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Conformity to the obligatory contour principle and the strict layer hypothesis: the avoidance of initial gemination in Maltese

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This research investigates how the avoidance of initial gemination in Maltese is motivated by conformity to the Obligatory Contour Principle (OCP) and the Strict Layer Hypothesis (SLH) in light of Optimality Theory (OT) as a framework. The data of this study were collected and analyzed qualitatively. The data in this study were harvested from existing literature reviews peculiar to the Phonology of Maltese. Furthermore, the same data were verified by consulting several native speakers of Maltese when necessary. This study concludes that initial gemination in Semitic verbs of pattern V (t-$C_1iC_2C_2eC_3$) derives from the assimilation of the [+coronal] feature of prefixes to the initial consonant of the following stem to conform to the OCP. Vowel prosthesis helps to affiliate an initial semi-syllable, as the peripheral member of this type of gemination, to the syllable node in order to comply with the SLH. Vowel prosthesis serves to ensure conformity to the OCP and to geminate integrity by the underlying initial geminates in non-Semitic verbs (from English and Italian) of CC-stems, which obey the SLH since their members belong to the same morpheme, unlike derivational forms. This research demonstrates the insightfulness of Optimality Theory (OT) as a framework to account for these phenomena in Maltese. The results of this study lead to future research pertinent to the analysis of both segmental and suprasegmental structures in Maltese in light of OT and their relationship to other languages such as Arabic, English, and Italian.

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Introduction

The Maltese language. Maltese is considered a combination of Semitic (mostly a descendant of Arabic), Romance (mostly Italian and Sicilian), and English (Borg. 1988; Galea, 2016; Paggio and Gatt, 2018; Vella, 2012). Thus, it encompasses elements from languages of three typologically diverse families: Semitic, Romance, and Germanic (Galea, 2016). Consequently, Mifsud (1995), Brincat (2004), and Spagnol (2011) regard Maltese as a language with three strata. The first stratum, the foundation of the language, which originates from Semitic, forms the basis of phonology, morphology, and the basic lexicon. The second stratum stems from Romance and involves lexical and syntactic formations. The third stratum is English, which is represented by extensive lexical items. Galea (2016) notes that the growth of Maltese has been affected by language contact between these three distinct influences. According to Comrie (2009), Maltese is typologically closer to Semitic than to Romance; nonetheless, Maltese has shifted toward Romance typologically due to the Romance influence. Despite the Romance and current English influence on Maltese, the Semitic characteristics in this language are very salient (Galea, 2016).

The Maltese Language has 24 consonants presented in Table 1 in the conventional arrangement according to place and manner of articulation as per Azzopardi (1981), Borg and Azzopardi-Alexander (1997), Mifsud (1995), and Galea (2016) (Table 2).

The following table is to provide the reader with the list of features of the relevant Maltese consonants.

Azzopardi (1981) and Azzopardi-Alexander (2002) present a set of eleven qualitatively and quantitatively distinct vowels for Maltese. Azzopardi (1981) observes that vowel length in Maltese is phonemic and that the inventory of Maltese comprises five short vowels and six long vowels, as shown in Fig. 1 (Azzopardi, 1981: 147):

Galea (2016) presents a list of minimal pairs for all vowels in Maltese, as shown in Table 3 below:

Diphthongs in Maltese are analyzed by Azzopardi (1981) as consisting of one of the vowel elements /ɪ ɛ ɐ ɔ/ and a transition to one of the glides (i.e., /j/ or /w/), as shown in the table below (Table 4):[1]

The possible syllable types in Maltese are presented by Azzopardi (1981) and Borg and Azzopardi-Alexander (1997). They argue that a vowel is mandatory. Three-consonant clusters are maximally allowed, while the coda position permits a two-consonant cluster (Galea, 2016; Galea and Ussishkin, 2018).

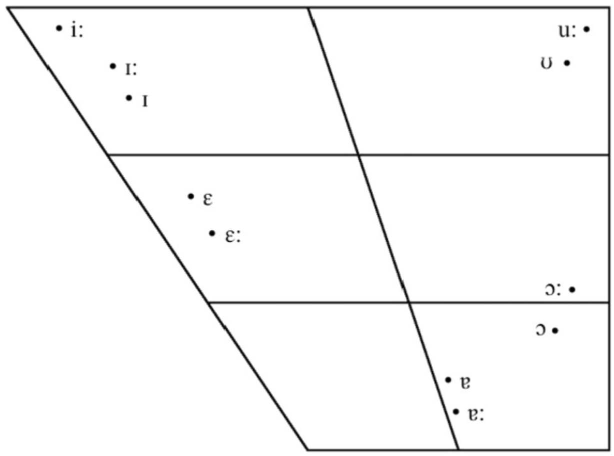

Fig. 1 The Maltese vowel chart. The Maltese consists of five short vowels /ɪ, ʊ, ɛ, ɔ, ɐ/ and six long vowels /iː, ɪː, ɛː, ɐː, ɔː, uː/. This vowel chart is cited from Azzopardi (1981: 147).

Table 1 Manner and place of articulation of consonants in Maltese (Azzopardi, 1981; Borg and Azzopardi-Alexander, 1997; Mifsud, 2008; Galea, 2016).

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Palatal	Velar	Glottal
Plosive	p b		t d				k g	ʔ
Nasal	m		n					
Fricative		f v		s z	ʃ ʒ			h
Affricate				ts dz	tʃ dʒ			
Approximant	w		ɹ			j		
Lateral			l					

Table 2 The list of features of the relevant Maltese consonants.

Features in Maltese	p	b	t	d	k	g	ʔ	m	n	f	v	s	z	ʃ	ʒ	h	ts	dz	tʃ	dʒ	w	ɹ	j	l
Consonant	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	+
Sonorant	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+
Approximant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+
Continuant	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	±	±	±	±	+	+	+	-
Nasal	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lateral	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Voice	-	+	-	+	-	+	-	+	+	-	+	-	+	-	+	-	-	+	-	+	+	+	+	+
Coronal	-	-	+	+	-	-	-	-	+	-	-	+	+	+	+	-	+	+	+	+	-	+	-	+
Anterior	+	+	+	+	-	-	-	+	+	+	+	+	+	-	-	-	+	+	-	-	+	+	-	+
Distributed	-	-	+	+	-	-	-	-	±	-	-	-	-	+	+	-	+	+	+	+	-	-	+	±
Labial	+	+	-	-	-	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-	-
Dorsal	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
High	-	-	-	-	+	+	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-
Back	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Low	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-

Table 3 Monophthongs in Maltese: Examples from minimal pairs (Galea, 2016: 14).

/ɪ/-/iː/-/ɪː/	[mɪt:] *mitt* 'hundred'	[miːt] *mit* 'myth'	[mɪːt] *miet* 'he died'
/ɛ/-/ɛː/	[tɛm:] *temm* 'he ended'	[tɛːm] *tegħem* 'he tasted'	
/ɐ/-/ɐː/	[rɐt:] *radd* 'he gave back'	[rɐːt] *rat* 'she saw'	
/ɔ/-/ɔː/	[bɔt:] *bott* 'bottle'	[bɔːt] *bogħod* 'far away'	
/ʊ/-/uː/	[kʊl:] *kull* 'every'	[kuːl] *kul* 'eat'	

Table 4 List of diphthongs with examples.

Diphthongs	Example
[ɛɪ] or [ɛj]	[fɛɪn] or [fɛjn] *fejn* 'where'
[ɛʊ]or [ɛw]	[sɛʊ] or [sɛw] *sew* 'right'
[ɐɪ] or [ɐj]	[zɐɪr] or [zɐjr] *żgħir* 'small'
[ɐʊ]or [ɐw]	[tɐʊ] or [tɐw] *taw* 'they gave'
[ɔɪ] or [ɔj]	[vɔɪt] or [vɔjt] *vojt* 'empty'
[ɔʊ]or [ɔw]	[(ʔ)ɔʊm] or [(ʔ)ɔwm] *għum* 'swim'

Therefore, according to Galea (2016) and Galea and Ussishkin (2018), the maximal syllable in Maltese is of the shape (C)(C)(C) V(C)(C)(C). Building on Azzopardi (1981), Borg and Azzopardi-Alexander (1997), Camilleri (2014), Galea (2016), and Galea and Ussishkin (2018) present the possible syllable structures in Maltese, listed in Table 5 in Appendix 1.

With regard to the syllable structure of Maltese, two points should be noted. First, the only mandatory syllable element is the nucleus, while onsets and codas are optional, since they are found in some syllable structures and are absent in others, such as V, Vː, VG, VCC, VCCC, V:C, VC, CV, CVː, CCV, CCVː, and CCCVː. Second, the final geminates are found underlyingly in Maltese; this would lead us to expose the properties of gemination in Maltese to readers who are not familiar with this language. Word-medial and word-final geminations are found in Maltese. The word-medial gemination is shown in the following examples:

(1) Medial Gemination derived from verb pattern II ($C_1VC_2C_2VC_3$) and verb pattern V (t–$C_1VC_2C_2VC_3$) (Galea, 2016):

verb pattern II ($C_1VC_2C_2VC_3$)	Output	Gloss
a. /ˈfɐ**ʔ.ʔ**ɐs/	[ˈfɐ**ʔ.ʔ**ɐs]	'to hatch'
b. /ˈʃɐ**h.h**ɐm/	[ˈʃɐ**h.h**ɐm]	'to fatten'
c. /ˈlɪ**b.b**ɛs/	[ˈlɪ**b.b**ɛs]	'to dress'
d. /ˈrɛs.sɐʔ/	[ˈrɛs.sɐʔ]	'to bring something closer'
e. /ˈdʒɛ**b.b**ɛt/	[ˈdʒɛ**b.b**ɛt]	'to pull'
f. /ˈʃɐ**r.r**ɐp/	[ˈʃɐ**r.r**ɐp]	'to make something wet'
g. /ˈkɪs.sɛr/	[ˈkɪs.sɛr]	'he smashed'
h. /ˈsɐf.fɐr/	[ˈsɐf.fɐr]	'to whistle'
verb pattern V (t– $C_1VC_2C_2VC_3$)	**Output**	**Gloss**
a. /ˈt–kɪs.sɛr/	[ˈtkɪs.sɛr]	'it was smashed'

Based on the above examples, items of medial gemination which derive from verb patterns II and V, are allocated to different syllables and are not being dominated together by one mora, as shown in the following representation:[2,3]

However, Galea (2016) states that the underlying medial gemination in Maltese does not originate from any morphophonological process. Consider the following examples:

(2) Underlying medial gemination in Maltese (Galea, 2016):

Input	Output	Gloss
a. /ˈpɐ**p.p**ɐ/	[ˈpɐ**p.p**ɐ]	'food'
b. /dʒɐ**p. ˈp**uːn/	[dʒɐ**p.ˈp**uːn]	'japan'

Although the medial geminations above do not result from any morphophonological process, their members are found in two different syllables and are not dominated by one mora as shown in the representation below:

McCarthy (1981), Camilleri (2013), Camilleri (2014) and Galea (2016) agree on the existence of final gemination in verbs derived from the biconsonantal root, i.e., C1G, with reference to Maltese and other Arabic dialects. Consider the following examples:

(3) Final gemination in verbs derived from the biconsonantal root of C_1G (McCarthy, 1981; Camilleri, 2013, Camilleri, 2014; Galea, 2016):

The biconsonantal root of C1G	Input	Output	Gloss
a. /d-ʔ-ʔ/	/dɐ**ʔʔ**/	[dɐ**ʔʔ**]	'to play'
b. /b-ʃ-ʃ/	/bɛ**ʃʃ**/	[bɛ**ʃʃ**]	'to spray'
c. /ʃ-m-m/	/ʃɐ**mm**/	[ʃɐ**mm**]	'to smell'

The examples above show that the members of final gemination are not allocated to different syllables and are dominated by one mora, compared to medial gemination, as shown in the following representation:

Galea (2016) states that final geminations are underlyingly found in nouns and adjectives with Semitic and non-Semitic origins in the Maltese lexicon. Consider the following examples:

(4) Underlying final gemination in Maltese (Galea, 2016):

Origin	Input	Output	Gloss
Semitic	/ɔ**mm**/	[ɔ**mm**]	'mother' (Noun)
Non-Semitic (Italian)	/zɪ**pp**/	[zɪ**pp**]	'zipper' (Noun)
Non-Semitic (Italian)	/lɪ**ʃʃ**/	[lɪ**ʃʃ**]	'smooth' (Adjective)

Based on the above examples, final geminations in nouns and adjectives from Semitic and non-Semitic origins do not arise through any morphophonological process. Their members are found within the same syllable and are dominated by one mora, as shown in the following representation:

Considering the syllable structure and the properties of geminates discussed above, Galea (2016) states that initial gemination is unattested in Maltese in either production and perception. He reports that the participants in his study perceive word-initial geminates as word-initial singletons since they could not distinguish between word-initial geminates and word-initial singletons, while the production of word-initial geminates always requires preceding vocalic insertion. A word-initial geminate as an ill-formed structure in Maltese is mentioned by scholars of the phonology of Maltese in the next subsection.

Literature review. Scholars who work on the phonology of Maltese, including Azzopardi (1981), Mifsud (1995), Hoberman and Aronoff (2003), and Galea (2016) have addressed the status of initial gemination in Maltese. Azzopardi (1981) notes that a geminate in Maltese is not in the word-initial position since it is preceded by a very short vowel /ɪ/, i.e., the prosthetic vowel. Mifsud (1995), who conducts a descriptive and comparative study on loan verbs in Maltese claims that the surface realization of an initial geminate in Maltese requires a prosthetic vowel unless the preceding word ends in a vowel. Hoberman and Aronoff's (2003) agreement with Mifsud (1995) is based on the fact that the prosthetic vowel always occurs before an initial geminate unless the preceding word in the same phonological phrase ends with a vowel. Galea (2016), who phonetically scrutinizes the production of syllable structure and gemination in Maltese infers that the phonology of this language disallows word-initial geminates, which motivates a vocalic insertion; hence, the purpose of this insertion is to syllabify all segments in a phonological string, e.g. /t–ʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$p/→ /ʃ$^{\mu}$.ʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$p/→ [ɪ$^{\mu}$ʃ$^{\mu}$.ʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$p] 'to get wet'.

However, none of the scholars above has considered the role of the *Obligatory Contour Principle* and the *Strict Layer Hypothesis* in the avoidance of initial geminates in Maltese in light of Parallel OT. Therefore, the aim of this study is to elaborate on the role of conformity to the *Obligatory Contour Principle* (OCP) and the *Strict Layer Hypothesis* (SLH) in the avoidance of initial geminates in Maltese using *Optimality Theory* (henceforth OT) as a framework. To do so, two questions have been addressed in this study: To what extent are initial geminates in Maltese avoided to conform to the Obligatory Contour Principle (OCP) and the Strict Layer Hypothesis (SLH)? How can OT account for the avoidance of initial geminates in Maltese to conform to the Obligatory Contour Principle (OCP) and the Strict Layer Hypothesis (SLH)? The significance of this study lies in demonstrating that conformity to the Obligatory Contour Principle (OCP) and the Strict Layer Hypothesis (SLH) is accomplished using Parallel Optimality Theory (OT) when dealing with initial gemination in Maltese.

Why are the Obligatory Contour Principle (OCP) and the Strict Layer Hypothesis (SLH) important in Maltese, especially when dealing with initial geminates? OCP and SLH are served to avoid the ill-formed representations in Maltese. The OCP eliminates the adjacent non-identical consonants of the same place feature, as an ill-formed representation, exemplified by the association of the prefix /t-/ with the initial consonant of the following stem of the same place feature through assimilation. The SLH is to avoid another ill-formed representation exemplified by an initial geminate as the result of the assimilation of the prefix /t-/ to the initial consonant of the following stem. Hence, the first member of this geminate, namely an initial semi-syllable, is directly dominated by the prosodic word rather than the syllable. Therefore, the vowel prosthesis is to affiliate the entire members of this geminate to the syllable node where the SLH is fulfilled. Moreover, the site of vowel epenthesis is determined by the OCP as well as geminate integrity, coping with the underlying initial geminates in non-Semitic verbs (from English and Italian) of CC-stems which do not violate the SLH since the members of the aforementioned geminate are within the same morpheme. OT, as a framework, (Prince and Smolensky, 1993), accounts for these phenomena using a single set of OT constraints rather than using several rules (i.e., conspiracy problem). Further details about the OCP and SLH as well as the framework of OT, are disclosed in the following sections. The next section elaborates on the OCP and gemination.

The OCP and gemination

The OCP (the short of Obligatory Contour Principle), as Yip (1988) stated, is considered the filter that can mark a representation as ungrammatical (i.e., ill-formed) and thus require that it should be fixed up. Leben (1973) first introduced the OCP to cope with tones since it prevents the adjacency of identical tones, as shown in the following representation.

The above representation is opposed to what OCP demands (Meyers, 1997:847) due to the existence of two adjacent high tones. These adjacent high tones will be forced to be represented in (5) by the OCP, where two syllables are associated with one high tone.

Other areas in Phonology reveal the usefulness of the OCP. For instance, McCarthy (1986) was the first who showed the usefulness of the OCP as a constraint "on the organization of non-prosodic or segmental phonology" (p.28).

(5) Obligatory Contour Principle (McCarthy, 1986:208)
At the melodic level, adjacent identical elements are prohibited.
The implementation of several kinds of phonological rules in the environment of two identical elements is motivated by the OCP (Yip, 1988; Keer, 1999). The violation of OCP is avoided by several repair strategies, including degemination, dissimilation, assimilation, epenthesis, and metathesis (Yip, 1988; Alderete, 1997; Itô and Mester, 1998; Keer, 1999; Elramli, 2012). Yip (1988) demonstrates two cases which lead to the correspondence with the OCP in a language: The first case is when one of the two identical matrices in a language is deleted and remains unfilled, i.e., degemination. The second case, which is concerned in the current study, is when one of two identical matrices in a language is deleted and is filled by spreading (total assimilation). Unlike the former case in a language, the latter case in a language yields gemination. Considering the second case above, Yip (1988) links Guerssel's (1978) data on total assimilation in Berber to the role of the OCP as a trigger. She observes that the total assimilation in Berber is run by the spreading of the voicing feature of coronals to other coronals, as shown in the following examples:

(6) Examples of Total assimilation in Berber (Yip, 1988:77)

a. t+dlu	→	d+dlu	'she covered'
b. t+dfəs	→	d+dfəs	'she folded'
c. ad+t+ru	→	at+t+ru	'she will cry'
d. ad+t+fa+m	→	at+t+fa+m	'you (plural) will yawn'

With regard to the examples in (6), Guerssel's (1978) rule of assimilation as a spreading rule was reformulated by Yip (1988) as in the representation below:

According to Yip (1988), the output of the above rule as a doubly linked structure is immune from the otherwise general rule of Schwa *Epenthesis* to break up triconsonantal clusters, i.e.,*[dədlu]. The rule (13), however, is not exempt from criticism. Yip (1988) reports that the shortcoming of this rule arises from the presence of the [+coronal] being unexplained; hence, a labial could be assimilated to the following velar in voicing by the same rule. Therefore, it is crucial to entail the feature geometry details in this case. The coronal tier in Berber is proposed by Yip (1988), and a sequence of two [coronal] nodes consequently incurs the violation of the OCP. This situation is represented by Yip (1988:78) below:

Yip (1988) states that one of the offending matrices, in this case, undergoes deletion, i.e., mostly the first matrix, since the violation of the OCP is on the coronal tier. Yip (1988) demonstrates the four possible ways of spreading coronals onto the first consonant in Berber, either through the lowest node represented by the coronal itself, the Root-node, the intervening supralaryngeal node, or the intervening place node. Coping with the two segments as string-adjacent, it is clear that the Root-node-the highest possible node-spreads since voicing assimilates. Thus, Yip (1988) indicates to this rule being maximal in correspondence with Archangeli and Pulleyblank (1986). Her finding is that the voicing assimilation rule in Berber is reduced to the operation of the OCP on the coronal tier; the first matrix is prone to deletion along with the independent motivation for spreading, resulting in total assimilation. The formal statement of the rule is in (7) (Yip, 1988:79).

(7) Berber voicing assimilation (Yip, 1988:79):

Domain:	Word
Tier:	coronal
Trigger:	
Change:	Delete first matrix

Another example of the role of the OCP in gemination is taken from the treatment of true and fake geminates in Palestinian Arabic (Rose, 2000). The members of any true geminate (i.e., underlying geminate) which are in the same morpheme are not split by vowel epenthesis to conform to the OCP as well as geminate integrity. Consider the following examples.

(8) True geminates in Palestinian Arabic (Rose, 2000:110)

a. si**tt** not *sit**i**t 'grandmother'
b. si**tt**-na→ si**tt**na not *sit**i**tna 'our grandmother'

On the other hand, vowel epenthesis in the same variety of Arabic can be used to split the members of fake geminates, which arise from the concatenation of a suffix with a final-consonant stem (Rose, 2000). For instance, vowel epenthesis is motivated by the association of the 1st person singular suffix /-t/ with the t-final stem, which yields a fake geminate, e.g., fut-t→fut**i**t not *fu**tt**.

The role of the OCP in gemination is also exemplified in the examination of the phonology of gemination in the Bani Sulaim dialect as a Bedouin Hijazi dialect spoken in Saudi Arabia in light of OT (AL SOLAMI, 2022). A high short non-final vowel /i/ in the imperfect 3rd person singular feminine /2nd person singular masculine prefix /ti-/, as an open syllable, that is attached to the verb roots undergoes High Vowel Deletion (HVD) (AL SOLAMI, 2022). The remaining segment of the prefix /t-/ assimilates to initial stem consonants with the same place feature (i.e., regressive assimilation) to avoid the violation of OCP, yielding initial geminates (AL SOLAMI, 2022), e.g., /ti-dab.bir/→/t-dab.bir/ →[ddab.bir] 'she/you (singular masculine) deal with'.

To summarize, the OCP has been shown in this section as a motive for the total assimilation, which is derived from the two adjacent identical matrices where one of them is liable to deletion to facilitate the spreading of another one, resulting in a geminate. This section also reveals how the OCP blocks vowel insertion when dealing with true or underlying geminates (i.e., geminate integrity) and how the vowel insertion, on the other hand, is permitted to avoid fake geminates that violate the OCP. Although an initial geminate is formed to avoid the violation of the OCP, its peripheral member (i.e., an initial semi-syllable), which belongs to a different morpheme violates the Strict Layer Hypothesis (SLH) since it is affiliated to Prosodic Word on prosodic hierarchy. The next section is to provide our readers with some knowledge about the Strict Layer Hypothesis.

The strict layer hypothesis (SLH)

Referring to 'the standard theory' of prosodic structure, the prosodic hierarchy and strict layering are the two fundamental properties of prosodic constituent representation as a well-formed labeled tree or bracketing that distinguish it from syntactic constituent structure representations (Selkirk, 1981a, 1981b, 1984, 2011; Itô, 1986; Nespor and Vogel, 1986; Beckman and Pierrehumbert, 1986; Pierrehumbert and Beckman, 1988; and others). The *Prosodic hierarchy*, according to Selkirk (1984, 2011) and Roca (1994), is an ordered set of prosodic category types.[4] Selkirk (2011:437) mentions that "these prosodic categories constitute possible node labels for prosodic structures and in the standard view are stipulated by phonological theory". Consider the following prosodic hierarchy:

Selkirk (2011) states that the nature of domination relations within a prosodic constituent structure in this standard theory is determined by phonological theory. This would attribute to the Strict Layer Hypothesis (Itô, 1986; Nespor and Vogel, 1986; Selkirk, 1984, 2011) as the name given to the idea that a prosodic constituent structure is strictly arranged on the basis of the ordered set of prosodic category types in the prosodic hierarchy above; hence, Rakhieh (2009:175) notes that this hypothesis "requires that every non-highest prosodic element be in its entirety a constituent belonging to the next highest category on the prosodic hierarchy". The following configuration conforms to the strict layer hypothesis (Figs. 2–15).

Considering the above configuration, Prosodic Word (PrWd) is directly dominated by Phonological Phrase (φ), which is dominated by Intonational Phrase (ι). However, the violation of the above hypothesis, as expressed by Selkirk (2011), if PrWd is directly dominated by Intonational Phrase (ι) rather than Phonological Phrase (φ) (i.e., *level-skipping*) as shown in the following configuration.

An example of the violation of the Strict Layer Hypothesis is expressed by Alqahtani (2020) when accounting for initial geminates, as non-actual surface forms, in Qassimi Arabic through prosthesis (i.e., the insertion of a glottal stop plus a vowel), nonetheless, these geminates result from the assimilation of the prefix /t-/ to stem-initial consonants of the verb forms II ($C_1VC_2C_2VC_3$), III ($C_1VVC_2VC_3$), and hollow verbs of the form (C_1VVC_2) to obey the OCP. Consider the following representation of /t-dʒa$^{\mu}$h$^{\mu}$.hi$^{\mu}$z/→ /**dʒ**$^{\mu}$.**dʒ**a$^{\mu}$h$^{\mu}$.hi$^{\mu}$z/ 'you/she prepare(s)' (Alqahtani, 2020: 363).

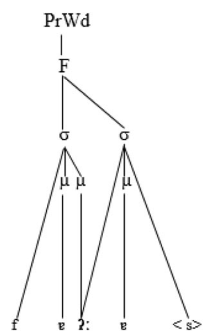

Fig. 2 The representation of the derived medial geminate in the output ['fɐʔ.ʔɐs] 'to hatch'. Both members of medial geminates are not dominated by one mora and are allocated to different syllables.

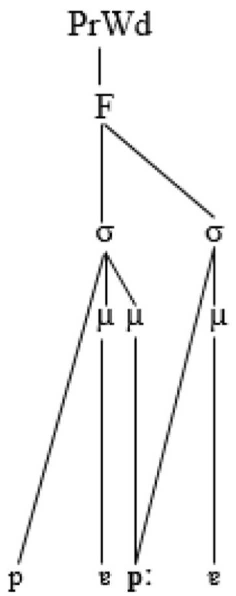

Fig. 3 The representation of the underlying medial geminate in /ˈpɐp.pɐ/ ‘food’. Both members of geminates are not dominated by one mora and are allocated to different syllables.

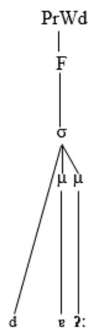

Fig. 4 The representation of the final gemination in the output [dɐ??] ‘to play’. The members of the final geminate are dominated by one mora and are being in one syllable.

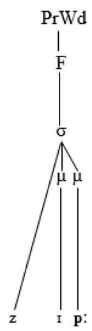

Fig. 5 The representation of the final geminate in the output [zɪpp] ‘zipper’. The final geminate in the output [zɪ**pp**] of the non-Semitic origin shows its members are dominated by one mora.

The representation above reveals the violation of the Strict Layer Hypothesis that is incurred by the initial geminate; hence, the peripheral member of this geminate is assigned to a semi-syllable, that is, the unsyllabified moraic consonant directly dominated by Prosodic Word rather than the syllable node in the prosodic hierarchy (Alqahtani, 2020). Therefore, the prosthesis is employed to affiliate this semi-syllable to the syllable node to match with the Strict Layer Hypothesis as shown in the following representation (Alqahtani, 2020:364).

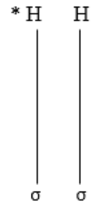

Fig. 6 The representation of the adjacent identical tones. These adjacent tones are prohibited since they incur a violation of the OCP.

Fig. 7 The representation of the tones that conforms to the OCP. Both syllables are linked to one high tone to avoid the violation of the OCP.

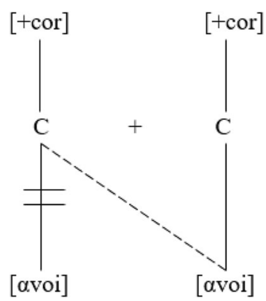

Fig. 8 The representation of Yip’s (1988:77) spreading rule. The purpose of this rule is to show how the violation of the OCP is segmentally avoided through voicing assimilation.

After demonstrating the Strict Layer Hypothesis as a constraint that militates against level-skipping by prosodic elements on the prosodic hierarchy, the next section is devoted to providing the reader with background information on Optimality Theory (OT) as a framework.

OT framework

The central tenet of OT is that Universal Grammar is mostly comprised of “a set of constraints on representational well-formedness, out of which individual grammars are constructed” (Prince and Smolensky, 1993: 2). The importance of these constraints is shown through the way they are ranked (Elramli, 2012). Based on what Prince and Smolensky’s (1993) book title (*Optimality Theory: Constraint Interaction in Generative Grammar*) indicates, OT is fundamentally considered an extension of generative phonology; thus, it essentially advocates the distinction between the underlying and surface levels of representation from a different prospective (Honeybone, 2009:146). This theory (OT), as mentioned by Lombardi (2001: 1), eliminates the use of rules and derivations and replaces them with well-formedness constraints which interact to determine the actual output.

The reason for using OT arises from the employment of its five fundamental principles that are identified by Prince and

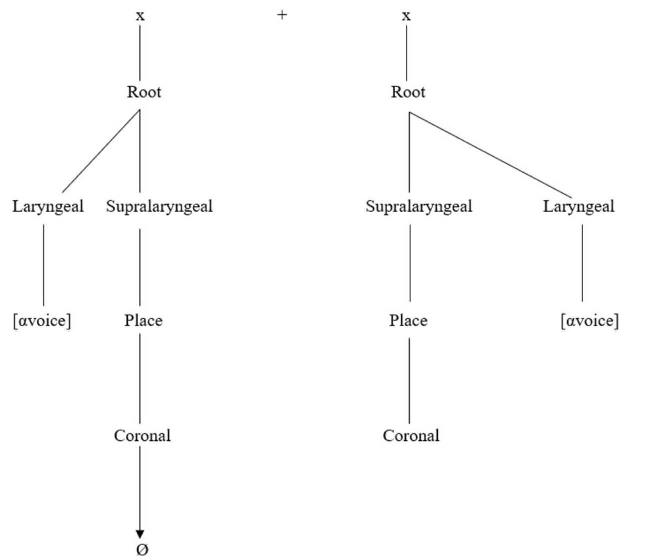

Fig. 9 The feature geometric representation of the Yip's (1988:77) spreading rule. This representation as reported by Yip (1988) is more accurate than the representation of the spreading rule in Fig. 8 when dealing with assimilation.

Phonological Utterance
↓
Intonational Phrase (ι)
↓
Phonological Phrase (φ)
↓
Prosodic Word (PrWd)
↓
Foot (F)
↓
Syllable (σ)
↓
Mora (μ)
↓
Segment

Fig. 10 Prosodic Hierarchy (Roca, 1994: 195). This hierarchy shows that every prosodic level should be straightforwardly dominated by the upper level; otherwise, it would violate the SLH.

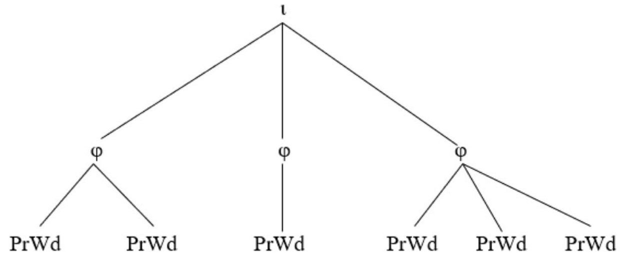

Fig. 11 The satisfaction of the Strict Layer Hypothesis (Selkirk, 2011:437). This representation shows that every prosodic level is straightforwardly dominated by the upper prosodic level, yielding the satisfaction of the Strict Layer Hypothesis (SLH).

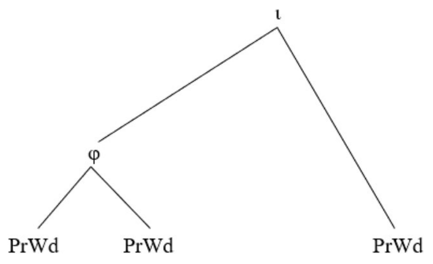

Fig. 12 The violation of the Strict Layer Hypothesis. This representation shows the violation of the strict Layer Hypothesis through level skipping.

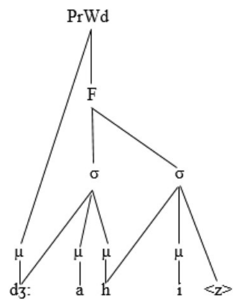

Fig. 13 The representation of /t-dʒa$^{\mu}$h$^{\mu}$.hi$^{\mu}$z/→ /dʒ$^{\mu}$.dʒa$^{\mu}$h$^{\mu}$.hi$^{\mu}$z/ 'you/she prepare(s)'. This representation shows that violation of the SLH through the affiliation of the first member of the initial geminate to the Prosodic Word rather than the syllable.

Smolensky (1993) and McCarthy and Prince (1996) to cope with the problematic issues in phonology. For instance, one of these problems is pertinent to the conspiracy problem in Yawelmani Yokuts (Kisseberth, 1970). The sequence of CCC is banned in Yawelmani Yokuts (Kisseberth, 1970). Therefore, two repair strategies, i.e., vowel epenthesis and consonant deletion, are used to solve such a symmetry in Yawelmani Yokuts; hence, vowel epenthesis is inserted after the first consonant, resulting in C*v*CC. However, both C*v*CC and CC*v*C are not permitted in Yawelmani Yokuts. For this reason, consonant deletion is the other repair strategy used to avoid the sequence of CCC in Yawelmani Yokuts; hence, a consonant that is not adjacent to a vowel is prone to deletion, i.e., the second consonant in a sequence like VC + CCV is deleted. These rules have the same purpose, which is to avoid the sequence of CCC. Non-linear theories in the mid-1970s, such as Autosegmental Phonology (Goldsmith, 1976) and Metrical Phonology (Liberman, 1975 and Liberman and Prince, 1977), aim to restrict the operation of rules; hence, narrowing the role of the rule component is due to constraints on representations. However, "the proposed universal constraints did not hold in every language all of the time. That is why the subsequent literature on autosegmental and metrical phonology, such as Pulleyblank (1986) and Hayes (1995), returned to language-particular rewrite rules as the central analytic mechanism" McCarthy (2008:6).

The significance of output constraints was recognized at the end of the 1980s by Paradis (1987) and Kaye et al. (1985;1990). Paradis (1987) introduced the *Theory of Constraint and Repair Strategy*. This theory demonstrates that a set of inviolable surface constraints accompanied by repair strategies can be used to solve violations that result from constraint conflicts. Government Phonology introduced by Kaye et al. (1985; 1990) accounts for phonological processes by a restricted set of universal principles and a series of language-specific-parameters rather than using rules. McCarthy and Prince (1993) indicate the significant role of output constraints in the emergence of OT as the theory of constraint interaction.

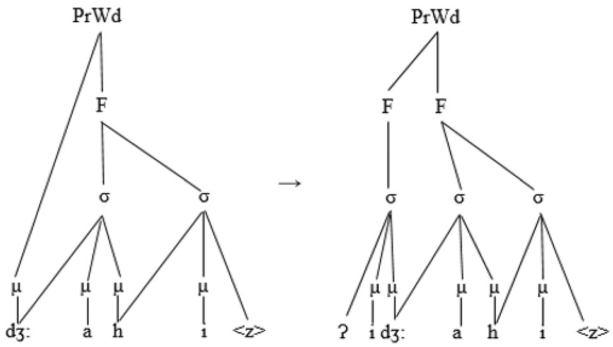

Fig. 14 The representation of the output [ʔi^{μ}dʒ^{μ}.dʒa^{μ}h^{μ}.hi^{μ}z] 'you/she prepare(s)' (Alqahtani, 2020:364). This representation shows that the prosthesis serves to affiliate the first member of the initial geminate to the syllable node to satisfy the SLH.

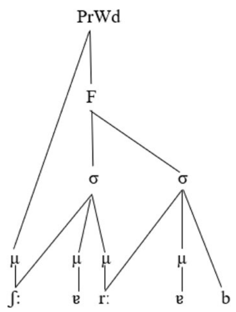

Fig. 15 The representation of the initial gemination of the Semitic verb /ʃ^{μ}.ʃɐ^{μ}r^{μ}.rɐ^{μ}b/ 'to get wet'. This representation shows that the SLH is violated by the first member of the initial geminate in Maltese due to level skipping.

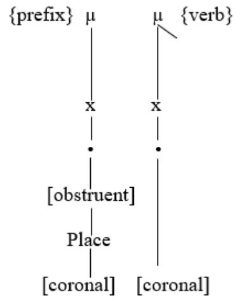

Fig. 16 The OCP violation (Watson, 2002:220). This representation shows that OCP is violated by the two non-identical consonants of the same place feature.

McCarthy (2008) defines the mechanism of OT as an input–output relation in which every input has a precise output. This mechanism is operated by two main components, namely GEN and EVAL, that should be in any grammar (Kager, 2010). These components distinguish OT as a theory of parallel input–output relation. An infinite number of possible candidates is functionally generated by GEN (i.e., 'GENERATOR') without any restriction, while these candidates are evaluated by EVAL (i.e., 'EVALUATOR') through a set of constraints that is ranked on a scale of language-particular phenomenon (Kager, 2010). An optimal candidate among other competing candidates is determined by EVAL (Kager, 2010). A flowchart in (9) below interprets the relation between both components:

(9) Input→GEN→Candidates→EVAL→Output (McCarthy, 2008:19)

Candidates generated by GEN are evaluated by CON (CONSTRAINT) as a well-known component used by EVAL in order to determine the optimal output (McCarthy, 2008). In fact, OT constraints are universal, which means that languages share the same universal OT constraints, but the difference between languages refers to the ranking of constraints since ranking OT constraints is language-specific. For instance, ONS, as an OT constraint that demands an onset, is ranked higher in languages that ban onsetless syllables, whereas the same constraint is ranked low in languages that permit onsetless syllables (Alqahtani, 2014). Simply, ONS as an OT constraint is universal, whereas the way it is ranked is language-specific. Constraints are not exempted from violations by candidates. Constraints in OT might be satisfied in some languages and are violated in others. In addition, an optimal output should not necessarily match the entire constraints with respect to a set of ranked constraints, whereas the optimal output should incur the least number of violations to become the most harmonic candidate (Prince and Smolensky, 1993; Kager, 2010; Alqahtani, 2014; Al Taisan, 2022). A 'LEXICON' in the grammar in which underlying forms (lexical representations) form the input to GEN (Kager, 2010:19). Unlike outputs, LEXICON is neither restricted nor undergoes evaluation by constraints; hence, this would recall the '*Richness of the Base*' hypothesis introduced by Prince and Smolensky (1993) and Smolensky (1996). This hypothesis states that "no constraints hold at the level of underlying forms" (Kager, 2010:19). Furthermore, the interaction between constraints is at the output level, not the input level (Smolensky, 1993, 1997).

OT constraints are divided into *Markedness* and *Faithfulness* constraints (Prince and Smolensky, 1993; McCarthy and Prince, 1995; McCarthy, 2008; Kager, 2010); markedness constraints are concerned with structural well-formedness while faithfulness constraints are to ensure that the output is perfectly correspondent to the input (Prince and Smolensky, 1993; McCarthy and Prince, 1995; McCarthy, 2008; Kager, 2010). In other words, markedness constraints require the avoidance of certain marked structures by the outputs. Some examples of markedness constraints are shown below:

(10) Some examples of Markedness constraints (Rakhieh, 2009:18):

a. *V$_{\text{NASAL}}$
Vowels must not be nasal.
b. *VOICED-CODA
Obstruents must not be voiced in the coda position.
c. *[ŋ
No word-initial velar nasal.
d. NO-CODA
Syllables are open.
e. *CLASH
No adjacent syllables are stressed.
f. ONSET
Syllables must have onsets.

Faithfulness constraints require outputs to be identical to the input. MAX and DEP are identified as the two classes of the faithfulness constraints (McCarthy and Prince, 1995; Kager, 2010). MAX militates against the deletion of the properties of the output that are correspondent to those of the input (i.e. no deletion), whereas DEP requires input–output correspondence without the addition of extra segments to the properties of the output (McCarthy and Prince, 1995; Kager, 2010), i.e., no insertion. An example of the interaction between markedness and faithfulness constraint is given by Al-Mohanna (1998) regarding the evaluation of the candidates of the input /VC/ in Urban Hijazi Arabic.[5] Consider the following tableau:[6]

Tableau (I) The evaluation of the candidates of the input /VC/ in Urban Hijazi Arabic

ONS≫MAX≫DEP≫-COD

/VC/	ONS	MAX	DEP	-COD
a.☞ /CVC/			*	*
b. /CV/		*!	*	
c. /VC/	*!			*

Candidate (a) has been chosen in the tableau above as optimal due to the satisfaction of ONS and MAX as highly-ranked constraints, while the same constraints are subject to fatal violation by candidates (b) and (c). Candidate (b) fails to be optimal since it fatally violates MAX because of the deletion of coda, nonetheless, it matches with ONS and -COD. Candidate (c), which is most faithful to the input, is eliminated due to the fatal violation of ONS.

Standard OT (Parallel OT) serves to solve the conspiracy problem in Yawelmani Yokuts (Kisseberth, 1970) discussed earlier through the elimination of the entire rules and replacing them with the output constraints which interact with each other to distinguish the desired output as optimal (Rakhieh, 2009) as shown in the following tableaux:[7]

Tableau (II): Consonant deletion in Yawelmani Yokuts.

C → ∅ / C+___C

giti:n+hnil	*COMPLEX	MAX-C$_{stem}$	MAX-C/___V	DEP-V	MAX-C
a. ☞gi.ti:n.nil					*
b. gi.t:n.hnil	*!				
c. gi.ti:h.nil		*!			*
d. gi.ti:n.hil			*!		*
e. gi.ti:n.hi.nil				*!	

Tableau (III): Vowel insertion in Yawelmani Yokuts.

∅ → V / C___C {#, C}

ʔilk+hin	*COMPLEX	MAX-C$_{stem}$	MAX-C/___V	DEP-V	MAX-C
a. ☞ʔi.lik.hin				*	
b. ʔil.khin	*!				
c. ʔil.hin		*!			*
d. ʔil.kin			*!		*

The potential shortcoming of standard OT is particular to its incapability of accounting for other phonological phenomena, such as phonological opacity, process interaction, and some cases of variation, even though it successfully manages to deal with many problematic issues in phonology (Prince and Smolensky, 1993; Rakhieh, 2009; Al Taisan, 2022).

The next section is devoted to demonstrating how Maltese data on gemination were gathered and to investigate how banning the initial geminates reflects conformity to the OCP and the SLH in Maltese within an OT framework.

Data collection and analysis

The current study has been conducted following two procedures. First, the data in this study were collected from existing literature reviews with regard to Maltese. Second, the data on gemination in Maltese, extracted from the extant literature, were verified by consulting several native speakers of Maltese when necessary.[8]

This section elucidates the formation of initial gemination in this language as the main topic of this study, as it is quite controversial compared to medial and final gemination. In Semitic Maltese verbs, initial geminates, as purely surface forms, arise from the assimilation of the prefix /t-/ with the features [+coronal, – sonorant, +obstruent] to stem-initial consonants with the same features in pattern V verbal forms (t-$C_1iC_2C_2eC_3$). Initial geminates in non-Semitic verbs in Maltese (i.e., from English and Italian) of CC-stems are morphological since they are derived from the verb forms in Italian and English. Consider the following examples:

(11) Initial geminates derived from the assimilation of the prefix /t-/ in verb pattern V(t-$C_1iC_2C_2eC_3$):

a. /t-dʒɛ$^{\mu}$b$^{\mu}$.bɛ$^{\mu}$d/→/dʒ$^{\mu}$.dʒɛ$^{\mu}$b$^{\mu}$.bɛ$^{\mu}$d/ →[ɪ$^{\mu}$dʒ$^{\mu}$.dʒɛ$^{\mu}$b$^{\mu}$.bɛd]/*[dʒɪ$^{\mu}$.dʒɛ$^{\mu}$b$^{\mu}$.bɛ$^{\mu}$d]	'to be restricted'
b. /t-ʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$b/→/ʃ$^{\mu}$.ʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$b/ →[ɪ$^{\mu}$ʃ$^{\mu}$.ʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$b] /*[ʃɪ$^{\mu}$.ʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$b]	'to get wet'
c. /t-da$^{\mu}$h$^{\mu}$.hɐ$^{\mu}$l/→/d$^{\mu}$.da$^{\mu}$h$^{\mu}$.hɐ$^{\mu}$l/ →[ɪ$^{\mu}$d$^{\mu}$.da$^{\mu}$h$^{\mu}$.hɐ$^{\mu}$l] /*[dɪ$^{\mu}$.da$^{\mu}$h$^{\mu}$.hɐ$^{\mu}$l]	'to be inserted'
d. /t-zɛ$^{\mu}$w$^{\mu}$.wɛ$^{\mu}$tʃ/→/z$^{\mu}$.zɛ$^{\mu}$w$^{\mu}$.wɛ$^{\mu}$tʃ/ →[ɪ$^{\mu}$z$^{\mu}$.zɛ$^{\mu}$w$^{\mu}$.wɛ$^{\mu}$tʃ] /*[zɪ$^{\mu}$.zɛ$^{\mu}$w$^{\mu}$.wɛ$^{\mu}$tʃ]	'to get married'
e. /t-sɐ$^{\mu}$k$^{\mu}$.kɐ$^{\mu}$r/→/s$^{\mu}$.sɐ$^{\mu}$k$^{\mu}$.kɐ$^{\mu}$r/ →[ɪ$^{\mu}$s$^{\mu}$.sɐ$^{\mu}$k$^{\mu}$.kɐ$^{\mu}$r] /*[sɪ$^{\mu}$.sɐ$^{\mu}$k$^{\mu}$.kɐ$^{\mu}$r]	'to lock oneself'
f. /t-dɐ$^{\mu}$b$^{\mu}$.bɐ$^{\mu}$r/→/d$^{\mu}$.dɐ$^{\mu}$b$^{\mu}$.bɐ$^{\mu}$r/ →[ɪ$^{\mu}$d$^{\mu}$.dɐ$^{\mu}$b$^{\mu}$.bɐ$^{\mu}$r]/*[dɪ$^{\mu}$.dɐ$^{\mu}$b$^{\mu}$.bɐ$^{\mu}$r]	'to become full of sores'
g. /t-dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$/→/d$^{\mu}$.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$/ →[ɪ$^{\mu}$d$^{\mu}$.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$]/*[dɪ$^{\mu}$.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$]	'to be cured'
h. /t-sɐ$^{\mu}$b$^{\mu}$.bɐ$^{\mu}$r/→/s$^{\mu}$.sɐ$^{\mu}$b$^{\mu}$.bɐ$^{\mu}$r/ →[ɪ$^{\mu}$s$^{\mu}$.sɐ$^{\mu}$b$^{\mu}$.bɐ$^{\mu}$r] /*[sɪ$^{\mu}$.sɐ$^{\mu}$b$^{\mu}$.bɐ$^{\mu}$r]	'to be comforted'
i. /t-ʃɐ$^{\mu}$m$^{\mu}$.mɐ$^{\mu}$r/→/ʃ$^{\mu}$.ʃɐ$^{\mu}$m$^{\mu}$.mɐ$^{\mu}$r/ →[ɪ$^{\mu}$ʃ$^{\mu}$.ʃɐ$^{\mu}$m$^{\mu}$.mɐ$^{\mu}$r]/*[ʃɪ$^{\mu}$.ʃɐ$^{\mu}$m$^{\mu}$.mɐ$^{\mu}$r]	'to roll up one's sleeves'
j. /t-sɐ$^{\mu}$d$^{\mu}$.dɐ$^{\mu}$t/→/s$^{\mu}$.sɐ$^{\mu}$d$^{\mu}$.dɐ$^{\mu}$t/ →[ɪ$^{\mu}$s$^{\mu}$.sɐ$^{\mu}$d$^{\mu}$.dɐ$^{\mu}$t] /*[sɪ$^{\mu}$.sɐ$^{\mu}$d$^{\mu}$.dɐ$^{\mu}$t]	'to become rusty'
k. /t-ʃɐ$^{\mu}$h$^{\mu}$.hɐ$^{\mu}$m/→/ʃ$^{\mu}$.ʃɐ$^{\mu}$h$^{\mu}$.hɐ$^{\mu}$m/ →[ɪ$^{\mu}$ʃ$^{\mu}$.ʃɐ$^{\mu}$h$^{\mu}$.hɐ$^{\mu}$m]/*[ʃɪ$^{\mu}$.ʃɐ$^{\mu}$h$^{\mu}$.hɐ$^{\mu}$m]	'to become fat'
l. /t-tʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$t/→/tʃ$^{\mu}$.tʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$t/ →[ɪ$^{\mu}$tʃ$^{\mu}$.tʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$t] /*[tʃɪ$^{\mu}$.tʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$t]	'to tear'

(12) Initial geminates in non-Semitic verbs (i.e., from English and Italian) of CC-stems:

a. /f:$^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$/	→	[ɪ$^{\mu}$f$^{\mu}$.fɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$] /*[fɪ$^{\mu}$.fɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$]	'to sign (Italian origin)'
b. /p:$^{\mu}$ɐ$^{\mu}$k$^{\mu}$.kja$^{\mu}$/	→	[ɪ$^{\mu}$p$^{\mu}$.pɐ$^{\mu}$k$^{\mu}$.kja$^{\mu}$]/ *[pɪ$^{\mu}$.pɐ$^{\mu}$k$^{\mu}$.kja$^{\mu}$]	'he packed' (English origin)'
c. /t:$^{\mu}$ɐ$^{\mu}$n$^{\mu}$.tɐ$^{\mu}$/	→	[ɪ$^{\mu}$t$^{\mu}$.tɐ$^{\mu}$n$^{\mu}$.te$^{\mu}$] /*[tɪ$^{\mu}$.tɐ$^{\mu}$n$^{\mu}$.tɐ$^{\mu}$]	'attempt'

As shown in the examples above, initial gemination can be derivational in Maltese as the result of the assimilation of the prefix /t-/, with the feature of [+coronal], to the following stem-initial consonants with the same features in verb pattern V (t-$C_1iC_2C_2eC_3$): This assimilation is motivated by the conformity to the Obligatory Contour Principle (OCP) while prosthesis is utilized to conform to the Strict Layer Hypothesis (SLH). The same behavior is attested in Qassimi Arabic (Alqahtani, 2020) as in section 3. The prosthesis is also utilized to conform to the OCP and geminate integrity when dealing with the underlying word-initial geminates in non-Semitic verbs (i.e., from English and Italian) of CC-stems, even though this type of initial gemination satisfies SLH. This phenomenon is also reported in the treatment of true geminates Palestinian Arabic (Rose, 2000) as in (8).

Initial geminates do not surface in Maltese. Nonetheless, this language has no restriction on word-initial clusters, as seen in subsection 1.1. Why are initial geminates not tolerated in Maltese? The derivational word-initial geminates in (11) are not tolerated in Maltese since the first members are assigned to semisyllables as unsyllabified moraic consonants, which are straightforwardly linked to the prosodic word rather than the syllable node in the prosodic hierarchy. This finding originates from the fact that initial geminates in Maltese, which as stated, result from the assimilation of prefixes to consonant-initial stems with the same features to avoid the violation of the OCP, are moraic since they attract stress similar to Arabic. Indeed, Maltese is most heavily influenced by the phonology of Arabic, according to Mifsud (1995), Brincat (2004), and Spagnol (2011), and geminates in Arabic are moraic due to their ability to attract stress. Consider the following representation of the initial gemination of the Semitic verb /ʃ$^{\mu}$.ʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$b/ 'to get wet':

In accordance with what is illustrated in section 3, the representation of the initial geminate above reveals that a semi-syllable is linked neither to a foot nor a syllable, which consequently leads to the fatal violation of undominated constraints on syllable and foot binarity.[9] For this reason, it must be linked to the prosodic word (i.e., level-skipping); nevertheless, it fails to satisfy the SLH.

The question that should be addressed is how do the derivational word-initial geminates in verb pattern V conform to the OCP? The OCP violation in a particular morphological domain results from the linearization of the morphological tier by Tier Conflation (TC). Therefore, to avoid such an OCP violation, as discussed in section 2, it is crucial to delete the root node of the left matrix (i.e., the matrix to which the prefix /t-/ is linked). The deletion of the leftmost matrix results in the slot being filled by the root node of the contiguous coronal through spreading from right to left, as shown in the representations below:[10]:

The processes of deletion of the leftmost root node and then the spreading of the right root node yield a geminate sequence. Following the schematic representation in Fig. 16, two adjacent non-identical consonants with the same feature, which result from the TC, violate the OCP.

Vowel epenthesis, in this case, serves to avoid such an SLH violation. However, addressing this issue with vowel epenthesis is different, based on the site of vowel insertion. For example, internal vowel epenthesis helps to affiliate a semi-syllable to the syllable node, plus it does not violate the OCP since the members of an initial geminate belong to different morphemes, i.e., not within the same syllable; however, in the meantime, this site of vowel epenthesis is not preferable in Maltese due to geminate integrity. That is, as demonstrated in section 2, geminate integrity, according to Hayes (1986), Kenstowicz (1994), and Curtis (2003), holds when members of a geminate are not split by internal vowel epenthesis (Curtis, 2003; Hayes, 1986; Kenstowicz, 1994). On the other hand, peripheral vowel epenthesis [ɪ] (i.e., a prosthetic vowel) functionally helps to maintain conformity to the OCP and SLH without violation of geminate integrity, as shown in the representation below. This behavior is taken into consideration in the OT analysis later on (Figs. 17–21).

However, the OCP would be problematic when coping with tautosyllabic clusters of the forms /st-/, /str-/, /dr-/, and /ʃtr-/ in words from English origin, nonetheless, these clusters avoid the violation of SLH; hence, these clusters surface adjacent coronals, yielding the violation of OCP, as shown in the following representation of [strɔ:] *strɐw* 'straw' (from English origin).

The above problem is considered to be a challenge for OT, as a framework, since the OCP constraint is violated by the aforementioned clusters as well as prefixes plus stem-initial consonants, as heterosyllabic clusters, with adjacent coronals as discussed before. Therefore, the OCP should be specific to be against word-initial heterosyllabic clusters which surface adjacent coronals. To translate this into a constraint-based analysis, the OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$ constraint militates against word-initial heterosyllabic clusters which surface adjacent coronals unless if the members of these clusters are identical. This constraint is used for the OT analysis in the next subsection.

Unlike initial geminates in (11), initial geminates in non-Semitic verbs (i.e., from English and Italian) in (12) conform to the SLH since their members belong to the same morpheme. Furthermore, this type of initial gemination does not violate the OCP. However, since initial geminates are not tolerated in Maltese, as discussed earlier, prosthesis is utilized to avoid such a type

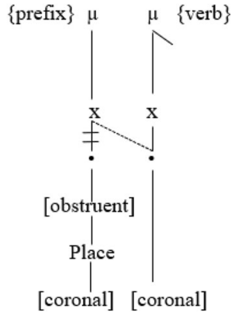

Fig. 17 The avoidance of the OCP violation (Watson, 2002:220). This representation shows how the OCP violation is avoided through the deletion of the leftmost matrix resulting in the slot being filled by the root node of the contiguous coronal through spreading from right to left.

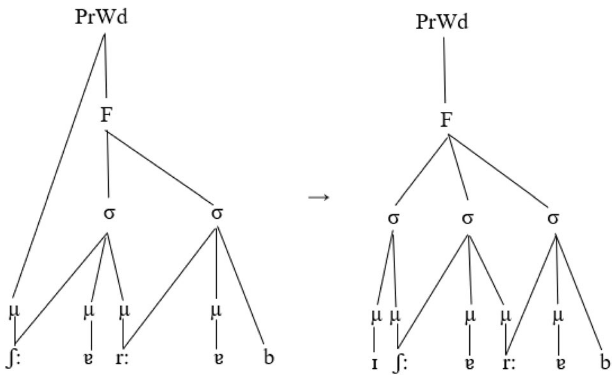

Fig. 18 The representation of /ʃ$^{\mu}$.ʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$b/→ [ɪ$^{\mu}$ʃ$^{\mu}$.ʃɐ$^{\mu}$r$^{\mu}$.rɐ$^{\mu}$b]. This representation shows how the violation of the SLH and the OCP is avoided by vowel prosthesis.

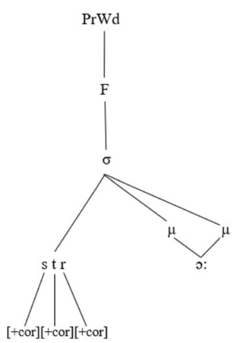

Fig. 19 The representation of [strɔ:] *strɐw* 'straw'. This representation shows the violation of the OCP through the initial tautosyllabic cluster /str-/ .

of initial gemination rather than the internal vowel epenthesis in order to concur with the OCP as well as geminate integrity. The avoidance of initial geminates in non-Semitic verbs in Maltese is accounted for using OT later on. Consider the following representation of/f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$/→[ɪ$^{\mu}$f$^{\mu}$.fɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$] 'to sign (Italian origin)':

By contrast, the representation below shows the violation of the OCP by internal vowel epenthesis in an initial geminate in a non-Semitic verb /f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$/ in Maltese:

After demonstrating the avoidance of initial geminations in Maltese that are found in Semitic and non-Semitic verbs, the next subsection is devoted to account for such avoidance using OT as a framework.

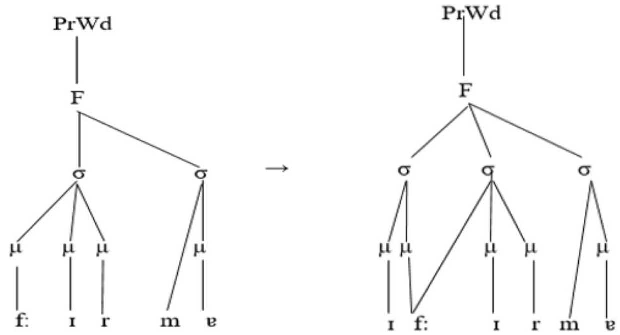

Fig. 20 The representation of /f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$/→[ɪ$^{\mu}$f$^{\mu}$.fɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$] 'to sign (Italian origin)'. This representation shows that vowel prosthesis serves to avoid the violation of the OCP when dealing with initial geminates of non-Semitic origins.

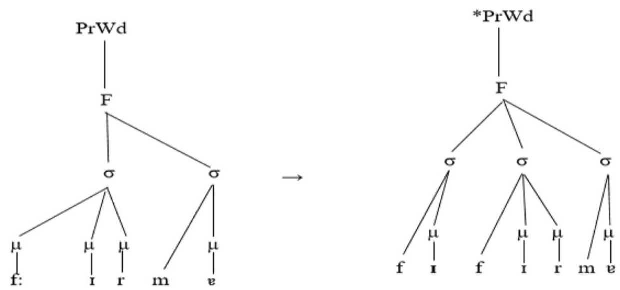

Fig. 21 The representation of /f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$/→ *[fɪ$^{\mu}$. fɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$]. This representation shows that the internal epenthesis incurs the violation of the OCP, coping with the initial geminates of non-Semitic origins.

The OT analysis of the avoidance of initial gemination in Maltese. Turning to the OT analysis, the following OT constraints are used to evaluate the candidates of the inputs /t-dɛ$^{\mu}$w$^{\mu}$·wɐ$^{\mu}$/→[ɪ$^{\mu}$d$^{\mu}$.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$] 'to be cured' and /s:$^{\mu}$ɔ$^{\mu}$l$^{\mu}$.vɐ$^{\mu}$/→[ɪ$^{\mu}$s$^{\mu}$.sɔ$^{\mu}$l$^{\mu}$.vɐ$^{\mu}$] 'to be solved' in the following tableaux. Consider the following OT constraints[11]:

(13) OT constraints:

---

a. OCP [+cor] $_{\text{Word-initial Heterosyllabic Clusters}}$
The [+coronal] members of word-initial heterosyllabic clusters are prohibited unless they are identical.
b. Strict Layer Hypothesis (SLH) (Kamran and Afsar, 2017:5)
Every component lower in the hierarchy is properly dominated by an element one level higher.
c. MAX (McCarthy and Prince, 1995)
Every segment of the input has a correspondent in the output (no deletion).
d. DEP (McCarthy and Prince, 1995)
Every segment of S_2 has a correspondent in S_1 (S_2 is "dependent on" S_1). (No epenthesis).
e. *GEM (Rose, 2000)
Assign a violation mark for every geminate.

The following set of ranking constraints is applied in the following tableau to evaluate the candidates of the input /t-dɛ$^{\mu}$w$^{\mu}$·wɐ$^{\mu}$/ 'to be cured' in the tableau below:

(14) OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$≫SLH≫ MAX, DEP≫*GEM

With regard to the set of ranking constraints above, OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$ is the most highly-ranked constraint to eliminate candidates with word-initial heterosyllabic clusters which surface adjacent [+cor], unless of the members of these clusters are identical. SLH is the second highly-ranked constraint which demands correspondence with the levels of the prosodic hierarchy. In other words, this constraint is against candidates with segments that are unaffiliated to the syllable node. MAX is the third highly-ranked constraint which is against any sort of deletion. DEP, as another faithfulness constraint, outranks *GEM to eliminate candidates with vowel epenthesis or consonant epenthesis. *GEM is the least ranked constraint since Maltese permits medial and final geminates. Consider the evaluation of candidates of the input /t-dɛ$^{\mu}$w$^{\mu}$·wɐ$^{\mu}$/ 'to be cured' in the following tableau.

Tableau (IV) Evaluating the Candidates of the Input /t-dɛ$^{\mu}$w$^{\mu}$·wɐ$^{\mu}$/ 'to be cured'

OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$ ≫SLH≫ MAX≫ DEP≫*GEM

/t-dɛ$^{\mu}$w$^{\mu}$·wɐ$^{\mu}$/	OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$	SLH	MAX	DEP	*GEM
a. t.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$	*!	*			*
b. d$^{\mu}$.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$		*!			**
c. ☹ tɪ$^{\mu}$.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$				*	*
d. ɪ$^{\mu}$d$^{\mu}$.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$				*	**!
e. dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$			*!		*

Candidates (a), (b), and (e) in tableau (6) fail to be optimal due to the fatal violation of OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$, SLH, and MAX ; hence, candidate (a), as the most faithful output to the input, fatally violates OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$ plus it violates SLH while candidate (b) satisfies OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$ through the regressive assimilation that targets the prefix /t-/. However, this process incurs the violation of SLH because it results in the initial semi-syllable, which is unaffiliated with the syllable node. Candidate (e) permits the deletion of the prefix /t-/ to avoid the violation of both OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$ and SLH, while the deletion of the aforementioned prefix leads to the fatal violation of MAX. Candidates (c) and (d) equally violate DEP, whereas the least violation of *GEM leads to determine candidate (c), as the wrong output, to be chosen as optimal, compared to candidate (d) as the desired output.[12] Considering the site of vowel epenthesis in candidates (c) and (d), internal vowel epenthesis is found in candidates (c) and (e) while a prosthetic vowel is available in candidate (d). Based on this observation, the following constraint is posited against internal vowel epenthesis:

(15) O-CONTIG (CONTIGUITY-IO) (McCarthy and Prince, 1995): The portion of S2 standing in correspondence forms a contiguous string. ('No Internal Insertion')

The above constraint outranks DEP in the following tableau to eliminate candidate (c) with internal vowel epenthesis.

Tableau (V) Evaluating the Candidates of the Input /t-dɛ$^{\mu}$w$^{\mu}$·wɐ$^{\mu}$/ 'to be cured'

OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$ ≫SLH≫ MAX≫ O-CONTIG≫ DEP≫*GEM

/t-dɛ$^{\mu}$w$^{\mu}$·wɐ$^{\mu}$/	OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$	SLH	MAX	O-CONTIG	DEP	*GEM
a. t.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$	*!	*				*
b. d$^{\mu}$.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$		*!				**
c. tɪ$^{\mu}$.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$				*!	*	*
d. ☞ ɪ$^{\mu}$d$^{\mu}$.dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$					*	**
e. dɛ$^{\mu}$w$^{\mu}$.wɐ$^{\mu}$			*!			*

The tableau above successfully determines candidate (d) as optimal through the satisfaction of the O-CONTIG constraint, which is, however, prone to violation by candidate (c). The next tableau is to evaluate the candidates of the input /f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$/ 'to sign':

Tableau (VI) Evaluating the candidates of the input /f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$/ 'to sign'

OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$ ≫SLH≫ MAX≫ O-CONTIG≫ DEP≫*GEM

/f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$/	OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$	SLH	MAX	O-CONTIG	DEP	*GEM
a. ☹ f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$						*
b. fɪ$^{\mu}$. fɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$				*!		
c. ɪ$^{\mu}$f$^{\mu}$.fɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$					*!	*
d. fɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$			*!			

The tableau above identifies candidate (a), the wrong output, as optimal, while the rest of the candidates fail to be optimal due to the violation of MAX, O-CONTIG, and DEP. To determine candidate (c) as optimal, we posit the following constraint against an initial gemination found in candidate (a):

(16) *Initial GEM:

Initial geminates are banned.

The above constraint outranks DEP to eliminate candidate (a) as seen in the following tableau:

Tableau (VII) Evaluating the candidates of the input /f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$/ 'to sign'

OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$≫SLH≫MAX≫O-CONTIG≫*Initial GEM ≫DEP≫*GEM

/f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$/	OCP [+cor] $_{\text{Word-initial Heterosyllabic Cluster}}$	SLH	MAX	O-CONTIG	*Initial GEM	DEP	*GEM
a. f: $^{\mu}$ɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$					*!		*
b. fɪ$^{\mu}$. fɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$				*!			
c. ☞ ɪ$^{\mu}$f$^{\mu}$.fɪ$^{\mu}$r$^{\mu}$. mɐ$^{\mu}$						*	*
d. fɪ$^{\mu}$r$^{\mu}$.mɐ$^{\mu}$			*!				

The initial geminate in candidate (a) incurs the violation of *Initial GEM, which is why the same candidate fails to be optimal. On the other hand, the internal vowel epenthesis in candidate (b) avoids the violation of *Initial GEM through the internal epenthesis, which consequently incurs the violation of O-CONTIG. Candidate (d) leads to degemination to conform to *Initial GEM, but it violates MAX. Therefore, the same tableau identifies the candidate (c), i.e., the desired output, as optimal.

To summarize, this section scrutinizes the conformity to the OCP and the SLH of the avoidance of initial geminates in Maltese within OT as an analytical framework. In Semitic Maltese verbs of pattern V as well as Semitic and non-Semitic nouns, the initial gemination stems from the assimilation of the prefixes with the [+coronal] place feature to following stem-initial consonants with the same feature. The purpose of this process is to abide by the OCP. This type of gemination, which is certainly derivational, is in conflict with the SLH due to the first half of the initial geminate, as a semi-syllable, being directly linked to the prosodic word rather than the syllable node: Both members of the initial geminate in this case belong to different morphemes. To conform to the SLH, the internal epenthetic vowel [ɪ] can be employed to assure the affiliation of the peripheral member of the initial geminate to the syllable node. Although this type of epenthetic vowel does not violate the OCP since the members of the initial geminate belong to different morphemes, it is disfavored in Maltese because of geminate integrity. Therefore, the prosthetic vowel [ɪ] serves to affiliate an initial semi-syllable to the syllable node and to maintain geminate integrity. On the other hand, initial geminates in non-Semitic verbs, as lexical geminates, concur with the SLH since their members belong to the same morpheme, and there is no initial semi-syllable. Internal vowel epenthesis, in this case, violates the OCP as well as geminate integrity. Therefore, a vowel prosthesis is used to avoid initial gemination and to conform to the OCP. OT has been shown here to be a framework capable of accounting for phenomena peculiar to the avoidance of initial gemination in Maltese.

Conclusion

This research has addressed conformity to the OCP and SLH in Maltese with a focus on initial gemination in Semitic verbs of pattern V as well as initial gemination in non-Semitic verbs. The initial gemination in Semitic verbs of pattern V is derived from the assimilation of prefixes with the [+coronal] feature to the following stem-initial consonants having the same feature in order to avoid OCP violation. Consequently, the first member of an initial geminate, in this case, is assigned as an initial semi-syllable affiliated to the prosodic word rather than the syllable node, violating the SLH. Internal vowel epenthesis can possibly assure conformity to the OCP and SLH since it helps to affiliate an initial semi-syllable to the syllable node, and splitting of the members of initial geminates in this case, which belongs to different morphemes, incurs no violation of the OCP. However, this type of vowel epenthesis is disfavored in Maltese due to geminate integrity. Therefore, vowel prosthesis is used for the same purpose as well as maintaining geminate integrity. Internal vowel epenthesis, in this case, violates the OCP as well as geminate integrity. For this reason, vowel prosthesis serves to ensure conformity to the OCP plus maintenance of geminate integrity. These phenomena have been analyzed using OT as a framework that has been shown to be capable of accounting for these phenomena in Maltese. The findings of this research open the door to examine segmental and suprasegmental structures in Maltese in light of OT and their relationship to other languages such as Arabic, English, and Italian. The segmental structure is represented by the features of segments, while the suprasegmental structure is represented by the syllable and its internal structure, mora, and foot.

Data availability

The data sources used in this study are available: Zenodo (https://doi.org/10.5281/zenodo.1181789); Kölner Universitäts Publikations Server (http://kups.ub.uni-koeln.de/id/eprint/6934).

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Notes

1 Galea (2016:14) refers to Azzopardi's (1981) analysis of diphthongs in Maltese to present the table of diphthongs in this language along with examples.
2 Moraic Theory is used for the entire representations in this paper since it prevails over other theories through distinguishing between light and heavy syllables. For further information about the other advantages of Moraic Theory over other theories, see Hyman (1985).
3 Note that a colon after a consonant represents a geminate. PrWd stands for Prosodic Word and F stands for a foot.
4 Selkirk (1984) and Nespor and Vogel (1986) agree that the prosodic hierarchy is a theory in which words and phrases may be parsed into prosodic constituents that form the domains of rule application.
5 Al-Mohanna (1998) attributed to -COD constraint which is known as NO-CODA by Kager (2010:94).
6 This tableau is cited from Alqahtani (2014:55).
7 Tableaux are cited from Rakhieh (2009:21).
8 Those native speakers are with no linguistic background.
9 The constraint here is on the syllable weight, which must not be trimoraic, i.e., a syllable with three morae, and on the foot size that should be bounded (binary). In other words, the binary (bounded) foot contains at most two syllables.
10 These schematic representations are adapted from Watson (2002: 220).
11 Kamran and Afsar (2017) attributed to Selkirk's (1984) reference to introduce SLH as a constraint in OT.
12 The sad emoticon, i.e., ☹, represents the wrong output that has been chosen as optimal.

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