Pharyngeal related non-lexical vowels in Sephardic Modern Hebrew[*]

Itsik Pariente
ACLC,
University of Amsterdam

This paper examines non-lexical vowels in Sephardic Modern Hebrew. It is argued that two kinds of vowel, which are triggered by the pharyngeal consonants, should be identified: (a) true epenthetic vowels that emerge on the surface to repair illicit (marked) syllable structures. (b) "Echo-vowels" that are created by overlapping a vowel and a pharyngeal consonant. These vowels do not repair illicit syllable structures, but rather ease the perception of clusters containing a pharyngeal. These vowels are not syllabic and phonological processes ignore them.

1. Introduction

In this paper, I examine non-lexical vowels in Sephardic Modern Hebrew (henceforth SMH). The notion of non-lexical vowels refers to vowels that appear at the surface level, but are not present in the lexicon. The non-lexical vowels that will be examined here are triggered by the pharyngeal consonants. The general properties of the two different groups are summarized in (1) (for a comprehensive comparison between the two groups see Hall 2003 §3).

(1) **Non-lexical vowel properties**

Property / Vowel type	Environment	Purpose	Quality	Syllabicity
Epenthetic vowels	Marked	Repair marked structures	Not copied (default)	Syllabic
Echo vowels	Unmarked	Ease perception of consonant clusters	Copied from the preceding vowel	Non-syllabic

The pharyngeal consonants (/ħ/ and /ʕ/) are marked and rare in the world's languages. In many languages, they trigger various phonological processes. In SMH, they trigger epenthesis, echo-vowels and vowel lowering. Analyses will be laid out in the framework of Optimality Theory (OT), Prince and Smolensky (1993/2004).

The paper is organized as follows: Section 2 gives the relevant language background. Section 3 describes and analyzes pharyngeal triggered epenthesis. Section 4 describes and analyzes pharyngeal triggered echo-vowels and section 5 compares both kinds of vowel, followed by conclusions.

2.   Language Background

This study is based on data from SMH, spoken by native speakers living in Israel. Hebrew today has two different dialects with almost identical grammars. In the revival of the language, people who spoke Arabic as a first language had no problem articulating the historical pharyngeals, whereas people who spoke European languages (mostly Yiddish and Russian) could not articulate pharyngeals. The descendants of the first group speak Sephardic Modern Hebrew, and the descendants of the second group speak General Modern Hebrew.[1]

The only difference between the general dialect and SMH is the existence of pharyngeal consonants in SMH. The dominant dialect in Israel is the general dialect. SMH is used in areas that are populated mostly by speakers of Sephardic descent.[2] The consonant inventory of SMH is as follows:

(2) The consonants of Sephardic Modern Hebrew

	Bilabial	Labio-dental	Alveolar	Palato-Alveolar	Palatal	Velar	Uvular	Pharyngeal (only in SMH)
Stop	p b		t d			k g		
Fricative		f v	s z	ʃ ʒ		x		ħ ʕ
Affricate			ts	tʃ dʒ				
Nasal	m		n					
Liquids			l				ʁ	
Glides					j			

Both dialects of Hebrew have five phonemic vowels. ATR is non-contrastive in Hebrew (Laufer 1990).

(3) The vowels in Sephardic Modern Hebrew

	Front	Back
High	i	u
Mid	e	o
Low		a

2.1 Root and Pattern Morphology

One approach to Semitic morphology (McCarthy 1979, 1981) is the *root-and-pattern* morphology (R&P). This view assumes a distinction between consonantal roots and vocalic templates. Stems are formed by the interdigitation of the consonantal root and the vocalic pattern (Nonconcatenative Morphology). The consonantal root encodes the core semantic properties, while the vocalic template encodes aspect, mood, voice and other grammatical properties.

Bat El (2003) offers a different approach which is surface-based, while eliminating the consonantal root from the grammar, using stems and words as the base for derivation, a point which is highly controversial in the literature (see Shimron 2003). This debate is outside the scope of this paper and while I will be adopting elements of Bat El's surface based approach, I will nevertheless assume the existence of the consonantal root as a morphological unit. The root usually consists of three consonants that appear in a fixed order.

Another layer in the structure of R&P words is the Prosodic Structure. The prosodic structure is derived by specific language ranking of universal prosodic constraints. According to this approach, the prosodic structure is **not** an abstract structure, but rather the result of the interaction among prosodic constraints. For example, Bat El argues that FOOTBINARITY and WORDMIN are responsible for disyllabic stems in the Hebrew verb system. The prosodic structure governs the interdigitation of the root consonants and the VP, which determines the syllabic structure of the stem.

VPs are the morphemes that determine the quality and the order of the conjugation vowels and are viewed by Bat El as constraints (as she views all morphemes as constraints). The VP and the prosodic structure form the *conjugation* (in Hebrew terminology the vocalic template for verbs is called a *binyan* (B), and for nouns, a *mishkal*). Some conjugations are accompanied by an affix.

The following table gives the verbal paradigms of some consonantal roots. The verbs are given in the third person singular form.

(4) Root and template paradigms

root \\ template	{p,g,ʃ}	{k,t,v}	{ʃ,t,k}
B1 CaCáC	*pagáʃ* 'bump into'	*katáv* 'write'	*ʃaták* 'be quiet'
B2 niCCáC	*nifgáʃ* 'meet'	*nixtáv* 'be written'	------------------
B3 iCCíC	*ifgíʃ* 'to bring together'	*ixtív* 'dictate'	*iʃtík* 'silence'
B4 CiCéC	----------------------	-----------------	*ʃiték* 'paralyze'
B5 itCaCéC	----------------------	*itkatév* 'correspond'	*iʃtaték* 'become silent'
miCCáC	*mifgáʃ* 'meeting'	*mixtáv* 'letter'	------------------
taCCíC	---------------------	*taxtív* 'dictate'	------------------

2.2 The Metrical System of Hebrew

Since pharyngeal echo vowels and epenthesis are interconnected with the metrical system of the language, I will briefly review the metrical system in this section.

Hebrew is a quantity insensitive language with final default stress According to Hayes (1995: 101), quantity insensitive languages are usually trochaic; however, final stress does not characterize trochaic languages (Graf 1999). Two competing analyses arise in light of Hayes' view. (a) The Hebrew stress system consists of binary strong feet (enclosed in square brackets), either iambic or trochaic ([*yéled*], [*gináv*]) (for example, Bolozky 1982, Graf and Ussishkin 2003, Bat El 2005). (b) Hebrew stress consists of trochaic feet, either binary or unary ([*yéled*], ga[*náv*]) (for example, Becker 2003).[3] I adopt here Pariente and Bolozky's (in preparation) trochaic analysis of Hebrew which claims that the accentual system of Modern Hebrew is best analyzed as consisting of trochaic feet, based on the behavior of loan words and certain stress shifts in the language.

(5) Stress related constraints
a. FTBIN (FOOT BINARITY)
     Feet are binary
b. IDENTSTRESS
     The output syllable corresponding to the input's stressed syllable is stressed [IDENTSTRESS can be active only in the presence of lexical stress and it plays no role in the absence if it.]
c. ALIGNR(Ft, PrWd)
     The right edge of the foot aligns with the right edge of the prosodic word
d. FINALSTRESS
     The final syllable in the prosodic word is stressed
e. TROCHEE
     The leftmost unit in the foot is prominent

The ranking of stress related constraints is given in (6):

(6) TROCHEE, IDENTSTRESS >> ALIGNR(Ft, PrWd), FINALSTRESS >> FTBIN

In the current analysis, that is based on (though not identical to) Becker 2003, TROCHEE is undominated so all feet are trochaic (binary or unary). In this type of analysis, TROCHEE must outrank FTBIN.

3.   Epenthesis

Epenthesis is one type of phonological process that repairs illicit clusters in the grammar of a language. In SMH, pharyngeal triggered epenthesis takes place in two cases: after a final voiced pharyngeal in order to convert the consonant from coda to onset position (3.1.). Before a final voiceless pharyngeal if the consonant is preceded by a non-low vowel (3.2.). In both cases, epenthesis repairs a marked structure and as I will show, the epenthetic vowels are not ignored by the phonology of the language.

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[3] Secondary stress in Hebrew is discussed in most of the generative literature on stress in Hebrew, beginning with Bolozky (1982), where it is described as appearing on every other syllable to left of the primary stress. However, Becker (2003) finds no acoustic evidence for secondary stress either by pitch or by vowel length. In the following example, Becker identified only one point of high pitch and one long vowel: *hagamadoním* 'the little dwarfs'.

3.1. Coda Prohibition Epenthesis

In SMH, both the voiced and the voiceless pharyngeal can appear freely in an onset position, and in word medial coda position. However, only voiceless pharyngeals can appear in word final coda position.[4] Consider the data in (7) (a dot indicates a syllable boundary). Examples are in the same vocalic templates.

(7) No ʕ in final coda position
ma.nó.ʕ**a** 'motor' cf. ma.nóf 'crane'
lóʕ**a** 'throat' cf. ʃót 'whip'
ja.nú.ʕ**a** 'he will move' cf. jakúm 'he will get up'
titparéʕ**a** 'she will misbehave' cf. titkadém 'she will advance'

The following constraint formulates this coda prohibition:

(8) Constraint on coda prohibition.
*ʕ]$_\sigma$
No ʕ in a coda position.

Since word medial codas are permitted in the language, *ʕ]$_\sigma$ must be ranked below DEP and MAX. This ranking is given in the following tableau.

(9) Medial coda evaluation

/miʕmad/	MAX	DEP	*ʕ]$_\sigma$
a. mi.mad	*!		
b. mi.ʕa.mad		*!	
☞c. maʕ^a.mad			*

In tableau (9), the winning candidate does not delete the pharyngeal or epenthesize a vowel before it (the vowel that appears before it is an echo vowel which is not the result of epenthesis (§4.)). This ranking however gives the wrong output for ʕ in final position.

(10) Wrong prediction of ʕ in final position

/paʁuʕ/	MAX	DEP	*ʕ]$_\sigma$
a. pa.ʁu	*!		
☞b. pa.ʁu.ʕa		*!	
☛c. pa.ʁuʕ			*

The black hand indicates the winning candidate which, in fact, is not the correct output, as opposed to a white hand which indicates the candidate which is the correct output. In tableau (10), the winning candidate is (c) which violates the low ranking constraint *ʕ]$_\sigma$. The actual output in the language is (b) with an epenthetic vowel after the pharyngeal. This vowel syllabifies the pharyngeal in an onset position to avoid a violation of the coda prohibition constraint. This outcome suggests the ranking of *ʕ]$_\sigma$

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[4] Epenthesis is blocked when the pharyngeal is preceded by *a* (an OCP effect), however, it is not relevant to the current issue (see Pariente 2006).

above DEP. However such ranking is not possible due to the lack of epenthesis in medial positions.

I argue that this paradox is a case of gang effects (Keller (2006), Jäger and Rosenbach (2006), Farris-Trimble (2008) among many others). A gang effect refers to cases where two violable lower-ranked constraints gang up against a higher-ranked constraint in order to rule out a candidate that violates both of them. This results in the winning of another candidate that violates the higher-ranked constraint only once.

I argue that SMH exhibits a combined markedness effect, and that foot structure is responsible for the difference between the behavior of medial and final codas. The ranking paradox presented is the outcome of the combined forces of the markedness constraint *ʕ]$_\sigma$ and the markedness constraint FTBIN (FOOT BINARITY).

Within OT, a mechanism for gang effect was proposed by Smolensky (1995) using local conjunction (LC). In LC, two constraints can be combined; a combined constraint is violated only by candidates that violate both combining constraints. The combined constraint is ranked above its combining constraints. The tableau below shows the ranking of DEP with respect to *ʕ]$_\sigma$ and FTBIN.

(11) Ranking of DEP, *ʕ]$_\sigma$ and FTBIN.

/paʁuʕ/	DEP	*ʕ]$_\sigma$	FTBIN
☞a. pa[ʁú.ʕa̠]	*!		
☛b. pa[ʁúʕ]		*	*

DEP outranks each of the constraints individually, and candidate (a) is ruled out by DEP. The winning candidate (b) violates *ʕ]$_\sigma$ and FTBIN. However if DEP is ranked below the combined constraint *ʕ]$_\sigma$&FTBIN ('no ʕ in coda position' and 'feet are binary') candidate (a) will win:

(12) Ranking of DEP and *ʕ]$_\sigma$&FTBIN.

/paʁuʕ/	*ʕ]$_\sigma$&FTBIN	DEP	*ʕ]$_\sigma$	FTBIN
☞a. pa[ʁú.ʕa̠]		*		
b. pa[ʁúʕ]	*!		*	*

Candidate (b) is ruled out because it violates the combined constraint. The outcome is an epenthetic vowel before a final voiced pharyngeal consonant creating an additional syllable and inverting the pharyngeal into an onset in stressed syllables only. Final ranking and evaluation of medial and final codas is given in (13) and (14).

(13) Evaluation of medial coda

/miʕmad/	MAX	TROCHEE	*ʕ]$_\sigma$&FTBIN	DEP	*ʕ]$_\sigma$	FTBIN
a. mi[mád]	*!					*
b. mi.ʕa[mád]				*!		*
☞c. ma[ʕᵃmád]					*	*
d. mi[ʕa̠mád]		*!		*		

(14) Evaluation of final coda

/paʁuʕ/	MAX	TROCHEE	*ʕ]σ&FTBIN	DEP	*ʕ]σ	FTBIN
a. pa[ʁú]	*!					*
b. pa[ʁúʕ]			*!		*	*
☞c. pa[ʁú.ʕa̲]				*		
d. [pa.ʁúʕ]		*!				

In tableau (13), candidate (a) is disqualified by MAX since the pharyngeal is deleted from the output. In candidate (b), a vowel is inserted to syllabify the pharyngeal to an onset position; however, it is disqualified by the high ranking constraint DEP. The winning candidate (c) is the faithful one (with regard to coda condition). The pharyngeal is syllabified as a coda even though it violates the low-ranked constraint *ʕ]σ. The vowel that is produced between the pharyngeal and the following consonant is not syllabic and thus does not change the syllable structure. Such echo-vowels are called 'Intrusive Vowels' and they are the result of gestural overlapping. This phenomenon will be addressed in section 4., and evidence for the non-syllabic nature of these vowels will be given.

Candidate (a), (b) and (c) all violate FTBIN. Candidate (d), on the other hand, epenthesizes a vowel after the pharyngeal to syllabify it as an onset, thus creating a binary foot. However, this foot is iambic and the candidate is ruled out by TROCHEE. Since the pharyngeal was not in a stressed syllable, we did not see the effect of *ʕ]σ&FTBIN.

In tableau (14), however, the pharyngeal is in a stressed syllable. The high ranking constraint *ʕ]σ&FTBIN disqualifies the faithful candidate (b). Candidate (a), which deletes the pharyngeal, is disqualified by MAX. Candidate (d) is disqualified by TROCHEE. The winning candidate is (c), in which an epenthetic vowel is inserted to syllabify the pharyngeal into an onset position.

3.2. Epenthesis to Prevent Adjacent Non-Low Vowels and Pharyngeals

One of the most well-known properties of the pharyngeals is their preference to appear next to a low vowel (McCarthy 1994). Phonetic studies on pharyngeals (Delattre 1971, Perkell 1971 among many others) show that low vowels involve some pharyngeal constriction, with concomitant acoustic similarities between the vowel [a] and the pharyngeals (high F_1).

SMH exhibits a variety of behaviors with regard to this prohibition. SMH deals with this demand in several ways depending on the nature of the pharyngeal, the syllabic position of the pharyngeal (onset or coda), the metrical position of the pharyngeal (stressed syllable vs. unstressed syllable) and the morphological system (nouns vs. verbs).

SMH permits pharyngeals to appear after a non-low vowel, if the non-low vowel and the pharyngeal are not syllabified into the same syllable, i.e. the pharyngeal is in an onset position. However, when pharyngeals are in a coda position, various processes take place (only epenthesis is relevant here, see Pariente 2006 for additional details).

If ħ appears after a stressed non-low vowel, [a] is inserted between the non-

low vowel and ħ (ʕ after a stressed vowel is not attested in the dialect).[5]

> (15) ħ after a stressed non-low vowel in the noun system
> ʃatíaħ 'carpet' cf. ʃatíl 'seedling'
> móaħ cf. 'brain' ʃót 'whip'
> ivtíaħ 'he promised' cf. itħil 'he began'
> imlíaħ 'he salted' cf. itħíl 'he began'

Within OT, the preference of low vowels in the environment of pharyngeals can be formulated by context sensitive markedness constraints. The prohibition on non-low vowels and pharyngeals is encoded in the constraint in (16).

> (16) $*V_{-low}$PHARYNGEAL$]_\sigma$[6] - 'non-low vowels before a pharyngeal are forbidden within the syllable'.

SMH prohibits non-low vowels from preceding pharyngeals. To solve such a situation, SMH implements different strategies depending on the status of the vowel preceding the pharyngeal: If the vowel is not stressed, it is lowered to [a] in the noun system and to [e] in the verb system (Pariente 2006). If the vowel is stressed, it does not change, however, epenthesis of the low vowel [a] occurs if the pharyngeal is the voiceless ħ (15). The voiced ʕ never appears after a stressed vowel (see footnote 5). Since epenthesis of [a] occurs, $*V_{-low}$PHARYNGEAL$]_\sigma$ and MAX must outrank DEP. This ranking is demonstrated in the tableau below:

(17) Epenthesis after a stressed vowel

/tapuħ/	$*V_{-low}$PHARYNGEAL$]_\sigma$	MAX	DEP
a. tapúħ	*!		
b. tapú		*!	
☞ c. tapúaħ			*

In tableau (17), the underlying form /tapuħ/contains a high vowel before a pharyngeal. The faithful candidate (a) is ruled out by $*V_{+high}$PHARYNGEAL$]_\sigma$ that militates against high vowels before ħ in the same syllable. In candidate (b), the pharyngeal is deleted to avoid the proximity of the high vowel to it, however, it is ruled out by the high ranking constraint MAX. In the winning candidate (c), a low vowel is inserted between ħ and the high vowel violating DEP.[7]

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[5] ʕ does not appear after a stressed vowel in the noun system since an epenthetic vowel is inserted to syllabify the ʕ into an onset position (see section 3.1.).
ʃavú.ʕa 'week' cf. tap.úz 'orange'
.ló.ʕa 'pharynx, throat, maw' cf. ʃót 'whip'
if.tí.ʕa 'he surprised' vs. it.ħil 'he began'.
[6] As Pariente (2006) observes, the prohibition on the proximity of non-low vowels to pharyngeals is hierarchical i.e. the prohibition in the domain of the syllable is a stronger prohibition than the general prohibition on the proximity of non-low vowels to pharyngeals. This distinction is not relevant for this discussion.
[7] For simplicity reasons, this tableau ignores candidates in which the stressed high vowel is lowered. Such lowering of stressed vowels does not occur. This is a case of positional blocking of a phonological process due to the positional privilege of

At this point, I would like to summarize the properties of the epenthetic vowels presented in 3.1. and 3.2. These vowels have to be syllabic, i.e. to create a syllable, since as shown in 3.1. they are parsed into feet, and feet in MH consist of syllables (Graf and Ussishkin 2003, Bat El 2005).

The default epenthetic vowel in SMH is [e] suggesting that [e] is the unmarked vowel in Hebrew (see Kitto and De Lacy 1999 for a discussion on the quality of epenthetic vowels). The quality of the vowels in (7) and (15), however, is always [a]. Appearance of low vowels before pharyngeals is a case of *The Emergence of the Unmarked* phenomenon (McCarthy & Prince 1994). In SMH, all vowels (including high vowels) can appear after a pharyngeal (e.g. ʕiʁ 'city'. ʕod 'more', ħof 'beach') and no lowering takes place, i.e. the faithfulness constraint IDENT [high/low] ('the value of the feature(s) high/low in the input is identical to their value in the output') must outrank the constraint militating for lowering high vowels after pharyngeals (*PHARYNGEALV$_{-low}$ 'non-low vowels after a pharyngeal are forbidden'). However, when epenthesis takes place, the vowel that emerges is [a] and not [e] due to the impact of *PHARYNGEALV$_{-low}$ that can manifest since no faithfulness relations to the input of the vowel quality are active in epenthesis.

4.   Vowel intrusion

This section describes and analyzes vowel intrusion (henceforth VI) in SMH. The term VI was coined by Hall (2003) and it refers to cases where a vowel emerges between two consonants, but the phonology of the language ignores it. Such vowels do not add a syllable to the word.

Within generative phonology, Steriade (1990) was the first to analyze this phenomenon as the result of overlapping. Steriade argues that these vowels are the result of gestures overlapping one another. The vowel is an audible acoustic release that results from overlapping vowels. A comparison of default and copied epenthetic vowels can also be found in Kitto and De Lacy (1999).

VI happens in consonant clusters that contain a sonorant (including gutturals). The vowel that is adjacent to the sonorant is always the vowel that overlaps this sonorant. Hall's analysis differs from Steriade's in a crucial point; while Steriade views these vowels as segmental and syllabic, Hall argues that intrusive vowels are not segments and behave unlike true epenthetic vowels.

Hall shows that syllable-related phonological processes, such as stress assignment, templatic reduplication, syncope, licensing of segmental contrasts, ablaut, and language games, ignore them. The data from SMH supports Hall's view.
The following list of properties characterizes vowel intrusion (Hall 2006 p.391.):

(18) Vowel intrusion properties
a. The vowel's quality is either schwa, a copy of a nearby vowel or influenced by the place of the surrounding consonants.
b. If the vowel copies the quality of another vowel over an intervening consonant, that consonant is a sonorant or guttural.
c. The vowel generally occurs in heterorganic clusters.

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stressed syllables (Beckman 1998). Stressed vowels fail to undergo a process which unstressed vowels are targeted for.

d. The vowel is likely to be optional, have a highly variable duration or disappear at fast speech rates.

e. The vowel does not seem to have the function of repairing illicit structures. The consonant clusters in which the vowel occurs may be less marked, in terms of sonority sequencing, than clusters which surface without vowel insertion in the same language.

Intrusive vowels do not only act differently from epenthetic vowels, they also have a different purpose; according to Hall (2006 p.407): "Vowel intrusion is driven by the need to make consonants in clusters perceptible. Epenthesis, on the other hand, is a way of repairing syllables that violate a language's abstract structural rules".

In SMH, only the voiced pharyngeal ʕ triggers vowel intrusion:

(19) SMH vowel intrusion
Nouns: taʕ**a**nit 'fast' cf. tafnit 'turn about'
maʕ**a**mad 'status' cf. migdal 'tower'
Verbs: eʕ**e**niʃ 'he punished' cf. iklit 'he recorded'
neʕ**e**daʁ 'he is/was missing' cf. niʃdad 'he is/was robbed'

4.1.   An Argument for a Copied Vowel Analysis: The Quality of the Vowel

In SMH, some phonotactic restrictions trigger vowel epenthesis due to the ranking of markedness constraints such as the OCP above DEP-V.

(20) SMH epenthesis
ʃal**e**la 'she revoked' cf. katva 'she wrote'
ʃ**e**zifim 'plums' cf. pʁitim 'items'

In the absence of pharyngeals, the default epenthetic vowel in SMH is [e]. However when epenthesis takes place after a pharyngeal, the epenthetic vowel is [a] rather than [e] (consider the data in (7) and (15) where [a] is inserted to prevent ʕ from syllabifying in a final coda position and to prevent the adjacency of ħ and non-low vowels respectively).

When epenthesis takes place in pharyngeal environments, [a] emerges due to TETU. The vowels that appear within ʕC clusters in (19), however, are not necessarily [a] as would be expected had they been epenthetic. The vowels that do appear are identical to the vowel preceding the pharyngeal, indicating that they are not true epenthetic vowels but rather copied vowels.

4.2.   The Analysis

The analysis is based on Hall (2003) and is adopted (and somewhat reduced) to suit SMH facts. Hall's (2003) analysis uses the theory of Articulatory Phonology (Browman & Goldstein 1986, 1992a, 1992b, 1995, Byrd 1996, Gafos 2002 among others).[8] Articulatory Phonology is a theory that organizes speech by using abstract gestures. Gestures are instructions to articulators to reach a particular constriction in the vocal tract like opening/closing the glottis. Hall develops a theory called Timing-

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[8] The relevant components of the theory are given very briefly. For more details see the literature mention in this section.

Augmented Surface Phonology (TASP) that organizes alignment of neighboring gestures. Each gesture begins with the onset of movement, then progresses to reach the target and then continues to the release and finally to the offset. The offset indicates that the articulator has completed the gestural command. When an articulator finishes the movement, it can move back to its resting point or it can receive an order of another gesture and start moving towards the next target.

(21) Landmarks in a gestural cycle (Gafos 2002:271).
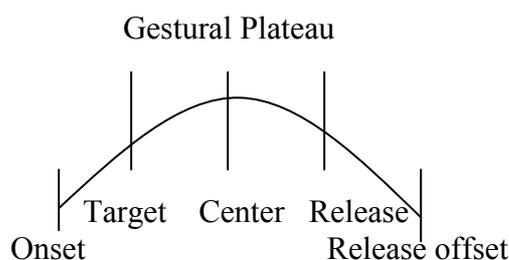
Gestural Plateau

Movement of the articulator in space is represented on the vertical axis, while the horizontal axis represents time. The middle of the gesture is called a 'gestural plateau'; it is the period when the constriction is actively held. In the middle of the gestural plateau is the C-center.

Though gestures are parsed below the segment like phonological features, there is one important difference between gestures and features: while features fall into a linear order, gestures do not; gestures can **overlap** one another.

Since gestures are on a somewhat different hierarchical level, their organization in OT grammar has to be explained with a new type of markedness constraint. Hall (2003) adopts Gafos' theory of gestural coordination. According to this theory, gestures are subject to independent alignment constraints (McCarthy & Prince 1993) that maximize perceptual cues in consonant clusters and avoid types of gestural overlap that are marked perceptually or articulatorily.

(22) The basic form of the constraints (Gafos 2002):
ALIGN (G_1, LANDMARK$_1$, G_2, LANDMARK$_2$)
Align landmark$_1$ of gesture$_1$ with landmark$_2$ of gesture$_2$.

The constraints that are relevant to SMH are given below:
(23) ALIGN (C_1, CENTER, C_2, ONSET) (Gafos 2002)
'In a C_1 C_2 sequence, the center of C_1 is aligned with the onset of C_2'.
This constraint militates for some acoustic release between CC clusters.

(24) ALIGN (C_1, RELEASE, C_2, TARGET) (Gafos 2002)
'In a C_1 C_2 sequence, the release of C_1 is aligned with the target of C_2'. (No acoustic release between CC clusters even in heterorganic clusters).

These two constraints are in conflict. When ALIGN (C_1, CENTER, C_2, ONSET) is ranked above ALIGN (C_1, RELEASE, C_2, TARGET), vowel intrusion will occur, and when ALIGN (C_1, RELEASE, C_2, TARGET) is ranked above ALIGN (C_1, CENTER, C_2, ONSET), vowel intrusion will not occur.

The following constraint militates for alignment of the vowel with respect to the peripheral consonant, i.e. it militates for heavy overlap between the vowel and

non-peripheral consonant. This constraint ensures that the acoustic release in a consonant cluster is a copied vowel (and it will not sound like a schwa).

(25) ALIGN (V, OFFSET, C]$_\sigma$, CENTER) (Hall 2004)
'The offset of every vowel is aligned with the center of the rightmost consonant that belongs to the same syllable as that vowel'.
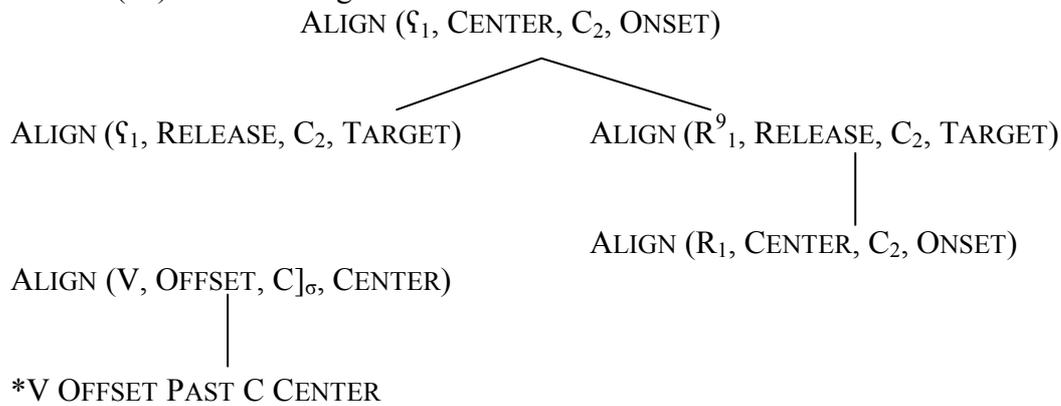
The last constraint militates against heavy overlapping. Therefore, if it is ranked high, the release (if there is an acoustic release) is not of a copied vowel.

(26) *V OFFSET PAST C CENTER (Hall 2004)
'In a sequence VC, the offset of V is not later than the center of C'.

Since only ʕ triggers vowel intrusion in SMH, the constraints below must be specified for ʕ. These constraints are also ranked differently from constraints that militate for vowel intrusion in other sonorants of the language. SMH ranking is given below:

(27) SMH ranking:
$$\text{ALIGN } (ʕ_1, \text{CENTER}, C_2, \text{ONSET})$$

ALIGN (ʕ$_1$, RELEASE, C$_2$, TARGET)   ALIGN (R[9]$_1$, RELEASE, C$_2$, TARGET)

ALIGN (R$_1$, CENTER, C$_2$, ONSET)

ALIGN (V, OFFSET, C]$_\sigma$, CENTER)

*V OFFSET PAST C CENTER

(28) SMH vowel intrusion

/maʕnak/	ALIGN (ʕ$_1$, CENTER, C$_2$, ONSET)	ALIGN (ʕ$_1$, RELEASE, C$_2$,	ALIGN (V, OFFSET, C]$_\sigma$, CENTER)	*V OFFSET PAST C CENTER
a. maʕnak	*!			
☞b. maʕanak		*		*
c. maʕənak		*	*!	

---

[9] R stands for all other sonorants in the language.

(29) Non-triggering vowel intrusion cluster

/milga/	ALIGN (R$_1$, RELEASE, C$_2$, TARGET)	ALIGN (R$_1$, CENTER, C$_2$, ONSET)	ALIGN (V, OFFSET, C]$_\sigma$, CENTER)	*V OFFSET PAST C CENTER
☞a. milga		*		
b. miliga	*!			*
c. miləga	*!		*	

In the tableaux above, two inputs /maʕmad/ and /milga/ are subject to the SMH hierarchy. In tableau (28), the vowel gesture extends to the center of [n] to satisfy ALIGN (V, OFFSET, C]$_\sigma$, CENTER). The result is a copied [a]. In tableau (29), ALIGN (R$_1$, RELEASE, C$_2$, TARGET) blocks the vowel gesture from extending to the center of [g] and no vowel is heard between the [l] and the [g].

4.2.1. Why not Epenthesis

Analysis of the vowel that is produced between two consonants in ʕC clusters in SMH as epenthetic can be appealing at first glance. Epenthesis is common in SMH especially in a pharyngeal environment (Pariente 2006), so assuming that these vowels are epenthetic does not require the assumption of two distinct phenomena in the phonology of the language.

Recall that in SMH, both the voiced and the voiceless pharyngeal can appear freely in an onset position, and in word medial coda position. However, the ability to appear in a final coda position is limited to the voiceless pharyngeal. Since the pharyngeal in ʕC clusters (the environment that triggers VI) is always in coda position, the prohibition on ʕC clusters could be viewed as coda prohibition, and the vowel that emerges between the two consonants could be viewed as epenthetic. Under this analysis, the *ʕC prohibition would just be specific case of *ʕ]$_\sigma$ as shown in the tableau below.

(30) Alternative analysis of *ʕC as *ʕ]$_\sigma$

/miʕmad/	MAX	*ʕ]$_\sigma$	DEP
a. mi.mad	*!		
b. miʕ.mad		*!	
c.☞ ma.ʕ**a**.mad			*

This analysis would raise two problems: (a) the quality of the vowel following the pharyngeal. (b) non-syllabicity.

4.2.1.1.   The Quality of the Vowel Following the Pharyngeal

In the absence of pharyngeals, the default epenthetic vowel in SMH is [e]. Assuming that epenthesis takes place in ʕC clusters (30), we get the following observations: (a) In the noun system, when epenthesis takes place after ʕ, the vowel that emerges is [a] (maʕ**a**mad and not *maʕemad). (b) The vowel that appears within ʕC clusters in the verb system is [e] (neʕedaʁ). This vowel is identical to the vowel preceding the pharyngeal.

Since epenthetic vowels are not copied, the value of the vowel can be considered as the value of the default epenthetic vowel in SMH that is [e]. The only way to explain the emergence of [e] after ʕ in the verb system is to assume that TETU effects, that cause the value of an epenthetic vowel to be [a] after a pharyngeal, are blocked somehow in the verb system so the default vowel is [e] in the verb system.

Solving this paradox, however, leads as to another one. If the default vowel in the verb system is [e] even after a pharyngeal, why is the vowel that emerges after a final voiced pharyngeal consonant (creating an additional syllable inverting the pharyngeal to an onset) always [a] (7)? The vowel that emerges in verbs like ja.nu.ʕ**a** suggests that TETU is **not** blocked in the verb system. If the impact of TETU is indeed apparent, epenthesis analysis cannot explain the emergence of two different vowels ([e] and [a]) in the same environment.

4.2.1.2.   Non-syllabicity

The evidence for non-syllabicity in SMH comes primarily from the phonological prohibition on the proximity of non-low vowels to pharyngeals. SMH permits pharyngeals to appear after a non-low vowel, if the non-low vowel and the pharyngeal are not syllabified into the same syllable, i.e. the pharyngeal is in an onset position.

> (31) Non-low vowel and pharyngeals syllabified into different syllables
> ta.**pu.**ħim 'apples' cf. ta.pu.zim 'oranges'
> je.ħa.pes 'he will search' cf. je.da.beʁ 'he will talk'
> si.ħek' he was playing' cf. jiʃ.tok' he will shut up'
> ma.**no.**ʕa 'motor' cf. ma.nof 'crane'
> ʃi.ʕeʁ' he assumed' cf. di.beʁ' he talked'

However, if the pharyngeal is preceded by an unstressed non-low vowel, the vowel preceding it is always lowered to [a] in the noun system and to [e] in the verb system.

> (32) Pharyngeal preceded by an unstressed non-low vowel
> Nouns: ma**ħ**.nák 'suffocation' cf. mig.**d**ál 'tower'
>   maħ.té.**ʁ**et 'underground' cf. mik.té.**ʁ**et 'pipe'
> Verbs: neħ.káʁ 'he was interrogated' cf. nig.maʁ 'it was finished'
>   eħ.lít 'he decided' cf. it.ħil 'he began'

The syllabic nature of the inserted vowels can be tested in cases where an unstressed non-low vowel precedes a Cʕ cluster, creating a cluster that is the target of VI in the language. Such cases are given in (32). In theory, the vowels that appear between ʕ and other consonants can create a syllable: /miʕmád/ → *miʕ**i̯**.mád. Under such syllabification, the high vowel preceding the pharyngeal and the pharyngeal are not

syllabified into the same syllable. As mentioned above, in that environment, high vowels stay high.

(33) Syllabification of the intrusive vowel as syllabic.

miʕmád →* mi ʕi̠ mád.
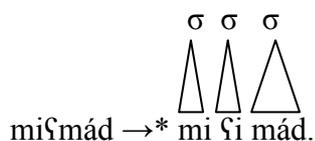
However, what does happen is that the high vowel is lowered by the rules of the language, i.e. it becomes [a] in the noun system and [e] in the verb system. If the high vowel is lowered and vowel lowering happens only in the domain of the syllable, we must conclude that the vowel inserted after the pharyngeal does not create a syllable, and the high vowel preceding the pharyngeal and the pharyngeal are syllabified in the same syllable. Since the vowel preceding the pharyngeal is lowered, the intrusive vowel must be low too since the two vowels are parts of a single vowel gesture.

(34) Syllabification of the intrusive vowel as non-syllabic.

miʕmád → maʕa̠ mád.
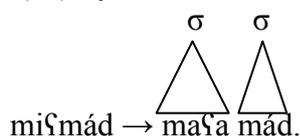
As shown above, the vowel that appears within ʕC clusters is not syllabic; however, the vowel that emerges in verbs like ja.nu.ʕ**a** is necessarily syllabic since it syllabifies the pharyngeal to an onset position and parsed into feet. Again, an epenthesis analysis cannot explain all the facts regarding the phenomenon.

4.2.2. Why not Rule Ordering

An approach to neutralize the problem of non-syllabicity is to analyze the emergent vowels between ʕ and the following consonant as an epenthetic vowel that is created via derivation. In such a scenario, vowel lowering precedes epenthesis between the pharyngeal and the following consonant:

(35) Derivation of vowel lowering and epenthesis

/miʕmad/	UR
maʕmad	Vowel lowering
maʕ.mad	Syllabification
maʕamad	Epenthesis (to prevent ʕ from being syllabified in coda position)
ma.ʕa.mad	Re-syllabification
[maʕamád]	FF

In this analysis, vowel lowering precedes epenthesis and since syllabification occurs after vowel lowering, the syllabified form *maʕ.mad* triggers epenthesis. Following this analysis, there is no need to assume that the vowel that emerges between the pharyngeal and the following consonant is not syllabic, since syllabification is a

recursive process. However such derivation wrongly predicts words with ʕ in a final position:

(36) Derivation of vowel lowering and epenthesis of words with ʕ in a final position

/manoʕ/	UR
manaʕ	Vowel lowering
ma.naʕ	Syllabification
manaʕa	Epenthesis (to prevent ʕ from being syllabified in coda position)
ma.na.ʕa	Re-syllabification
[manáʕa]	FF

The actual form is [ma.no.ʕa] with no vowel lowering occurring since ʕ is syllabified as an onset. The data supports the OT grammar; it seems that all processes (the prohibition of adjacent non-low vowels and pharyngeals, syllabification and epenthesis) are evaluated together, and inter levels and re-syllabification actually predict the wrong outcome.

4.2.3. Typological Observation

Hall (2003) points out that VI is restricted only to sonorants. And in some languages it is restricted to only a subset of sonorants. Hall (2003. p 28) gives the following hierarchy:

(37) Vowel intrusion triggers
(Obstruents, if ever) → Other approximants, nasals → [r] → [l] → [ɾ], [ʁ] → gutturals
Among nasals: [m] → [n]

So if [m] triggers VI in a language, [n] will trigger it as well.
　　Regarding gutturals, Hall says: "In languages that have vowel intrusion with gutturals, there are no cases where only a subset of the gutturals trigger it (unless one of the gutturals does not occur in the correct position, like Kekchi [h]). No implicational hierarchy within the guttural class can be established at present." (Hall 2003. p. 28).
　　SMH is a language in which [ʕ] triggers VI but [ħ] does not. Based on these data, Hall's observation can be expanded by stipulating that if [ʕ] triggers VI in a language; [ħ] will not necessarily trigger it as well.

(38) Hierarchy among the pharyngeals.
*([ʕ] → [ħ])
A language can allow heavy overlap between vowels and ʕ, without allowing the same degree of overlap between vowels and ħ.

5.　　Conclusion

In this paper, I have examined the two types of vowels that appear in the surface forms due to processes that are triggered by the pharyngeal consonants in SMH. It

was argued that these two types are different from one another and that they exhibit different properties. Table (39) summarizes these differences.

(39)   Non-lexical vowels properties

Property / Vowel type	Environment	Quality	Syllabicity
True epenthetic vowels	(a) After final ʕ that is preceded by a stressed vowel. (b) Between non-low stressed vowel and final ħ.	Always [a].	Syllabic
Intrusive echo vowels	Between ʕ and another consonant.	Depends on the vowel preceding the pharyngeal (copied); [a] or [e].	Non-syllabic

Arguments for different analyses were presented and it was shown that an epenthesis analysis of intrusive vowels collapses.

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