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Gradual Vowel Epenthesis in Urban Hijazi Arabic

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Abstract: In this paper, vowel epenthesis in Urban Hijazi Arabic is analysed as a process of gradual structural build-up. Harmonic Serialism, a derivational framework of Optimality Theory, provides the theoretical foundation to illustrate the arguments. Rather than epenthesising an entire vowel all at once, featural structure progressively increases in successive steps. This accumulation continues until the required vowel quality is achieved. Specifically, the constraint hierarchy predicts high epenthetic vowels to occur in closed syllables and the low epenthetic vowel in open syllables. The same constraint hierarchy, however, is also expected to predict both gradual epenthesis and gradual deletion. In that regard, a seemingly paradoxical situation is created when the very same intermediate vowel quality is achieved through accumulation or attrition of featural structure. This particular vowel quality, in exactly the same environment, will have to continue gaining internal structure towards epenthesis or continue losing internal structure towards deletion. Eventually, identifying the path that the derivation takes to reach a certain vowel will help to resolve the issue.

Keywords: vowel epenthesis; vowel deletion; Harmonic Serialism; Optimality Theory; featural structure; local conjunction

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1. Introduction

Harmonic Serialism (HS) (McCarthy 2000, 2006, 2010, 2016) is a serial version of the parallel Optimality Theory (P-OT) (Prince and Smolensky 1993/2004; McCarthy and Prince 1993a, 1993b). The main difference between them lies in their most distinctive properties of serialism (gradualness) versus parallelism. In P-OT, multiple parallel processes allow GEN to simultaneously effect a number of changes in an input. As a result, the candidates submitted to EVAL can in principle be radically different from one another and from their underlying representations. In HS, GEN is much more regulated, and the variation in any candidate set it produces is considerably limited. This is a direct consequence of the gradual change GEN is permitted to cause in output candidates. Specifically, GEN is not sanctioned to perform more than a single change to any candidate it produces.

This restricted scope of GEN, the commitment to minimal change, in HS may seem crippling, as natural languages have examples of surface representations that are changed more than once, i.e., differing from their underlying forms in more than one way. In response, HS incorporates a loop into its basic architecture, so an optimal candidate is resubmitted to another pass of GEN-EVAL. This resubmission continues with a further harmonic improvement (change) in each pass until the derivation converges on an optimum that cannot be further improved. This should be the true output. Each of these GEN-EVAL passes is called a Step and is given a number (Step 1, Step 2, Step 3, . . . and so on). In this paper, such principles of HS are applied to examples of vowel deletion and vowel epenthesis in Urban Hijazi Arabic (UHA). The discussion should provide some insight into the plausibility of HS as an instrumental supplement to Optimality Theory.

Gradualness, a property of HS, is manifested in the process of segmental deletion, as discussed in McCarthy (2019). The question of how segments delete is discussed at length, considering whether segment deletion is the result of a single operation or of multiple successive ones that gradually reduce a segment's structure. The argument outlined by McCarthy assumes gradualness as implemented in a number of reduction steps, depending on how complex a segment structure is. The limitation of the minimal change imposed on GEN is the justification for such stepwise deletion, as no operation is allowed by GEN to delete more than one structural element of a (complex) segment at once. As mentioned by McCarthy, several consequences will logically follow from this rationale of gradual segment reduction. Most obvious is the number of steps needed to delete segments with relatively complex internal structure when compared to those steps needed to delete segments with simpler structure. The former will certainly require more steps than the latter. Apparently, the reason for this difference is that gradualness in reducing a structure composed of a larger number of elements takes more steps than are needed for one with fewer elements. Another important consequence McCarthy associates with gradual deletion involves constraint rankings. Generally, a constraint ranking proposed to prompt the deletion of a given segment will suffice for the deletion of a structurally simpler one, but not vice versa. The explanation offered by McCarthy assumes that the derivational steps for deleting a simpler segment normally constitute a subset of those for deleting a more complex one. These consequences will be examined further when the principles of gradualness are applied to vowel epenthesis.

In this paper, vowel epenthesis is represented as a materialisation of the principles of HS. The plausibility of the property of gradualness, which has been demonstrated to have interesting empirical consequences for segmental deletion processes, is further established by the analysis of vowel epenthesis in UHA. In the proposed account, a whole vowel is not inserted in a single operation. Instead, gradual vowel epenthesis manages the progression of the featural structure of vowels, only allowing one feature to be accumulated at a time, in several successive steps. What is fundamental to such analysis is the minimality of feature insertion, whereby the language inserts as few features as necessary. This minimal accumulation of features is regulated by harmonic improvement; only a marked structure justifies inserting more features. In this regard, gradual epenthesis could very well be considered as an example representing HS's modus operandi. This minimal and harmonically improving build-up will account for the attested variations in epenthetic vowels in different environments in UHA.

While the high epenthetic vowels [i] and [u] occur in closed syllables, only the low epenthetic vowel [a] surfaces in open, unstressed non-final syllables in UHA. The language systematically avoids having high epenthetic vowels in this particular environment because it is the trigger for another process of high vowel deletion. In other words, the epenthetic vowel is the featurally minimal [i], unless that creates the environment where [i] is targeted for deletion, in which case the epenthetic vowel is [a]. An input such as /ʔism/ surfaces with a high epenthetic vowel inserted between the final two consonants, as in [ʔi.sim] 'name'. However, only the low [a] is allowed as an epenthetic vowel in forms such as /bintna/ → [bin.ta.na], where it occurs in an open syllable. As mentioned earlier, gradual epenthesis is the analytical framework proposed to account for such a discrepancy.

A challenge the proposed account must deal with concerns the path and the directions of progression for the two processes of deletion and epenthesis. Clearly, any constraint hierarchy proposed for the analysis of either of the two processes (epenthesis or deletion) will have to account for the other. Specifically, the grammar should predict a path for deletion that initially targets a (high) vowel and progressively causes the reduction in its structure until it vanishes. Conversely, the very same grammar should also identify the environment for vowel epenthesis and progressively cause the build-up of its structure until the vowel quality required for that environment is achieved. What is interesting here is that the paths for both processes are identical, but obviously the progression in each moves in the opposite direction of the other. Specifically, if gradual deletion is achieved through a sequence of harmonically improving candidates, how can gradual epenthesis also be harmonically improving when it is basically taking the opposite direction of the same path? In other words, if harmonic improvement justifies a reduction such as (xxx →

xx → x → ∅), which ultimately achieves deletion, does it also justify a build-up such as (xxx ← xx ← x ← ∅) to achieve epenthesis?

The remainder of this paper is structured as follows. In Section 2, the process of high vowel deletion in UHA is discussed, and the basic constraints offered in McCarthy (2019) are presented, showing how they affect the analysis of gradual deletion. The basic arguments and discussion are given in Section 3. It is divided into two subsections, one on high vowel anaptyxis and one on low vowel epenthesis. Collectively, these subsections clarify how the proposed account of gradual epenthesis predicts different vowel quality in different environments. Finally, Section 4 offers the concluding remarks.

2. High Vowel Deletion

High vowel deletion is discussed at length in McCarthy (2019). This process is found in a number of Arabic dialects such as Cairene (Watson 2002). Here, the arguments are applied to data from UHA, Jarrah (1993) and Al-Mohanna (1998), among others. The objective is twofold: to identify the derivation path leading to deletion, which will then be reversed for epenthesis, and to designate the set of constraints and the constraint hierarchy (i.e., to explain the grammar) that will supposedly be compatible with any processes of deletion or epenthesis in the language. In other words, looking into the possibility of whether epenthesis is also gradual requires examining McCarthy's main proposals concerning gradual deletion. Ultimately, this should facilitate adopting the same rationale for the analysis of vowel epenthesis in UHA. Before going into the details of this, however, it is helpful to consider the main syllable types in Arabic, generally, and in UHA in particular.

The basic syllable inventory in Arabic includes two main types of syllables, light and heavy, with no major restrictions on their distribution (Brame 1970; Al-Ani and May 1978; Broselow 1979; McCarthy 1979; Selkirk 1981; among others). The light syllable is monomoraic, with a short vowel obligatorily preceded by a single consonant (CV). In addition, the heavy (bimoraic) syllable has a coda consonant or another timing slot for a long vowel (CVC or CVV). Another syllable type, with a more restricted distribution, is also attested to in Arabic. This third syllable type mainly occurs as the final syllable in a word. It is usually referred to as the superheavy syllable, since it is composed of a heavy syllable plus a final consonant (CVCC or CVVC). These generalisations are consistent with UHA (Ingham 1971; Bakala 1973; Abu-Mansour 1987; Jarrah 1993; Al-Mohanna 1998).

(1) Syllable Types in UHA

Light	CV	[ba.ga.rah] 'a cow'	
Heavy	CVC, CVV	[mak.tab] 'an office'	[kaa.tib] 'a writer'
Superheavy	CVCC, CVVC	[ʔa.kalt] 'I ate'	[faa.nuus] 'a lantern'

As do most Arabic dialects, UHA also has a relatively simple vowel system. The vowel inventory contains only three vowels: the high vowels /i/, /u/, and the low vowel /a/ (plus their longer counterparts /ii/, /uu/, and /aa/).[1] As documented in several descriptive and analytical studies, a short high vowel in UHA is deleted when it occurs in an unstressed non-final open syllable (Ingham 1971; Abu-Mansour 1987; Jarrah 1993; Al-Mohanna 1998). Apparently, this process of deletion does not affect the low vowel in the same environment.

(2) (i) High Vowel Deletion

a.	/nidim + u/	['nid.mu]	'they felt remorse'
b.	/fihim + at/	['fih.mat]	'she understood'
c.	/simiʕ + ak/	['sim.ʕak]	'he heard you (M.SG)'

(ii) Low Vowel Non-Deletion

a.	/saħab + u/	['sa.ħa.bu]	'they pulled'
b.	/katab + at/	['ka.ta.bat]	'she wrote'
c.	/madaħ + ak/	['ma.da.ħak]	'he praised you (M.SG)'

To explain the process of high vowel deletion as one that involves gradual reduction, McCarthy (2019) adopted the views of vowel representation promoted in Schane (1984), Hulst (1989), Clements (1991), and others. He assumes that vowels vary in how complex (or not) their internal structures are. Specifically, the more features a vowel has, the more complex its internal structure is. This should mean that the low vowel [a], which bears the features [Colour] and [Open], has a more complex internal structure if compared to the high vowels [i] and [u] that only bear [Colour]. This also means that the reduced vowel [ə], with a bare root node, has the least or basically no internal structure as such. From this, McCarthy's fundamental assumption follows. Namely, interpreting vowel deletion as a gradual process of reduction will entail that single vowel features and bare root nodes are individually deleted in successive steps of the derivation.

(3) Gradual Vowel Deletion

/a/	[Colour], [Open]
↓	
/i/ or /u/	[Colour]
↓	
[ə]	[ ] (Bare root node)
↓	
∅	Vowel deletion completed

The number of derivational steps depends on how complex the internal structure of a given vowel is. This shows that both the low vowel [a] and the two high vowels [i] and [u] share the final two steps of the derivation: the reduction from [i] or [u] to [ə] and the complete deletion of [ə]. The process of deleting the low vowel, nevertheless, requires the initial step of reducing [a] to [i] or [u], resulting in a total of three steps to achieve the entire process from /a/ to ∅, rather than only two steps in the case of deleting /i/ or /u/.

(4) Derivational Steps in Vowel Deletion

(i)	/a/→[i] or [u]→[ə]→∅	(three-step derivations, then convergence)
(ii)	/i/ or /u/→[ə]→∅	(two-step derivations, then convergence)
(iii)	[ə]→∅	(one-step derivation, then convergence)

Having established how gradual reduction leads to vowel deletion, McCarthy formulated the markedness constraints that will collectively cause vowel deletion. The two constraints below are taken from McCarthy (2019).

(5) Vowel Deletion Constraints

a. $^*V_{WEAK}$
Assign a violation mark to every vowel in the Weak context that bears the features [Colour] and/or [Open].
b. *[ ]
Assign a violation mark for every instance of the featureless vowel [ə].

The constraint $^*V_{WEAK}$ penalises vowels with internal featural structure, no matter how complex that structure is, when any of these vowels is in the Weak context, i.e., when it occurs in an unstressed, non-final open syllable, which is the environment where a high vowel is deleted in UHA. This means that $^*V_{WEAK}$ is violated in candidates such as ′fi.hi.mat or ′ka.ta.bat as the vowel of the penult in each meets the two conditions necessary to incur a violation; it qualifies for the description of the Weak context and bears the features [Colour] and/or [Open]. Conversely, the constraint *[ ] militates against the featureless vowel [ə]. If compared with $^*V_{WEAK}$, the constraint *[ ] promotes the opposite state of affairs with respect to internal featural structure. As much as the featureless vowel [ə] in the candidate fi.hə.mat violates *[ ], it satisfies $^*V_{WEAK}$.

In addition to the two constraints above, McCarthy also assumes that any deletion of a vowel feature or even of a bare vowel root node will result in a violation of the faithfulness constraint MAX (McCarthy and Prince 1995). With this definition, MAX will be violated in both derivational steps needed for high vowel deletion, one violation in the step /i/ or /u/ → [ə] where the high vowel loses its featural structure and one violation in the step [ə] → ∅ where the featureless vowel is deleted.

The constraint ranking proposed by McCarthy for differential dialects of Arabic, one of which is UHA, will suffice.[2] The relative rankings between the three constraints introduced thus far will trigger the gradual reduction of any high vowel in the Weak context. As this process will necessarily sanction an intermediate winner with a featureless vowel, the constraint *V_{WEAK} will dominate *[ ]. This ranking means that it is less costly to have a featureless vowel than to have one with internal structure in the Weak context. Obviously, this statement is consistent with the gradual path towards deletion. The other ranking argument involves the constraints *[ ] and MAX. The output candidate in which the bare vowel root node of the input is deleted ([ə] → ∅) is not be rendered optimal unless *[ ] dominates MAX.

(6) Constraint Hierarchy for High Vowel Deletion

*V_{WEAK} >> *[ ] >> MAX

The tableaux[3] below, which are adapted from McCarthy (2019), summarise the HS analysis of high vowel deletion.

(7) High Vowel Deletion

(i) HS analysis of /fihim + at/ → [fih.mat] 'she understood'—Step 1

/fihim + at/	*V_{WEAK}	*[ ]	MAX
a. → fi.hə.mat		1	1
b. fi.hi.mat	1W	L	L

(ii) HS analysis of /fihim + at/ → [fih.mat] 'she understood'—Step 2

fi.hə.mat	*V_{WEAK}	*[ ]	MAX
a. → fih.mat			1
b. fi.hə.mat		1W	L

(iii) HS analysis of /fihim + at/ → [fih.mat] 'she understood'—Step 3 (convergence)

fih.mat	*V_{WEAK}	*[ ]	MAX
a. → fih.mat			
b. fi.hə.mat		1W	

The three tableaux in (7) demonstrate how gradually a high vowel in the Weak context deletes: /i/ → [ə] → ∅. In the first step, the high vowel loses its simple featural structure.[4] Then, the bare root node of the vowel [ə] is deleted in the second step, and the derivation converges in the third step where the candidate with the deleted high vowel is elected again as the most harmonic.[5] Each of the first two steps represents a single change from its input. Apparently, the initial syllable in candidates such as fi.hi.mat or fi.hə.mat does not qualify as Weak because it bears stress. Hence, no such syllable will incur any violation of the constraint *V_{WEAK}.

Low vowel non-deletion in UHA and other differential dialects of Arabic is also a consequence of the high ranking of *V_{WEAK}, which will cause the derivation to converge at the first step. As indicated by McCarthy, *V_{WEAK} instigates high vowel deletion by favouring a single-step elimination of its relatively simple featural structure. This one-step reduction is unattainable with the low vowel, which requires two derivational steps to achieve [ə], removing [Open] in the first, then [Colour] in the second. Particularly, it is not possible for GEN in such cases to produce any candidate that satisfies *V_{WEAK} at the first step.

(8) Low Vowel Non-Deletion

HS analysis of /katab + at/ → [ka.ta.bat] 'she wrote'—Step 1 (convergence)

/katab + at/	*V_{WEAK}	*[ ]	MAX
a. → ka.ta.bat	1		
b. ka.ti.bat	1		1W

In the single step in (8), where the derivation converges, deletion of the low vowel is stopped in its tracks. The candidate (8 b), with the only possible single change towards deletion, loses to the perfectly faithful candidate, as both equally violate *V_{WEAK}.

In the following section, two processes of vowel epenthesis in UHA are treated as the reverse derivations of gradual vowel reduction. Empirical evidence supports the argument for gradual epenthesis with a reversed deletion path: ∅ → [ə] → [i]/[u] → [a]. As discussed below, one of the two processes of vowel epenthesis will converge on the high vowels, but the other will exhaust all derivations until it reaches [a]. Nonetheless, any plausibly gradual analysis of epenthesis will necessarily uphold the same constraint ranking as discussed above for gradual deletion.

3. Vowel Epenthesis in UHA

Fundamentally, the discussion in this section is a response to a question put forward in McCarthy (2019). As demonstrated above, McCarthy treats deletion, rather than epenthesis, as a process of gradual reduction. By that, he assumes that GEN in HS does not produce candidates in which complex structures making up segments are deleted in one step. In the conclusion of his article, McCarthy asks the question of whether epenthesis is also gradual, offering a view that endorses such a statement. Thus, the main objective in this section is to employ derivations in HS to analyse instances of vowel epenthesis in UHA. More precisely, the fundamental question to consider is whether gradualness, as a property of HS, is also capable of manifesting itself in a multi-step derivational process that builds up the epenthetic vowel's internal structure. Eventually, such a process will converge on a particular vowel identity that varies from one environment to another. The empirical consequences of any gradual epenthesis of this nature are valid and in harmony with surface-true outputs in UHA.

Two types of vowel epenthesis are present in UHA, high vowel epenthesis (anaptyxis) and low vowel epenthesis. For example, an input such as /ʔism/ will surface as [ʔi.s**i**m] with a high epenthetic vowel inserted to break up the final consonantal cluster, but with inputs such as /bintna/ the epenthetic vowel is always low as in the surface form [bin.t**a**.na]. As discussed in more detail in the following two subsections, triggering vowel epenthesis in both cases will always be straightforward. The analytical challenge, however, resides in explaining how the language opts for the high vowel rather than the low vowel in one case, and vice versa in the other. The goal in this section is to demonstrate how gradual epenthesis resolves this issue.

3.1. High Vowel Anaptyxis

In this subsection, HS is presented as the theoretical framework that offers a plausible account for a process of high vowel epenthesis in UHA. Gradual vowel epenthesis can be viewed as a process of constructing vowel internal structure in successive steps through which the vowel featural structure, and hence the vowel itself, changes gradually until the derivation converges at a step where the required vowel is achieved. This means that vowel epenthesis does not always dictate going all the way from ∅ to [a], as a vowel in between is sometimes predictable by the derivation.

As attested in UHA, some forms exhibit an anaptyctic vowel inserted to break up a final biconsonantal cluster (Ingham 1971; Abu-Mansour 1987; Jarrah 1993; Al-Mohanna 1998). What triggers this process of vowel epenthesis is the sonority peak on the final consonant of the cluster; that consonant is more sonorous than the one preceding it. The lists of forms below provide some examples.

(9) High Vowel Anaptyxis

(i)	a.	/ʔism/	→	[ʔi.sim]	'name'
	b.	/ħibr/	→	[ħi.bir]	'ink'
	c.	/ʔidn/	→	[ʔi.din]	'ear'
	d.	/tˤifl/	→	[tˤi.fil]	'baby'
(ii)	a.	/gutˤn/	→	[gu.tˤun]	'cotton'
	b.	/rubʕ/	→	[ru.buʕ]	'quarter'
	c.	/ʃuʁl/	→	[ʃu.ʁul]	'work'
	d.	/ʃukr/	→	[ʃu.kur]	'gratitude'

(iii)	a.	/ʔakl/	→	[ʔa.kil]	'food'
	b.	/madħ/	→	[ma.diħ]	'praise'
	c.	/tamr/	→	[ta.mur]	'dates'
	d.	/sˤabʁ/	→	[sˤa.buʁ]	'dye'

These forms show that the epenthetic (anaptyctic) vowel is always a high vowel ([i] or [u]), no matter what the stem's vowel is ([i], [u], or [a]).[6] For the two groups of examples (9 i) and (9 ii), the assumption that the stem's vowel spreads rightward might seem at first to be the most straightforward justification for the high epenthetic vowel. This, however, is only a superficial observation about this alternation. Examining the examples in (9 iii) can help redirect the attention towards a more plausible generalisation. Even though the stem's vowel in each of these forms is always the low vowel [a], the epenthetic vowels are consistently high.[7]

Gradual epenthesis, as an example of derivations in HS, should justify this situation. The sequence starting with ∅, passing to the featureless vowel [ə], and eventually achieving a high epenthetic vowel will suffice for this particular environment. Converging at that step, where the high vowel is inserted, will deny the low epenthetic vowel.

To better understand the tableaux that demonstrate the gradual high vowel epenthesis, it will be helpful to introduce two important constraints. As (vowel) epenthesis is being considered, the faithfulness constraint DEP must be highlighted in the hierarchy. It will be violated when adding any internal featural structure or any bare vowel root node. The other constraint, known as the Sonority Peak Principle (SPP), is the one that is responsible for inserting the epenthetic vowel in the first place. Formulated in Clements (1997), this markedness constraint interprets sonority peaks as syllable peaks.

(10) Sonority Peak Principle (SPP)

Within the syllabification domain, sonority peaks contain syllable peaks.

The SPP will be ranked undominated,[8] and DEP will be ranked relatively low in the hierarchy. Introducing these two constraints and ranking them as such should not disturb the deletion process discussed above.

The tableaux below formally illustrate how a process such as high vowel anaptyxis is analysed as a progression along the path of successive minimal changes. Ultimately, such changes will gradually build up the epenthetic vowel through various steps in the derivation: ∅ → [ə] → [i].

(11) High Vowel Epenthesis

(i) HS analysis of /ʔakl/ → [ʔa.kil] 'food'—Step 1

/ʔakl/	SPP	$*V_{WEAK}$	*[ ]	MAX	DEP
a. → ʔa.kəl			1		1
b. ʔakl	1W		L		L

(ii) HS analysis of /ʔakl/ → [ʔa.kil] 'food'—Step 2

ʔa.kəl	SPP	$*V_{WEAK}$	*[ ]	MAX	DEP
a. → ʔa.kil					1
b. ʔakl	1W			1W	L
c. ʔa.kəl			1W		L

(iii) HS analysis of /ʔakl/ → [ʔa.kil] 'food'—Step 3 (convergence)

ʔa.kil	SPP	$*V_{WEAK}$	*[ ]	MAX	DEP
a. → ʔa.kil					
b. ʔa.kal					1W
c. ʔa.kəl			1W	1W	

In the first step, GEN produces (11 i a), which is the most relevant SPP satisfier.[9] With the limitation of minimal change imposed on GEN, such a candidate is the only possible form with an epenthetic vowel breaking up the biconsonantal cluster. As the optimum in Step 1, that candidate directly becomes the input in Step 2. At this intermediate stage in the derivation, the two possible options (besides the input itself) are either adding featural structure (11 ii a) or deleting the bare root node (11 ii b). The candidate with the high epenthetic vowel wins, not only in this step but also in Step 3. There, the true output competes with a possible candidate that has a low epenthetic vowel (11 iii b). The latter loses because of the needless DEP violation it incurs, and the derivation converges on ʔa.kil. Finally, it is worth noting that the constraint $*V_{WEAK}$ is never violated in any of the tableaux in (11), as no candidate depicts any vowel in the Weak context.

In the following subsection, a different process of vowel epenthesis in UHA is examined. Interestingly, the epenthetic segment there is the low vowel [a]. Nevertheless, the assumption of gradual epenthesis will still be instrumental in explaining this apparent discrepancy between the two processes of vowel epenthesis.

3.2. Low Vowel Epenthesis

In this subsection, a more prevalent process of vowel epenthesis in UHA is analysed, where a low (rather than a high) vowel is inserted. The main objective is to further test the plausibility of the hypothesis of gradual epenthesis, as an application of HS. In this case, however, vowel epenthesis dictates covering a longer path of minimal changes, i.e., gradual structuring of vowel featural content. Here, the theoretical framework predicts that gradual vowel epenthesis spans the full range: ∅ → [ə] → [i] → [a].

As occurs in other Arabic dialects, UHA will usually insert an epenthetic vowel, chiefly to maintain the condition on the distribution of superheavy syllables, which are mainly confined to the end of the prosodic word (Ingham 1971; Abu-Mansour 1987; Jarrah 1993; Al-Mohanna 1998). Generally, when a consonant-initial suffix is added to a word ending in a CVCC or CVVC sequence, the epenthetic vowel [a] helps resyllabify the base's final consonant as an onset of a newly created syllable. This will deny superheavy syllables from occurring non-finally. The lists of forms below provide some examples.

(12) Low Vowel Epenthesis

(i)	a.	/bint + na/	→	[bin.ta.na]	'our daughter'
	b.	/ʔuχt + ha/	→	[ʔuχ.ta.ha]	'her sister'
	c.	/beet + hum/	→	[bee.ta.hum]	'their house'
	d.	/faanuus + kum/	→	[faa.nuu.sa.kum]	'your *pl.* lantern'
(ii)	a.	/ʃuft + ha/	→	[ʃuf.ta.ha]	'I saw her'
	b.	/darrast + na/	→	[dar.ras.ta.na]	'you (M.SG) taught us'
	c.	/d͡ʒaat + kum/	→	[d͡ʒaa.ta.kum]	'she came to you *pl.*'
	d.	/foog + hum/	→	[foo.ga.hum]	'above them'

Clearly, the epenthetic vowel in all forms in (12) is always [a]. As with high vowel anaptyxis, there is no reason to assume that other vowels in the form are in any way responsible for the identity of the epenthetic vowel. Another obvious generalisation concerning the epenthetic vowel in such forms is that it always occurs in an open syllable (Farwaneh 1995).[10] Consequently, and as suggested in McCarthy (2019), the serial derivation is predicted to continue gradual epenthesis from [i] to [a] to avoid creating the environment for high vowel deletion, the Weak context. This assumption will be examined in a subsequent discussion.

What triggers this process of vowel epenthesis is the condition of syllable maximal moraicity. Maximally, syllables in UHA are bimoraic. As formulated in Al-Mohanna (1998, 2010), the constraint SYL-MX(μμ) maintains the maximal moraic content of syllables, when ranked undominated.[11]

(13) SYL-MX(μμ)

Syllables are maximally bimoraic.

It is assumed that vowel epenthesis is the least costly among the possible SYL-MX(μμ) satisfiers, all of which will ultimately avoid nonfinal superheavy syllables.

With this in mind, it is now appropriate to investigate how HS, in the form of gradual vowel epenthesis, predicts the low epenthetic vowel [a] in an open syllable. If compared to high vowel anaptyxis, low vowel epenthesis should require an extra step progressing the epenthetic vowel from [i] to [a]. Achieving [a] from ∅, assuming the same set of constraints for high vowel deletion and high vowel anaptyxis, might be somewhat challenging. Further constraints will necessarily be added to the hierarchy. Even so, the dominance relations holding between the constraints introduced so far (for UHA) will not be altered in any way.

(14) HS analysis of /bint + na/ → [bin.ta.na] 'our daughter'—Step 1

/bint + na/	SYL-MX(μμ)	*V$_{\text{WEAK}}$	*[ ]	MAX	DEP
a. → bin.tə.na			1		1
b. bint.na	1W		L		L

This is the initial step of gradual epenthesis, where the featureless vowel [ə] is inserted to break up the triconsonantal cluster and satisfy SYL-MX(μμ). The most harmonic candidate bin.tə.na progresses to the next step as an input.

With this set of constraints and the constraint hierarchy in (14), it will be considerably difficult to achieve the desired optimisation in Step 2. For gradual epenthesis to progress, a featural structure will have to be added to the featureless vowel, so [ə] becomes [i]. At this step, however, EVAL will not evaluate the intended optimum bin.ti.na as more harmonic than bin.tə.na. As illustrated in the tableau below, the former violates the higher ranked constraint *V$_{\text{WEAK}}$ while the latter does not.[12]

(15) HS analysis of /bint + na/ → [bin.ta.na] 'our daughter'—Step 2 (halted)

bin.tə.na	SYL-MX(μμ)	*V$_{\text{WEAK}}$	*[ ]	MAX	DEP
a. ☹ bin.ti.na		1W	L		1W
b. 💣 bin.tə.na			1		

The progression from [ə] to [i], as represented by candidate (15 a), is not the winner since augmenting the featural structure in [ə] to achieve [i] creates a vowel in the Weak context that bears the feature [Colour]. Obviously, this results in a *V$_{\text{WEAK}}$ violation. This should not come as a surprise. In the first place, this constraint ranking was proposed to effect high vowel deletion and militate against forms such as bin.ti.na. In this regard, it might be argued that a complication of this nature is not specific to the current analysis of epenthesis in UHA. It can be seen as a more general problem of gradualness, specifically when the paths of the processes considered are identical, but the progressions are moving in opposite directions, e.g., featural accumulation vs. featural attrition.

The proposed solution for this paradox resides in the difference between the featureless vowel in the candidates fi.hə.mat (7 i a) and bin.tə.na (14 a). The vowel [ə] results from structural deletion in fi.hə.mat, but it results from structural epenthesis in bin.tə.na. More specifically, the underlying representation loses structure in (7) but gains structure in (14). This difference in MAX versus DEP violations will help resolve the issue. In particular, it is assumed that achieving [ə] by adding structure to the underlying representation comes at a cost if compared to achieving it by deleting structure. Analytically, what this assumption means is that the root node of any featureless vowel in an output must have a corresponding root node in the underlying representation. This condition will rule out any [ə] if its root node is inserted.

The prohibition against inserting a [ə] clearly assumes a faithfulness component and a markedness component. Hence, a local conjunction, in the sense of Smolensky (1995), of faithfulness and markedness should in principle attain the desired effect. Firstly, the faithfulness distinction can be maintained by a FAITH-UO constraint. As formulated in Hauser et al. (2016), FAITH-UO constraints assess faithfulness to the underlying representation at any step in the derivation. Therefore, a candidate at any stage in the gradual epenthesis will incur a violation when its identified correspondence to the underlying representation is compromised. The proposed FAITH-UO constraint is DEP-UO, which is the first of two conjoined constraints proposed for the HS analysis of gradual epenthesis in UHA. The second conjoined constraint is *[ ], which serves the markedness component by ruling out featureless vowels. This local conjunction is formalised in (16).

(16) Local Conjunction: DEP-UO&*[ ]
a. DEP-UO
Every segment of the output has a correspondent in the underlying representation.
b. *[ ]
Assign a violation mark for every instance of the featureless vowel [ə].

Being a local conjunction, the constraint DEP-UO&*[ ] is only violated when both constraints DEP-UO and *[ ] are violated in a certain candidate. It will also always be assumed that the constraint DEP-UO&*[ ] outranks any one of the two conjoined constraints. Simply, this constraint is violated by any instance of [ə] that does not correspond to a segment in the underlying representation. The first conjoined constraint bans any insertion in the underlying string, and the second conjoined constraint militates against the featureless vowel.

The featureless vowel is never surface true in UHA, so it is well justified to have DEP-UO&*[ ] relatively highly ranked. Specifically, it will be ranked lower than SYL-MX(μμ) but higher than *V_{WEAK} and all other constraints to allow optimising bin.tə.na in Step 1, but will rule it out in successive steps. With this constraint, the derivation is resumed in Step 2.

(17) HS analysis of /bint + na/ → [bin.ta.na] 'our daughter'—Step 2

/bint + na/ bin.tə.na	SYL-MX(μμ)	DEP-UO &*[ ]	*V_{WEAK}	*[ ]	MAX	DEP
a. → bin.ti.na			1			1
b. bin.tə.na		1W	L	1W		L
c. bint.na	1W		L		1W	L

The candidate bin.tə.na (17 b) is ruled out because it is not faithful to the underlying representation as far as epenthesis is concerned and because it includes an instance of [ə]. On the other hand, the winner at this step bin.ti.na only violates one of the two conjoined constraints, DEP-UO, but satisfies *[ ] by virtue of not having any featureless vowels. Consequently, bin.ti.na, with this minimal change depicting harmonic improvement from the input to Step 2, is optimised and submitted to GEN in Step 3.

The intended optimum for the next step is the candidate with the epenthetic low vowel bin.ta.na, which represents the true surface output for this derivation. This candidate will compete with the winner in Step 2 bin.ti.na, which is the candidate identical to the input in Step 3. However, with the constraint hierarchy proposed so far, the intended optimum will lose as both candidates equally violate *V_{WEAK}, but the non-surface-true bin.ti.na will better satisfy DEP.

(18) HS analysis of /bint + na/ → [bin.ta.na] 'our daughter'—Step 3 (halted)

/bint + na/ bin.ti.na	SYL-MX(μμ)	DEP-UO &*[ ]	*V_{WEAK}	*[ ]	MAX	DEP
a. ☹ bin.ta.na			1			1W
b. 💣 bin.ti.na			1			

The fact that any possible minimal change in Step 3 is ruled out by this set of constraints means that the derivation will converge on the false output *bin.ti.na, a non-surface-true form.

A candidate such as bin.ti.na is considered problematic, not only because it has a vowel in the Weak context but also most certainly because the root node of that vowel is inserted. An underlying high vowel in such a Weak context will be subject to deletion, as discussed above. Therefore, gradual epenthesis must not be allowed to converge on a syllabic configuration that is highly marked in the language. To avoid this obstacle, the proposed account will again resort to a local conjunction of faithfulness and markedness.

(19) Local Conjunction: DEP-UO[V_{+HIGH}]&*V_{WEAK}

a. DEP-UO[V_{+HIGH}]
Every high vowel in the output has a correspondent in the underlying representation.
b. *V_{WEAK}
Assign a violation mark to every vowel in the Weak context that bears the features [Colour] and/or [Open].

With the local conjunction DEP-UO[V_{+HIGH}]&*V_{WEAK}, the epenthetic low vowel [a] is rendered most harmonic, and gradual epenthesis can progress to the final (convergence) step. It must be noted that introducing the two (local conjunction) constraints to account for the low vowel epenthesis in UHA, DEP-UO&*[ ], and DEP-UO[V_{+HIGH}]&*V_{WEAK} will have no effect on any element of the previous discussion. More specifically, high vowel anaptyxis will not be blocked by the constraint DEP-UO[V_{+HIGH}]&*V_{WEAK}, as the inserted high vowel is not in the Weak context. Additionally, any high vowel that has a correspondent in the underlying representation will not incur any violation of this constraint. The two following tableaux illustrate Step 3 and the convergence in Step 4.

(20) HS analysis of /bint + na/ → [bin.ta.na] 'our daughter'—Step 3

/bint + na/ bin.ti.na	SYL-MX(μμ)	DEP-UO &*[ ]	DEP-UO[V_{+HIGH}] &*V_{WEAK}	*V_{WEAK}	*[ ]	MAX	DEP
a.→ bin.ta.na				1			1
b. bin.ti.na			1W	1			L
c. bin.tə.na		1W		L	1W	1W	L

(21) HS analysis of /bint + na/ → [bin.ta.na] 'our daughter'—Step 4 (convergence)

/bint + na/ bin.ta.na	SYL-MX(μμ)	DEP-UO &*[ ]	DEP-UO[V_{+HIGH}] &*V_{WEAK}	*V_{WEAK}	*[ ]	MAX	DEP
a.→ bin.ta.na				1			
b. bin.ti.na			1W	1		1W	

A candidate such as (20 b) violates the constraint DEP-UO[V_{+HIGH}]&*V_{WEAK} because it contains a high vowel in the Weak context that has no correspondent in the underlying representation. The true output is candidate (20 a), which only violates $V_{W_{EAK}}$ but satisfies DEP-UO[V_{+HIGH}].

The intended true output of the process of low vowel epenthesis is achieved by adopting the HS model, as instantiated in gradual epenthesis. Unlike the case of high vowel anaptyxis, gradual low vowel epenthesis is encouraged by the grammar to effect a further minimal change and to add featural structure to attain the low epenthetic vowel [a] from the high vowel [i].[13] In the three derivational steps, harmonic improvement (or constraint satisfaction) is the basic motivation for the minimal changes applied. This harmonically improving path is shown below:

(22) Harmonic Improvement Tableau /bint + na/ → [bin.ta.na] 'our daughter'

	SYL-MX(μμ)	DEP-UO &*[ ]	DEP-UO[V_{+HIGH}] &*V_{WEAK}	*V_{WEAK}	*[ ]	MAX	DEP
Faithful bint.na	1						
Step 1 bin.tə.na		1			1		1
Step 2 bin.ti.na			1	1			1
Step 3 bin.ta.na				1			1
Step 4 bin.ta.na	convergence						

4. Conclusions

The discussion mainly focusses on the question of whether epenthesis can be treated as a gradual process that involves successive steps of building up the epenthetic segment's internal structure. Two processes of vowel epenthesis from UHA are examined. The distinction between the two processes, regarding what vowel to epenthesise, is accounted for as differences in the stages of convergence, as the ultimate step in the HS architecture. In high vowel anaptyxis, the process of gradual epenthesis converges on the vowel [i]. The additional minimal change [i] $\rightarrow$ [a] is not deemed optimal when the epenthetic [i] is inserted in the first place to break up a final biconsonantal cluster. This vowel insertion does not create the environment where a high vowel is normally deleted. In other words, as no vowel occurs in the weak context, no violation of *V_{WEAK} is triggered, and, consequently, no further minimal change is required. In such case, adding further featural structure turns out to be redundant and only violates constraints to satisfy none. On the other hand, the low vowel [a] is epenthesised in an open syllable to avoid having a high vowel in the Weak context, the environment that triggers deletion. What this means is that insertion beyond what is absolutely necessary is only licensed by markedness constraints violated by the minimal insertion. Essentially, this is the logic behind HS: gradual minimal change that is justified by harmonic improvement.

The restricted version of GEN in HS instigates dividing vowel epenthesis into multiple operations of minimal feature insertion. Such minimal operations, which can be viewed as individual building blocks, line up in a progressive ascending sequence, leading to the full segment epenthesis. These minimal insertions and the sequential build-up allow the grammar to interrupt the process at any intermediate stage whenever the required vowel quality is attained. Harmonic improvement is considered as the regulatory force managing this process of gradual epenthesis: triggering the process in the first place, prompting further feature insertion operations, and determining when the process is halted. What this fundamentally means is that change, in the form of feature accumulation, is sanctioned only when a marked structure is identified in an underlying representation or in an intermediate winner.

As applied to cases of vowel epenthesis in UHA, this harmonically improving progression of segmental feature insertions explains the difference in epenthetic vowel quality in closed and in open syllables. The derivation converges on the epenthetic vowel [i] when the vowel occurs in a closed syllable, but it converges on [a] in open syllables. The main difference between the two epenthetic vowels is in their feature structures, with [a] being more complex than [i]. As far as the process of gradual epenthesis is concerned, achieving this difference requires a further step in the derivation. This step that adds to the feature structure may only be justified if it achieves harmonic improvement, i.e., if it results in a less marked structure. In the case of UHA, the marked structure that the language systematically avoids is one in which an epenthetic high vowel occurs in an open syllable, because it is normally targeted by high vowel deletion in such environment. Therefore, the grammar logically opts for a more harmonically improved output candidate and encourages a further step in the derivation. In this step, the constraint DEP-UO[V_{+HIGH}]&*V_{WEAK} is employed to select bin.ta.na rather than the winner in the previous step bin.ti.na.

Although the proposed constraint hierarchy evaluates the opposing processes of deletion versus epenthesis in an open syllable, it optimises the true outputs in both. What proves to be instrumental to achieving this is the distinction between the two possible directions in the progression that leads to a particular candidate, i.e., through deletion or epenthesis. Specifically, the predicament that the proposed account had to resolve is caused by the opposite directions that gradual deletion and gradual epenthesis take along the same path. What helped overcome this analytical challenge is the local conjunction combining faithfulness constraints, as represented by FAITH-UO, and markedness constraints. Both local conjunctions, DEP-UO&*[ ] and DEP-UO[V_{+HIGH}]&*V_{WEAK}, evaluate a candidate's faithfulness to the underlying representation and also penalise vowel markedness. The consistent use of DEP-UO to fix the problems with gradual non-minimal epenthesis merits attention. In both cases, epenthesis is kept to a minimum unless such minimality violates a conjunction of markedness with DEP-UO, in which case gradual epenthesis continues harmonically, improving the candidate set.

A possible P-OT account for the variability of epenthetic vowels in UHA could benefit from ranked markedness constraints. For example, the interaction of constraints such as *low and *nonlow, as detailed in Lombardi (2003), could, in principle, deal with the generalisation that [a] is epenthesised to avoid creating a marked syllable. In theory, a standard P-OT approach should have no problem in obtaining the alternation between epenthetic vowels, interpreting the facts that [i] is generally less marked as an epenthetic vowel than [a] but that [a] is specifically less marked in the Weak context. An advantage of the gradual epenthesis approach is in how it complements McCarthy's gradual deletion account, where it is categorically stated that the prime motivation for the stepwise reduction is harmonic improvement, rather than markedness distinctions.

A more specific issue with accounts adopting P-OT, such as the one Lombardi offers, concerns how markedness constraints are ranked. Lombardi argues that [ə] is preferred as an epenthetic vowel when it is available in a given language; otherwise, it is either [i] or [a], with no fixed markedness hierarchy holding between these two vowels. Instead, Lombardi suggests adopting language-specific rankings of constraints such as *low and *nonlow to render one of these vowels more harmonic than the other. In this way, any analysis of vowel epenthesis in UHA may propose the basic ranking *low >> *nonlow, which means [i] rather than [a] is the default epenthetic vowel. Then, [a] is selected as epenthetic only if an independent third constraint militates against [i] in a specific position. Apparently, this proposed ranking of markedness constraints is by and large arbitrary and not independently supported. On the other hand, the gradual epenthesis account proposed in this paper shows how the preference for [i] over [a] as an epenthetic vowel in UHA emerges from the gradual approach.

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Notes

1 The vowels /eː/ and /oː/ are excluded from the vowel inventory of UHA because they are treated as underlying /aj/ and /aw/, respectively.

2 In such dialects, only high vowels are deleted when they occur in the Weak context. As shown in (2), a low vowel in differential dialects is not deleted in that environment. However, in non-differential dialects, such as Yamani, all three vowels are deleted in that environment.

3 Comparative tableaux (Prince 2002) illustrate the discussion throughout. The arrow shows the most harmonic candidate, and the integers represent the number of violations. Less harmonic candidates are assessed for each constraint. Specifically, a (W) indicates a constraint favouring the winner, and an (L) indicates a constraint favouring the losing candidate being assessed.

4 In (7 i), another candidate is possible. This candidate gains featural structure, rather than loses it *fi.ha.mat. As clarified in more detail in the subsequent discussion, such a candidate will also violate $*V_{WEAK}$. In addition, it will violate the faithfulness constraint DEP, as structure is added.

5 As assumed in the subsequent discussion, a candidate such as (7 iii b) also violates the faithfulness constraint DEP, as there is an instance of epenthesis.

6 As discussed at some length in Jarrah (1993), there are some forms where the epenthetic vowel is [a], as in /baħr/ → [ba.ħar] 'sea'. These are conditioned forms, however. The first consonant of the final underlying consonant cluster is always a guttural [+pharyngeal]. Consequently, Jarrah (1993) assumed "that the pharyngeal vowel /a/ always occurs with these pharyngeals" (Jarrah 1993, p. 107).

7 The forms in (9 i and ii), in which the preceding vowel is either /i/ or /µ/, might be accounted for as instances of vowel copy. This is an interesting proposition but is beyond the scope of the paper. What is also worthy of further consideration is the

variation in the quality of the epenthetic high vowel in (9 iii), /i/ or /µ/. Although this alternation is observed in Jarrah (1993), no phonetic or phonological explanation is offered, leaving it for further research.

8 The constraint SPP predicts that the final consonant in each of the forms in (9), being a sonority peak, is a syllable peak. Consequently, GEN is expected to produce a minimally changed candidate such as [ʔakˡ], with a final syllabic consonant. The proposed account assumes that syllabic consonants, which do not occur in UHA at all, are ruled out independently, so they will not be considered in the tableaux.

9 The proposed account assumes that a candidate such as *ʔak.lə is ruled out by an alignment constraint such as ALIGN-RIGHT.

10 Breaking up a quadri-consonantal cluster will render the epenthetic vowel in a closed syllable, /gult + l + hum/ → [gul.tal.hum] 'I told them'. Such consonantal clusters only occur when a verb is followed by the dative suffix, /l/ or /b/, which necessarily requires an object suffix to follow. This special and conditioned case, where an epenthetic low vowel is inserted into a closed syllable, can be examined separately on its own merits.

11 The constraint *COMP-SYLL, as proposed in McCarthy (2008), should also achieve the required effect, as it disfavours CVCC and CVVC syllables.

12 The sad face ☹ appears next to the intended winner, and the bomb symbol 💣 appears next to the wrongly selected candidate.

13 An alternative to the FAITH-UO analysis can benefit from an anti-faithfulness constraint, as formulated in Alderete (2001). Though anti-faithfulness constraints are categorised by McCarthy (2016) as being incompatible with HS, an anti-faithfulness constraint such as ¬ IDENT [ ] will militate against corresponding segments agreeing on the featureless vowel. This will rule out a candidate such as bin.tə.na from Step 2. However, ruling out such a candidate from Step 3 is not possible unless there is a further condition placed on GEN preventing it from generating previous inputs.

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