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Abstract

The purpose of this paper is to examine the phonological and morphological patterning of geminates in Moroccan Arabic (MA), using the constraint-based framework of Optimality Theory (Prince & Smolensky 1993/2004; McCarthy & Prince,1993a, 1993b, 1995). In particular, the central aim of this work is to uncover the constraint interactions responsible for the creation and distribution of the geminate patterns attested in MA. The questions we seek to answer are: (a) What motivates the occurrence of geminates in MA? (b) How can a sequence of non-identical consonants be transformed into a geminate consonant? (c) What is the role of gemination in word formation?

Keywords: lexical geminates; phonological geminates;

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morphological geminates; assimilation; syllabification; word formation; Optimality Theory; Moroccan Arabic

0. Introduction

Geminates have been given different phonological characterizations over the course of the development of phonological theory. In linear phonology, a geminate is regarded either as a single segment specified for the feature [+long] (Chomsky & Halle, 1968) or as a sequence of two identical consonants (Kenstowicz & Pyle, 1973).

(1) Geminate representations in linear phonology

C	C_y	C_y
[+long]	[-long]	[-long]

In non-linear phonology, a geminate is defined in terms of prosodic association to two skeletal positions (McCarthy, 1979, 1981) or a mora (Hyman, 1985; McCarthy & Prince, 1986; Hayes, 1989).

(2) Geminate representations in non-linear phonology

In principle, a geminate is not always a unit of phonemic contrast as it may have other roles defined by the various pathways through which geminates can be created. For example, in many languages, geminates function as morphological markers, derived to serve different morphological roles.

Phonetically, the difference between a geminate and a singleton is described in terms of tenseness, such that geminates are [+tense] and singletons are [-tense]. This means that geminates are articulated with longer constriction in the vocal tract compared to 'normal' consonants. Besides, durations of articulation may vary depending on the quality of the geminate (e.g. stop or fricative geminate) (Cohn et al., 1999), the position of the geminate (i.e. medial or peripheral) or the elements surrounding the geminate (e.g. vowels or consonants) (Pajak, 2009a, b). On average, it has been shown that a geminate can be 1.5 to 3 times longer than its corresponding singleton (see Hankamer & Lahiri, 1988; Ladefoged & Maddieson, 1996; Thurgood & Demenko, 2001, 1993; Ridouane, 2010; Khattab & Al-Tamimi, 2014 for more on the phonetic properties of geminates).

Geminate consonants appear in many languages around the globe. Previous studies have shown that these languages tend to vary in terms of their geminate inventories. Differences may concern the ways through which geminates can surface in the phonological systems of these languages or the restrictions placed on geminates' featural composition and lexical position (Kawahara, 2007; Pajak, 2009a-b). On the extreme sides of this cross-linguistic variation of geminate inventories, there exist languages that allow geminates from all major class features and in all positions (e.g. Moroccan Amazigh; see Saib (1977) for data from Tamazight and Bensoukas (2001) for data from Tashlhit), and languages that permit only the least marked geminate structures, namely intervocalic voiceless obstruent geminates (e.g. Japanese (Kawahara, 2005, 2015; Kawahara & Melanie, 2017; Kubozono, Ito & Mester, 2008).

In this cross-linguistic context, the purpose of this paper is to provide a bird's eye view of the issue of gemination in MA through establishing a taxonomy of the geminate structures that arise in the language. To this end, we will show that geminates in MA are fundamentally lexical, but can also be phonologically and morphologically derived. We will also show that MA patterns with languages that put no restrictions on geminates, allowing all kinds of geminate structures both feature-wise and position-wise. The majority of our data is drawn from the MA variety referred to as 'Average Moroccan Arabic' in Benhallam & Dahbi (1990) and 'Standard Moroccan Arabic' in Ech-Charfi (2004). Such a variety is characterized by the elimination of dialectal and regional particularities. However, we also refer to data from other regional and rural varieties. For example, the data in (40) below is drawn from the MA variety spoken in the region of Safi.

The remainder of this paper is structured as follows. Section 1 introduces the different sound classes that geminates can belong to and the word positions they can occur in. Section 2 draws a distinction between fake geminates and true geminates. Section 3 describes the various ways through which geminates can arise in MA. It specifically shows that the patterns of geminates attested in MA can be lexical, phonological as well as morphological. Section 4 sums up the content of this paper.

1. The Distribution of Geminates in Moroccan Arabic

1.1 The featural composition of geminates

According to Perlmutter (1995), languages where phonological contrasts occur between single and geminate consonants or short and long vowels are said to have contrasts in phonological quantity (e.g. /b/ vs. /bb/), in addition to the more common contrasts in phonological quality (e.g. /b/ vs. /p/).

MA is one of the few languages that allow all types of geminates. Other languages that put no segmental restrictions on the occurrence of their geminates include, Buginese (Podesva, 2000), a Western Austronesian language spoken in South Sulawesi, Hungarian (Polgardi, 2005) and Tashlhit (Boukous, 1982)[2]. Different other languages vary in the extent to which they constrain the occurrence of geminates. In Trukese, all consonants have geminate counterparts with the exception of glides (Hart, 1991). In Japanese, voiced consonants, be they sonorant or obstruent, may not geminate (Kubozono et al. 2008). Selayarese, which is closely related to Buginese, does not allow voiced obstruent geminates (Podesva, 2000). In Somali, the only type of geminates permitted are voiceless stops (Blevins, 2008). In fact, it was cross-linguistically observed that the number of geminates, in languages that allow them, is always less than or equal to the number of singletons (Blevins, 2005).

Based on these language-specific observations, typological studies of geminates have suggested a number of universal generalizations. Cross-linguistically, geminate obstruents were found to be more frequent than geminate sonorants. The presence of the latter in a language usually implies the existence of obstruent geminates as well (Kawahara, 2007; Podesva, 2002). Within the obstruent category itself, voiceless stops were observed to be more common than voiced stops and fricatives (Maddieson, 2008; Podesva, 2002).

Drawing on data that we have gathered, it has been observed that MA does not impose any restrictions on the featural composition of long consonants, allowing all kinds of geminates. The result is that every singleton in the segmental inventory of MA has a geminate counterpart, which can be either lexical or derived. To be more specific, the geminate inventory of MA contains geminate stops, geminate fricatives, geminate nasals, geminate liquids and geminate glides.[3] For illustrative purposes, examples for each class of sounds are provided in (3):

[2] In Tashlhit, geminate glides can be underlying. Bensoukas (2001) provides the following items: ajjis ‘horse’ and awwun ‘stone’.

[3] Geminate glides in MA are restrictedly derived through morphological gemination. For example, morphological causatives that are based on medial weak roots with high vowels appear with corresponding geminate glides (e.g. fəjjəq ‘to waken up’; dəwwəṛ ‘to turn’).

(3) The segmental content of geminates in MA

Obstruents			
Stops:	*Voiceless*	sə**kk**a	‘rail’
	Voiced	ɣə**dd**a	‘tomorrow’
Fricatives:	*Voiceless*	g^{w}ə**ff**a	‘sack’
	Voiced	ħa**ʒʒ**a	‘female pilgrim’
Sonorants			
Nasals:		bə**nn**a	‘flavor’
		sə**mm**an	‘quail’
Liquids:		fə**ll**us	‘hatchling’
		mə**ṛṛ**a	‘one time’
Glides:		sə**ww**əl	‘to ask’
		xə**jj**əṭ	‘to sew’

1.2 The position of geminates

It has also been noted that geminates in MA can arbitrarily occur in word-medial, word-final as well as word-initial positions. MA has only a handful of words with lexical initial geminates. Yet, peripheral (or edge) geminates (i.e. initial and final geminates) may arise elsewhere due a process of total assimilation between the definite article and the first radical element of some nouns or the perfective 1st person pronoun and the final radical element of some verbs, as in ***ssuq*** and *ʃə**tt*** in (4).

(4) The position of geminates in MA

a. Word-initially		*b. Word-medially*		*c. Word-finally*	
mm^{w}i	‘my mother’	sə**nn**a	‘tooth’	ʒə**ṛṛ**	‘to pull’
bb^{w}a	‘my father’	g^{w}ə**ff**a	‘sack’	mu**xx**	‘brain’
dda	‘took’	ħə**nn**a	‘henna’	ṛə**ʃʃ**	‘to spray’
ssuq	‘the market’	fə**zz**əg	‘to make wet’	ʃə**tt**	‘I saw’

Peripheral geminates are believed to be cross-linguistically less common while medial, more specifically intervocalic, geminates are the most preferred (Davis & Topintzi, 2017; Dmitrieva, 2012; Pajak, 2013). Like MA, Tashlhit has geminate consonants in all positions (Bensoukas, 2001). Hungarian allows only medial intervocalic geminates and final ones (Polgradi, 2005). In Italian and Japanese, geminates can only occur intervocalically (Curtis, 2003). This implies that a language with peripheral geminates is more likely to contain word-internal geminates whereas a language with intervocalic geminates does not necessarily tolerate edge geminates (Thurgood, 1993).

Two main approaches have been suggested to explain the crosslinguistic variation of geminate inventories. In this concern, variations in the nature and position of geminates have been argued to be the result of constraints on phonetic markedness or otherwise the outcome of distinct diachronic origins. The phonetically-based approach attributes the variation to perceptual difficulties. For instance, Kawahara (2007) suggests that geminate sonorants are disfavored because they are less perceptible than geminate obstruents. Similarly, Pajak (2009a, b) argues that positional asymmetry of geminates is also believed to follow from perceptual restrictions, in that geminates adjacent to consonants are harder to perceive by listeners than geminates adjacent to vowels.

According to the historical approach, variation in geminate inventories is believed to be related to the various historical sources and the diachronic evolution of geminates in the languages which include them (Blevins, 2004). For Blevins, it is true that geminate consonants are more marked than short ones, but no geminate type or position should be seen as less or more exceptional than others, for it is equally possible that any geminate type in any position can evolve if the appropriate conditions are available. Blevins (2004) identifies seven diachronic pathways through which geminates can evolve into phonemic segments. These are listed below:

(a) assimilation in consonant clusters
(b) assimilation between consonants and adjacent vowels/glides
(c) vowel syncope
(d) lengthening under stress
(e) boundary lengthening
(f) reinterpretation of a voicing contrast
(g) reanalysis of identical C+C sequences

All of these pathways refer to phonological processes that affect a sequence of non-identical or identical segments. However, we suggest that geminates can evolve from morphological change as well. To substantiate our claim, we refer to a category of verbs in MA that come in the same morphological shape of causative verbs, without expressing the meaning of causativity. Instead, they surprisingly behave more like simple verbs. Put differently, these verbs comprise medial geminates that seem to be central to their basic lexical meaning rather than being morphologically expressive. Some of these verbs are provided in (5):

(5) Apparent causatives

ɦə**ww**əd	‘to get down’
nə**qq**əz	‘to jump’
sə**ll**əm	‘to greet’
wə**ll**əf	‘to get used to’
wə**rr**i	‘to show’

Nevertheless, if considered from a diachronic perspective, these forms can be claimed to be originally causative verbs that have lost their meaning of causativity and turned into simple verbs over time. We can adduce support for this claim by comparing the relevant verbs with some of their semantically-related corresponding nouns, like the ones cited below for each verb in (5):

(6) Corresponding nouns

ɦə**w**da	'a slope'
tən**q**iza	'a jump'
təs**l**ima	'a handshake'
wə**l**f	'getting used to'
twə**r**ja	'showing'

These forms suggest that what actually appears to be lexical geminates in the verbs in (5) have singleton counterparts in some distant semantically-related words. This somehow hints at their derivable nature. If that is really the case, then this can be seen as a striking example of morphological and semantic discrepancy, whereby some morphological pattern has diverged from its original meaning to express a new one. In this case, verbs that were initially morphological causatives have lost some of their semantic meaning but kept their templatic shape intact. Along that process, the relevant geminates have become morphologically inactive. By the same reasoning, we predict that more causative verbs would undergo this semantic shift, and therefore more geminates would become lexical-like segments.

2. True vs. Fake Geminates

A distinction is in order between true geminates and false (or apparent) ones. True geminates are those that are base-generated (i.e. lexical) or derived via assimilation or morphological lengthening. In other words, a language is said to have true geminates if and only if one of the following is true: (i) they contrast phonemically with singletons (ii) they appear morpheme internally (iii) they get derived by total assimilation or (iv) they mark morphological exponence. MA is an example of a language where all the above conditions hold true. As a result, it is very safe to say that the language contains true geminates.

Fake geminates, on the other hand, are identical consonants that accidentally occur across morpheme or phrase boundaries. These may even appear in languages that lack true geminates. For instance, the examples below from English and MA alike represent cases of fake geminates which span different morphemes in the absence of any obvious assimilation. In English, this is very common in compounds. The examples from MA are past participle forms where the [m-] of the past participle morpheme coincides with the /m/ of the verb stems: [mədd], [mnəʕ] and [mlək].

(7) Fake geminates in English

un-natural	/ʌ**n**ˈ**n**ætʃəɹəl/
rat-tail	/ˈræ**t**ˌ**t**eɪl/
book-case	/ˌbʊ**k**ˈ**k**eɪs/

(8) Fake geminates in MA

mmdud		məmdud	‘stretched
mmnuʕ	[hypercorrected forms of]	məmnuʕ	‘forbidden’
mmluk		məmluk	‘owned’

Schwa epenthesis can be used as a test to distinguish true geminates from fake geminates in MA (for more on the phonology of schwa in MA, see Al Ghadi 1990/2014, 1994; Benhallam, 1980, 1989/1990, 1991; Benkaddour, 1982; Benkirane, 1982; Bensoukas & Boudlal, 2012a-b; Boudlal 2001). True geminates normally block schwa epenthesis while fake ones permit it. This can be credited to the different phonological representations that underlie each one. In autosegmental CV phonology (Goldsmith, 1976; McCarthy, 1979), true geminates are represented as one melodic element linked to two C-slots in the skeletal tier. Hence, given the non-crossing association lines constraint that regulates autosegmental representations, epenthesis is not allowed. (9) below provides a visual illustration. On the other hand, fake geminates are represented as two independent melodic elements associated to distinct positions. Under this representation, schwa epenthesis can take place without violating the non-crossing association lines constraint; this is exemplified by (10).

(9) True geminates block epenthesis

(10) Fake geminates allow epenthesis

As a result, when two identical heteromorphic consonants occur side-by-side by sheer coincidence, they should be distinguished from geminate consonants derived by assimilation.

Nevertheless, there is no phonetic clear-cut difference between true and fake geminates since both can be “characterized by a single articulatory gesture, or by two distinct articulatory gestures" (Blevins, 2004, p. 170). Phonologically speaking, true geminates are most likely to be represented differently from fake ones, given their distinct behavior with regards to phonological rules in many languages. However, there is the view that geminates that can appear morpheme-internally and those that arise across morpheme boundaries are no different, in that they behave similarly in regards to certain phonological processes, hence both should be represented as normal consonant clusters. For example, Saib (1977) argues for a sequential analysis of geminates in Berber based on their behavior vis-à-vis consonant clusters. Accordingly, it would be unnecessary to have a distinction between fake and true geminates in such a case.

In this work, we are concerned with true geminates. In particular, we are interested in the phonological and morphological distribution of true geminates in the sound system of MA. More precisely, we endeavor to examine the phonological processes which can give rise to geminates as well as the latter's role as units of phonemic contrast and morphological marking. Thus, throughout this work, the term 'geminate' will be used to refer exclusively to true geminates, unless otherwise specified.

3. The Origin of Geminates in Moroccan Arabic

3.1 Lexical geminates

In order to emphasize the above-mentioned observations, we proceed to show that geminates in MA are basically underlyingly-motivated, in the sense that a singleton-geminate alternation can invoke a change in meaning. This fact would firmly establish the contrastive nature of geminates in MA as phonemes that should be equally placed into the phonemic inventory of MA. The basic consonant inventory of MA looks as follows:

(11) The consonant inventory of MA

	Labial	*Alveolar*	*Alveo-palatal*	*Velar*	*Uvular*	*Pharyngeal*	*Glottal*
Stops	b, bb	t, ṭ d, ḍ tt, ṭṭ dd, ḍḍ		k, g kk, gg	q, qq		(ʔ)
Fricatives	f, ff	s, ṣ z, ẓ ss, ṣṣ zz, ẓẓ	ʃ, ʒ ʃʃ, ʒʒ		x, ɣ xx, ɣɣ	ħ, ʕ ħħ, ʕʕ	ɦ, ɦɦ
Nasals	m, mm	n, nn					
Liquids		l, ll r, ṛ rr, ṛṛ					
Glides	w, ww		j, jj				

In order to securely establish the phonemic nature of geminates in MA, the data in (12) lists a number of minimal pairs -or near minimal pairs- that demonstrate how substituting a singleton with a geminate can lead to a total alteration in lexical meaning.

(12) The distinctiveness of geminates in Moroccan Arabic:[4]

a. *Word-medial contrast*

ħna	‘we’	ħənna	‘henna’
flus	‘money’	fəllus	‘hatchling’
mṛa	‘woman’	məṛṛa	‘one time’
ɣla	‘being expensive’	ɣəlla	‘crop’
gfa	‘back of neck’	gəffa	‘bag’
ħluf	‘oath’	ħəlluf	‘boar’
bna	‘he built’	bənna	‘flavor’
ħaʒa	‘thing’	ħaʒʒa	‘female pilgrim’
ʃalal	‘paralysis’	ʃəllal	‘waterfall’
ħmam	‘pigeon’	ħəmmam	‘bath’
ʒafaf	‘drought’	ʒəffaf	‘a floor mop’
brika	‘lighter’	bərraka	‘corrugated-metal house’
skər	‘to get drunk’	sukkəṛ	‘sugar’
smən	‘salted butter’	səmman	‘quail’
mika	‘plastic’	mikki	‘a cartoon character’
ħda	‘next’	ħədda	‘body building’
ɣda	‘lunch’	ɣədda	‘tomorrow’
bṛa	‘letter’	bəṛṛa	‘outside’

b. *Word-final contrast*

fik	‘in you’	fəkk	‘separate’
ḍar	‘house’	ḍərr	‘hurt’
ʒaṛ	‘neighbor’	ʒəṛṛ	‘drag’
ħal	‘situation’	ħəll	‘open’
mal	‘he leaned’	məll	‘get bored’
duq	‘taste’	dəqq	‘knock’
xud	‘take’	xədd	‘cheek’
dub	‘melt’	dubb	‘bear’
kul	‘eat’	kull	‘all’
ʕum	‘swim’	ʕəmm	‘uncle’
dum	‘last’	dəmm	‘blood’
buq	‘loudspeaker’	bəqq	‘bedbugs’
ʒud	‘generosity’	ʒədd	‘grandfather’
ʕiʃ	‘live’	ʕəʃʃ	‘nest’

c. *Word-initial contrast*

mat	‘he died’	mm^wət	‘the mother of’
bat	‘spend the night’	bb^wat	‘the father of’
ssaṭ	‘the sound of slapping’	saṭ	‘boy’ (slang)
bbaq	‘the sound of falling’	baqi	‘not yet’

[4] In IPA, a geminate is commonly transcribed as two adjacent identical consonants (e.g. [tt], [ss], [ll]…). This way of transcribing geminates is conventionally motivated, and hence does not make any theoretical claims about how geminates are phonologically represented. All it tries to convey is that geminates are somehow phonologically and phonetically different from their singleton counterparts.

The data demonstrates that geminates in MA phonemically contrast with singletons in all positions: initially, medially and finally. Like MA, languages such as Tashlhit, Italian, Japanese and Finnish also have contrasts between geminates and singletons. Some Examples are shown below:

(13) Geminate contrast in other languages:

Tashlhit:	i**m**i 'mouth' – i**mm**i 'mother'
Italian:	fa**t**o 'fate' – fa**tt**o 'fact'
Japanese:	sa**k**a 'hill' – sa**kk**a 'author'
Finnish:	ta**k**a 'back' – ta**kk**a 'fireplace'

We proceed by showing how these segments are produced by an OT grammar in MA. In OT, the interaction between markedness constraints and faithfulness ones determines the inventory of structures that are permitted to surface in output forms. For every feature specified in the input, there should be a faithfulness constraint that requires it to stay and a markedness constraint that militates against its presence in the output. If markedness is dominant, the relevant feature would be neutralized. However, if faithfulness ranks higher instead, the designated feature would be preserved, and thus included in the segmental inventory of the language under study. Either way, one of the competing constraints would be violated by the optimal candidate, and that should be the one ranked lower by the grammar.

The consonantal inventory of MA consists of singletons and geminates alike. In fact, every singleton seems to unrestrictedly have a geminate counterpart. In English, as in many other languages, geminates are unattested, in the sense that consonantal length is not distinctive in these languages. The markedness constraint that penalizes the appearance of geminates is named *GEM. If this constraint is dominating faithfulness, geminates will be absent from the grammar, English is a case in point. In MA, however, *GEM should be dominated by the faithfulness constraint MAX-GEM, which demands the input specification for consonantal length to be preserved in the output. In this way, whenever a geminate is posited in the input, it would find its way to the output form thanks to the ranking MAX-GEM >> *GEM.

(14) Constraints responsible for underlying geminates in MA

a. **MAX-GEM**:
An input Length specification and its output correspondent must be identical.

b. ***GEM**:
Geminate consonants are prohibited.

The interaction between MAX-GEM and *GEM is demonstrated by the following tableau:

(15) Lexical geminates

/tt/	MAX-GEM	*GEM
a. t	*!	
☞ b. tt		*

Geminate consonants are generally marked structures, but some geminates are more marked than others. Based on typological and perceptual evidence, it was proposed that the constraint *GEM should be broken down into a number of sub-family constraints that target specific instantiations of geminates. As has been mentioned earlier, languages tend to prefer some geminates more than others, considering their segmental composition and lexical position (see Podesva, 2002; Kawahara, 2007; Pajak, 2010). For instance, Kawahara (2007) and Pajak (2009a, b) suggested the following universal rankings to account for the cross-linguistic variations in geminate occurrences:

(16) Segmental markedness hierarchy (Kawahara, 2007)

*GemGlide >> *GemLiquid >> *GemNasal >> *GemObstruent

(17) Contextual markedness hierarchy (Pajak, 2009a, b)

non-vowel adjacent	>> single vowel-adjacent	>> intervocalic
*#GC, *CG#, *CGC;	*#GV, *VG#, *VGC, *CGV;	*VGV

According to the segmental markedness hierarchy, geminate glides appear to be the least favored type of geminates whereas obstruent geminates are more tolerated by virtue of being down in the hierarchy. Note that this hierarchy is based on a sonority scale. The more sonorous a geminate gets, the less favored it becomes. According to the contextual markedness hierarchy, however, geminates are mostly found intervocalically, while consonant-adjacent geminates are less common. However, since MA allows all sorts of geminates, irrespective of their segmental content or place in the word, the only relevant constraint for us is the general constraint *GEM. On the contrary, the vocalic inventory of MA does not contain long vowels as they never phonemically contrast with short vowels in the language. The vocalic inventory of MA is limited to three underlying short vowels /i, u, a/ and an epenthetic schwa /ə/. For the sake of illustration, the vocalic inventory of MA is schematized below:

(18) The vocalic inventory of MA

High	i		u
Mid		(ə)	
Low	a		

For this reason, the markedness constraint that sanctions the presence of long vowels, written as *V:, is set to dominate faithfulness (*V: >> IDENT-IO-Long-V).

(19) Long vowels are not attested in MA

/V:/	*V:	IDENT-IO [Long-V]
☞ a. V		*
b. V:	*!	

Basically, there should be no restrictions imposed on underlying structures. In other words, the grammar is free to posit any type of input. This is a central property of the lexicon in OT, dubbed the Richness of the Base. The basic idea is that structural well-formedness should be determined solely through constraint interaction without any stipulations at the level of underlying representations. It is then the role of constraint hierarchy (i.e. Eval) to determine which forms would surface and which would not.

3.2 Phonological geminates

3.2.1 Geminates through assimilation

Not only do geminates function as distinctive segments that contribute lexical contrast in MA, but they also happen to be phonologically derived. The bulk of initial geminates in MA are derived by a process of total assimilation that occurs between the definite article /l+/ and nouns whose first consonant is a coronal sound. The affected segment is the definite article morpheme, whose feature specifications completely change to match the feature specifications of whatever coronal sound the designated noun begins with. This case of assimilation is illustrated by the following items:

(20) Phonologically derived geminates

a. Assimilating nouns

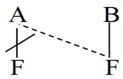
/l-ʃəms/	ʃʃəms	‘the sun’
/l-ḍar/	ḍḍar	‘the house’
/l-suq/	ssuq	‘the market’
/l-tuma/	ttuma	‘garlic’
/l-ʒlbana/	ʒʒəlbana	‘green peas’

b. Non-assimilating nouns

/l-qamaṛ/	lqamaṛ	‘the moon’
/l-ħiṭ/	lħiṭ	‘the wall’
/l-bab/	lbab	‘the door’
/l-qamiʒa/	lqamiʒa	‘the shirt’
/l-kina/	lkina	‘the pill’

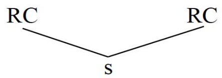
In the theory of feature geometry (Clements, 1985; Sagey, 1986; Selkirk, 1990), which assumes an internal hierarchical structure of features, total assimilation is believed to involve the spreading of the feature set of the triggering segment to replace the feature set of the targeted segment; the replaced feature set is then deleted.

(21) Total assimilation in feature geometry:



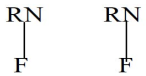
This representation implies that all features of the trigger, Segment B, spread to replace the already specified features of the affected segment A. This process gives rise to a double-linked feature set that spans two root nodes. The theory assumes a multiple association analysis of length, whereby geminates are linked to two root nodes:

(22) Underlying long consonants:



As a result, geminates derived by assimilation and those that are lexical appear to be identically represented as segments multiply associated to two root nodes. Therefore, they are posited to be distinguished from sequences of identical consonants across morpheme boundaries. These are normally represented as two independent feature sets, each linked to a root node of its own.

(23) Identical heteromorphemic consonants



The fact that geminates derived by total assimilation are represented the same as underlying geminates, with one feature set associated to two root nodes, is supported by phonological evidence. Despite being derived from a sequence of two heteromorphemic consonants, these geminates behave the same as underlying geminates with respect to rules of epenthesis, in that they resist the application of the latter by remaining unbroken, unlike consonant clusters. For instance, in MA, geminates created by total assimilation behave as a monolithic segment, rather than a cluster of consonants:

(24)

a.	/l-sma/	ssma	*səsm	‘the sky’
	/l-ḍṛa/	ḍḍṛa	*ḍəḍṛa	‘the corn’
b.	/ktṛa/	kəṭṛa		‘plenty’
	/ħʃma/	ħəʃma		‘shyness’

Were they clusters of identical consonants, the derived geminates in (24a) would get split by a schwa in the same way the clusters in (24b) are. Nevertheless, schwa epenthesis is blocked in those items (see Noamane (2018a) and references therein, namely Benhallam (1991), for an elaborate account of geminate integrity in MA).

With this in mind, we claim that the assimilation process affecting the definite article is motivated by a dictate of the constraint AGREE-Coronal, which requires identical feature specifications of adjacent coronal sounds. The demand of this constraint takes effect when it dominates the faithfulness constraint IDENT-IO (F), militating against any change of input features. The ranking relations of these constraints are illustrated in the tableaux below:

(25) AGREE-Cor >> IDENT-IO (F): assimilation forces violation of faithfulness

/l-suq/	AGREE-Cor	IDENT-IO (F)
☞ a. ssuq		*
b. l-suq	*!	

This tableau shows that satisfaction of AGREE-Cor is more important than satisfaction of IDENT-IO (F). Therefore, the feature specifications of the root consonant and the affix should identically agree at the expense of violating faithfulness.

So far, the directionality of the assimilation process would be assumed to be governed by a faithfulness constraint which demands the preservation of the featural identity of the initial root consonant at the expense of the featural identity of the definite article affix. Such a constraint is formally written as IDENT-RtC_1 –where Rt and C_1 refer to the root and the first radical element, respectively.

In a previous analysis (see Rguibi, 2001:104), the whole root was seen as a privileged position that triggers total assimilation. For us, however, it is precisely the root-initial segment which triggers assimilation with the definite article, especially that the shared features are contributed by this particular position. Our view follows from the fact that roots are not fully immune to phonological change. More specifically, elsewhere, root-final and root-medial segments are prone to phonological alternation like in the case of causative derivation, whereby root-medial segments get geminated (e.g. √ktb → kəttəb) or in the case of the 1st person singular morpheme suffixation in which root-final segments get assimilated (e.g. /mṛəḍ-t/ → mṛəttt). It remains that the only position which is consistently privileged over the others is the root-initial segment.

(26)

/l-suq/	AGREE-Cor	IDENT-IO (F)	IDENT-RtC$_1$
☞a. ssuq		*	
b. l-suq	*!		
c. lluq		*	*!

Candidate (26b) is out early in the competition as it violates the high ranked constraint AGREE-Cor. The optimal candidate (26a) ties with candidate (26c) since they equally satisfy AGREE-Cor and violate IDENT-IO (F). Candidate (26c) satisfies AGREE-Cor differently, however. It spreads the features of the definite article and deletes those of the root consonant. Here comes the role of the constraint IDENT-RtC$_1$ as a tie breaker. In OT, the ranking of tie-breakers, in connection with the other constraints, is irrelevant. This constraint privileges the maintenance of the feature specifications of the root consonant over the maintenance of the features of the affix. Candidate (26c) violates this constraint, and hence loses in the competition. Candidate (26a) wins out.

If a noun begins with a non-coronal sound, however, the stipulation of the constraint AGREE-Coronal would not be completely met. In this case, assimilation would not take place. A candidate where the definite article morpheme would assimilate to a non-coronal sound would be penalized, and thus ruled out by IDENT-IO (F). The non-assimilating candidate fares better on the ranking since it satisfies both AGREE-Cor and IDENT-IO (F).

(27) The constraints responsible for the assimilation of the definite Article in MA:

a. **AGREE-Coronal**:
Adjacent coronal segments must be identical feature-wise.

b. **IDENT-IO (F)**:
Corresponding segments in input and output must have identical feature values.

c. **IDENT-RtC$_1$:**
An input feature specification in the first segment of the root and its output correspondent must be identical.

(28) AGREE-Cor has no effect: No assimilation

/l-ħiṭ/	AGREE-Cor	IDENT-IO (F)
a. ħħiṭ		*!
☞b. lħiṭ		

Despite the fact that the emergent structure of this assimilation process is a word initial geminate, in violation of the markedness constraint *GEM, the latter does not seem to have any active role in this assimilatory process. Geminates happen to follow naturally from the interaction between AGREE-Coronal and IDENT-IO (F). However, the created geminate structure is set to comprise the morphological exponence of both the assimilated affix and the initial root consonant. As a result, the grammar requires the faithfulness constraint MAX-Affix to dominate *GEM in order to ensure the realization of the definite article in the output form, and hence prevent *GEM from cancelling out the derived geminate structure. Without this dominance relation, the definite article affix could be compromised in favor of obviating a geminate structure.

(29) MAX-Affix >> *GEM: the definite article affix should have a correspondent in the output

/l-suq/	MAX-Affix	*GEM
☞a. ssuq		*
b. suq	*!	

This ranking ensures that the definite article affix has a correspondent in the output form, instead of being deleted for the sake of avoiding the creation of geminates. In this case, the violation of *GEM is less costly than the violation of MAX-Affix.

There is another case of total assimilation that gives rise to geminates in MA. This takes place between the final radical element of verbs and the 1st person past tense suffix [-t]. The assimilation is consistently triggered by coronal stops and exceptionally occurs with other sounds. The data in (31a) shows that if a verb ends in a coronal stop, it then totally assimilates to the suffix [-t], deriving the geminate /tt/ in every case. The items in (31b) are exceptions to this generalization. The relevant verbs therein end in a fricative and a labial stop, respectively. Yet, the data in (30c) includes verbs ending in the same sounds without triggering any assimilation. On this basis, we render the items in (30b) as exceptions. (30c) also emphasizes the fact that only coronal stops trigger assimilation and not just any coronal. (30d) is provided to show that non-coronals never get involved in this assimilation interaction.

(30)

(i) Assimilating verbs

a.	/ʒbəd-t/	ʒbə**tt**	'I pulled out'
	/ṣrəṭ-t/	ṣrə**tt**	'I swallowed'
	/ɦbəṭ-t/	ɦbə**tt**	'I came down'
	/ħfəḍ-t/	ħfə**tt**	'I memorized'
	/mrəḍ-t/	mrə**tt**	'I got sick'
b.	/ʃəf-t/	ʃə**tt**	'I saw'
	/ʒəb-t/	ʒə**tt**	'I brought'

(ii) Non-assimilating verbs

c.	/nzəl-t/	nzəlt	'I got off'
	/nʒəṛ-t/	nʒəṛt	'I sharpened'
	/ħbəs-t/	ħbəst	'I stopped'
	/qfəz-t/	qfəzt	'I panicked'
d.	/rkəb-t/	rkəbt	'I mounted'
	/ħləm-t/	ħləmt	'I dreamed'
	/dfəʕ-t/	dfəʕt	'I pushed'
	/dəq-t/	dəqt	'I tasted'
	/dəx-t/	dəxt	'I got confused'
	/ħləf-t/	ħləft	'I swore'

The constraints and interactions responsible for this effect are akin to the ones involved in the definite article assimilation. The basic interaction is: AGREE-Coronal-Stop outranking IDENT-IO (F). This ranking selects assimilated outputs over non-assimilated ones. The AGREE constraint demands that adjacent coronal-stops should have identical feature specifications. The directionality of the assimilation process in question seems to be governed by IDENT-Affix. Such a constraint penalizes any candidate that sacrifices the feature specifications of the affix.

(31)

/ʒbəd-t/	AGREE-Cor-stop	IDENT-IO (F)	IDENT-Affix
☞a. ʒbətt		*	
b. ʒbədt	*!		
c. ʒbədd		*	*!

As we go over the competing candidates, candidate (31a) emerges as the winner as it satisfies the AGREE constraint as well as the faithfulness constraint preserving the identity of the suffix, IDENT-Affix. Candidate

(31b) loses for violating AGREE. Despite obeying AGREE, candidate (31c) is ruled out due to its violation of IDENT-Affix.

By way of comparison, the assimilatory processes discussed above point out to an anomalous situation, whereby the directionality of assimilation is determined by means of root faithfulness in the first case and affix faithfulness in the second. The problem is that this implies that root faithfulness outranks affix faithfulness in the context of the definite article assimilation, while affix faithfulness outranks root faithfulness in the context of 1st person assimilation. In light of the inadequacy of positional faithfulness to consistently derive the directionality of assimilation in MA, we follow Pater and Werle (2001, 2003) in encoding directionality into the standard AGREE constraint in the following way:

(32) **AGREE-Left [Coronal]**:

A coronal consonant preceding another coronal must be identical with it.

This will allow us to unify both assimilatory processes under one analysis as demonstrated by the tableaux below:

(33) Definite article assimilation

/l-suq/	AGREE-L-Cor	IDENT-IO (F)
☞ a. ssuq		*
b. l-suq	*!	
c. lluq	*!	

(34) 1st person pronoun assimilation

/ʒbəd-t/	AGREE-L-Cor-Stop	IDENT-IO (F)
☞ a. ʒbətt		*
b. ʒbədt	*!	
c. ʒbədd	*!	

This means that the new version of the AGREE constraint can be violated in two ways. First, it can be violated by candidates where assimilation does not take effect. Second, it can also be violated by candidates whose assimilation is progressive (i.e. left-to-right) instead of being regressive (i.e. right-to-left).

However, the examples in (35) from MA could be a source of confusion. What is of interest here is that we have a case of two identical consonants appearing across morpheme boundaries. In this particular case, the definite article /l/ coincides with nouns whose initial segment is the sound /l/.

(35)

UR		*Derived forms*
/l-lubja/	llubja	'the beans'
/l-limun/	llimun	'the orange'
/l-luʕba/	lluʕba	'the toy'
/l-lil/	llil	'the night'
/l-lun/	llun	'the color'

The question now is whether to consider this sequence a case of fake geminates or a case of true geminates that are derived. We have seen earlier that MA has a process of total assimilation between the definite article and any initial coronal sound belonging to the noun it attaches to, creating derived geminates. When a noun begins with a non-coronal sound, the definite article and the relevant non-coronal preserve their status as two independent segments. In (35), the stipulation of the constraint AGREE-Coronal is satisfied, hence assimilation is expected to take place. The items in (35) could illude us in believing that we have a case of fake geminates, while in fact the assimilation process changes the structure of the underlying forms as follows:

(36)

This can be adequately corroborated by the behavior of the derived geminates in the following items:

(37)

/l-lɦa/	llɦa	*ləlɦa	'hard palate'
/l-lɣa/	llɣa	*ləlɣa	'gossip'

It has been shown earlier that schwa epenthesis represents a firm diagnosis that can mark off true geminates from fake ones. By the same standard, the geminates in (37) are entitled to the true-geminate status since schwa epenthesis is blocked from applying to them. Were they mere sequences of heteromorphemic identical segments, schwa epenthesis would have split them in the same way it does with fake geminates in the following examples:

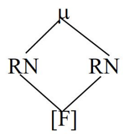
(38)

/m-mdud/	məmdud	'stretched'
/m-mnuʕ/	məmnuʕ	'forbidden'

While Heselwood and Watson (2013) concede that geminates like those in (20) and (35) satisfy the description of true geminates by virtue of observing geminate integrity, it does not assume that they are derived through total assimilation, at least synchronically speaking. The authors believe that those geminates behave more like lexical (i.e. non-derived) geminates, and hence should be depicted as such. This view was based on the conviction that assimilation should typically be optional, meaning that non-assimilating forms should be allowed to occur in the grammar in question. The process of total assimilation that affects the definite article in Arabic does not allow optionality, however, in that only assimilated forms are possible. Heselwood and Watson (2013) suggests that these geminates should be treated as diachronically fossilized geminates that have become lexicalized though their morphological trace is still known. Whether that is true or not, for us, even in the case of a synchronic assimilation process, which is how we treat it, the emergent phonological structure will be the same as that of lexical geminates (i.e. a multiply associated melodic element). This suffices to explain why any geminate, be it derived or lexical, blocks epenthesis.

To complete the picture, besides representing geminates as a single feature set linked to two root nodes at the segmental level, we will also assume that a prosodic mora is dominating the relevant root nodes. The reason for this is to be able to explain the cross-linguistic prosodic patterning of geminates as segments that contribute weight to words based on evidence from word minimality, stress placement and compensatory lengthening (Hayes, 1989; Davis, 1994, 1999a-b, 2003, 2011; 2014; also, see Noamane (2018c, 2019) for more on the behavior and the representation of geminates in Moroccan Arabic). The full representation looks as follows:

(39) A moraic two-root node model



In what follows, we will be referring to the moraic level of our representation. In particular, it will be argued that gemination can also be triggered by means of attaching a mora to singletons.

3.2.2. Gemination as prosodic structure improvement

Assimilation is not the only phonological process that gives rise to geminates in MA. In fact, geminates can also be created by means of a process of consonant lengthening that serves the purpose of improving the prosodic structure of the forms involved. In the data below, it could be argued that the suffixation of the /u/, representing the 3rd person masculine pronoun, triggers the lengthening of the consonant /t/ to supply an onset for the newly created syllable. The outcome of this process consists in the creation of the geminated affix [tt] in the relevant forms. Some illustrative examples are shown below:

(40) Gemination by syllabification

a. Vowel deletion

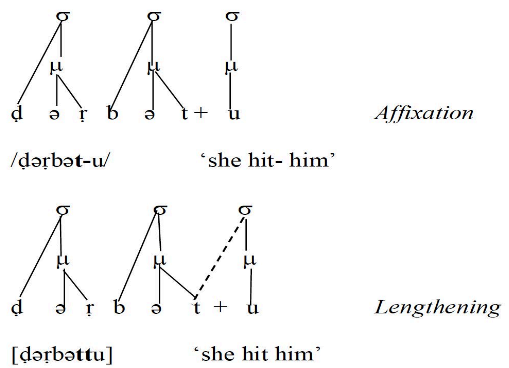
/ḍəṛbat/	ḍəṛbət	‘she hit’
/ʃəṛbat/	ʃəṛbət	‘she drank’
/qətlat/	qətlət	‘she killed’
/nəʃṛat/	nəʃṛət	‘she hung’

b. Gemination

/ḍəṛbət-u/	ḍəṛbə**tt**u	‘she hit him’
/ʃəṛbət-u/	ʃəṛbə**tt**u	‘she drank it
/qətlət-u/	qətlə**tt**u	‘she killed him’
/nəʃṛət-u/	nəʃṛə**tt**u	‘she hung it’

The gemination in the items in (40) could be thought of as following from syllable well-formedness, in that the affix [t], in forms such as *ḍəṛbə***t** ‘she hit’, lengthens after attaching to the third person pronoun [u] for the sake of supplying the ensuing syllable with an onset. This process can be illustrated as follows:

(41)



In dealing with this case of gemination, we choose to refer to the constraints shown in (42) below:

(42) Constraints responsible for gemination by syllabification

a. **ONSET**:
Syllables must have onsets.

b. ***GEM**:
Geminate consonants are banned.

The constraint in (42a) prohibits the existence of geminate consonants in the language. (42d) stipulates that syllables must have an onset. The tableau in (43) demonstrates how these two constraints interact to yield the expected structure. It shows that in the wake of affixing the vocalic 3rd person personal pronoun, the constraint ONSET demands that the subsequent syllable must have an onset. If the mora is linked to a consonant, a geminate structure is derived. For this to be possible, LINK-μ should outrank the constraint against long consonants, *GEM.

(43)

/ḍərbət-u/	ONSET	*GEM
☞ a. ḍəṛ.bət.tu		*
b. ḍəṛ.bət.u	*!	

The optimal candidate lengthens the consonant /t/ to create an onset for the subsequent syllable. Creating an onset this way happens at the expense of violating the low-ranking *GEM. The candidate in (43b) loses for violating ONSET. Another possible candidate could be *ḍəṛ.bə.tu*, whose second syllable is open and headed by schwa. However, in MA, schwa has been proved to be nonmoraic (Bensoukas & Boudlal, 2012a-b). This means that it cannot occur in an open syllable, nor can it be the head of a monosyllabic word. The constraint that represents these restrictions is *μ/ə. Therefore, *ḍəṛ.bə.tu* has to excluded for violating *μ/ə.

3.3 Morphological gemination

Besides being lexical or phonological, geminates in MA come in a third flavor, in that they can be morphologically induced. In particular, geminates in MA can work as morphological markers in derived forms like morphological causatives, agent nouns and instrument nouns. These forms appear with a medial geminate that corresponds to a singleton in the base form. In the case of causatives, the sole morphological marker is the geminate itself (Noamane, 2018b). As for agent and instrument nouns, additional morphological material is present, namely a vowel /a/ marking nominality in both structures and an extra /a/ specific to instrument nouns, behaving as a feminine marker. Examples of these derived forms are provided below:

(44) Morphologically derived geminates:

(i) The causative verb

ktəb	'to write'	kəttəb	'to make write'
ħṛəb	'to run away'	ħəṛṛəb	'to make run away'
xsər	'lose'	xəssər	'to cause lose'
zləq	'slip'	zəlləq	'to cause slip'
ʃṛəb	'drink'	ʃəṛṛəb	'to make drink'

(ii) The agent noun

fləħ	'to farm'	fəllaħ	'farmer'
nʒəṛ	'to sharpen'	nəʒʒaṛ	'carpenter'
gzər	'to butcher'	gəzzar	'butcher'
bni	'to build'	bənnaj	'mason'
ʃuf	'to see'	ʃəwwaf	'fortuneteller'

(iii) The instrument noun

ɣsəl	'to clean'	ɣəssala	'washing machine'
sməʕ	'to listen'	səmmaʕa	'headset'
skət	'to be quite'	səkkata	'pacifier'
kwi	'to weld'	kəwwaja	'welding machine'
sqi	'to water'	səqqaja	'fountain'

MA is not alone in using gemination for morphological purposes. Several other patterns of morphological gemination occur in languages like Tashlhit (Bensoukas, 2001) Choctaw (Lombardi & McCarthy, 1991) and Keley-i (Samek-Lodovici, 1993), to name but a few. In accounting for these patterns of morphological gemination, we posit a moraic affix that we argue to be fully or partially responsible for the morphological marking of the forms in question via lengthening the medial consonant of their corresponding base forms. Given the fact that gemination in the forms under investigation is consistently medial, it is hard to determine the canonical position of the moraic affix prior to its infixation. For this reason, it is being assumed that the mora originates at the right edge since the latter represents the less marked position of affixal patterns cross-linguistically. Accordingly, the affixation of the moraic affix would need to be formally governed by the following alignment constraint:

(45) **ALIGN-R (μ, Rt)**

The moraic affix should be right-aligned.

This constraint demands a match between the right edge of the root and that of the moraic affix. Therefore, it is violated whenever the mora appears anywhere other than the right edge. The question now is: what is responsible for the infixal linearization of the moraic affix in the output forms? In answering this question, it is argued that the infixation of the mora is enforced by some phonological restrictions on output forms. Precisely, it is advocated that infixation in the relevant forms is enforced by the quest for the least marked possible syllabification of the input material, in accordance with the syllabic well-formedness constraints of MA, represented by the following constraint:

(46) **σWF**: The output form should satisfy the following markedness constraints on syllable well-formedness:

- **ONSET**: syllables must have onsets
- ***μ/C_h**: a consonant should not be the head of a syllable
- ***Empty-headedσ**: a syllable must have a nucleus
- ***μ/ə**: schwas are nonmoraic

This constraint prevents the mora from attaching to the right edge so as not to violate any of the markedness sub-constraints that constitute it. With this constraint dominating ALIGN-R (μ, Rt), we get the medial gemination that characterizes causatives, agent nouns and instrument nouns. This is illustrated by the following tableau:

(47) σWF >> ALIGN-R (μ)

Input: μ √ktb	σWF	ALIGN-R (μ, Rt)
☞a. kəttəb		*
b. k.təb.b	*!	

This tableau shows that candidate (47b), where the mora is realized on the right edge, incurs a fatal violation of σWF since it features two occurrences of syllabic consonants. Candidate (47a), however, comes in good terms with the stipulations of σWF since it successfully avoids the violation of its constituent markedness constraints via infixing the moraic affix. In addition to ALIGN-R (μ, Rt) and σWF, a faithfulness constraint that ensures the moraic affix is both parsed and filled is needed. To this end, the following constraint is postulated:

(48) **MAX-Affix**

The input affixal material should be preserved in the output form.

In order for this constraint to be satisfied, it has to dominate the faithfulness constraint preserving the weight identity of the input elements of the base root. Such a constraint is formally represented as follows:

(49) **IDENT-IO (Weight)**

The weight specification of the root must be preserved in the output.

The interaction between these two constraints is exemplified by the tableau below, whereby the candidate that does not realize the mora is regarded as sub-optimal for violating the dominating MAX-Affix.

(50) MAX-Affix >> IDENT-IO (Weight)

Input: μ √ktb	MAX-Affix	IDENT-IO (Weight)
☞a. kəttəb		*
b. ktəb	*!	

The winning candidate, however, is morphologically marked by means of geminating the second segment of its base form. The following tableau summarizes all the previous interactions:

(51) MAX-Affix >> IDENT-IO (Weight); σWF >> ALIGN-R (μ, Rt)

Input: μ √ktb	MAX-Affix	σWF	IDENT-IO-W	ALIGN-R (μ, Rt)
☞ a. kəttəb			*	*
b. ktəb	*!			
c. k.kət.b		*!	*	**
d. k.təb.b		*!	*	

What is new here is candidate (51c), where the moraic affix is realized further to the left, leading to the gemination of the first segment of the root. Such a candidate incurs multiple violations of ALIGN-R (μ, Rt). Most importantly, just like candidate (51d), it incurs a fatal violation of σWF due to the fact that a moraic consonant is formed in this case (see Noamane (2018d) for a detailed articulation of this analysis).

4. Conclusion

In this paper, we have provided a taxonomy of geminate patterns in MA. We have shown that, in MA, geminates can be lexically motivated or emerge as the result of specific phonological and morphological processes. Phonologically, it has been demonstrated that geminates can be derived through a process of total assimilation on two occasions: (i) total assimilation between the definite article and the initial coronal consonant of nouns or (ii) total assimilation between the first-person past pronoun and the final coronal-stop consonant of verbs. Prosodic lengthening has also been pointed out to give rise to phonologically derived geminates. Morphologically, it has been shown that geminates can play the role of a morphological marker, leading to the formation of morphological causatives, agent nouns and instrument nouns. In terms of position, geminates have been shown to occur word-initially, word-medially and word-finally. Also, it has been pointed out that geminates may come from every major class feature that is present in the phonological system of MA.

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