tʰum] 'pumpkin'	<kd͡zud͡z> [kʰə.d͡zud͡z] 'vile'	<tʒoxk'> [tʰə.ʒoχk] 'hell'	<k'ʃ-el> [kʰə.ʃ-el] 'to drive'	<dxur> [də.χuɾ] 'sad'	<xmor> [χə.moɾ] 'dough'	<klux> [kʰə.luχ] 'head'	<p'ṙel> [pʰə.ɾel] 'to spread'

Similarly for 3C clusters (Table 9), a schwa is placed after the first consonant, forming a closed CəC syllable. Again, these 3C clusters can involve a diverse permutation of possible consonants.

Table 9: Epenthesis in initial 3-consonant clusters: <CCCV> → [CəC.CV]

C + plosive + C			C + fricative + C			C + sonorant + C		
<pdgan> [pʰəd.gɑn] 'well-fed'	<tbt͡ʃ'il> [tʰəp.t͡ʃ-il] 'to touch'	<mgrad> [məgɾɑd] 'scissors'	<p'sxel> [pʰəs.χ-el] 'to vomit'	<tʒvar> [tʰəʒ.vɑɾ] 'hard'	<kʒdil> [kʰəʒ.d-il] 'to quarrel'	<p'rgel> [pʰəɾ.g-el] 'to save'	<t'mpug> [tʰəm.pʰug] 'drum'	<k'nk'uʃ> [kʰəŋ.kʰuʃ] 'delicate'

In pronunciation, these initial clusters undergo epenthesis via very simple constraints (2). We assume a general constraint $*CC_\sigma$ that is violated by illicit complex onsets or complex codas. As a constraint on the correspondence between ORs and SRs, we utilize the constraint <>/ə/ that is violated whenever a schwa in the SR does not have a corresponding grapheme in the OR (Hamann & Colombo 2017). This constraint is analogous to a Dep constraint between URs and SRs. This constraint is outranked by $*CC_\sigma$, thus licensing schwa epenthesis. For a 2C cluster like <mnal> 'to stay', a schwa is epenthesized after the first consonant *mənal*. The constraint Onset prevents epenthesis before the consonant: **əm.nal*. Similarly for a 3C cluster like <krban>, a single schwa is placed after the first consonant thanks to these constraints: *kʰəɾ.ban* 'pocket'.

(2) *Constraint system 2C and 3C clusters*

a. <>/ə/ — Do not insert a schwa in the SR if it has no correspondent in the OR.

b. Onset (Ons) — Do not have onsetless syllables. This is essentially a Dep constraint for OR-SR correspondence.

c. Constraint ranking — $*CC_\sigma >>$ <>/ə/, Onset

d. *Pronouncing 2C clusters and 3C clusters for* [mə.nɑl] 'to stay' *and* [kʰəɾ.bɑn] 'pocket'

<mnal> (/mnɑl/)		$*CC_\sigma$	<>/ə/	Ons
a.	mnɑl	*!		
b.	əm.nɑl		*	*!
c. ☞	mə.nɑl		*	

<krban> (/kʰɾbɑn/)		$*CC_\sigma$	<>/ə/	Ons
a.	kʰɾbɑn	*!		
b. ☞	kʰəɾ.bɑn		*	
c.	kʰə.ɾə.bɑn		**!	

In the above tableaux, the actual input for the derivation is just the OR. We include the UR for illustrative convenience (and it almost always matches the OR).[6] The constraint <>/ə/ only works over ORs and SRs. Interested readers can equivalently replace this constraint with Dep, and turn the OR-SR mapping to a UR-SR one.

[6] We include both the OR and UR and not just the UR. This is because we think it's methodologically unsound (§2.2) to first treat the UR as the input without first justifying why the UR lacks the schwas. We avoid this circularity by treating the OR as input, and then showing how the OR-based UR would look like.

3.1.2 4C clusters and larger

For 2C and 3C clusters, syllabifying the ORs is straightforward. But for larger clusters, we see variation in where schwas are pronounced. We argue that the placement is based on sonority and directionality.

In 4C clusters, there are largely two classes of words based on the location and number of epenthesized schwas. In one class of words (Table 10), a single schwa is inserted after first consonant: <CCCCV> → [C_1əC_2C_3.CV]. Here, C_2C_3 form a complex coda.

Table 10: Epenthesis in initial 4-consonant clusters: <CCCCV> → [C_1əC_2C_3.C_4V] where C_2C_3 are a well-formed complex coda

C + nasal + plosive			C + nasal + affricate			C + rhotic + plosive		
<p'ndṙel>	<t͡s'ngnil>	<gntrug>	<d͡znd͡zɣar>	<gnt͡sni>	<d͡ʒnd͡ʒɣug>	<grdser>	<gṙt'nil>	<xrdt͡ʃ'il>
[pʰənd.ɾ-el]	[t͡səŋg.n-il]	[gəntʰ.ɾug]	[d͡zənd͡z.ʁɑɾ]	[gənt͡s.ni]	[d͡ʒənd͡ʒ.ʁug]	[gəɾt.seɾ]	[gəɾd.n-il]	[χəɾt.t͡ʃ-il]
‘to seek’	‘to pup’	‘frankincense’	‘mugwet’	‘elm’	‘sparrow’	‘junior’	‘to lean’	‘to be scared’

The use of a single schwa after C_1 is predicable because a single schwa is all that’s needed to syllable this cluster. Our current set of constraints can derive this (3).

(3) *Deriving 4C clusters with one schwa in* [pʰənd.ɾel] ‘to seek’

<p'ndṙel> (/pʰndɾel/)		$*CC_\sigma$	<>/ə/
a.	pʰndɾel	$*!$	
b. ☞	pʰənd.ɾel		$*$
c.	pʰə.nəd.ɾel		$**!$

But in a separate set of words, two schwas are found: <CCCCV> → [Cə.CəC.CV] (Table 11). One schwa is after the first consonant, another after the second. Two schwas are needed because C_2C_3 cannot form a licit complex coda.

Table 11: Epenthesis in initial 4-consonant clusters: <CCCCV> → [C_1ə.C_2əC_3.C_4V] where C_2C_3 are rising-sonority and cannot form a complex coda

C + stop + rhotic			C + fricative + sonorant		
<mgrdel>	[mə.gəɾ.d-el]	‘to baptize’	<lɣrd͡ʒel>	[lə.ʁəɾ.d͡ʒ-el]	‘to taint’
<t͡skṙdal>	[t͡sə.kʰəɾ.d-al]	‘to belch’	<tɣrtel>	[tʰə.ʁəɾ.tʰ-el]	‘to shake’
<lp'ṙdal>	[lə.pʰəɾ.d-ɑl]	‘to jabber’	<tʒntag>	[tʰə.ʒən.tʰɑg]	‘dreadful’
<ʃbrdel>	[ʃə.bəɾ.d-el]	‘to put away’	<xʃrdal>	[χə.ʃəɾ.d-ɑl]	‘to murmur’
<t't'ṙgit͡ʃ'>	[tʰə.tʰəɾ.git͡ʃ]	‘wood-sorrel’	<mxrd͡ʒil>	[mə.χəɾ.d͡ʒ-il]	‘to plunge’

For the words in Table 11, C_2C_3 are a rising-sonority cluster and thus cannot be parsed into a complex coda. A second schwa is thus needed. However, the current constraint system cannot explain the reason why the schwa appears after C_2, and not after C_3: <mgrdel> → *mə.gəɾ.del* and not **məg.ɾə.del* ‘to baptize’. Notice that the correct output generates a medial closed syllable *gəɾ*, while the incorrect output generates a medial open syllable *ɾə*.[7]

To motivate the location of the schwa, I argue that the relevant factor is directional syllabification (ter Mors 1985; Noske 1985; Itô 1986; Svantesson 1995; Farwaneh 1995). Specifically, syllables are parsed

[7] The generalization is strong. Vaux examined almost 100 possible 4C combinations and found no cases of two initial open syllables: [C_1ə.C_2ə.CCV] (Vaux 1998:24).

right-to-left. Syllabification aims to fit as many segments into a C(j)VCC template as possible.[8] Schwas are epenthesized to syllabify clusters that are not adjacent to a vowel.

To illustrate, (4c) shows a derivation of right-to-left parsing via a rule-based system for [mə.gəɾ.del] 'to baptize' (Itô 1986, 1989). This can be equivalently derived via parallelist alignment constraints (McCarthy & Prince 1993; Mester & Padgett 1994; Crowhurst & Hewitt 1995). The alignment constraint Align-σ-L aims to reduce the number of segments that separate a syllable from the word-initial edge. The analogous constraint Align-R is not shown because it is inactive and low-ranked.[9]

(4) *Deriving two schwas via directional syllabification for* [mə.gəɾ.del] 'to baptize'

a. Align-σ-L — Assign a violation for every segment that separates a syllable from the left-edge.

b. Constraint ranking — $^{*}CC_{\sigma}$ >> Align-σ-L

c. *Deriving via rules*

	<mgrdel>
R->L	{mgr}.del
	{m}.gəɾ.del
	[mə.gəɾ.del]

d. *Deriving via constraints*

<mgrdel> (/mgɾdel/)			$^{*}CC_{\sigma}$	<>/ə/	Align-σ-L
a.		mgɾdel	∗!		
b.		məgɾ.del	∗!	∗	4
c.	☞	mə.gəɾ.del		∗∗	7
d.		məg.ɾə.del		∗∗	8!

Note that our alignment constraints use gradient violations, not categorical ones (McCarthy 2003). It's not obvious how we can use categorical alignment instead. One alternative is to use directional constraints (Eisner 2000).

Based on the above data, one could argue that the motivation for the schwa's location is based on the syllable contact law (Seo 2011), or due to both directionality and syllable contact (Rose 2000). But this is false.[10] There are 4C clusters where there is epenthesis between C_2C_3 even though C_2C_3 form a falling-sonority cluster: <CCCCV> → [Cə.CəC.CV] (Table 12). Here, C_2C_3 cannot form a complex coda for various reasons, which we discussed in §2.3. Syllable contact would make the incorrect prediction of *[CəC.Cə.CV].

[8] In a rule-based system, such a template must exist as a mental object for the sake of template-filling. In an OT system, such a template is epiphenomenal.

[9] I use directionality as the main predictor for schwa epenthesis. Coincidentally, Vaux (1998)'s analysis of Armenian utilizes also right-to-left syllabification as a secondary tool. The main tool he uses for schwa epenthesis is syllabic consonants (p. 61–87). On page 94, he incorporates right-to-left directionality in order to predict word-medial complex codas like [ɑ**nt͡s**.rev] 'rain'. The use of directionality in this paper is thus incomparable to how Vaux uses it simply because we use directionality for different purposes. He likewise dismisses a templatic approach for schwa epenthesis with CVC templates, but doesn't discuss CVCC templates (p. 78).

[10] Although there is no evidence of a synchronic role for the syllable contact law in schwa epenthesis, there is diachronic evidence that is consistent with the syllable contact law from diachronic metathesis in Classical Armenian (DeLisi 2013, 2015).

Table 12: Epenthesis in initial 4-consonant clusters: <CCCCV> → [C$_1$ə.C$_2$əC$_3$.C$_4$V] where C_2C_3 are falling-sonority and cannot form a complex coda

C + lateral + C			C + rhotic + C		
<blʃgel>	<xlrdel>	<plntorel>	<mṙldal>	<krmp'al>	<vṙndel>
[bə.ləʃ.k-el]	[χə.ləɾ.d-el]	[pʰə.lən.to.ɾ-el]	[mə.ɾəl.d-ɑl]	[kʰə.ɾəm.pʰ-ɑl]	[və.ɾən.d-el]
'to soil'	'to move'	'to sew hastily'	'to murmur'	'to thump'	'to expel'

The above data can be generated via directional syllabification by the same constraints and ranking in (4). Directional syllabification can likewise explain schwa epenthesis in larger clusters (Table 13). For 5C clusters, two schwas are needed. When C$_3$C$_4$ can form a complex coda, then a schwa is added after C$_2$: <d͡ʒmṙt'gel> → *d͡ʒə.məɾt.kʰel* 'to wrinkle'. Otherwise, a schwa is added after C$_3$: <hrmʃdug> → *həɾ.məʃ.tug* 'jostling'.

Table 13: Epenthesis in initial 5-consonant clusters

<C$_1$C$_2$C$_3$C$_4$C$_5$V> → [C$_1$ə.C$_2$əC$_3$C$_4$.C$_5$V] where C$_3$C$_4$ are a well-formed complex coda					
<d͡ʒmṙt'gel>	[d͡ʒə.məɾt.k-el]	'to wrinkle'	<p'ṙnkdal>	[pʰə.ɾəŋk.tʰ-ɑl]	'to sneeze'
<C$_1$C$_2$C$_3$C$_4$C$_5$V> → [C$_1$əC$_2$.C$_3$əC$_4$.C$_5$V] where C$_3$C$_4$ are not a well-formed complex coda					
<hrmʃdug>	<ʃnt'ṙgil>	<gndndot͡s'>	<t'rmnt͡ʃal>	<pltrɣan>	<t'rt'nt͡ʃug>
[həɾ.məʃ.tug]	[ʃən.tʰəɾ.g-il]	[gən.dən.dot͡s]	[tʰəɾ.mənt͡ʃ-ɑl]	[pʰəl.tʰəɾ.ʁɑn]	[tʰəɾ.tʰən.t͡ʃug]
'jostling'	'to crouch'	'plaster'	'to murmur'	'hogweeds'	'wood sorrel'

Again, the location of these schwas is predicted by directional syllabification. We illustrate in (5) for [d͡ʒə.məɾt.kel] 'to wrinkle' and [həɾ.məʃ.tug] 'jostling', whether via rules or constraints

(5) a. *Deriving epenthesis in 4C clusters via rules*

	<d͡ʒmṙt'gel>
R->L	{d͡ʒmṙt}.kʰel
	{d͡ʒ}.məɾt.kʰel
	[d͡ʒə.məɾt.kʰel]

	<hrmʃdug>
R->L	{hrmʃ}.tug
	{hr}.məʃ.tug
	[həɾ.məʃ.tug]

b. *Deriving single epenthesis in 4C clusters via constraints for* [d͡ʒə.məɾt.kʰel] 'to wrinkle'

<d͡ʒmṙt'gel> (/d͡ʒmɾtʰkʰel/)			*CC$_\sigma$	<>/ə/	ALIGN-σ-L
a.		d͡ʒmɾtkʰel	*!		
b.	☞	d͡ʒə.məɾt.kʰel		**	7
c.		d͡ʒəm.ɾət.kʰel		**	9!

c. *Deriving double epenthesis in 4C clusters via constraints for* [həɾ.məʃ.tug] 'jostling'

<hrmʃdug> (/hɾmʃtug/)			*CC$_\sigma$	<>/ə/	ALIGN-σ-L
a.		hɾmʃtug	*!		
b.		hə.ɾəmʃ.tug	*!	**	7
c.	☞	həɾ.məʃ.tug		**	9

Larger clusters are rarer (Table 6). I have found only the following two which are likely to involve bound roots, without obvious reduplication or other morphemes. The location of the schwa is again predicted by directional syllabification.[11]

(6) a. *Epenthesis in initial 6-consonant clusters:* <CCCCCCV> → [CəCC.CəC.CV]

<k'rt'mnt͡ʃel>	[kʰəɾtʰ.mən.t͡ʃ-el]	'to murmur'
<gnt͡smnt͡sug>	[gənt͡s.mən.t͡s-ug]	'winter cress'

b. *Deriving* <CCCCCCV> → [CəCC.CəC.CV] *in* [kʰəɾtʰ.mən.t͡ʃel] 'to murmur'

<k'rt'mnt͡ʃel> (/kʰɾtʰmnt͡ʃel/)			$*CC_\sigma$	<>/ə/	ALIGN-σ-L
a.	☞	kʰəɾtʰ.mən.t͡ʃel		∗∗	11
b.		kʰəɾ.tʰəm.nə.t͡ʃel		∗∗∗!	17!
c.		kʰəɾ.tʰə.mən.t͡ʃel		∗∗∗!	16!
d.		kʰə.ɾətʰ.mən.t͡ʃel		∗∗∗!	15!

Thus, when converting ORs to SRs, right-to-left syllabification can generate the location of epenthetic schwas in initial clusters. The next subsections show that directional syllabification can also explain schwa insertion in medial and final clusters.

3.2 Root-medial and word-medial clusters

Word-medially, we can have intervocalic consonant clusters that range from two to four members. Intervocalically, <VCV> and <VCCV> clusters are predictably syllabified as [V.CV] and [VC.CV] (Table 14). It doesn't matter if the medial CC has falling sonority or not.[12]

Table 14: Intervocalic <V(C)CV> clusters are parsed as [V(C).CV]

<VCV>→V.CV			<VCCV>→VC.CV			<VCCV>→VC.CV		
<tarag> [tʰɑ.ɾɑg] 'drawer'	<seɣan> [se.ʁɑn] 'table'	<kumar> [kʰu.mɑɾ] 'amount'	<harkank'> [hɑɾ.kʰ-ɑŋkʰ] 'respect'	<barġil> [bɑɾ.g-il] 'to sleep'	<koknot͡s'> [kʰokʰ.not͡s] 'apron'	<abril> [ɑb.ɾ-il] 'to live'	<badrasd> [bɑd.ɾɑst] 'ready'	<akṙav> [ɑkʰ.ɾɑv] 'crow'

For 3C clusters <VC_1C_2CV> (Table 15), we find two possible parses. First, if C_1C_2 can form a complex coda, then there is no schwa epenthesis: ***hajd.ni*** 'clear'. Otherwise, a schwa is added after C_1: ***pʰe.dəɾ.vɑɾ*** 'February'.[13]

[11] The example [gənt͡s.mən.t͡s-ug] 'winter cress' might be a case of onset corruption in pseudo-reduplication: /gnt͡s-mnt͡s-ug/ (§4.2.3).

[12] VCjV clusters are variably syllabified [sen.jɑg ∼ se.njɑg] 'room'. This variation is tangential to schwa epenthesis.

[13] There are limited exceptions due to diachronic syncope. For example, the orthographic form <hasgnal> 'to understand' is pronounced as [hɑs.kə.nɑl] with unexpected epenthesis: ****hɑsk.nɑl***. This schwa is a reflex of diachronic syncope from an earlier form of the word <hasganal>∼[hɑs.kɑ.nɑl]. The schwa must be present in the UR /hɑskʰənɑl/, and exceptionally absent from the OR.

Table 15: Syllabification of intervocalic <VCCCV> clusters, with or without epenthesis

<VCCCV>	VCC.CV		<VCCCV>	V.CəC.CV	
<haydni>	[hɑjd.ni]	'clear'	<p'edrvar>	[pe.dəɾ.vɑɾ]	'February'
<t'arkmanel>	[tɑɾkʰ.mɑ.n-el]	'to translate'	<makl͡ts'il>	[mɑ.kʰəl.t͡s-il]	'to climb'
<marzban>	[mɑɾz-bɑn]	'governor'	<badʃkam>	[bɑ.dəʃ.kɑm]	'balcony'
<kaɣdni>	[kʰɑχt.ni]	'secret'	<amt͡ʃ'nal>	[ɑ.mət͡ʃ-nɑl]	'to be ashamed'
<antranig>	[ɑntʰ.ɾɑ.nig]	'firstborn'	<gornkan>	[go.ɾəŋ.kʰɑn]	'honey-lotus'
<ant͡srev>	[ɑnt͡s.ɾev]	'rain'	<d͡ʒagnteɣ>	[d͡ʒɑ.gən.tʰeʁ]	'beet-root'
<baʃdbanel>	[bɑʃt.pɑ.n-el]	'to protect'	<aɣʃgorel>	[ɑ.ʁəʃ.ko.ɾ-el]	'to oblige'

The epenthesized schwa again respects directional syllabification. This is illustrated in (7) for *pʰe.dəɾ.vɑɾ* 'February'.

(7) a. *Deriving epenthesis in word-medial <VCCCV> clusters with rules*

	<p'edrvar>
R->L	{p'edr}.vɑɾ
	{p'e}.dəɾ.vɑɾ
	[pʰe.dəɾ.vɑɾ]

b. *Deriving epenthesis in word-medial <VCCCV> clusters with constraints*

<p'edrvar> (/pʰedɾvɑɾ/)		$*CC_\sigma$	<>/ə/	ALIGN-σ-L
a.	pʰed.ɾvɑɾ	$*$!		3
b. ☞	pʰe.dəɾ.vɑɾ		$*$	7
c.	pʰed.ɾə.vɑɾ		$*$	8!

Larger intervocalic clusters are rare but attested, such as 4C clusters: <$VC_1C_2C_3C_4V$> (Table 16).[14] If C_2C_3 can be a complex coda, then a schwa is placed before C_2: *ɑ.bəsp.ɾel* 'to order'.[15] Otherwise, a schwa is placed after C_2: *hɑŋ.kʰəɾ.vɑn* 'refuge'.

Table 16: Schwa epenthesis in word-medial 4C

<VCCCV>	V.CəCC.CV		<absbrel>	[ɑ.bəsp.ɾ-el]	'to order'
/VCCCCV/	VC.CəC.CV		/VCCCCV/	VC.CəC.CV	
<hankrvan>	[hɑŋ.kʰəɾ.vɑn]	'refuge'	<dardɣnel>	[dɑɾ.dəʁ.n-el]	'to disperse'
<and͡ʒrgil>	[ɑn.d͡ʒəɾ.g-il]	'to entangle oneself'	<ergnt͡ʃ'il>	[jeɾ.gən.t͡ʃ-il]	'to fear'
<pot͡s'gldal>	[pʰot͡s.kəl.d-ɑl]	'to blaze'	<asbnt͡ʃagan>	[ɑs.pən.t͡ʃ-ɑ.gɑn]	'hospitable'
<sahmṙgel>	[sɑh.məɾ.g-el]	'to bewilder'	<mardnt͡ʃ'el>	[mɑɾ.dən.t͡ʃ-el]	'to dispute'
<əngrgel>	[əŋ.gəɾ.g-el]	'to draw back'	<əngɣmel>	[əŋ.gəʁ.m-el]	'to immerse'

Thus, even medial clusters are predictably syllabified via a right-to-left parse (8).

[14] I have not been able to find larger root-medial clusters. Although word-medial 5C clusters (and larger) are attested, the ones that I have found always involve an intervening morpheme boundary, such as a compound boundary (§4.2.2).

[15] Some speakers pronounce this word as [ɑ.bəs.pə.ɾel]. The extra unexpected schwa is due to diachronic syncope from an earlier form with a vowel: <absbarel>. Thus such speakers have a UR /ɑbspʰəɾəl/ with an underlying schwa (see footnote 13). Some authors list this word without any pronounced schwas *aps.prel* (Allen 1950:182). This is due to schwa elision in connected speech because of the presence of frication (Hovakimyan 2016) (see §5.2).

(8) a. *Deriving* <VCCCCV> → [V.CəCC.CV] *in* [ɑ.bəsp.ɾel] ‘to order’

<absbrel> (/ɑbsp^{h}ɾ-el/)		*CC$_{\sigma}$	<>/ə/	ALIGN-σ-L
a.	ɑbs.pɾel	*!*		3
b. ☞	ɑ.bəsp.ɾel		*	6
c.	ɑb.səp.ɾel		*	7!

b. *Deriving* <VCCCCV> → [VC.CəC.CV] *in* [hɑŋ.k^{h}əɾ.vɑn] ‘refuge’

<hankrvan> (/hɑnk^{h}ɾvɑn/)		*CC$_{\sigma}$	<>/ə/	ALIGN-σ-L
a.	hɑŋk^{h}.ɾvɑn	*!*		4
b.	hɑŋk^{h}.ɾə.vɑn		*	10!
c. ☞	hɑŋ.k^{h}əɾ.vɑn		*	9

The next section shows the same result for final clusters.

3.3 Root-final and word-final cluster

Root-finally and word-finally, 2C and 3C consonant clusters exist. Larger clusters do not exist. These restrictions are due to historical factors (Vaux 1998:26,83). We again find epenthesis in the expected locations due to the right-to-left syllabification.[16]

For 2C clusters, most cases involve a falling-sonority cluster that can form a complex coda (Table 17). Here, no schwa is inserted.

Table 17: No final epenthesis in <VCC> → [VC$_1$C$_2$] if C$_1$C$_2$ can form a complex coda

<paxd>	<isg>	<pand>	<ʃunt͡ʃ'>	<p'aṙk'>	<haverʒ>	<hars>	<ayd>	<d͡zayr>
[p^{h}ɑχt]	[isk]	[p^{h}ɑnd]	[ʃunt͡ʃ]	[p^{h}ɑɾk^{h}]	[hɑ.veɾʒ]	[hɑɾs]	[ɑjd]	[d͡zɑjɾ]
‘luck’	‘but’	‘prison’	‘breath’	‘glory’	‘eternally’	‘bride’	‘cheek’	‘end’

But there are some words where the 2C cluster cannot form a licit complex coda (Table 18). These clusters are usually <Cn> or <Cr> clusters. Some are <Cɣ>. In standard speech, a schwa is added after the first consonant.

Table 18: Epenthesis in final <VCC> → [V.C$_1$əC$_2$] if C$_1$C$_2$ cannot form a complex coda

<VCɣ>	<VCr>					<VCn>		
<god͡ʒɣ> [god͡ʒəʁ] [god͡ʒʁ] ‘trunk’	<vakr> [vɑ.k^{h}əɾ] [vɑk^{h}ɾ] ‘tiger’	<p'ok'r> [p^{h}o.k^{h}əɾ] [p^{h}ok^{h}ɾ] ‘small’	<ipr> [i.p^{h}əɾ] ‘as’	<dedr> [de.dəɾ] ‘tract’	<manr> [mɑ.nəɾ] ‘small’	<uremn> [u.ɾe.mən] ‘thus’	<vahakn> [vɑ.hɑ.k^{h}ən] a name	<taṙn> [t^{h}ɑ.ɾən] [t^{h}ɑɾn] ‘bitter’

In standard speech, a final rising-sonority cluster undergoes epenthesis. But in colloquial speech for some lexemes, the schwa is optional: *t^{h}ɑ.ɾən∼t^{h}ɑɾn* ‘bitter’. It is unclear what are the conditions for this optionality. It is also unclear what is the prosodic status of the final rhotic in these schwa-less clusters. It could be an extrasyllabic appendix or a syllabic rhotic. I leave this variation as an open question. What matters is that these clusters can undergo epenthesis, and the schwa is always after C$_1$.[17]

[16] Larger final clusters are due to the appendix *-k^{h}*. See footnote 4. Clusters that end in a sonorant /m,n,ɾ/ diachronically arose from the lost of subsequent syllables (Մուրադյան 1973, Մուքիասյան 2004:53).

[17] For final *ɾn*, epenthesis is less common when the word is polysyllabic: *jeʁeɾn* ‘crime’. Interestingly, final <VCm>

In 3C clusters, there is limited variation (Table 19). I have found only one case where a schwa is added after C_1. Most other cases have epenthesis after C_2. The use of epenthesis in 3C clusters is the norm in both dialects.[18]

Table 19: Epenthesis in final 3C clusters:

<VCCC> → [V.C_1əC_2C_3] if C_2C_3 can form a complex coda						<gozṙn>	[go.zərn]	‘young camel’
<VCCC> → [VC_1.$C_{2ə}C_3$] if C_2C_3 cannot form a complex coda								
<VCCɣ>			<VCCr>			<VCCn>		
<argɣ>	<ankɣ>	<osdɣ>	<gaysr>	<gard͡zr>	<part͡sr>	<aysink'n>	<arzn>	<garʃn>
[ɑɾ.gəʁ]	[ɑŋ.kʰəʁ]	[vos.təʁ]	[gɑj.səɾ]	[gɑɾ.d͡zəɾ]	[pʰɑɾ.t͡səɾ]	[ɑj.siŋ.kʰən]	[ɑɾ.zən]	[gɑɾ.ʃən]
‘box’	‘vulture’	‘viscum’	‘emperor’	‘stiff’	‘high’	‘that is’	‘alum’	‘sinew’

For 2C and 3C clusters, the placement of the schwa follows from directional syllabification (9).

(9) a. *Deriving* <VCC> → [V.CəC] *in* [mɑ.nəɾ] ‘small’

<manr> (/mɑnɾ/)		*CC_σ	<>/ə/	ALIGN-σ-L
a.	mɑnɾ	*!		
b. ☞	mɑ.nəɾ		*	2
c.	mɑn.ɾə		*	3!

b. *Deriving* <VCCC> → [V.CəCC] *in* [go.zərn] ‘young camel’

<gozṙn> (/gozrn/)		*CC_σ	<>/ə/	ALIGN-σ-L
a.	gozrn	*!		
b. ☞	go.zərn		*	2
c.	goz.rən		*	3!

c. *Deriving* <VCCC> → [V.CəCC] *in* [gɑj.səɾ] ‘emperor’

<gaysr> (/gɑjsɾ/)		*CC_σ	<>/ə/	ALIGN-σ-L
a.	gɑjsɾ	*!		
b. ☞	gɑj.sər		*	3
c.	gɑjs.ɾə		*	4!

4 Deviations

The previous section argued that schwa epenthesis can be modeled via right-to-left directional syllabification. The analysis ends up creating the following epiphenomenal generalizations that make Armenian prioritize

clusters generally don't undergo epenthesis: *goʁt* ‘side’; but there is reported variation (Johnson 1954:156). Furthermore, for final <VCn> or <VCr> clusters, most grammars prescribe the epenthesized alternate as the only pronunciation, whether for Western (Bardakjian & Thomson 1977:244–6) and Eastern Armenian (Ղարագյուլյան 1974:153, 1979:37; Սարգարյան 1997:53,74; Սարգսյան 1987:216; Minassian 1980:24). One early structuralist grammar describes the pronunciation of a Western speaker who regularly uses the schwa-less variant for <VCr> clusters (Fairbanks 1948:20); this is also reported in Ավետիսյան (2011:14). I leave this variation for future work; see Vaux (2003) for discussion.

[18] Some 3C words like <asdɣ> ‘star’ undergo epenthesis in modern Istanbul Western Armenian *as.təʁ*, but not in Lebanese Western Armenian *astχ∼asχ*. Further variation for this word is attested in Vaux (2003). Idiolectal variation is attested by Fairbanks (1948:22) who documents a Western speaker who regularly blocks epenthesis in final <VCCr> clusters.

the formation of codas over onsets (i.e., a rime or coda language: Broselow 1992; Farwaneh 1995; Kiparsky 2003).

(10) *Epiphenomenal generalizations from directional syllabification*

a. Schwa epenthesis must not create word-medial open *Cə* syllables.

b. Schwa epenthesis minimizes the number of syllables.

Such epiphenomenal generalizations aren't part of the mental grammar of Armenian reader-speakers. But, they are useful heuristics for linguists. If the location of some inserted schwa violates the above heuristics, then this violation indicates that some other linguistic factor is affecting the schwa's location. In this section, we go through corners of the Armenian grammar which violate the above epiphenomenal properties. These deviations are due to complications from the phonology (§4.1) or the morphology (§4.2), specifically involving sibilant-stop clusters or morpheme-syllable alignment. These complications constitute their own constraints on schwa epenthesis.

4.1 Phonologically-induced deviations: Sibilant-stop clusters

For root-initial 2C clusters, the generalization was that the schwa was epenthesized after the first consonant. This creates a root-initial open syllable. This generalization is robust with one core exception. Specifically, root-initial sibilant-stop-vowel (STV) clusters undergo schwa prothesis. That is, the schwa is placed before the sibilant. This behavior is cross-linguistically unsurprising (Fleischhacker 2001; Goad 2011).

The sibilant can be *s,z* and the stop can have any place of articulation (Table 20). If either the stop or sibilant is voiceless in the orthography, then they both surface as voiceless.

Table 20: Schwa prothesis in sibilant-stop clusters: <STV> → [əS.TV]

s/z + labial + V			s/z + coronal + V			s/z + velar + V		
<sbasel> [əs.pɑ.s-el] 'to wait'	<sp'op'el> [əs.po.p-el] 'to comfort'	<zpaɣil> [əs.pɑ.ʁ-il] 'to be busy'	<sdanal> [əs.tɑ.n-ɑl] 'to receive'	<sdibel> [əs.ti.b-el] 'to force'	<sdebɣin> [əs.teb.ʁin] 'carrot'	<sgizp> [əs.kisp] 'beginning'	<zkal> [əs.k-ɑl] 'to feel'	<zkesd> [əs.kest] 'clothes'
<sbann-el> [əs.pɑn.nel] 'to kill'	<sbunk> [əs.puŋkʰ] 'sponge'	<sbaṙnal> [əs.pɑɾ.n-ɑl] 'to threaten'	<sdukel> [əs.tu.kʰ-el] 'to certify'	<sdor> [əs.toɾ] 'below'	<sdeʁd͡zel> [əs.teʁ.d͡z-el] 'to create'	<sk'ant͡ʃ'eli> [əs.kɑn.t͡ʃe.li] 'admirable	<zkuyʃ> [əs.kujʃ] 'careful'	<zkayṙ> [əs.kɑjɾ] 'belch'

If C_2 is an fricative or sonorant, then the schwa is added medially, not initially (Table 21; Աճառյան 1971:341; Vaux 1998:24,101).[19]

Table 21: Medial schwa epenthesis in SCV clusters where C is not a stop

s/z + fricative + V			s/z + sonorant + V				
<sxal> [sə.χɑl] 'wrong'	<sɣot͡s'> [sə.ʁot͡s] 'saw'	<zvart'> [zə.vɑɾtʰ] 'joyous'	<snunt> [sə.nuntʰ] 'nutrition'	<slak'> [səlɑkʰ] 'arrow'	<slanal> [səlɑnɑl] 'to rush'	<srah> [səɾɑh] 'hall'	<zruyt͡s'> [zəɾujt͡s] 'narrative'

[19] I could not find any native words where C_2 is an affricate. The closest case I could find was a nativized borrowing <sd͡ʒux> → [səd͡ʒuχ] 'sujuk'. Most initial *zm* clusters are pronounced with medial epenthesis: <zmurs> → ***zə.murs*** 'myrrh'. One class of exceptions is represented by the word <zmaylil> which is pronounced with schwa prothesis: ***əz.maj.lil*** 'to admire'. This is because the initial *z* here is a reflex of the Classical Armenian prefix *əz* (Աճառյան 1971:239–40). Synchronically, this morphological segmentation is lost for some cases like ***əz.maj.lil***, and the word's pronunciation is simply an exception.

To capture obligatory prothesis for *STV* clusters, I use the contiguity constraint in (11) (Lamontagne 1996; Prince & Smolensky 2004). This contiguity constraint requires that root-initial orthographic *STV* clusters stay contiguous in the SR. It outranks Onset. I demonstrate with the word <sdor> [əs.toɾ] ‘below’ and <sxal> [sə.χɑl] ‘wrong’. I set aside the devoicing.

(11) a. Cont-STV — Assign a violation for a root-initial sibilant-stop-vowel (STV) cluster that is contiguous in the OR but not SR.

b. Constraint ranking — $*CC_\sigma$, Cont-STV >> Onset

c. *Deriving* <STV> → [əS.TV] *for* [əs.toɾ] ‘below’

<sdor> (/st^{h}oɾ/)	$*CC_\sigma$	Cont-STV	Ons
a. stoɾ	∗!		
b. ☞ əs.toɾ			∗
c. sə.toɾ		∗!	

d. *Deriving* <SCV> → [Sə.CV] *for* [sə.χɑl] ‘wrong’

<sxal> (/sχɑl/)	$*CC_\sigma$	Cont-STV	Ons
a. sχɑl	∗!		
b. əs.χɑl			∗!
c. ☞ sə.χɑl			

In Eastern Armenian, schwa prothesis is variable: <sdamok's>→[(ə)stɑ.mok^{h}s] ‘stomach’. The quality of the prothesized vowel is very weak in Eastern (Ավետիսյան 2011:13). Because of language contact with Russian, word-initial STV clusters are often pronounced without any schwa prothesis (Minassian 1980:20; Խաչատրյան 1988:62; Vaux 1998:25,101; Սուքիասյան 2004:27–8,61; Dum-Tragut 2009:31), though schwa prothesis is still possible (Աճառյան 1971:241; Ղարագյուլյան 1974:139–40; Մարգարյան 1997:200). One grammar (Ղարագյուլյան 1974) documents the common lack of prothesis in Eastern borrowings (p. 64) and neologisms (p. 140), while prothesis is common in dialectal poetry (p. 141). Without schwa prothesis, the initial sibilant is arguably extrasyllabic, whether as a semisyllable (DeLisi 2015) or an appendix (Vaux 2003; Vaux & Wolfe 2009); see Hovakimyan (2016) for acoustic evidence. However, there is a recent trend in Eastern Armenian that clusters without prothesis are variably pronounced with medial epenthesis: Western *əs.pa.sel* ‘to wait’ vs. Eastern *s(ə).pa.sel* (Խաչատրյան 1988:62; Ղարագյուլյան 1974:140, 1979:35). This may indicate the gradual loss or demotion of appendixes and Cont-STV in Eastern.

Back to Western, for prothesis, the sibilant can be *s* or *z*. If the sibilant is /ʃ/, then we have prothesis when the stop is coronal *t* for some words (Table 22; Bardakjian & Thomson 1977:243). For other places of articulation for the stop, we generally have medial epenthesis. Some *ʃk* words have reported variation (Աճառյան 1971:242; Սաքապետոյեան 2011).

Table 22: Variable schwa prothesis in <ʃC> clusters

[əʃ.tV]		[əʃ.kV ∼ ʃə.kV]		[ʃə.kV]	[əʃ.pV]		
<ʃdab>	<ʃdemaran>	<ʃgahel>	<ʃgot'ag>	<ʃk'eɣ>	<ʃp'ot'>	<ʃp'el>	<ʃp'anal>
[əʃ.tɑb]	[əʃ.te.mɑ.ɾɑn]	[əʃ.kɑ.h-el]	[əʃ.kot^{h}ɑg]	[ʃə.k^{h}eʁ]	[ʃə.p^{h}ot^{h}]	[ʃə.p^{h}-el]	[ʃə.p^{h}ɑ.nɑl]
		[ʃə.gɑ.hel]	[ʃə.go.t^{h}ag]				
‘haste’	‘depository’	‘to hiss’	‘banishment’	’superb’	‘confused’	‘to rub’	‘to spoil’

No such prothesis is found when the sibilant is /ʃ/ while the consonant is a non-stop (Table 23). There is likewise no prothesis for the voiced sibilant /ʒ/ (Vaux 1998:24).

Table 23: No schwa prothesis for other <ʃC> clusters or for <ʒC>

[ʃə.CV]					[ʒə.CV]		
<ʃʃug>	<ʃvi>	<ʃnorhk'>	<ʃlor>	<ʃṙayl>	<ʒbid>	<ʒbirh>	<ʒlad>
[ʃə.ʃug]	[ʃə.vi]	[ʃə.noɾk^{h}]	[ʃə.loɾ]	[ʃə.ɾɑjl]	[ʒə.bid]	[ʒə.biɾh]	[ʒə.lɑd]
'whisper'	'pipe'	'grace'	'plum'	'lavish'	'smile'	'bold'	'mean'

More refined versions of this contiguity constraint are needed to capture variable prothesis for *ʃ*C clusters. I put this issue aside.

More complications are found in 3C clusters (Table 24). When C_1 is a non-sibilant, then medial epenthesis is found: <krban> → [kəɾ.bɑn] 'pocket' (§3.1). But when C_1 is sibilant *s*, then we find schwa-prothesis if C_2 is a coronal stop, and medial epenthesis otherwise (Ղարագյուլյան 1974:140; Vaux 1998:25,101–2).[20]

Table 24: Schwa prothesis in stCV clusters, but medial epenthesis elsewhere

s + coronal + C + V			s + non-coronal + C + V		s + non-stop + C + V		
<sdrug>	<sdvar>	<sdver>	<sp'ṙel>	<sk'lil>	<sxdor>	<sntig>	<sṙnag>
[əst.ɾug]	[əst.vɑɾ]	[əst.veɾ]	[səp^{h}.ɾel]	[sək^{h}.lil]	[səχ.toɾ]	[sən.t^{h}ig]	[səɾ.nɑg]
'slave'	'thick	'shadow'	'to spread'	'to be discouraged'	'garlic'	'mercury'	'axle'

This variation can be captured by positing a separate constraint Cont-stC (12). This constraint requires that root-initial *stC* clusters stay contiguous: [əst.ɾug] 'slave'. This constraint is active only when the sibilant precedes a coronal stop, not for any other type of obstruent: [səp^{h}.ɾel] 'to spread'. With this constraint, we can derive the location of the schwa in sCC clusters. I omit the constraint Cont-STV because it is irrelevant in root-initial sCC clusters.

(12) a. Cont-stC — Assign a violation for a root-initial sibilant-coronal-consonant (stC) cluster that is contiguous in the OR but not SR.

b. Constraint ranking — $*CC_\sigma$, Cont-stC >> Onset

c. *Deriving* <stCV> → [əst.CV] *for* [əst.ɾug] 'slave'

<sdrug> (/st^{h}ɾug/)		$*CC_\sigma$	Cont-stC	Ons
a.	stɾug	*!		
b. ☞	əst.ɾug			*
c.	sət.ɾug		*!	

d. *Deriving* <sCCV> → [səC.CV] *for* [səp^{h}.ɾel] 'to spread'

<sp'ṙel> (/sp^{h}ɾel/)		$*CC_\sigma$	Cont-stC	Ons
a.	sp^{h}ɾel	*!		
b.	əsp^{h}.ɾel			*!
c. ☞	səp^{h}.ɾel			

[20] In Eastern Armenian, schwa prothesis is optional in STV clusters, rendering the initial *s* an appendix. In stCV clusters, the appendix *s* can be syllabified with a subsequent consonant *t*: Western *əst.ɾug* vs. Eastern *st.ɾuk* 'slave', Western *əst.ver* vs. Eastern *st.ver* 'shadow'. But there is reported variation for some Eastern speakers who utilize medial epenthesis, whether before the stop *sət.ɾuk* (Ղարագյուլյան 1979:140), or after the stop *s.tə.ver* (Աբեղյան 1933:47). Furthermore, it is reported that schwa prothesis is more common in clusters that are more than two consonants (Ղարագյուլյան 1974:142).

The same generalization is found in sCCC clusters and sCCC which trigger two schwas (Table 25). We have prothesis if C_2 is a coronal stop; otherwise medial epenthesis (Աճառյան 1971:341; Ղարագյուլյան 1974:140; Vaux 1998:25–6).[21] In Eastern Armenian, variable prothesis applies more often in these larger clusters than in smaller clusters (Ղարագյուլյան 1974:142).

Table 25: Schwa prothesis in stCC(C)V clusters, but medial epenthesis elsewhere

stCC	sCCC			stCCC	sCCCC
<sdnkank'>	<sbrtil>	<sblxel>	<sgrt'el>	<sdrtʃal>	<sp'rt'nel>
[əs.təŋ.k^{h}ɑŋk^h]	[sə.bəɾ.t^{h}il]	[sə.bəl.χel]	[sə.gəɾ.t^{h}el]	[əs.təɾ.t͡ʃɑl]	[sə.p^{h}əɾt^h.nel]
‘spasm’	‘to slip’	‘to slip’	‘to excoriate’	‘to regret’	‘to pale’

The same Cont-stC constraint can interact with directional syllabification to generate the location of the two schwas. Note that Cont-stC outranks Onset, while Align-σ-L is currently unranked among them.

(13) a. *Deriving* <stCCV>→[əs.təC.CV] *for* [əs.təŋ.k^{h}ɑŋk^h] ‘spasm’

<sdnkank'> (/st^{h}nkɑnk^h/)		Cont-stC	Ons	Align-σ-L
a. ☞	əs.təŋ.k^{h}ɑŋk^h		∗	7
b.	əst.nə.k^{h}ɑŋk^h		∗	8!
c.	sə.t^{h}əŋ.k^{h}ɑŋk^h	∗!		7
d.	sət^h.nə.k^{h}ɑŋk^h	∗!		8

b. *Deriving* <sCCCV>→[əs.CəC.CV] *for* [sə.bəɾ.t^{h}il] ‘to slip’

<sbrtil> (/sbɾt^{h}il/)		Cont-stC	Ons	Align-σ-L
a.	əs.pəɾ.t^{h}il		∗!	7
b.	əsp.ɾə.t^{h}il		∗!	8!
c. ☞	sə.bəɾ.t^{h}il			7
d.	səb.ɾə.t^{h}il			8!

Thus, initial sibilant-stop clusters operate slightly differently from other clusters due to contiguity. Otherwise, the phonology of schwa epenthesis respects right-to-left syllabification.

4.2 Morphologically-induced deviations

Previous examples of epenthesis consisted of free-standing roots, or bound roots with suffixes. In more complex types of morphology, we find that schwa epenthesis respects morphological left-edges in prefixation (§4.2.1,) compounding (§4.2.2), and reduplication (§4.2.3). Specifically, we find that the left-edges of roots stay aligned with syllable boundaries at the expense of optimal right-to-left parsing, with limited deviation. We formalize this deviation with alignment constraints.

Note that throughout this section, we often place a morpheme boundary (-) in the orthographic form for illustration, but this boundary is not actually represented in the orthography.

4.2.1 Prefixation

Armenian is primarily suffixing but it does have some productive prefixes. The most productive derivational prefix is the negative prefix *an-* (Table 26). It can be added to adjectives as a category-preserving prefix, or to

[21] A spurious exception is the word <sgsil> [əs.kə.sil] ‘to start’. This word is morphologically/diachronically related to the word <sgizp> [əs.kisp] ‘beginning’. The initial and medial schwa in the former correspond to the vowels in the latter.

nouns and verb roots as a category-changing prefix. The prefix is parsed as a separate syllable before C-initial roots, while its consonant is an onset before V-initial roots.

Table 26: Negative prefix /ɑn-/

an- + Adj				*an-* + Noun or Root			
[hɑm.pʰeɾ]	'patient'	[d͡zɑ.notʰ]	'known'	[kʰoɾd͡z]	'work'	[hɑχ.t-el]	'to conquer'
[ɑn-hɑm.pʰeɾ]	'impatient'	[ɑn-d͡zɑ.notʰ]	'unknown'	[ɑŋ-kʰoɾd͡z]	'unemployed'	[ɑn-hɑχt]	'invincible'
[ɑɾ.tʰɑɾ]	'just'	[o.kʰud]	'useful'	[i.mɑst]	'meaning'	[uχt]	'promise'
[ɑ.n-ɑɾ.tʰɑɾ]	'unjust'	[ɑ.n-o.kʰud]	'useless'	[ɑ.n-i.mɑst]	'meaningless'	[ɑ.n-uχt]	'uncovenanted'

Schwa epenthesis applies in consonant clusters in roots and ignores the prefix (Table 27). If a schwa appears in the root in isolation, then the schwa likewise appears under prefixation. A schwa is epenthesized even if the consonant cluster could've been syllabified with the prefix.[22]

Table 27: Schwa epenthesis with prefix /ɑn-/

<an-CCV> → [ɑn-Cə.CV]				<an-CCCV> → [ɑn-CəC.CV]			
<tram>	<an-tram>	<pnag>	<an-pnag>	<nʃmar>	<an-nʃmar>	<ʒxdeli>	<an-ʒxdeli>
[tʰə.ɾɑm]	[ɑn-tʰə.ɾɑm]	[pʰə.nɑg]	[ɑn-pʰə.nɑg]	[nəʃ.mɑɾ]	[ɑn-nəʃ.mɑɾ]	[ʒəχ.te.li]	[ɑn-ʒəχ.te.li]
	*ɑntʰ.ɾɑm		*ɑnpʰ.nɑg				
'money'	'money-less'	'inhabitant'	'uninhabited'	'mark'	'unperceived'	'deniable'	'undeniable'

To capture the above dependencies, we can use either cyclicity or alignment. I utilize alignment. The alignment constraint (14) requires that the root-initial segment starts a syllable. It is outranked by a constraint against heterosyllabic /C.V/ sequences, thus allowing V-initial roots to syllabify with prefixes (14d).[23] The alignment constraint outranks Align-σ-L, thus maintaining the schwas of root-initial schwas in clusters (14e). Vowel reduction (§6) later provides evidence for the role of alignment that cannot be handled via cyclicity alone.[24]

(14) a. *C.V — Assign a violation if a consonant-vowel sequence is heterosyllabic.

b. Align(M,σ)-L — Assign a violation if the left-edge of a morpheme is not aligned with left-edge of syllable.

c. Constraint ranking — *C.V >> Align(M,σ)-L >> Align-σ-L,<>/ə/

d. *Deriving* <an-V> → [ɑ.n-V]

<an-artar> (/ɑn-ɑɾtʰɑɾ/)		*CC$_\sigma$	*C.V	Align(M,σ)-L	Align-σ-L	<>/ə/
a.	ɑn.ɑɾ.tʰɑɾ		*!		6	
b. ☞	ɑ.nɑɾ.tʰɑɾ			*	5	

[22] It's difficult to find prefixed roots with larger root-initial clusters, but they exist: <trtveli> → [tʰəɾtʰveli] 'excitable', <antrtveli> → [ɑn-tʰəɾtʰveli] 'unshakeable'.

[23] We cannot use a general Onset constraint for this purpose because word-medial /V.V/ sequences are attested: [ɑmenɑ-uɾɑχ] 'happiest' with the superlative prefix [ɑmenɑ].

[24] Coincidentally, Vaux (1998:89)'s system does utilize cyclicity, but not to capture identity relations between free-standing words and their derived forms in schwa epenthesis, but to interpret the behavior of pseudo-reduplicative roots. See the appendix for explanation of this. Vaux's chapter likewise doesn't have any prefixation or compound data; thus the reader wouldn't realize that his cyclic account could also capture prefixation and compounding data. It coincidentally does.

e. *Deriving* <an-CCV> → [ɑn-Cə.CV]

<an-tram> (/ɑn-tʰɾɑm/)		*CC$_\sigma$	*C.V	Align(M,σ)-L	Align-σ-L	<>/ə/
a.	ɑntʰ.ɾɑm			*!	3	
b.	ɑ.nətʰ.ɾɑm			*!	5	*
c. ☞	ɑn.tʰə.ɾɑm				6	*

We likewise find epenthesis in prefixes themselves (Table 28). The verbal negation prefix is *t͡ʃ-*. It is prefixed faithfully before a V-initial verb. A schwa is epenthesized before C-initial verbs. For roots with initial consonant clusters, we see schwas both in the prefix and in the root, possibly leading to a sequence of open syllables that would generally be avoided by right-to-left parsing. The positive indicative prefix is *g-* and it behaves the same.[25]

Table 28: Schwa epenthesis with verbal prefixes /t͡ʃ(ə)-, g(ə)-/

	'I take'		'I love'		'I push'		
Subjunctive	<aṙnem>	[ɑɾ.nem]	<sirem>	[si.ɾem]	<hrem>	[hə.ɾem]	
Negative	<t͡ʃ'-aṙnem>	[t͡ʃ-ɑɾ.nem]	<t͡ʃ'-sirem>	[t͡ʃə-si.ɾem]	<t͡ʃ'-hrem>	[t͡ʃə-hə.ɾem]	*t͡ʃeh.ɾem
Indicative	<g-aṙnem>	[g-ɑɾ.nem]	<g-sirem>	[gə-si.ɾem]	<g-hrem>	[gə-hə.ɾem]	*gəh.ɾem

The two open-syllable schwas in *t͡ʃə-hə.ɾem* follow straightforwardly from right-to-left parsing, root-syllable alignment, and onset requirements (Table 15). Such a sequence of two open syllables would be blocked inside roots, but is permitted across the prefix-root boundary.

(15) *Deriving multiple epenthesis in prefixation for* [t͡ʃə-hə.ɾem] 'I don't push'

<t͡ʃ'-hrem> (/t͡ʃʰ-hɾem/)		*CC$_\sigma$	Align(M,σ)-L	Align-σ-L	<>/ə/	Onset
a.	t͡ʃhɾem	*!	*			
b.	t͡ʃəh.ɾem		*!	3	*	
c.	ət͡ʃ.həɾem			6	**	*!
d. ☞	t͡ʃə.hə.ɾem			6	**	

A few other consonantal prefixes exist and they show the expected locations of schwa epenthesis, e.g. the negative adjectivalizers <d->, <tʒ->, and <dʒ-> (Table 29).

Table 29: Schwa epenthesis in other consonantal prefixes

<d> + CV		<dʒ> + CV		<tʒ> + CV	
<keʁ>	<d-keʁ>	<kuyn>	<dʒ-kuyn>	<koh>	<tʒ-koh>
[kʰeʁ]	[də-kʰeʁ]	[kʰujn]	[dəʃ-kujn]	[kʰoh]	[tʰəʃ-koh]
'beauty'	'ugly'	'color'	'discolored'	'content'	'discontent'

A minor complication arises from root-initial sibilant-stop clusters (Table 30). These undergo prothesis in isolation. The schwa survives after C prefixes and after the negative *an-* prefix. Note that *nz* and *ns* complex codas are generally avoided word-medially for native words (§2.3), thus they are illicit.

[25] The two prefixes cannot be added together.

Table 30: Schwa prothesis in prefixation to sibilant-stop clusters

<zkam>	<t͡ʃ'-zkam>	<g-zkam>	<zkali>	<an-zkali>	<zkuʃ>	<an-zkuʃ>
[əs.kɑm]	[t͡ʃəs.kɑm]	[gəs.kɑm]	[əs.kɑ.li]	[ɑ.nəs.kɑ.li]	[əs.kuʃ]	[ɑ.nəs.kuʃ]
'I feel (subj.)'	'I don't feel (subj.)'	'I feel'	'sensible'	'insensible'	'careful'	'careless'

The current constraint system captures the data (16). The constraint Cont-STV is high-ranked enough to always require that sibilant-stop cluster stays contiguous. This necessitates a violation of Align(M,σ)-L. I show the derivation of a C-prefixed word below.

(16) *Deriving prothesis in prefixation to sibilant-stop clusters for* [t͡ʃə-s.kɑm] 'I don't feel'

<t͡ʃ-zkam> (/tʃ-skʰɑm/)	*CC$_\sigma$	Cont-STV	Align(M,σ)-L	Align-σ-L	<>/ə/
a. t͡ʃskɑm	*!		*		
b. ☞ t͡ʃəs.kɑm			*	3	*
c. t͡ʃə.sə.kʰɑm		*!		6	**

For prefixed ST-clusters, it seems that the sibilant can never become part of a preceding complex coda. For the prefix *an-*, this is avoided because [ns] is a marked complex coda word-medially. But there is a prefix *ver-* which can attach before consonant clusters (Table 31). When it attached to an ST-cluster, we see epenthesis even though [ɾs] is a perfectly licit complex coda.

Table 31: Schwa prothesis between [ɾ] and sibilant-stop clusters

<mɣel>	<ver-mɣel>	<sdanal>	<ver-sdanal>	<zkal>	<ver-zkal>
[mə.ʁel]	[veɾ.mə.ʁel]	[əs.tɑ.nɑl]	[ve.ɾəs.tɑ.nɑl]	[əs.kɑl]	[ve.ɾəs.kɑl]
			*veɾs.tɑ.nɑl		*veɾs.kɑl
'to push'	'to push upward'	'to receive'	'to receive again'	'to feel'	'to feel again'

To capture the above margin of the Armenian grammar, I utilize a constraint that is violated if the sibilant of a root-initial ST-cluster forms a complex coda without its stop (17).[26] Further complications with sibilants arise in compounding, which we discuss in the next section.

(17) a. *VC-S.T — Assign a violation if a root-initial sibilant is part of a sibilant-stop cluster, but forms a complex coda without its stop.

b. Constraint ranking — *CC$_\sigma$, *VC-S.T , Cont-STV >> Align(M,σ)-L

c. *Deriving prothesis to avoid complex codas in prefixation for* [ve.ɾəs.tɑ.nɑl] 'to receive again'

<ver-sdanal> (/veɾ-stʰɑnɑl/)	*CC$_\sigma$	*VC-S.T	Cont-STV	Align(M,σ)-L
a. veɾs.tɑ.nɑl		*!		*
b. ☞ ve.ɾəs.tɑ.nɑl				*
c. veɾ.sə.tɑ.nɑl			*!	

Thus, prefix boundaries trigger schwa insertion to form word-medial open-syllables. This is due to prioritizing root-syllable alignment over right-to-left syllabification. Sibilants present a minor complication.

[26] An alternative constraint is to ban a complex coda that contains consonants from different morphemes. Such a constraint has been processed for another corner of schwa epenthesis in possessive suffixes (Dolatian 2022).

4.2.2 Compounding

We have seen so far that prefix boundaries create syllable structures which violate maximal right-to-left parsing. This is due to a high-ranked constraint that prefers keeping root left-edges aligned with syllables. We see further instances of this in compounding.

In the prefixal data, the use of schwa epenthesis was necessary even if the schwa-less forms would have syllabifiable clusters: <an-tram> → [ɑn-tʰəɾɑm, *ɑntʰ.ɾɑm] ‘moneyless’. The apparent redundant use of schwas is more visible in compounding because compounds involve linking vowels.

A compound is generally formed by concatenating two stems with a linking vowel *-ɑ-* (18). If the second stem is V-initial, we usually find that the linking vowel is absent, and that the two stems are syllabified together.

(18) a. ʒɑm + t͡sujt͡s ‘time + sign’ b. ɑ.gant͡ʃ + oʁ ‘ear + earring’
ʒɑ.m-ɑ-t͡sujt͡s ‘clock’ ɑ.gɑn.t͡ʃ-oʁ ‘earring’

When the second stem has an orthographic cluster, we find schwa epenthesis in the expected location (Table 32). If the stem or root has a schwa in isolation, then it keeps the schwa in compounding. The schwa is not dropped even though the output would be a syllabifiable cluster: *d͡ʒa.ʃa.sə.ɾah* not **d͡ʒa.ʃas.ɾah* ‘dining hall’.

Table 32: Schwa epenthesis in compounds

<d͡ʒaʃ>	<srah>	<d͡ʒaʃ-a-srah>	<vart>	<ʒbid>	<vart-a-ʒbid>
[d͡ʒaʃ]	[səɾɑh]	[d͡ʒɑ.ʃɑ.sə.ɾɑh]	[vɑɾtʰ]	[ʒəbid]	[vɑɾ.tʰɑ.ʒə.bid]
‘food’	‘hall’	‘dining-hall’	‘rose’	‘smile’	‘smiley (person)’

In fact, there are many near-minimal pairs where the presence of a schwa distinguishes a compound from a root-suffix construction (Աճառյան 1971:279; Ղարագյուլյան 1974:170): *ʃarʒ-a-nəgar* ‘cinema’ vs. *vaŋg-er* ‘syllables’ (Table 33).

Table 33: Near-minimal pairs from epenthesis in compounds

<ʃarʒ>	<ngar>	<ʃarʒ-a-ngar>	<vang-er>	<hart͡s'>	<zruyt͡s'>	<hart͡s'-a-zruyt͡s>	<zazreli>
[ʃɑɾʒ]	[nəgɑɾ]	[ʃɑɾ.ʒɑ.nə.gɑɾ]	[vɑŋ.geɾ]	[hɑɾt͡s]	[zə.ɾujt͡s]	[hɑɾ.t͡sɑ.zə.ɾujt͡s]	[zɑz.ɾe.li]
‘motion’	‘picture’	‘cinema’	‘syllable-PL’	‘issue’	‘dialogue’	‘interview’	‘disgusting’

The location of the schwa in the second root is unmotivated with respect to syllabification. A simple parse wouldn’t have used a schwa at all: **d͡ʒa.ʃas.ɾah*. The schwa is necessary because of root-syllable alignment. This is illustrated in (19).

(19) *Deriving epenthesis in compounds for* [d͡ʒɑʃ-ɑ-səɾɑh] ‘dining-hall’

<d͡ʒaʃ-a-srah> (/d͡ʒɑʃ-ɑ-sɾɑh/)	*CC$_\sigma$	ALIGN(M,σ)-L	ALIGN-σ-L	<>/ə/
a. d͡ʒɑ.ʃɑs.ɾɑh		*!	7	
b. ☞ d͡ʒɑ.ʃɑ.sə.ɾɑh			12	*

Furthermore, there is a small handful of high-frequency compounds which *lack* a word-internal schwa (Ղարագյուլյան 1974:171). For such words, the presence of an internal schwa likely existed in early stages of the language: <ham-a-lsaran>→[hɑm-ɑ-ləsɑɾɑn] 'university', literally 'all-auditorium'. But in the modern language, the schwa is absent: [hɑmɑlsɑɾɑn]. The absence suggests that such compounds have become grammaticalized or fossilized from root-root compounds into root-suffix constructions.

When the second stem starts with a sibilant-stop cluster, we see striking behaviors (Table 34). Most cases of such compounds involve exocentric compounds. Here, we do not find epenthesis (Ղարագյուլյան 1979, Սուքիասյան 2004:27–28,61). The second stem's sibilant is resyllabified with the linking vowel: *se.vas.kest* 'dressed in black'.[27]

Table 34: Variation in schwa prothesis for sibilant-stop clusters in compounds

<sev>	<zkesd>	<sev-a-zkesd>	<pan>	<sdeɣd͡z-el>	<pan-a-sdeɣd͡z>
[sev]	[əs.kest]	[se.vas.kest]	[pʰɑn]	[əs.teʁd͡z]	[pʰɑ.nɑs.teʁd͡z]
'black'	'dress'	'dressed in black'	'thing'	'to create'	'poet'

The absence of the above schwa follows from our current constraint system (20). Root-syllable alignment has to be violated in order to maintain contiguity. Epenthesis is unneeded because the sibilant can resyllabify with the linking vowel, without creating a complex coda.

(20) *Deriving lack of epenthesis for sibilant-stop clusters in compounds* [se.vɑs.kest] 'dressed in black'

<sev-a-zkesd> (/sev-ɑ-skʰestʰ/)		*CC$_\sigma$	*VC-S.T	Cont-STV	Align(M,σ)-L	Onset
a.	☞ se.vɑs.kest				*	
b.	se.vɑ.əs.kest				*	*!
c.	se.vɑ.sə.kest			*!		

In sum, compounding creates morphological boundaries which are respected by schwa epenthesis at the expense of directional syllabification. Sibilant-stop clusters must stay contiguous, at the expense of morpheme-syllable alignment.

4.2.3 Reduplication and pseudo-reduplication

The last morphological construction we consider is reduplication. In brief, Armenian has prefixing reduplicative morphology. As prefixation, the reduplicant boundary can trigger schwa epenthesis at the left edge of roots.

There are different types of reduplicative structures in Armenian, e.g., onomatopoeic reduplication (Vaux 1998:22), echo reduplication of phrases (Vaux 1998:246), intensive CVX-reduplication of adjectives (Vaux 1998:242), and adverbalizing reduplication of adjectives (Moravcsik 1978). We focus on another category of reduplication that I call verbal reduplication. Here, the root of a verb is reduplicated, usually to show an intensity or out-of-control reading (Աբրահամյան 1959; Թոխմախյան 1988; Simonian 1996).

In citation form, simple verbs consist of a root, theme vowel, and infinitival suffix *-l*. The canonical type of verbal reduplication involves reduplicating a CVC(C) root on its own (Table 35). The meaning of the derived verb is sometimes compositionally predicted from that of the un-reduplicated word, but not always. The two copies tend to stay identical even if it creates clusters of heterogenous voicing or post-fricative aspiration: *tʰo<u>ʁ-tʰ</u>oʁ-al* 'to tremble'.

[27] Dolatian (2020:83) reports that for some endocentric compounds, we do find schwa prothesis and vowel hiatus: <sk-a-zkesd> → [sə.kʰɑ.əs.kest] 'mourning dress'. This seems like a recent and slowly emerging pattern which he analyzes by arguing that the head of endocentric compounds forms a separate prosodic constituent, i.e., a prosodic stem (Downing 1999; Dolatian 2021b). Data however is too limited to make strong generalizations.

Table 35: Canonical CVC verb root reduplication from existing bases

[ʃoʁ-ɑl] 'to shine'	[ʃoʁ-ʃoʁ-ɑl] 'to dazzle'	[t͡ʃɑɾ] 'evil'	[t͡ʃɑɾ-t͡ʃɑɾ-el] 'to torture'	[tʰoʁ-ɑl] 'to tremble'	[tʰoʁ-tʰoʁ-ɑl] '(intense)'	[tʰoɾ-il] 'to distill'	[tʰoɾ-tʰoɾ-il] 'to imbibe'
[d͡zɑp-el] 'to clap'	[d͡zɑp-d͡zɑp-el] 'to smack lips'	[gɑpʰ-el] 'to beat'	[gɑpʰ-gɑpʰ-el] 'to grind teeth'	[hos-il] 'to flow'	[hos-hos-el] (intense)	[ʃob-el] 'to steal'	[ʃob-ʃob-el] (id.)

This type of reduplication is 'canonical' in that it is not accompanied by any segmental modifications to either copy of the root. However, it's relatively rare to have canonical reduplication where the root has a non-schwa vowel. What's more common is to reduplicate a verb where the root's only vowel is a schwa (Table 36). The schwa surfaces in both copies, but it is orthographically absent in both copies of the root.

Table 36: Canonical CəC reduplication from existing bases

<ʃp'el> [ʃəpʰ-el] 'to rub'	<ʃp'ʃp'el> [ʃəpʰ-ʃəpʰ-el] (intense)	<xlel> [χəl-el] 'to pluck out'	<xlxlel> [χəl-χəl-el] 'to neglect'	<kzel> [kʰəz-el] 'to comb wool'	<kzkzel> [kʰəz-kʰəz-el] (intense)
<lmel> [ləm-el] 'to compress'	<lmlmel> [ləm-ləm-el] 'to chew'	<p'lil> [pʰəl-il] 'to fall in ruins'	<p'lp'lil> [pʰəl-pʰəl-il] (id.)	<tval> [tʰəv-ɑl] 'to vibrate'	<tvtval> [tʰəv-tʰəv-ɑl] (intense)

Although not as common as monosyllabic CVC roots, there are some rare cases of CVCC roots in verbal reduplication as well as bisyllabic roots (Table 37). The root syllables surface with schwas.

Table 37: Verbal reduplication with closed syllables and bisyllables

Verbal reduplication of roots with closed syllables					
<pxgal> [pʰəχk-ɑl] 'to belch'	<pxgpxgal> [pʰəχk-pʰəχk-ɑl] (intense)	<txgal> [tʰəχk-ɑl] 'to cough'	<txgtxgal> [tʰəχk-tʰəχk-ɑl] (intense)	<tmpal> [tʰəmpʰ-ɑl] 'to rumble'	<tmptmpal> [tʰəmpʰ-tʰəmp-ɑl] (intense)
Verbal reduplication of bisyllabic roots Cə.CVCC-Cə.CVCC-					
<t'rmp'al>	[tʰə.ɾəm.pʰ-ɑl]	'to tumble'	<t'rmp't'rmp'al>	[tʰə.ɾəmpʰ-tʰə.ɾəm.pʰ-ɑl]	(freq.)
<trnkal>	[tə.ɾəŋ.kʰ-ɑl]	'to rumble'	<trnktrnkal>	[tʰə.ɾəŋkʰ-tʰə.ɾəŋ.kʰ-ɑl]	(cont.)
<ʃrxgal>	[ʃə.ɾəχ.k-ɑl]	'to bang (noise)'	<ʃrxgʃrxgal>	ʃə.ɾəχk-ʃə.ɾəχ.k-ɑl]	(freq.)

For all these varieties of reduplication, the location of the two schwas follows from the interaction of schwa epenthesis and the left-syllable-alignment of roots (21). The reduplicant boundary causes a schwa to be inserted at the left-edge of the root. This creates a word-medial open syllable at the expense of directional syllabification.

(21) *Deriving schwa epenthesis in verbal reduplication for* [ʃəpʰ-ʃəpʰ-el] 'to rub (intense)'

<ʃp'-ʃp'-el> (/ʃpʰ-ʃpʰ-el/)		*CC$_\sigma$	ALIGN(M,σ)-L	ALIGN-σ-L	<>/ə/
a.	ʃpʰʃpʰel	∗!	∗		
b. ☞	ʃəpʰ.ʃə.pʰel			8	∗∗
c.	ʃə.pʰəʃ.pel		∗!	7	∗∗

The above data concerns canonical verbal reduplication whereby the the two copies are identical. Another common construction is change the vowel of the second copy into a schwa (Table 38). I call this 'syncopated reduplication'. Diachronically, the missing vowel was present at an earlier stage of the language, but is now exceptionally absent (Աբրահամյան 1959). Orthographically, the schwa is unwritten.

Table 38: Syncopated reduplication CVC-CəC- from existing bases

<vazel>	<vazvzel>	<k'aʃel>	<k'aʃk'ʃel>	<toɣal>	<toɣtɣal>
[vɑz-el]	[vɑz-vəz-el]	[kʰɑʃ-el]	[kʰɑʃ-kʰəʃ-el]	[tʰoʁ-ɑl]	[tʰoʁ-tʰəʁ-ɑl]
'to run'	'to run around'	'to pull'	'to haul out'	'to tremble'	(intense)
<t'ap'el>	<t'ap't'ap'el>	<xapel>	<xapxpel>	<d͡zep'el>	<d͡zep'd͡zp'el>
[tʰɑpʰ-el]	[tʰɑpʰ-tʰəpʰ-el]	[χɑpʰ-el]	[χɑpʰ-χəpʰ-el]	[d͡zepʰ-el]	[d͡zepʰ-d͡zəpʰ-ɑl]
'to throw'	'to throw around'	'to deceive'	(intense)	'to coat'	(intense)

Regardless of the above variation, given the OR and the morphological structure, the presence of the medial schwa is predicted thanks to left-alignment of roots to syllables (22).

(22) *Deriving syncopated reduplication in* [kʰɑʃ-kʰəʃ-el] 'to haul out'

<k'aʃ-k'ʃ-el> (/kʰɑʃ-kʰʃ-el/)			$*CC_\sigma$	Align(M,σ)-L	Align-σ-L
a.		kʰɑʃk.ʃel		∗!	4
b.	☞	kʰaʃ.kʰə.ʃel			8
c.		kʰɑ.ʃəkʰ.ʃel		∗!	7

In the above cases of canonical and syncopated reduplication, the reduplicated verb has a lexically-related un-reduplicated verb, i.e., a base verb. The lexicon thus provides evidence that the reduplicated verb is derived from the un-reduplicated verb. However, there are cases of pseudo-reduplication (Table 39), whereby a reduplicated verb lacks a lexically-related un-reduplicated form.

Table 39: Pseudo-reduplication of verbs without a base

<kṙkṙal>	<dndnal>	<t'p't'pal>	<xʃxʃal>	<gmgmal>	<p'sp'sal>
[kʰəɾ-kʰəɾ-ɑl]	[dən-dən-ɑl]	[tʰəpʰ-tʰəpʰ-ɑl]	[χəʃ-χəʃ-ɑl]	[gəm-gəm-ɑl]	[pʰəs-pʰəs-ɑl]
'to croak'	'to loiter'	'to wing'	'to be stirred'	'to lisp'	'to whisper'

The above words are not related to any unreduplicated word. They are thus synchronically underived but reduplicative stems (Stolz, Levkovych & Dewein 2009). I call them pseudo-reduplicative. We can analyse the morphological structure of these words in two ways. One is to treat the pseudo-reduplication as morphologically-triggered, meaning that a verb like *kʰər.kʰə.ɾ-el* 'to croak' contains two semi-identical bound morphs: *kʰəɾ-kʰəɾ-el*. A two-morph analysis is a common analysis for early work on pseudo-reduplication in Austronesian languages (Clynes 1995), and is sometimes called internal or double reduplication (Buckley 1997). The use of two morphs would trigger schwa epenthesis in order to make the left-edge of the second morph aligned with a syllable (23).

(23) *Deriving schwa epenthesis in pseudo-reduplication for* [kʰəɾ-kʰəɾ-ɑl] 'to croak'

<kṙ-kṙ-al> (/kʰɾ-kʰɾ-ɑl/)			$*CC_\sigma$	Align(M,σ)-L	Align-σ-L
a.		kʰəɾkʰ.ɾɑl		∗!	
b.	☞	kʰəɾ.kʰə.ɾɑl			8
c.		kʰə.ɾəkʰ.ɾɑl		∗!	7

In contrast, another approach is to analyze the pseudo-reduplication as phonologically-triggered, i.e., aggressive reduplication (Zuraw 2002; Yu 2004; Bat-El 2006; Stanton 2020; Repetti-Ludlow 2021). In this approach, a word like *kʰər.kʰəɾ-al* would consist of a single bound root morph /kʰɾkʰɾ/ or [kʰəɾkʰəɾ-]. In order to trigger epenthesis in an open syllable *kʰəɾ.kʰə.ɾal*, we would need a constraint like Redup which would require that sequences of (nearly-)identical substrings become more identical: /kʰɾkʰɾ/ becomes [kʰəɾ.kʰə.ɾ-] and not **kʰəɾkʰ.ɾ-* so that we have two identical substrings [kʰəɾ]. For simplicity, I go for the morphologically-based two-morph analysis for the pseudo-reduplication of verbs.[28]

Baseless verbs show the need for morph boundaries to trigger schwa epenthesis. Similar data comes from 'corrupted reduplication' whereby the two copies differ in either their onset or coda. For onset corruption (Table 40), the second copy's onset onset has undergone diachronic lenition to a bilabial segment.

Table 40: Corrupted reduplication of onsets

<k'sel>	<k'smsel>	<xazel>	<xazmzel>	<xzmzel>	<xzpzel>
[kʰəs-el]	[kʰəs-məs-el]	[χɑz-el]	[χɑz-məz-el]	[χəz-məz-el]	[χəz-pəz-el]
'to scrape'	(intense)	'to draw'	'to scribble'	'to scribble'	'to scribble'

For coda corruption (Table 41), the two codas share a place of articulation but differ in their manner of articulation. Corrupted reduplication involves syncopation in either copy, both copies, or neither copy. A corrupted reduplicated verb can have a base verb or not.

Table 41: Corrupted reduplication of codas

<gzgdel>	<tntt͡ʃ'el>	<bsbɣal>	<vrvnal>	<gd͡zgdil>	<brbdel>
[gəz-gəd-el]	[tʰən-tət͡ʃ-el]	[bəs-bəʁ-ɑl]	[vəɾ-vən-ɑl]	[gəd͡z-gəd-il]	[bəɾ-bəd-el]
'to coil up'	'to murmur'	'to shine'	'to tremble'	'to squat'	'to scrutinize'

The two copies are no longer segmentally identical, but the reduplicative structure is recoverable because of the near-identity between the two copies. As before, the location of the schwa is predictable due to the morph boundary.

5 Psychological reality of schwa epenthesis

The previous sections went through a variety of phonological and morphological contexts where we see schwa epenthesis. These factors are summarized in Figure 1 with undominated constraints on syllable structure and contiguity. These constraints dominate morpheme alignment. There are various low-ranked constraints on directional syllabification, epenthesis, and onsets.

[28] Although there isn't evidence for phonologically-based pseudo-reduplication from verbal reduplication, there is some evidence for it from vowel reduction. For example in Western Armenian, for the root word <grgin> [gəɾgín] 'double', its derivatives generally delete the high vowel: <grgn-el> [gəɾg.nél] 'to repeat'. But for Eastern Armenian, Սարգարյան (1997:97) reports that the cognate can be optionally pronounced with a schwa: [kəɾk.nel ∼ kəɾ.kə.nel] 'to repeat'. For these derivatives, the root is still a single morph *kəɾkn-* ∼ *kəɾkən-*. I hypothesize that the optional presence of the schwa is due to phonologically-triggered pseudo-reduplication. More data is however needed.

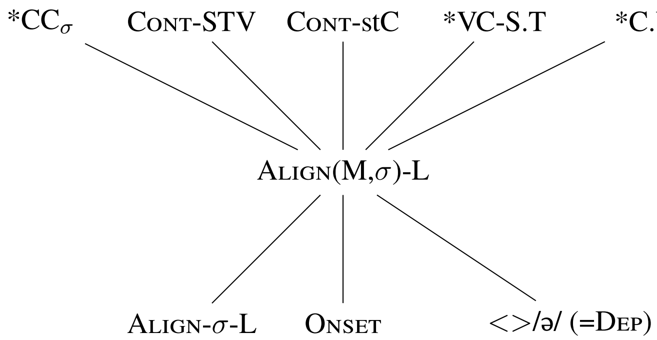

Figure 1: Hasse diagram for schwa epenthesis constraints from sections §3–4

The data focused on the role of schwa epenthesis as a spelling-pronunciation rule, i.e., as a transformation from orthographic forms to surface pronunciation forms. This section discusses the significance of the data in terms of psychological reality, both for the orthography (§5.1) and for phonology proper (§5.2).

5.1 Diachronic and synchronic status of orthographic rules

The previous sections argued that schwa epenthesis is a systematic process that relates orthographic forms to surface pronunciation forms. This section argues that such a spelling-pronunciation rule has been active since Classical Armenian, and it is acquired subconsciously and productively by native readers.

Modern Armenian is written in the Armenian script, a script that has been used since its invention for Classical Armenian (CA). Many modern words with unwritten schwas are diachronic reflexes of Classical Armenian forms. One could hypothesize that the modern pronunciation forms with schwas descend from classical forms that were not pronounced with schwas. But this is false.

Classical Armenian was also a CVCC language that banned complex onsets and had strict restrictions on complex codas. As an ancient language, we don't know how CA was exactly spoken 2000 years ago. However, at some time between the 8th and 12th centuries, Armenians developed a 'traditional pronunciation' for Classical Armenian words (Godel 1975:24; Macak 2017:1039). Part of this convention is to pronounce unwritten schwas in exactly the same places as their modern forms (Godel 1975:16; Thomson 1989:116; Macak 2017:1043). Some of these unwritten schwas are diachronic reflexes of Proto-Indo-European full vowels that got reduced in Proto-Armenian (Vaux 1998:26). For Classical and Modern Armenian (24), there is no synchronic evidence of an unreduced vowel in the underlying form for these unwritten schwas.

(24)	Ortho.	Trans.	CA (Godel 1975:116)	Modern Western Armenian
	կրակ	<grag>	[kə.ɾɑk]	[gə.ɾɑg] 'fire'

Thus, these epenthetic schwas are diachronically stable. They have been pronounced but unwritten for at least 1,000 years. There have been a few attempts at formalizing the rules for pronouncing these unwritten schwas for Classical Armenian (Hammalian 1984; Schwink 1994; Pierce 2007). Pierce (2007) has noted that as a spelling-pronunciation rule, essentially the same schwa epenthesis rules are active for Classical Armenian and for Modern Armenian.

For the Modern Armenian grammar, all the previous sections showed that the spelling-pronunciation rule for schwa epenthesis is a systematic rule for converting orthographic forms to pronunciation forms. As a rule, the question is then how this rule is taught or transferred by native speakers. In my experience, L1 textbooks written in Armenian don't provide rules for schwa epenthesis, but at most just list out different cluster sizes and their schwas.[29] The Armenian teachers who I have consulted told me they don't explicitly

[29] Textbooks written in English for adult second-language learners often give a long array of patterns of schwa

teach any schwa epenthesis rules. Thus, school children pick up the rules for schwa epenthesis without ever getting explicit instruction on how to apply schwa epenthesis in small or large clusters. It thus seems that schwa epenthesis, as a spelling-pronunciation rule, is passively acquired by literate Armenian speakers. This rule is not taught.

Given that this spelling-pronunciation rule is acquired and not taught, the next question is whether this rule is synchronically active in the mental grammar of a literate speaker. Evidence suggests this rule truly is productive. Essentially, if an adept reader is given the OR of some unknown form, then the reader will pronounce the SR with schwas placed in the expected locations. For example, Vaux (1998:66) gave a native speaker a list of almost 100 attested Armenian words that had long consonant clusters. The speaker only knew 20% of these words, but he correctly pronounced all but 7 words. Of those 7 'mistakes', his mistakes were because he gave the wrong morphological parse for these unknown words. Similar results were obtained elsewhere (Հովհաննիսյան 2014:ch6).

Thus, as a rule for relating orthography to phonology, schwa epenthesis is a stable and psychologically real grammatical process. As we explore in the next section, all of this data is a strong argument that the underlying representations match the orthography by lacking these epenthetic schwas.

5.2 Phonological status of schwa epenthesis

As a spelling-pronunciation rule, schwa epenthesis is productive. The next question is whether schwa epenthesis is just restricted to being a spelling-pronunciation rule, or whether it is also a phonological rule. I argue that schwa epenthesis likewise resides in the transformation of URs to SRs. The rule is an early lexical rule that creates phonologically visible schwas and that creates opacity.

5.2.1 Epenthesis is a phonological rule

Within the linguistic literature on Armenian, there is debate on whether these unwritten schwas are present in the lexical representation of words (Խաչատրյան 1966, 1988; Khachaturian 1985) or not (Hamp 1963; Гулакян 1965; Vaux 1998). If present, then the phonological grammar would not need a schwa epenthesis rule. Like Vaux (1998), I argue that for ORs that have an unwritten schwa, the underlying representation (UR) likewise lacks this schwa. I provide two pieces of evidence for this. The first is that schwa epenthesis applies in nativized loanwords to create maximally CVCC syllables (25a), cf. to native words (25b) (Vaux 1998:67). The lack of epenthesis is seen as typical of non-nativized loanwords (Ղարագյուլյան 1974:64–5).

(25)	a.	<t'rak't'or>	[tʰə.ɾɑk.toɾ]	'tractor'	b.	<tram>	[tʰə.ɾɑm]	'money'
		<gram>	[gə.ɾɑm]	'gram'		<gronk'>	[gə.ɾoŋkʰ]	'religion'

Second, the pronunciation and placement of these unwritten schwas is predictable and governed by morphological parses.[30] If schwa epenthesis is sensitive to such morphology, then this highly suggests that the OR has a close connection to morphophonological representations (= URs).

Because of these factors, I argue that schwa epenthesis applies both from ORs to SRs, and from URs to SRs. This means that ORs and URs are largely identical, putting aside some voicing mismatches in clusters.

epenthesis for different types of clusters. But for clusters of size 3 and above, these textbooks treat epenthetic schwas as random and as something to be memorized (Bardakjian & Thomson 1977). This is further evidence that schwa epenthesis is an acquired rule, not a taught rule. Furthermore, the only time I see any sense of instruction is when children are taught that they need to hyphenate words that are broken across lines: <tram>∼[tʰəɾam] 'money' is hyphenated as <tə-ram>. But this hyphenation is then just teaching readers to write words as they are pronounced.

[30] Kiparsky (2018) distinguishes three levels of representation (UR, lexical representation, SR). If we apply his system, these unwritten schwas can be considered as absent from morphophonemic representation (URs) and as not M-phonemes. These schwas are added in the derivation during the stem-level stratum. The outputted schwas are thus phonemes in the lexical representation (L-phonemes).

The same morphological and phonological constraints from the previous sections control the distribution of epenthetic schwas, both from ORs and from URs. One would only need to add a Dep constraint that controls the correspondence between URs to SRs. This Dep constraint would be equally ranked as our <>/ə/ constraint that governs between ORs and SRs.

In contrast to unwritten schwas, a schwa is written in the OR when its pronunciation is not predicted by morphology or by directional syllabification. Diachronically, these written schwas are often a reflex of sporadic unpredictable vowel reduction, e.g., the Modern Western word <ənel>→[ənel] 'to do' descends from an earlier form <anel>.[31]Synchronically, these written schwa must likewise be present in the UR: /ənel/.

To illustrate, consider the near-minimal pair in (26). These derivations show how the SR can be derived from either the OR or UR, mitigated by UR-to-SR constraints (Max, Dep) and their analogous OR-to-SR constraints (<X>//, <>/ə/). The Max-like constraint for ORs is taken from (Hamann & Colombo 2017:690).

(26) a. <ənger>, /əngeɾ/ → [əŋ.geɾ] 'friend'

<ənger> /əngeɾ/	*CC$_\sigma$	<X>// Max	Ons	<>/ə/ Dep
a. ☞ əŋgeɾ			*	
b. ngeɾ	*!	*!		
c. nə.geɾ		*!		*

b. <ngar>, /ngɑɾ/ → [nə.gɑɾ] 'picture'

<ngar> /ngɑɾ/	*CC$_\sigma$	<X>// Max	Ons	<>/ə/ Dep
a. əŋ.gɑɾ			*!	*
b. ngɑɾ	*!			
c. ☞ nə.gɑɾ				*

For the phonology, these epenthetic schwas are not added late in the phonological derivation, but must be inserted early, as a lexical rule. For example, the Armenian plural suffix displays syllable-conditioned allomorphy (27a): *-er* after monosyllabic bases, *-ner* after polysyllabic ones (Vaux 2003). Epenthetic schwas are counted in the plural (27b).[32]

(27) a. *Realization rules for the plural*

pl → *-eɾ* / σ _
-neɾ / elsewhere

b. *Schwa epenthesis and syllable-counting allomorphy*

<pag>	<pager>	<danag>	<danagner>	<tkal>	<tkalner>
[pʰɑg]	[pʰɑg-eɾ]	[dɑ.nɑg]	[dɑ.nɑg-neɾ]	[tʰə.kʰɑl]	[tʰə.kʰɑl-neɾ]
'yard'	'yards'	'knife'	'knives'	'spoon'	'spoons'

[31] There are a handful of exceptions where an unpredictable schwa is present in the UR but not in the OR: footnotes 13, 15.

[32] For CVCC with final rising-clusters, schwas appear in isolation: <vakr>→[vɑ.kʰəɾ] 'tiger'. These roots are treated as monosyllabic in the plural, take the *-er* suffix, and don't use a schwa: [vɑkʰ.ɾ-eɾ] 'tiger-pl'. For space, I cannot discuss how schwa epenthesis behaves in these words. One could either argue that schwa epenthesis in final clusters applies late due to root-final extraprosodicity (Vaux 1998, 2003), because of a cyclic rule of schwa deletion (Svantesson 1995; Burzio 2005), or due to the interaction of syllabic and trapped consonants (Scheer 2008). This issue does not affect my analysis.

Besides allomorphy, other evidence for the relatively early timing of phonological insertion of schwas includes the involvement of schwas in language games (Հովհաննիսյան 2014; Hovhannisyan 2011) and perception (Hovakimyan 2016). In sum, schwa epenthesis is a phonological rule that applies early in the derivation, early enough to interact with morphological structure and license allomorphy. Further evidence of its derivational timing is presented next.

5.2.2 Opacity of schwa epenthesis

Schwa epenthesis is a phonological rule that applies early in the derivation. This section shows that variable articulatory weakness of the schwa has led to the emergence of a phonological process of schwa elision in connected speech. This post-lexical process has created opacity with schwa epenthesis and allomorphy. The opacity is further evidence of the early and phonological nature of schwa epenthesis.

In terms of articulation and perception, the epenthesized schwa is often described as weak before sonorants *-ɾ, -n* and the fricative *-ʁ* when epenthesized into a two-consonant cluster (Ղարագյուլյան 1979:37, 1974:145,167–9, Մարգարյան 1997:51,58, Ավետիսյան 2011:13). Some go far as calling schwas in this context excrescent (Հովհաննիսյան 2012:89). The schwa is perceptually stronger when part of a closed syllable (Ղարագյուլյան 1974:169).

In connected speech, these inserted schwas can variably delete in certain prosodic and segmental contexts (Խաչատրյան 1988:73; Թոխմախյան 1988). These contexts include word-initial [CəɾV∼CɾV] and around fricated consonants. This deleted schwa is still perceivable to speakers, e.g., in language games (Hovakimyan 2016). The existence of elision is often mis-analyzed as the lack of epenthesis in early grammars (Kogian 1949:20–1; Fairbanks 1948:12–3,19; Johnson 1954:9–11,29–32). Ղարագյուլյան (1979:126,145–150) extensively documents the factors of elision. These factors include word length, syllable structure, syllable position, and the manner of articulation of flanking consonants.

This process of schwa elision applies late in the phonological derivation as an optional post-lexical rule. Evidence for the lateness of deletion comes from allomorphy and opacity (Table 42). An inserted schwa can license the polysyllabic-selecting plural suffix *-neɾ*, and then end up deleting due to schwa elision.

Table 42: Schwa epenthesis and syllable-counting allomorphy

<tram>	<tram>	<k'ʃoɣ>	<k'ʃoɣ>
[tʰə.ɾɑm]	[tʰ(ə).ɾɑm-neɾ]	[kʰə.ʃoʁ]	[kʰ(ə).ʃoʁ-neɾ]
‘money’	‘monies’	‘driver’	‘drivers’

The interaction of epenthesis, allomorphy, and elision leads to inter-stratal opacity (Kiparsky 2000; Bermúdez-Otero 2011) caused by input-driven phonologically-conditioned allomorphy (Paster 2006, 2009). I illustrate a simple cyclic derivation in Table 43. Epenthesis and allomorphy apply in the lexical stratum. The presence of the epenthetic schwa licenses the plural allomorph *-neɾ*. Post-lexically, this same schwa is optionally deleted, making the choice of allomorphy opaque.

Table 43: Derivation of plural forms with epenthesis then elision for [kʰ(ə)ʃoʁ-neɾ] ‘drivers’

Input			/kʰʃoʁ + PL/
Lexical stratum	Cycle 1	Spell-out	kʰʃoʁ
		Schwa epenthesis	kʰəʃoʁ
	Cycle 2	Spell-out (allomorphy)	kʰəʃoʁ-neɾ
Post-lexical stratum		Schwa elision (optional)	kʰəʃoʁneɾ ∼ kʰʃoʁneɾ

The above patterns show that the epenthetic schwa is epenthetic, not intrusive (Vaux 2003; Hall 2003, 2006). The schwa is phonologically present early in the derivation in order to license the right types of syllable-counting allomorphy. In sum, the orthography is highly suggestive of the underlying form of words, and schwa epenthesis feeds morphophonological processes.

6 Distinctness of schwa epenthesis and vowel reduction

Having established what factors control schwa epenthesis, this section asks "*Do all unwritten schwas follow the same phonological constraints?*". The answer is 'no'. We focus on vowel reduction (Vaux 1998; Khanjian 2009) which creates reduced schwas. Such schwas follow different constraints.

Briefly, roots get final stress, and suffixes trigger stress shift. When a root's stressed high vowel becomes destressed in the derivative, that high vowel is either deleted or replaced by a schwa (Table 44). The orthography represents reduction by simply omitting the high vowel. Note that in this section, we only use SRs and URs because the orthography is not helpful.

Table 44: Basics of vowel reduction

Reduction to zero		Reduction to schwa	
'husband'	'to marry'	'paper'	'pamphlet'
[ɑmusín]	ɑmu**sn**-ɑnál	t^{h}**u**χt	t^{h}**ə**χt-íg
<amusin>	<amusnanal>	<t'uɣt'>	<t'ɣt'ig>

There are various morphological factors that condition the application of vowel reduction (Dolatian 2021a). An empirical question is whether the reduced schwa in words like [t^{h}əχt-ig] is epenthetic (Vaux 1998; Khanjian 2009) vs. the output correspondent of the destressed high vowel (Խաչատրյան 1966, 1988; Khachaturian 1985). We call these approaches Deletion+Epenthesis and Direct Reduction. The Deletion+Epenthesis approach predicts that the location of surface schwas is governed by the same schwa epenthesis constraints, while the Direct Reduction approach predicts that the surface location will match the vowel's underlying location.

This section entertains a Deletion+Epenthesis approach (§6.1). We find however that such a stance requires adding constraints that conspire to make the reduced schwa be in the same location as the high vowel (§6.2). This acts as conceptual evidence for the Direct Reduction approach (formalized in Appendix B). Furthermore, disentangling vowel reduction from epenthesis provides find evidence for morpheme-alignment effects in prefixation (§6.3).

6.1 Basic distribution of reduced schwas

First, consider contexts where the high vowel is deleted (Table 45). These are basically contexts where deletion would create a syllabifiable consonant cluster. We use the symbol v̌ to designate destressed high vowels.

Table 45: Contexts for reduction to zero

V.Cv̌.C-V					
ɑ.mís	'month'	ɑ.múɾ	'hard'	zɑ.d'ig	'Easter'
ɑm.s-ɑ.gɑ́n	'monthly'	ɑm.ɾ-ó͡ts	'fortress'	zɑd.g-ɑ.gɑ́n	'Easter-related'
VC.Cv̌.C-V					
ɑɾ.t^{h}ún	'awake'	jeɾ.k^{h}í͡tʃ	'singer'	t^{h}əm.p^{h}úg	'drum'
ɑɾt.n-ɑ.gɑ́n	'vigilant'	jeɾk^{h}.͡tʃ-u.hí	'female singer'	t^{h}əmp.k^{h}-a-háɾ	'drummer'

Second, consider contexts (Table 46) where the vowel is reduced to a schwa such that the location of the schwa a) matches the location of the high vowel, and b) matches the location predicted by right-to-left schwa epenthesis. Informally, schwa epenthesis predicts that the reduced schwa should not be in a word-medial open syllable.

Table 46: Contexts where the reduced schwa is predicted by both Deletion+Epenthesis and Direct Reduction

Cv̆.C-V					
mís	'meat'	kʰídz	'line'	χúl	'deaf'
mə.s-e.ʁén	'meat products'	kʰə.dz-ɑ.gán	'linear'	χə.l-u.tʰjún	'deafness'
Cv̆C.C-V					
pʰúɾtʰ	'wool'	víʃt	'affliction'	lúɾt͡ʃ	'serious'
pʰəɾ.tʰ-e.ʁén	'woolen goods'	vəʃ.t-ɑ.gán	'afflicting (adj)'	ləɾ.t͡ʃ-u.tʰjún	'seriousness'
V.Cv̆C.C-V					
je.ʁúŋkʰ	'nail'	χoɾúɾtʰ	'advice'	sə.núntʰ	'nutrition'
je.ʁən.kʰ-ɑ.vóɾ	'having nails'	χo.ɾəɾ.tʰ-ɑ.gán	'adviser'	sə.nən.tʰ-ɑ.gán	'nutritious'
VC.Cv̆C.C-V					
ɑn.tʰúntʰ	'abyss'	pʰɑm.pʰúʃt	'cyst'	χəɾ.χínt͡ʃ	'neigh'
ɑn.tʰən.tʰ-ɑ.gán	'hellish'	pʰɑm.pʰəʃ.t-ɑ.jín	'cystic'	χəɾ.χən.t͡ʃ-él	'to neigh'

The above data can be easily generated by the Deletion+Epenthesis approach (28). Assume a high-ranking constraint **ĭ,*ŭ* against destressed high-vowels (see Dolatian 2021a for an exact formulation of this constraint). Given the stressed base [ɑmís] 'month', the high vowel deletes by default. A schwa is epenthesized to resolve the consonant cluster, as in the derivative of [jeʁúŋkʰ] 'nail'. The location of the schwa optimizes right-to-left syllabification.

(28) *Deletion + Epenthesis in vowel reduction* (hypothetical constraint system)

a. *Reduction to schwa*: [jeʁuŋkʰ] 'nail' *to* [jeʁəŋkʰ-ɑvóɾ] 'having nails'

[jeʁúŋkʰ] /-ɑvoɾ/	*ĭ,*ŭ	*CC$_\sigma$	Max	Dep	Align-σ-L
a. je.ʁŭŋ.kʰɑ.vóɾ	∗!				14
b. jeʁŋ.kʰɑ.vóɾ		∗!	∗		10
c. ☞ je.ʁəŋ.kʰɑ.vóɾ			∗	∗	14
d. jeʁ.nə.kʰɑ.vóɾ			∗	∗	16!

b. *Reduction to zero*: [ɑmís] 'month' *to* [ɑms-ɑgán] 'monthly'

[ɑmís] /-ɑgɑn/	*ĭ,*ŭ	*CC$_\sigma$	Max	Dep	Align-σ-L
a. ɑ.mĭ.sɑ.gán	∗!				9
b. ☞ ɑm.sɑ.gán			∗		6
c. ɑ.mə.sɑ.gán			∗	∗!	9

6.2 Divergences between reduction and epenthesis

Although schwa epenthesis can predict the location of most reduced schwas, there are contexts where the reduced schwa is found in a word-medial open syllable (Table 47). Here, the original high vowel is in a /VC(C)v̆C-V/ context such that deletion would create an unsyllabifiable cluster, thus a schwa is needed.

Table 47: /V(C).Cv̆.C-V/ contexts where the reduced schwa is in a medial open-syllable

ɑz.nív	'sincere'	həd.bíd	'buffoon'
ɑz.nə.v-u.tʰjún	'sincerity'	həd.bə.d-áŋkʰ	'buffoonery'
ɑrp.ʃíɾ	'drunken'	hɑs.míg	'jasmine'
ɑrpʰ.ʃə.ɾ-u.tʰjún	'drunkenness'	hɑs.mə.g-ɑ-kʰáɾ	'jade'

Deletion+Epenthesis predicts that the surface schwa should be *before* the original vowel's location so that we get a closed syllable. But this is an incorrect prediction (29), and the schwa is in the same location as the high vowel: [ɑz.nív] derives *ɑz.nə.vu.tʰjun* instead of **ɑ.zən.vu.tʰjun*.

(29) *Deletion+Epenthesis incorrectly predicts the location of the reduced schwa in* [ɑznəv-utʰjun] 'sincerity'

[ɑznív] /-utʰjun/	*ĭ,*ŭ	*CC$_\sigma$	Max	Dep	Align-σ-L
a. ɑz.nĭ.vu.tʰjún	∗!				12
b. ɑzn.vu.tʰjún		∗!	∗		8
c. ☹ ɑ.zən.vu.tʰjún			∗	∗	11
d. ɑz.nə.vu.tʰjún			∗	∗	12!

For the Direct Reduction approach, the location of the schwa is predictable simply because the schwa is the output correspondent of the high vowel. But in the Deletion+Epenthesis approach (30), the clearest way to force the location of the reduced schwa is to argue that there is an anti-contiguity constraint (Alderete 2001).

(30) *Hypothetical constraints for Deletion+Epenthesis*

a. Anti-Cont — Assign a violation if x, y are non-contiguous in the input, but contiguous in the output. (violated in $xuy \to xy$, satisfied in $xuy \to xvy$)

b. Constraint ranking — Dep >> Anti-Cont >> Align-σ-L

c. *Deletion + Epenthesis works with anti-contiguity*

[ɑznív] /-utʰjun/	*ĭ,*ŭ	*CC$_\sigma$	Max	Dep	Anti-Cont	Align-σ-L
a. ɑz.nĭ.vu.tʰjún	∗!					12
b. ɑzn.vu.tʰjún		∗!	∗		∗	8
c. ɑ.zən.vu.tʰjún			∗	∗	∗!	11
d. ☞ ɑz.nə.vu.tʰjún			∗	∗		12

This anti-contiguity requires that if some segment u (the high vowel) was deleted between x, y, then some element (the schwa) must get epenthesized in the same location as u. The end result is that this constraint favors the reduced schwa surfacing in the same location as the deleted high vowel.

Within a rule-based system, Vaux captures the above unexpected reduced schwas by positing a difference between schwas epenthesized via cyclic syllabification (what we call inserted schwas), vs. schwas inserted via post-cyclic syllabification (Vaux 1998:ch3.3.4). He posits that vowel reduction is high vowel deletion, and feeds post-cyclic syllabification, and post-cyclic syllabification prefers creating new syllables instead of modifying previous syllables: //.ɑz.nĭ.vu.tʰjún// → //.ɑz.{n}.vu.tʰjún// → [.ɑz.nə.vu.tʰjún] where {} marks unsyllabified material.

Thus, it is technically possible to derive reduced schwas via epenthesis. But to do so, we need additional constraints that conspire to make the location of the reduced schwa match the location of the original vowel, even at the expense of right-to-left syllabification. This causes us to question why the child learner should posit that that these reduced schwas are epenthetic rather than just the output correspondents of the high vowel.

There are additional cases where the reduced schwa is used in locations where schwa epenthesis does not predict, but in the location of the original high vowel. For words that have a /VCv̌CC-V/ context, the high vowel is replaced by a schwa *even* if deletion would've created a syllabifiable consonant cluster (Table 48).

Table 48: Deletion is blocked if the schwa is in a closed syllable /V.Cv̌C.C-V/

hɑ.ɾúst	'rich'	go.ɾúst	'loss'	ɑm.bɑ.ɾíʃt	'impious'
hɑ.ɾəs.t-u.tʰjún	'richness'	go.ɾəs.t-ɑ.gɑ́n	'losable'	ɑm.bɑ.ɾəʃ.t-u.tʰjún	'impiety'
*hɑɾs.t-u.tʰjún		*goɾs.t-ɑ.gɑ́n		*ɑm.bɑɾʃ.t-u.tʰjún	'impiety'
cf. hɑ**ɾs**.n-íkʰ	'wedding'	cf. t͡ʃo**ɾs**.n-ót͡s	'quaternary'	cf. gɑ**ɾʃ**.n-éʁ	'nervous'

Consider the near-minimal pair below between a /VCv̌CC-V/ context and a /VCCv̌C-V/ context. In both words, deletion would create a syllabifiable fricative-stop cluster. Deletion is found in (31a) but not (31b). For Vaux's system, we would require that the post-cyclic syllabification algorithm can create new simplex codas, but not new complex codas; similar band-aids would need to be used for our Deletion+Epenthesis system.

(31) a. bɑɾ.síg 'Persian'
bɑɾs.k-ɑs.tɑ́n 'Persia'
*bɑɾ.sə.g-ɑs.tɑ́n

b. bɑɾísp 'fortress'
*bɑɾs.p-él 'to fortify'
bɑ.ɾəs.p-él

Finally, consider /Sv̌T-V/ contexts (32) (Vaux 1998:102). Here, the high vowel is flanked by a sibilant and stop. Whereas schwa epenthesis uses schwa prothesis in /STV/ clusters to get [əSTV], vowel reduction always reduces the high vowel to a schwa [SəT-V] instead of prothesis [əST-V]. Such divergences can again arise with the Deletion+Epenthesis approach.

(32) a. súk 'grief'
sə.kʰ-ɑ́l 'to grieve'
*əs.k-ɑ́l

b. /skʰispʰ/ 'beginning'
*səkísp
əs.kísp

As is clear, for the Deletion+Epenthesis approach, additional mechanisms are needed to force schwa epenthesis to place the reduced schwas in the same location of the high vowel.[33] I do not formulate such constraints for space. But the need for such constraints reinforce the fact that a single monolithic analysis for inserted schwas and reduced schwas obfuscates the fact that the two schwas display subtle empirical differences. In Appendix B, I flesh out a Direct Reduction approach which handles the unexpected schwas.

6.3 Cyclicity vs. morpheme alignment

By distinguishing vowel reduction from schwa epenthesis, we likewise find evidence that Armenian phonology requires both cyclicity *and* morpheme-syllable alignment.

Recall from §4.2.1 that prefixes can induce schwa epenthesis in roots. The location of the root schwa is constant in the un-prefixed and prefixed forms: /tʰɾɑm/→[tʰəɾɑm] 'money' vs. /ɑn-tʰɾɑm/→[ɑn-tʰəɾɑm]

[33] There are two corners of the grammar where the reduced schwa is not in the same location as the high vowel (passives and rhotic-vowel sequences; Vaux 1998:105ff). For either an epenthesis or direct reduction approach, these two cases require their own special mechanisms again. See Dolatian (forthcoming) for data and analysis.

'moneyless'. This constancy is not predicted by right-to-left syllabification, but is enforced by requiring left-alignment of morpheme-syllable boundaries.

The schwa epenthesis data did not allow us to distinguish between a cyclic vs. alignment account for these post-prefix schwas. However vowel reduction provides evidence that alignment is the main factor. Consider the CVC roots in (33). These roots get prefixed to form a VC-CVC derivative. These prefixed forms then get suffixed. Suffixation triggers vowel reduction.

(33)	a.	dún	'house'	b.	kʰún	'sleep'
		ɑn-dún	'homeless'		ɑŋ-kʰún	'sleepless'
		ɑn-dən-utʰjún	'homelessness'		ɑŋ-kʰən-utʰjún	'sleeplessness'

In the suffixed forms, the root's high vowel is reduced to a schwa. Such a schwa is predicted by morpheme-alignment (34a). But within a simple cyclic framework where, the input to suffixation is prefixed word [VC-CVC] because of the semantics. If we assume bracket erasure (Orgun 2002), then this prefix boundary should be invisible, meaning there wouldn't be a morpheme-alignment constraint (34b). But without this constraint, then we incorrectly predict [VCC.CV...] without any schwa.

(34) Need for alignment for vowel reduction after prefixes (Deletion+Epenthesis)

a. Deriving the reduced schwa via alignment

[ɑn-dún] /-utʰjun/	*ĭ,*ŭ	*CC$_\sigma$	Max	Align (M,σ)-L	Dep	Anti-Cont	Align σ-L
a. ɑn.dŭ.nu.tʰjún	∗!						12
b. ɑnd.nu.tʰjún			∗	∗!		∗	8
c. ɑ.nəd.n.vu.tʰjún			∗	∗!	∗	∗	11
d. ☞ ɑn.də.nu.tʰjún			∗		∗		12

b. Failing to derive the reduced schwa without alignment

[ɑn-dún] /-utʰjun/	*ĭ,*ŭ	*CC$_\sigma$	Max	Dep	Anti-Cont	Align-σ-L
a. ɑn.dŭ.nu.tʰjún	∗!					12
b. ☹ ɑnd.nu.tʰjún			∗		∗	8
c. ɑ.nəd.n.vu.tʰjún			∗	∗!	∗	11
d. ɑn.də.nu.tʰjún			∗	∗!		12

The above prefix data act as a bracketing paradox because a) vowel reduction is triggered by suffixation, but b) the output of reduction is sensitive to the internal prefix-root boundary (Pesetsky 1979, 1985; Newell 2019). In terms of semantic scope, the suffix has scope over the prefix. The vowel reduction data thus cannot work with an analysis that uses bracket erasure to remove prefix boundaries.[34] See Elkins (2020) for cross-linguistically similar data on prefixes.

Thus, by disentangling schwa epenthesis from vowel reduction, we find that vowel reduction explicitly requires morpheme-alignment in order to predict the location of reduced schwas in prefix-root-suffix constructions.

[34] As an alternative approach with Late Adjunction (Newell 2005, 2019), we could argue that vowel reduction applies to a root-suffix construction, and that the prefix is later added by the morphology. But this analysis is unlikely because the prefix is a category-changing prefix. The prefix turns the root from a noun into an adjective, and then the suffix turns the adjective back into a noun. Another alternative is to make the prefix have morphological low scope (because of the semantics), but the prefix has a phonological diacritic that makes it spell-out late (Halle & Vergnaud 1987). See Dolatian (2021b:appendix) for how such alternative analyses affect other bracketing paradoxes in the language.

7 Conclusion

Orthographic representations can often encourage phonological analyses, or inversely be motivated by a phonological analysis. This paper documented schwa epenthesis in Armenian, as a spelling-pronunciation rule or as a transformation from orthographic forms to surface forms. The rule targets consonant clusters that can range in size and location. The location of the epenthetic schwa is motivated primarily from directional syllabification, with deviations caused by sibilant-stop contiguity and morpheme-syllable alignment.

As a process, schwa epenthessis is passively acquired by literate speakers, is productive, and is psychologically real. Because of its systematicity, schwa epenthesis is simultaneously a part of the phonology proper. It applies not only from orthographic forms to surface pronunciations, but also from underlying forms to surface forms. The orthography is thus a proxy for the underlying representations. Schwa epenthesis is integrated tightly into the language's morphophonology, can interact with allomorphy, and takes part in opacity.

Because schwa epenthesis is also a phonological rule, a reviewer wonders if we can abandon schwa epenthesis as a OR-SR transformation and just use it as a UR-SR transformation. Such a stance however is psychologically unreal. If an Armenian speaker is literate, then they must have a mental grammar that can read existing and nonce words (do a OR-SR transformation), otherwise they wouldn't be literate. Furthermore, having both an OR-SR and UR-SR transformation does create a duplication of generalizations for the two processes, but such duplication is evidence that such generalizations are extremely robust language-internally. As for pre-literate speakers, the fact that the URs lack these epenthetic schwas likely helps these speakers learn how to read the likewise schwa-less ORs.

In sum, the Armenian schwa is a case of nearly isomorphic interaction between orthography, phonology, and morphology.

Abbreviations

PL	plural
GEN	genitive
freq.	frequentative
cont.	continuative
id.	identical

Appendix A: Vaux's analysis

This paper developed an analysis of Armenian schwa epenthesis using directional syllabification. In this appendix, I briefly go over previously published alternative analyses.

Vaux (1993, 1998:ch3) is one of the most comprehensive analyses of Armenian schwa epenthesis. His analysis starts out by treating the OR as equivalent to the UR. Epenthesis then applies from UR to SR. Consonant clusters undergo an abstract process of syllabification in which some consonants are able to be assigned to syllable nuclei (35). Within a cluster, the choice of which consonant is assigned to a syllable nucleus depends will depend on its sonority, its phonological context, and the presence of morpheme boundaries. These syllabic consonants are then replaced by a Cə or əC sequence at a later stage in the derivation. His analysis is inspired by Dell & Elmedlaoui (1985)'s treatment of Imdlawn Tashlhiyt Berber.

(35) <tram>, /t^{h}ɾɑm/ → T.ram → [t^{h}ə.ɾɑm] 'money'

I cannot compactly summarize his analysis because of space. His analysis is quite complex and integrates cyclicity, final consonant extraprosodicity, and constraints on sonority (see Frampton 2011 for similar sonority-based constraints in syllabification). His analysis can cover a wide range of the data that is discussed in this paper, but not all of it. His analysis makes incorrect predictions for initial clusters of four consonants that precede a morpheme boundary: <$C_1C_2C_3C_4$-V> (Table 49). In brief, if C_2C_3 can form a complex coda, and if C_3 is less sonorous C_4, then Vaux's analysis argues that we should find word-medial open syllables: CəC.Cə.C-V. This pattern is caused by his *Sonority Blocking Constraint* and by requiring that final consonants are extraprosodic at every cycle. He applies such a pattern for two words which I list below in their Eastern form from Vaux (1998:87). I provide a corresponding Western form.

Table 49: Vaux's analysis for initial 4C clusters

	Orthography	UR	SR	
Eastern	<krkʒel>	/ɡɾɡʒ-el/	[ɡəɾ.ɡə.ʒ-el]	'be very sour'
Western	<krkʒel>	/k^{h}ɾk^{h}ʒ-el/	[k^{h}əɾ.k^{h}ə.ʒ-el]	
Eastern	<tnt'ṙel>	/dnt^{h}ṙ-el/	[dən.t^{h}ə.r-el]	'be astonished'
Western	<tnt'ṙel>	/t^{h}nt^{h}ɾ-el/	[t^{h}ən.t^{h}ə.ɾ-el]	

The problem with this analysis is twofold (Table 50). First, it doesn't acknowledge the fact that the above examples are pseudo-reduplicative. Second, the analysis makes the wrong predictions for analogous cases of 4-initial clusters that precede a morpheme boundary but are not pseudo-reduplicative (§3.1). For example, the word /p^{h}ndɾ-el/ takes a single schwa [p^{h}ənd.ɾ-el]. Vaux's analysis cannot trigger only one schwa in such forms, while triggering two schwas in the above forms.

Table 50: Problematic examples for Vaux's analysis

	Orthography	UR	SR	Vaux's prediction	
Eastern	<p'ndṙel>	/p^{h}ntṙ-el/	[p^{h}əntr-el]	*p^{h}ən.tə.r-el	'to seek'
Western	<p'ndṙel>	/p^{h}ndɾ-el/	[p^{h}ənd.ɾ-el]	*p^{h}ən.də.ɾ-el	
Eastern	<t͡s'ngnel>	/t͡s^{h}nkn-el/	[t͡s^{h}əŋk.n-el]	*t͡s^{h}əŋ.kə.n-el	'to pup'
Western	<t͡s'ngnil>	/t͡sngn-il/	[t͡səŋɡ.n-il]	*t͡səŋ.ɡə.n-il	

In contrast, I can explain words like [p^{h}ənd.ɾ-el] thanks to directional syllabification. As for the words with two schwas in (Table 49), I analyze these words as pseudo-reduplicative with corrupted onsets or codas (Table 51). The internal pseudo-reduplicative boundary triggers the internal schwa.

Table 51: My morphological parse for Vaux's examples

	Orthography	UR	SR	
Eastern	<krkʒel>	/ɡr-ɡʒ-el/	[ɡəɾ.ɡə.ʒ-el]	'be very sour'
Western	<krkʒel>	/k^{h}ɾ-k^{h}ʒ-el/	[k^{h}əɾ.k^{h}ə.ʒ-el]	
Eastern	<tnt'ṙel>	/dn-t^{h}r-el/	[dən.t^{h}ə.ɾ-el]	'be astonished'
Western	<tnt'ṙel>	/t^{h}n-t^{h}ɾ-el/	[t^{h}ən.t^{h}ə.ɾ-el]	

To fix Vaux's analysis, we have two fix two things (Bert Vaux, p.c.). First, we must include morpheme symbols in the pseudo-reduplicative words above. This will ensure that those words correctly get two schwas. As for #CCCCV words like [p^{h}əndɾ-el] with one schwa, we can abandon the idea that final consonants are extraprosodic at every cycle. They are instead extraprosodic only at the last cycle.

Appendix B: Direct reduction

Section 6 explored the most obvious analysis for vowel reduction as composed of vowel deletion feeding schwa epenthesis. We found that this analysis faces many challenges in accounting for the data. This section explores an alternative analysis whereby vowel reduction does not involve schwa epenthesis at all: the reduced schwa is the output correspondent of the original high vowel.[35]

The data sets from §6.1 and §6.2 require a high-ranking constraint **ĭ,*ŭ* against destressed high-vowels (see Dolatian 2021a for an exact formulation of this constraint). This constraint competes against reduction to zero (MAX) and reduction to schwa (ID[F]). Note the correspondence indexes disambiguate epenthetic schwas from reduced schwas (36).

(36) *Constraints and ranking for Direct Reduction*

a. MAX — Assign a violation if a segment is deleted (= if the vowel deleted).

b. ID[F] — Assign a violation if the features of a segment changed (= if the vowel reduced to a schwa).[36]

c. Constraint ranking — *ĭ,*ŭ, $*CC_\sigma >>$ DEP, MAX, ID[F], ALIGN-σ-L

d. *Reduction to schwa*: [jeʁuŋkʰ] 'nail' *to* [jeʁəŋkʰ-ɑvóɾ] 'having nails'

		[jeʁú$_1$ŋkʰ] /-ɑvoɾ/	*ĭ,*ŭ	$*CC_\sigma$	DEP	MAX	ID[F]	ALIGN-σ-L
a.		je.ʁŭ$_1$ŋ.kʰɑ.vóɾ	*!					14
b.		jeʁŋ.kʰɑ.vóɾ		*!		*		10
c.		je.ʁə$_2$ŋ.kʰɑ.vóɾ			*!	*!		14
d.		jeʁ.nə$_2$.kʰɑ.vóɾ			*!	*!		16!
e.	☞	je.ʁə$_1$.ŋ.kʰɑ.vóɾ					*!	14

The main setback for the Deletion+Epenthesis approach is that it cannot explain why the high vowel is reduced to zero for words like (37a), but reduced to schwa for words like (37b), repeated from (31). Deletion would create syllabifiable clusters in both. In contrast, the Direct Reduction approach suggests that this difference is because deletion can only happen for word-medial open syllables but not for closed syllables.

(37) a. bɑɾ.síg 'Persian'
bɑɾs.k-ɑs.tɑ́n 'Persia'
*bɑɾ.sə.g-ɑs.tɑ́n

b. bɑɾísp 'fortress'
*bɑɾs.p-él 'to fortify'
bɑ.ɾəs.p-él

To build up this generalization, consider what contexts allow or disallow medial [Cə] syllables (Table 52). Such syllables are found when a) the schwa is epenthetic and there's a preceding morpheme boundary, b) the schwa is reduced and its deletion would create an unsyllabifiable cluster, and c) the schwa is underlying and unpredictably located because of diachronic syncope. Other logically possible contexts for open syllables are blocked, both for epenthesis and for reduction.

Table 52: Contexts that allow disallow medial [Cə] syllables

	Base or UR			Type	Factor
a)	[tʰəɾɑm]	[ɑn-tʰə.ɾɑm]	'moneyless'	Epenthetic	Morpheme-alignment (14)
b)	[ɑz.nív]	[ɑz.nə.v-utʰjun]	'sincerity'	Reduced	Unsyllabifiable deletion (Table 47)
c)	/hɑskʰənɑl/	[hɑs.kə.nɑl]	'to understand'	Underlying	Faithfulness (footnote 13)

We can summarize the above contexts in (38). There is a low-ranked constraint against word-medial open [Cə] syllables. This constraint is low-ranked because such syllables are attested. There is however a

[35] This analysis means that Armenian has both a rule of schwa epenthesis and a rule of schwa deletion. Typologically similar cases of languages with epenthesis and deletion of the same type of vowel include Lillooet (Gouskova 2003:ch4) and Mongolian (Svantesson 1995).

high-ranked constraint conjunction with a generic faithfulness constraint F. This constraint conjunction is violated whenever such a syllable is created via faithfulness violations (epenthesis and reduction), but not by underlying structures (underlying schwas). This constraint essentially distinguishes underlying schwas (which don't violate this constraint) from phonologically derived schwas (which violate this constraint) as a type of Derived Environment Effect (Kiparsky 1973, 1993; Łubowicz 2002; Hall 2006; Burzio 2011).

(38) *Constraints against medial [Cə] syllables*

a. *...Cə... — Assign a violation for a word-medial open syllable with a schwa [Cə].

b. *...Cə...&F — Assign a violation for a word-medial open syllable with a schwa [Cə] that was created via violating a faithfulness constraint (DEP or ID[F]).

c. Constraint ranking — ALIGN(M,σ)-L >> *...Cə...&F >> MAX >> *...Cə...

We illustrate below for the epenthetic and underlying cases in (39). Note that the violated faithfulness constraint here is DEP, which we don't show because its constraint ranking is complicated.

(39) a. Creating a medial [Cə] syllable because of morpheme alignment for ('moneyless', Table 52:a)

/ɑn-tʰɾɑm/	ALIGN(M,σ)-L	*...Cə...&F	MAX	*...Cə...
a. ɑntʰ.ɾɑm	∗!			
b. ɑ.nətʰ.ɾɑm	∗!			
c. ☞ ɑn.tʰə.ɾɑm		∗		∗

b. Creating a medial [Cə] syllable because of faithfulness ('to understand', Table 52:c)

/haskʰənɑl/	ALIGN(M,σ)-L	*...Cə...&F	MAX	*...Cə...
a. ☞ has.kə.nɑl				∗
b. hask.nɑl			∗!	

With these constraints, we can then formalize the vowel reduction data. First, for derivatives of words like [ɑmís], the high vowel is deleted to avoid creating a medial [Cə] syllable.

(40) Reduction to zero for Direct Reduction ('monthly', Table 45)

[ɑ.mí$_1$s] /-ɑgɑn/	*ĭ,*ŭ	*CC$_\sigma$	*...Cə...&F	MAX	DEP	ID[F]
a. ɑ.mĭ$_1$.sɑ.gɑ́n	∗!					
b. ☞ ɑm.sɑ.gɑ́n				∗		
c. ɑ.mə$_2$.sɑ.gɑ́n			∗!	∗	∗	
d. ɑ.mə$_1$.sɑ.gɑ́n			∗!			∗

Second, for derivatives of words like [bɑɾsíg] vs. [bɑɾísp] (37), the vowel is reduced to zero in the former but not the latter. This is because reduction to schwa would create a medial [Cə] syllable in the former. The constraint MAX must outrank ID[F].

(41) *Direct Reduction to schwa for open vs. closed syllables*

a. Constraint ranking *...Cə...&F >> MAX >> ID[F]

b. *Direct Reduction to zero for* [bɑɾs.gɑs.tɑn] ('Persia', 37a)

[bɑɾ.sí$_1$g] /-ɑst^{h}ɑn/			*ĭ,*ŭ	*CC$_\sigma$	*...Cə...&F	MAX	ID[F]	DEP
a.		bɑɾ.sĭ$_1$.gɑs.tán	∗!					
b.	☞	bɑɾs.gɑs.tán				∗		
c.		bɑɾ.sə$_2$.gɑs.tán			∗!	∗		∗
d.		bɑɾ.sə$_1$.gɑs.tán			∗!		∗	

c. Direct Reduction to schwa from [bɑ.ɾəs.p-el] ('to fortify', 37b)

[bɑ.ɾí$_1$sp] /-el/			*ĭ,*ŭ	*CC$_\sigma$	*...Cə...&F	MAX	ID[F]	DEP
a.		bɑ.ɾĭ$_1$s.pél	∗!					
b.		bɑɾs.pél				∗!		
c.		bɑ.ɾə$_2$s.pél				∗!		∗
d.	☞	bɑ.ɾə$_1$s.pél					∗	

For derivatives of words like [bɑɾísp], the Direct Reduction requires that reduction to schwa is the default behavior, while deletion is a last resort.[37] This is in contrast to the Deletion+Epenthesis approach, where deletion is treated as the default behavior, while using a schwa is a last resort.

Finally, for derivatives of words like [ɑznív] (Table 52:b), the high vowel is reduced to schwa. A medial [Cə] syllable is created because deletion would create an unsyllabifiable cluster. To predict why we prefer reduction to a [Cə] syllable in the same location, rather than deletion and epenthesis of a [CəC] syllable, we need DEP to outrank our constraint conjunction. This means that we prefer creating reduced schwas in [Cə] syllables rather than epenthesizing [CəC] syllables.

(42) Direct Reduction to schwa in open syllables to avoid unsyllabifiable clusters

a. Constraint ranking DEP >> *...Cə...&F >> MAX >> ID[F]

b. Derivation for [ɑz.nə.vu.t^{h}jun] ('sincerity', Table 47)

[ɑz.ní$_1$v] /-ut^{h}jun/			*ĭ,*ŭ	*CC$_\sigma$	DEP	*...Cə...&F	MAX	ID[F]
a.		ɑz.nĭ$_1$.vu.t^{h}jún	∗!					
b.		ɑzn.vu.t^{h}jún		∗!			∗	
c.		ɑ.zə$_2$n.vu.t^{h}jún			∗!		∗	
d.		ɑz.nə$_2$.vu.t^{h}jún			∗!	∗	∗	
e.	☞	ɑz.nə$_1$.vu.t^{h}jún				∗		∗

To summarize, we need a separate constraint system to handle vowel reduction within the Direct Reduction approach. Such a ranking can be united with our main constraint system for schwa epenthesis. The union of these rankings is in Figure 2.

[37] This is contra most previous work which assumed that deletion is the default, and that the use of a schwa was a last resort (Vaux 1998; Khanjian 2009; Dolatian 2021a). To my knowledge, Hammalian (1984:94,130ff) is the only source to treat deletion as a last resort. He has a reduction to schwa rule feeding a schwa deletion rule.

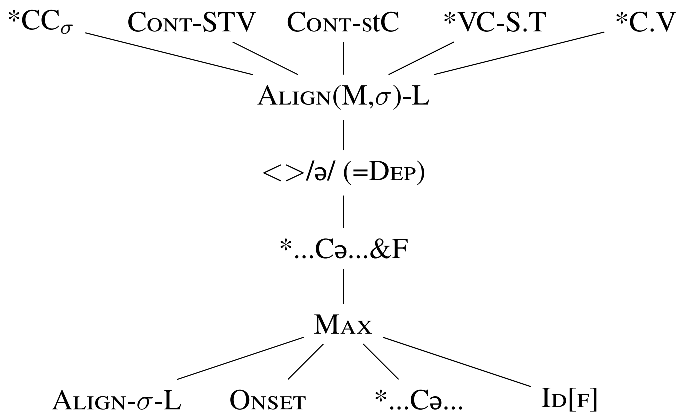

Figure 2: Hasse diagram for schwa epenthesis constraints from sections §3–4 and for vowel reduction from Appendix B

The constraint system is quite complicated. The supplementary materials contain the various OT tableaux that we used to determine the ranking of the union of the schwa epenthesis and direct reduction. The tableau are complete with violation counts for all the constraints. The data was run against OT-Help (Staubs et al. 2010) to validate the correctness of our analysis.

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Hossep Dolatian
Department of Linguistics
Stony Brook University
100 Nicolls Road
Stony Brook, NY 11794 USA
hossep.dolatian@alumni.stonybrook.edu