Chapter 8

Contexts for Epenthesis in Harmonic Serialism

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8.1 Introduction

A theory of phonological grammar should produce phonological patterns that actually exist in the world's languages, while at the same time failing to predict typologically unattested patterns. Models based on Optimality Theory (Prince and Smolensky 1993/2004) make typological predictions through the mechanism of *factorial typology*. Given a set of constraints in Con, every logically possible arrangement of those constraints represents a pattern that is predicted to be possible in human language. If no possible arrangement of those constraints can produce a particular pattern, a language with that pattern is predicted not to exist.

OT as proposed by Prince and Smolensky solves the problem of 'conspiracies' pointed out by Kisseberth (1970), by producing in a principled way many possible repairs for the same marked structure. This allows an account of within-language conspiracies of the type discussed by Kisseberth, and also makes typological predictions: when a constraint militating against a marked phonological structure interacts with two or more constraints preferring different specific repairs, the factorial typology predicts that different languages should repair the same marked structure in different ways (see Pater 1999 for a worked-through example).

This ability to produce multiple repairs overgenerates, however: it frequently predicts a repair for a particular type of marked structure that is not found cross-linguistically. Theoretical modifications of OT that have been proposed to solve this 'too-many-solutions' problem include the P-map (Steriade 2001/2008), Targeted Constraints (Wilson 2001), and Procedural Constraints (Blumenfeld 2006). It remains a challenge, however, to rule out particular repairs for the cases in which they are unattested, while at the same time allowing for attested multiple repairs for a single constraint (see e.g. McCarthy 2002 and Pater 2003).

Harmonic Serialism (Prince and Smolensky 1993/2004, McCarthy 2007, *et seq*.), uses constraint interaction together with a restricted Gen and a serial evaluation framework. While serialism does not provide a general solution to the too-many-solutions problem, it does constrain the set of possible repairs to a particular marked structure. Specifically, the only repairs which can resolve the marked structure are those which can do so in a *harmonically improving* fashion. A harmonically improving derivation is one in which a form's harmony under the constraint ranking increases at each derivational stage. Because of this requirement, there are some conceivable output forms which are 'globally' optimal, but which are not reachable. Examples of solutions to too-many-repairs problems that make use of this property include McCarthy (2008), Pizzo (2010), Jesney (2011) and Staubs (this volume).

In this paper, I propose a restriction on the set of operations contained in Gen in Harmonic Serialism (HS), which leads to the prediction that epenthesis can be used to repair syllable-structure and segmental markedness, but cannot repair metrical markedness (such as stress clashes and lapses). Epenthesis to repair these structures is predicted by parallel OT but is unattested cross-linguistically.

I propose that the operation of epenthesis in Gen is constrained in two closely related ways. First, it must be distinct from the operation of prosodic structure building. This means that segmental epenthesis and syllable or foot building cannot occur in the same step. Second, epenthesis must satisfy the prosodic markedness constraint Exhaustivity (Selkirk 1995). This constraint forbids 'level skipping', in the prosodic tree – violations would include a syllable adjoined directly to a prosodic word without an intervening foot, or a segment adjoined directly to a foot without also being parsed into a syllable. The proposal is that epenthesis obeys Exhaustivity in that segments may be epenthesized directly into an existing syllable (the next level up on the prosodic hierarchy) but not into an existing foot, prosodic word, prosodic phrase, etc.

In HS with these restrictions on Gen, epenthesis may be used to resolve violations of syllable-structure markedness constraints and segmental phonotactic markedness constraints, but it cannot be used to resolve violations of metrical markedness constraints, which depend on structure above the level of the syllable. Outputs that use epenthesis to resolve violations of metrical markedness constraints never surface as optimal because they are unreachable in the derivation. Although they are globally optimal under some constraint rankings, the required derivational paths are not harmonically improving under any constraint ranking.

The paper is structured as follows: Section 8.2 provides an overview of the types of markedness which epenthesis is observed to resolve cross-linguistically. Section 8.3 introduces and formally defines the proposed restrictions on GEN, and discusses their consequences. In particular, Sections 8.3.3 and 8.3.4 demonstrate that epenthesis cannot resolve a violation of any of *CLASH, FOOTBINARITY, *LAPSE, or NONFINALITY. Section 8.4 briefly discusses attested epenthesis-triggering environments and demonstrates that HS with the proposed restrictions on GEN accounts for these cases. Finally, Section 8.5 concludes.

8.2 Typology of epenthesis-triggering environments

8.2.1 What occurs

Broselow (1982) shows that epenthesis can be used to resolve three types of markedness: syllable-structure markedness, segmental phonotactic markedness, and word-subminimality.[1] An epenthetic vowel can resolve syllable-structure markedness by allowing a bad coda to be re-syllabified as an onset, for example. Broselow gives Swahili as an example of such a case.

(1) Obstruents forbidden in codas in Swahili:
tiket ~ tiket$\underline{\text{i}}$ *ticket*
ratli ~ rat$\underline{\text{i}}$li *pound*

Epenthesis can also resolve phonotactic markedness which is defined purely in terms of segmental content, and which does not depend on higher-level structure. One of Broselow's examples is Winnebago epenthesis, which separates an obstruent and a sonorant – a sequence that is forbidden regardless of the syllable structure in which it occurs. Likewise, in Mohawk a consonant cannot be followed by a glottal stop,

1 Broselow's terminology differs somewhat from mine – she calls these 'syllabic', 'segmental' and 'prosodic' markedness, respectively.

and when it otherwise would in the surface form, an epenthetic vowel intervenes.

(2) Winnebago: obstruent-sonorant sequences forbidden (Dorsey's Law)
hoʃwaʒa → hoʃa̲waʒa *be sick, 2pl*

(3) Mohawk: Consonant+glottal stop clusters forbidden
o+nʌst+ʔ → onʌste̲ʔ *corn, nom.*

Another example of epenthesis for segmental markedness comes from English plural formation, where epenthesis breaks up sequences of sibilants.

(4) English plural:
bɹʌʃ+s → bɹʌʃə̲z

In none of these three cases can epenthesis be construed as resolving syllabic markedness. English and Winnebago both permit sibilant codas, and Mohawk permits obstruent coda clusters, so the epenthesis in (2–4) is apparently not to eliminate bad codas, contrary to Swahili.

The final situation where epenthesis is attested is in resolving word-subminimality. Hayes (1995) lists about thirty languages exhibiting what he calls the 'minimal word syndrome'. Broselow gives an example from Mohawk, where monosyllabic words are forbidden and a long vowel is epenthesized at the beginning of the word to resolve them.

(5) Mohawk: Monosyllabic words forbidden
k+ek+k+s → i̲ː̲keks *I eat*

All three of these types of pattern have standard analyses in Parallel OT using well-motivated constraints.

8.2.2 What doesn't occur

Blumenfeld (2006, ch. 4) notes a typological gap: epenthesis does not apparently occur to resolve metrical markedness such as stress clash or lapse or foot-subminimality. He examines the factorial typology produced in Parallel OT by constraints such as Nonfinality, FootBinarity, *Clash, and *Lapse interacting with Dep and other prosodic constraints such as Parse and the Weight-to-Stress Principle. He shows possible rankings of these constraints which produce languages in which epenthesis is used to avoid violations of these constraints. I will summarize these findings here. Before beginning, though, I provide the notational system that I will use throughout the rest of this paper in (6); note in particular that foot boundaries are indicated with square brackets. I will also be underlining epenthetic segments.

(6) Notational system:

Syllable boundaries	( )
Foot boundaries	[ ]
Prosodic Word boundaries	{ }
Unparsed segments	< >

Marked prosodic structures arise because of the pressure of conflicting high-ranked constraints that motivate foot building, such as Parse, or the Weight-to-Stress Principle (Prince and Smolensky 1993/2004).

(7) Weight-to-Stress Principle (WSP): Assign a violation to every heavy syllable that is not stressed.[2]

In particular, the WSP can interact with other prosodic markedness constraints to produce epenthesis. I will illustrate this first with the constraint Nonfinality.

(8) Nonfinality: Assign a violation to every stressed syllable that is final in a prosodic word.

When the WSP and Nonfinality are both ranked above Dep ('Assign a violation to every segment in the output which is not present in the input'), then a syllable will be epenthesized just in case it avoids a violation of both. The surface forms of such a language would follow a pattern like that in (9).

(9) Epenthesis repairs Nonfinality violations (unattested)

a. /batki/ → {[(bát)(ki)]}
b. /batki + ta/ → {[(bát)(ki)](ta)}
c. /baduk/ → {[(ba)(dúk)](ʔə)} *{[(ba)(dúk)]}
d. /baduk + ta/ → {[(ba)(dúk)](ta)}

2 Constraint definitions have been modified from their sources to follow the prescription for constraint definition in McCarthy (2003). As far as I can tell this does not change the violation profiles.

In this language all heavy syllables (syllables with a coda) are stressed, and just in case a stressed heavy would be final in the prosodic word, a syllable is epenthesized. This language can be produced by ranking WSP and NONFINALITY over DEP.

(10) WSP, NONFINALITY ≫ DEP

	/baduk/	WSP	NONFINALITY	DEP
a. →	{[(ba)(dúk)](ʔə)}			1
b.	{[(ba)(dúk)]}		1W	L
c.	{[(bá)(duk)]}	1W		L

In this tableau, the WSP forces the heavy syllable to be stressed. This syllable is final in the prosodic word in candidate (b), violating NONFINALITY. However, in the winning candidate, (a), an extra syllable is epenthesized, intervening between the heavy syllable and the prosodic word edge.

When *CLASH and the WSP are both high ranked, epenthesis can likewise obtain.

(11) *CLASH: Assign a violation to every pair of adjacent stressed syllables

With both constraints ranked above DEP, all heavy syllables will be stressed, but an extra syllable will be epenthesized just in case two heavy syllables are next to each other.

(12) Epenthesis repairs stress clash (unattested)

a.	/baduk/	→	[(ba)(dúk)]
b.	/baduk + ti/	→	[(ba)(dúk)](ti)
c.	/baduk + kit/	→	[(ba)(dúk)][(<u>ʔə</u>)(kít)] * [(ba)(dúk)][(kít)]

(13) WSP, *CLASH ≫ DEP

	/baduk + kit/	WSP	*CLASH	DEP
a. →	[(ba)(dúk)][(<u>ʔə</u>)(kít)]			2
b.	[(ba)(dúk)](kit)	1W		L
c.	[(ba)(dúk)][(kít)]		1W	L

The case of *LAPSE looks very similar.

(14) *LAPSE: Assign a violation to every pair of adjacent unstressed syllables.

If the WSP and *Lapse both outrank Dep, then for some inputs, a stress lapse will be avoided through epenthesis of an extra syllable. This is demonstrated in the tableau in (15).

(15) WSP, *Lapse ≫ Dep

	/bakdupikib/	WSP	*Lapse	Dep
a. →	[(bák)(du)][(pí)(ʔi)][(kíb)]			2
b.	[(bak)(dú)][(pi)(kíb)]	1 W		L
c.	[(bák)(du)][(pi)(kíb)]		1 W	L

In this tableau, the WSP forces all the heavy syllables ([bak], [kib]) to be stressed, ruling out the candidate with alternating stress in b. Because of the placement of the heavy syllables, stressing both of them results in a stress lapse, as in c. Candidate a. avoids both violations by epenthesizing an extra syllable and building a new foot around it.

The language where WSP, *Lapse ≫ Dep is a language where all heavy syllables are stressed, and a syllable is epenthesized and a foot built with it just in case stressing all heavies would result in a stress lapse. Such a language would have surface alternations like those in (16).

(16) Epenthesis repairs stress lapse (unattested)

a.	/baduk/	→	[(ba)(dúk)]
b.	/baduk + pikit/	→	[(ba)(dúk)][(pi)(kít)]
c.	/batki/	→	[(bát)(ki)]
d.	/batki + pikit/	→	[(bát)(ki)][(pí)(ʔi)][(kít)] *[(bát)(ki)][(pi)(kít)]

Other conflicting constraints can interact with Nonfinality, *Clash, and *Lapse to force epenthesis, including faithfulness to underlying stress, constraints on foot shape, or even alignment constraints.

The final case of predicted epenthesis to resolve metrical markedness that I will discuss involves FootBinarity interacting with the structure-motivating constraint Parse-syll.

(17) FootBinarity (FtBin): Assign a violation to every foot that does not contain two syllables.

(18) Parse-syll: Assign a violation to every syllable that is not parsed into a foot.

Foot binarity can be enforced at a syllabic or at a moraic level of analysis. In this paper I will focus on binarity at the syllabic level only, since only that level would enforce epenthesis of an entirely new vowel. Binarity at the moraic level can be resolved by epenthesis of a mora without a new segment.

If FOOTBINARITY and PARSE-SYLL both outrank DEP, then a syllable would be epenthesized just in case the foot would otherwise be subminimal. This is a language in which every input syllable is footed, and epenthesis applies to make every foot binary. This would be a language in which all prosodic words are even-parity.

(19) Epenthesis repairs subminimal feet (unattested):

a.	/bata/	→	[(bá)(ta)]
b.	/bataka/	→	[(bá)(ta)][(ká)(ʔə)] *[(bá)(ta)][(ká)] *[(bá)(ta)](ka)
c.	/bataka + pi/	→	[(bá)(ta)][(ká)(pi)]

(20) PARSE-SYLL, FTBIN ≫ DEP

	/bataka/	PARSE-SYLL	FTBIN	DEP
a. →	[(bá)(ta)][(ká)(ʔə)]			2
b.	[(bá)(ta)][(ká)]		1W	L
c.	[(bá)(ta)](ka)	1W		L

In this tableau, candidate c. fails because it does not parse all the existing syllables into feet, and candidate b. fails because one of the feet is subminimal. Candidate a. solves both these problems, by epenthesizing an extra syllable.

McCarthy and Prince (1986), and McCarthy and Prince (1993), argue that FTBIN *can* be repaired by epenthesis, just in case it is the only foot in the prosodic word. Specifically, they argue that foot binarity plays a role in determining the size of a minimal word in languages with word minimality (such as Mohawk, (5)). They argue that the 'minimal word syndrome' (Hayes, 1995) is an emergent effect that arises out of the joint action of two contraints: a requirement that words have at least one foot, and a limit on foot size (of which FTBIN is an example). A language like Mohawk, in which words must be at least bisyllabic, would be analyzed with FTBIN and a constraint requiring prosodic words to have at least one foot.

(21) PROSODICWORDHEAD (PRWDHEAD): Assign a violation to every prosodic word that does not have a head foot.

PrWdHead forces all prosodic words to have a head foot. If a language does not allow degenerate (monosyllabic) feet, then the language cannot have words that are smaller than the smallest allowable foot. This can be modeled with PrWdHead, FtBin ≫ Dep, as seen in (22), in which an actual word of Mohawk is derived.

(22) PrWdHead, FtBin ≫ Dep

	/k+ek+k+s/	PrWdHead	FtBin	Dep
a. →	{[(í̱:)(keks)]}			1
b.	{[(kéks)]}		1W	L
c.	{(keks)}	1W		L

In the winner, a., a new syllable is epenthesized and incorporated into the foot so that the prosodic word can have at least one foot, and that foot can be well-formed. This approach predicts that the smallest word a language allows will be the same size as the smallest foot a language allows. For example, if a language allows degenerate monosyllabic, monomoraic feet then it will also allow monosyllabic, monomoraic words. If the smallest feet a language allows are monosyllabic but bimoraic then its smallest words will also be monosyllabic but bimoraic.

More recent work (Piggott 1993, 2010, Garrett 1999) argues that this prediction is false. Piggott and Garrett demonstrate that many languages have minimal word requirements that are not the same as their minimal foot requirements. An example given by Piggott is the Arawan language Paumari, in which monomoraic syllables can be footed in odd-parity words (for example: (má)(sikò), *'ear'*), but the smallest prosodic words are bimoraic (koá, *'mouse'*, but *ko). Garrett further shows that some languages have minimal word sizes that are unattested as minimal foot sizes cross-linguistically. An example is 'CCV or CVC' in Yakima (Hargus and Beavert, 2006). Piggott argues for an independent constraint requiring word-minimality. In light of these arguments I will treat the case of epenthesis to avoid a violation of foot sub-minimality as a true gap that needs to be accounted for. The case of epenthesis to avoid subminimal words will be taken up again in Section 8.4.3.

In summary, while epenthetic material is observed to resolve violations of syllable-structure markedness, segmental phonotactic markedness, and word-subminimality, it is not observed to resolve violations of the metrical markedness constraints Nonfinality, *Clash, *Lapse, and FootBinarity. Parallel OT predicts that it should, however, in that each of these constraints can interact with some conflicting constraint that motivates foot building (WSP, PARSE-SYLL, etc.) to force epenthesis just in case it would avoid a violation of both constraints.

It should be noted that although no categorical epenthesis processes have been found which occur specifically to resolve violations of the metrical markedness constraints discussed here, Hall (2011) discusses variable processes of epenthesis which are conditioned by metrical factors. Examples include French schwa epenthesis (Coté 2000), Dutch schwa epenthesis (Booij, 1995), and epenthesis at Intonational-phrase edges in Galician (Martinez-Gill 1997). Hall makes the generalization that variable epenthetic processes can sometimes be affected by metrical considerations, but no categorical epenthesis process is conditioned by metrical markedness. I leave this apparent difference between categorical processes and variable ones for future work.

8.3 Eliminating epenthesis pathologies in HS

8.3.1 Restricting GEN

In Parallel OT, the set of operations in GEN and their possible interactions is unbounded, and it is the constraint set and ranking that do all of the work of choosing an output from an input. Operations in HS's GEN are much more restricted, and they cannot combine within a derivational stage. Because of this, the exact content of GEN plays a much greater role in determining the final outcome of the derivation. Thus, the study of GEN plays a central role in the development of HS. A theory of the content of GEN must be based on typological considerations. In this section, I will make a claim about GEN, proposing a specific definition of epenthesis with limited structure-building abilities. I will then demonstrate that this definition of epenthesis restricts the set of potential environments for epenthesis in ways that agree with the typological facts given in Section 8.2 above.

Specifically, in order to account for the typological generalization that epenthesis occurs to repair bad syllable structure, but not bad foot structure, I propose that epenthesis is a separate operation from the creation of new prosodic structure (syllable-building, for example), and further that epenthesis obeys EXHAUSTIVITY in that segments can only be epenthesized into existing syllables, not into any higher-level prosodic structure (feet, prosodic words, phrases).

I propose to define epenthesis as in (23).

(23) Epenthesis: Insert a segment at any linear position in the input string.

For Example:

Input:	Batka
Candidates:	əbatka
	bəatka
	baətka
	batəka
	⋮

This operation can be used to resolve segmental markedness like the constraint against adjacent sibilants that affects the shape of the English plural:

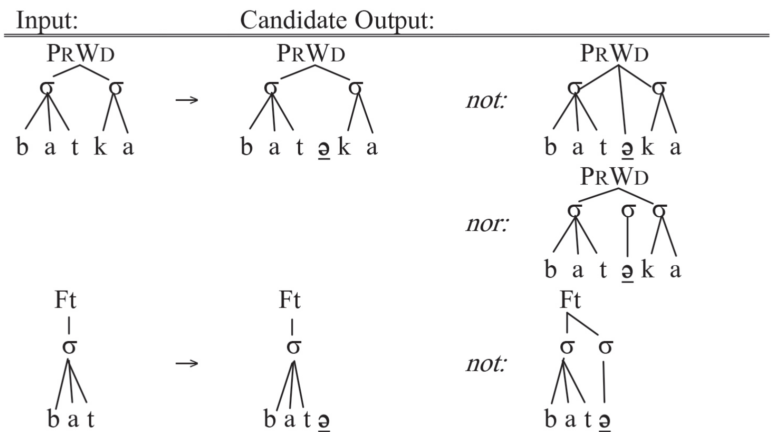
(24) OCP-Sibilant, ≫ Dep

	/bɹʌʃ +z/	OCP-Sibilant	Dep
a. →	bɹʌʃəz		1
b.	bɹʌʃz	1W	L
c.	bəɹʌʃz	1W	1

But Epenthesis does not include parsing into prosodic structure. If a segment is epenthesized into a string that has some prosodic structure, it's left out of that structure.

Epenthesized segments can later be incorporated, gradually, into prosodic Epenthesized segments can later be incorporated, gradually, into prosodic structure, as shown in (25).

(25) Epenthesis in action



Epenthesized segments can later be incorporated, gradually, into prosodic structure, as shown in (26). Recall from (6) that angled brackets indicate an unparsed segment.

(26) Parsing into prosodic structure

Input		Epenthesis		Syllabification		Parsing I		Parsing II
{(bat)(ka)}	→	{(bat)<ə̲>(ka)}	→	{(bat)<(ə̲)>(ka)}	→	{(bat)(ə̲)(ka)}		
[(bát)]	→	[(bát)]ə̲	→	[(bát)](ə̲)	→	[(bát)(ə̲)]		
{[(bát)]}	→	{[(bát)]}ə̲	→	{[(bát)]}(ə̲)	→	{[(bát)](ə̲)}	→	{[(bat)(ə̲)]}

In order for these chains of forms to arise in a derivation, they must be harmonically improving. Each step must do a better job than the one before it of satisfying the constraint set. In the next section I will show that the step of epenthesis is not harmonically improving with respect to the relevant metrical markedness constraints and faithfulness constraints. This means that epenthesis can never occur in such a situation, even when the epenthetic segment would eventually, once prosodified, resolve a violation of a high ranked metrical markedness constraint.

8.3.2 Motivation

In this section, I will briefly provide some theory-internal motivation for the above restriction on Gen. I hope this discussion will lead towards a more general theory of Gen for prosodic structure building.

The Strict Layer Hypothesis (Selkirk 1981, 1984, Nespor and Vogel, 1986) imposes the restriction of Exhaustivity on prosodic structure.

(27) Exhaustivity (Selkirk 1995):
No Ci immediately dominates a constituent Cj, j < i-1,
e.g. 'No PWd immediately dominates a σ.'

Exhaustivity simply states that no levels of the prosodic hierarchy are 'skipped'. A syllable cannot be adjoined directly to a prosodic word, or a foot to a prosodic phrase. Exhaustivity is violated in surface forms in some languages, which show evidence especially that syllables can be adjoined directly to the prosodic word, and not footed (Selkirk 1995 and references therein). Therefore, Selkirk argues that it should be a violable constraint in an OT-type framework.

The restriction on Gen proposed above can be restated more generally, and in terms of Exhaustivity:

(28) EPENTHESIS RESPECTS EXHAUSTIVITY:
No epenthetic constituent Cj, may be immediately dominated by a Ci, where j < i-1,
e.g. 'No epenthetic σ may be immediately dominated by a PrWd.'

This generalization is not a violable constraint in CON, but rather is a statement about the content of GEN. It does not restrict the behavior of epenthetic segments *after* they are epenthesized, but only restricts the process of epenthesis. An epenthetic segment, for example, cannot be epenthesized into an existing prosodic word, but if it were epenthesized before prosodic structure building happened, then it could later be parsed into a prosodic word without first being syllabified. If it were possible to epenthesize whole feet, or whole syllables, then according to this generalization, it would be possible to epenthesize a whole syllable into an existing foot, but not into an existing prosodic word. Likewise, it would be possible to epenthesize a whole foot into an existing prosodic word, but not into an existing prosodic phrase.

I will argue in Section 8.3.3 that it might be desirable to allow a process of whole-syllable epenthesis into GEN.[3]

8.3.3 Epenthesis to resolve metrical markedness in not harmonically improving

In order for epenthesis to resolve a violation of *LAPSE, an input must go through a specific series of derivational stages. These are illustrated in (29). First, foot building operations must produce the bad structure, the stress lapse. Then, epenthesis must occur. Then, the epenthetic vowel must be syllabified and parsed into a foot. Only after this last step is the stress lapse removed.

(29) Required derivational stages

		⋮
	(foot-building operations)	[(bák)(du)](pi)[(kíb)(ti)]
1.	EPENTHESIS	[(bák)(du)](pi)ə̲[(kíb)(ti)]
2.	Syllabification	[(bák)(du)](pi)(ə̲)[(kíb)(ti)]
3.	Foot Building	[(bák)(du)][(pí)(ə̲)][(kíb)(ti)]

3 I am assuming that there is no operation which can epenthesize an empty prosodic category, such as a foot or a syllable. I know of no independent evidence that such operations are necessary, and they would allow a 'loophole' through which segmental epenthesis be used after all to resolve prosodic markedness like subminimal feet.

Although syllabification and foot building would each be harmonically improving, epenthesis at the first stage is not. The candidate in (30b.), with epenthesis, is harmonically bounded since it does nothing to help the *Lapse violation, and incurs a gratuitous violation of Dep.

(30) *Lapse ≫ Dep

	[(bák)(du)](pi)[(kíb)(ti)]	*Lapse	Dep
a. →	[(bák)(du)](pi)[(kíb)(ti)]	1	
b.	[(bák)(du)](pi)ə[(kíb)(ti)]	1	1W

Candidate b. is harmonically bounded by candidate a., and the derivation converges at this step, on the epenthesis-less candidate.

The form in (29, 3.), in which a segment has been epenthesized, syllabified, and parsed into a new foot, is more harmonic given the constraint set and the ranking of *Lapse ≫ Dep, than the candidate with no epenthesis. However, because of the restriction on Gen, this form is not available as a candidate at the first stage, and because it is not in the candidate set it cannot be selected. This form will never make it into the candidate set, and thus will never be chosen as the winner.

In a similar way, epenthesis to resolve violations of Nonfinality and FtBin isn't harmonically improving. Example (31) shows the derivational stages required to reach a form that uses epenthesis to satisfy one of these constraints.

(31) Required derivational stages

		Nonfinality	FtBin
		⋮	⋮
	(foot-building operations)	{[(bák)]}	[(bák)]
1.	Epenthesis	{[(bák)]}ə	[(bák)]ə
2.	Syllabification	{[(bák)]}(ə)	[(bák)](ə)
3.	Foot Building	{[(bák)](ə)}	[(bák)(ə)]

Epenthesis is not harmonically improving in either of these cases. The violation of Nonfinality is not removed until after the epenthetic segment has been syllabified and parsed into a prosodic word. The violation of FtBin is not removed until the segment has been syllabified and parsed into a foot. In both cases, epenthesis at step 1 is harmonically bounded, since it does not fix the violation of the markedness constraint, but does introduce a gratuitous violation of Dep.

*8.3.4 The special case of *Clash*

In this section, I will discuss the constraint *Clash, arguing that its definition should be grid based. Only under a grid-based definition does the constraint behave like *Lapse, Nonfinality, and FootBinarity. Under the definition in (11), a violation of *Clash can be resolved in a single step. This is demonstrated in (32).

(32) *Clash ≫ Dep

	[(ba)(dúk)][(pít)(ki)]	*Clash	Dep
a. →	[(ba)(dúk)]ə̲[(pít)(ki)]		1
b.	[(ba)(dúk)][(pít)(ki)]	1W	L

According to the definition in (11), *Clash is violated whenever two stresses are adjacent, and in candidate a., epenthesis has applied, causing the stressed syllables to now be non-adjacent. Presumably later in the derivation the epenthesized syllable will get prosodified, but it does not need to get prosodified in order to separate the two stressed syllables, removing the violation of *Clash.

Kager (1993) defines a stress clash simply as a pair of adjacent stressed syllables, and this is how the OT constraint has typically been defined. Earlier work on stress clash, however, provides a more detailed definition of what counts as 'adjacent' stresses for the purposes of clash assessment. Liberman and Prince (1977) and Prince (1983) define a stress clash in terms of the metrical grid. In a metrical grid, the syllable is the minimal unit of prominence, and each syllable gets one grid mark. Syllables get additional grid marks for additional levels of prominence, such as secondary word stress, primary word stress, phrasal stress, etc. This is illustrated in (33) with the name of the Dundee soccer team (clashes are circled):

(33)

			X	
	X		X	
x	X		X	
X	X	x	X	x
Dun-	Dee	U-	ni-	ted

Prince (1983) defines a stress clash in terms of the metrical grid thus: 'if two entries are adjacent, with no intervening entry one level down, they will be said to "clash".' Two entries are adjacent if there is no intervening grid mark at their same level of prominence. Thus, the top two grid marks of the syllable 'dee' are adjacent to the middle two grid marks of 'ni-'. In (33), there are two stress clashes, 'Dun-' with 'dee', and 'dee' with 'ni-'. Prince justifies this definition of adjacency by showing that clashes like the second do trigger stress retraction. In fact, this example is frequently realized as in (34).

(34)

			X	
X			X	
X	X		X	
X	X	x	X	x
Dun-	Dee	U-	ni-	ted

In (34), 'dee' and 'ni-' are no longer clashing. Although they are adjacent on the second level up of the grid, they are not adjacent on the next level down – they are separated by 'U-'.

Consider (35), in which material is epenthesized between two stressed syllables. In a., the epenthesized material is parsed into a syllable, and therefore projects a grid mark at the lowest level, which intervenes between the stresses making them no longer adjacent. In b., the epenthesized material is unsyllabified, and therefore doesn't project a grid mark, and thus doesn't resolve the stress clash.

(35)

a.			x	b.			x
	X		x		x		x
	X	X	x		x		x
	[(bàk)]	(ə)	[(ták)]		[(bàk)]	<u>ə</u>	[(ták)]

Thus, only epenthesized material that is fully syllabified can remove the stress clash. Clashes that involve higher levels of prominence would require higher levels of prosodic structure to intervene in order to resolve the stress clash. However, under the definition of epenthesis given in (23), and the definition of adjacency given above, epenthesis can never be used to resolve stress clashes, even at a low level of prominence. The derivational stages that would be required for epenthesis to resolve a stress clash are given in (36).

(36) Required derivational stages

		⋮
	(foot-building operations)	[(bàk)][(ták)]
1.	Epenthesis	[(bàk)] ə̲ [(ták)]
2.	Syllabification	[(bàk)](ə̲)[(ták)]

By the definition of adjacency above, the stress clash is not resolved in the first step with epenthesis, and since it is not resolved, this step is not harmonically improving with respect to these constraints.

(37) *Clash ≫ Dep

	[(ba)(dúk)][(pít)(ki)]	*Clash	Dep
a. →	[(ba)(dúk)][(pít)(ki)]	1	
b.	[(ba)(dúk)] ə̲ [(pít)(ki)]	1	1W

Although the stress clash would be resolved in the second step after syllabification, that step cannot be reached, since the epenthetic candidate is not optimal in step 1. In fact, the derivation converges on [(ba)(dúk)][(pít)(ki)].

8.4 Attested epenthesis

I've argued for a restriction on Gen in HS preventing segments from being epenthesized into prosodic structure higher than the level of the syllable. I show that HS with this restriction is restrictive enough that it never produces segmental epenthesis as a repair for violations of the metrical markedness constraints *Clash, *Lapse, Nonfinality, and Ftbin. In this section I will briefly demonstrate that segmental epenthesis can still be used in the attested cases, namely to repair bad syllable structure and segmental phonotactic markedness. I will argue that attested epenthesis to resolve word-subminimality is not segmental epenthesis, but rather morpheme epenthesis, and as such should be dealt with slightly differently.

8.4.1 For segmental markedness

The success of epenthesis in resolving a segmental markedness problem is not contingent on the existence of any prosodic structure. Because of this, an epenthetic segment can alleviate segmental markedness without being parsed, and so it can always do so in a single step. An example of epenthesis to resolve the adjacent-sibilants problem in the English plural is given in (24), repeated below. The epenthetic segment does not need to be parsed into any prosodic structure to separate the sibilants from each other, and thus satisfies OCP-SIBILANT in a single step.

(24) OCP-SIBILANT, ≫ DEP

	/bɹʌʃ +z/	OCP-SIBILANT	DEP
a. →	bɹʌʃəz		1
b.	bɹʌʃz	1W	L
c.	bəɹʌʃz	1W	1

8.4.2 *For syllable structure*

Elfner (2009, this volume) presents an analysis of stress-epenthesis interactions in HS, in which she uses a single operation of epenthesis of a segment plus adjunction of that segment to an existing syllable – that is, epenthesis into a syllable. As long as a segment can be epenthesized and simultaneously parsed into a syllable, epenthesis can be used to resolve syllable-level markedness. To illustrate, consider the case of Kwak'wala, where vowels are epenthesized to avoid syllable-initial clusters (Elfner, 2009, pp16-19)

The Kwak'wala root /p'ɬa/, 'to blink', must first be syllabified:

(38) Syllabification of /p'ɬa/ : Step 1

	/p'ɬa/	SONNUC	*COMPLEX	PARSESEG	SYLL-HEAD	DEP-V
a. →	p'(ɬa$_{\mu}$)			1		
b.	(p'ɬ$_{\mu}$)a	1W		1		
c.	p'ɬ(a$_{\mu}$)			2W		
d.	(p')ɬa			2W	1W	

The first step is the creation of what Elfner calls a 'core syllable' – a syllable with an onset and a moraic nucleus. Parsing two segments into a core syllable is a single step. The constraint nicknamed SONNUC militates against the creation of core syllables whose nuclei are not sonorous enough, like that in candidate b. Candidate d. represents another type of syllable, the 'minor syllable', whose nucleus is not moraic. Because its nucleus is not moraic, this syllable doesn't violate SONNUC, but it does violate SYLL-HEAD, which militates against mora-less syllables. In the second step, formation of a minor syllable with the initial consonant will be optimal:

(39) Syllabification of /p'ɬa/ : Step 2

p'(ɬa$_\mu$)	SonNuc	*Complex	ParseSeg	Syll-Head	Dep-V
a. → (p')(ɬa$_\mu$)				1	
b. (p'ɬa$_\mu$)		1W			
c. (p'$_\mu$)(ɬa$_\mu$)	1W				
d. p'(ɬa$_\mu$)			1W		

Once a minor syllable is formed, a vowel can be epenthesized to repair the Syll-Head violation.

(40) Syllabification of /p'ɬa/ : Step 3

(p')(ɬa$_\mu$)	SonNuc	*Complex	ParseSeg	Syll-Head	Dep-V
a. → (p'ə̠)(ɬa$_\mu$)					1
b. (p')(ɬa$_\mu$)				1W	L
c. p'(ɬa$_\mu$)			1W		L

The derivation converges here because the structure (p'ə̠)(ɬa$_\mu$) is maximally harmonic under the constraint ranking. Any further changes would only make it worse. In a similar way, epenthesis can be used to resolve complex codas, or to avoid codas altogether, through a series of stages.

(41) Required derivational stages

Input	Core syllabification	(Adjunction)	Minor syllable formation	Epenthesis
/p'ɬa/	p'(ɬa)		(p')(ɬa)	(p'ə̠)(ɬa)
/tapk/	(ta)pk	(tap)k	(tap)(k)	(tap)(kə̠)
/tap/	(ta)p		(ta)(k)	(ta)(kə̠)

Minor syllable formation occurs in each case to avoid a violation of syllable-structure markedness constraint. In the cases with clusters it is *Complex, and in the coda case it is *Coda. After the minor syllable is formed, epenthesis can apply into that syllable, resolving that syllable's markedness (it is headless).

8.4.3 For word-minimality

The last type of epenthesis discussed by Broselow (1982) is epenthesis for word minimality. Above, I claimed that epenthesis does not occur to remove a violation of FootBinarity. I also cited Garrett (1999) and Piggott (1993, 2010) as arguing that word minimality is unrelated to foot-minimality. Piggott argues for a constraint MinWd, whose exact definition is language specific, and which is enforced separately from FtBin.

(42) MinimalWord (MinWd) (Piggott, 2010, p.10)
A Prosodic Word contains more that one syllable (or mora).

With the definition of epenthesis given above, epenthesis cannot be used to resolve a violation of this constraint either. This is because an epenthetic segment would have to be first syllabified, and then parsed into a syllable in order to satisfy the constraint.

(43) Required derivational stages

		⋮
	(prosodic-word building)	{(bak)}
1.	Epenthesis	{(bak)}ə̲
2.	Incorporation into the prosodic word	{(bak)ə̲}
3.	Syllabification	{(bak)(ə̲)}

Only at the final of these steps does epenthesis resolve a violation of MinWd. At the first step, epenthesis is not optimal, because the epenthetic segment does not remove any violations, and incurs a gratuitous violation of Dep.

This seems like a wrong prediction, since epenthesis can apparently be used to resolve word-minimality. However, I propose that the epenthesis used to resolve word-minimality is not segmental epenthesis, but rather morpheme epenthesis, and thus is not subject to the same constraints.

Wolf (2008) proposes morpheme-epenthesis as an operation in Gen which violates a faithfulness constraint Dep-M(FS), which militates against insertion of feature-structure that is not present in the input. He argues for this operation from cases like the augmentative [-pa] in Pitjantjatjara. In Pitjantjatjara, whenever a word ends with a consonant, the semantically vacuous [-pa] is added (/mankur/ → [mankurpa], but /mankur + tu/ → [mankurtu]). As an epenthetic sequence, [-pa] is problematic for two reasons. First, it contains a labial, which is otherwise unattested as an epenthetic segment cross-linguistically, and second, it has more material than is necessary to satisfy the requirement that words end in a vowel. Epenthesis of a vowel would be sufficient to solve the problem; why does the [p] show up as well? The answer that Wolf gives is that [-pa] is not an example of segmental epenthesis, but rather of morpheme epenthesis.

Sequences epenthesized to resolve word-minimality are often similarly typologically marked. For example, the epenthetic vowel that is used for word minimality in Mohawk (Broselow, 1982) is completely different from the epenthetic vowel used for other types of marked structures in the language: [e] is used to resolve stop-glottal sequences, while [i] is used to form a minimal word.

(44) Mohawk epenthesis:

o+nʌst+ʔ → onʌsteʔ	*corn, nom.*
k+ek+k+s → iːkeks	*I eat*

A similar discrepancy is observed in Swahili (Hinnebusch and Mirza, 1998).

(45) Swahili epenthesis:

ratli → ratili	*pound*
la → kula	*eat*

In Swahili, what is epenthesized for word minimality is not only different from what is epenthesized for coda avoidance, but also bears all the hallmarks of the Pitjantjatjara [-pa]: [k] is typologically unattested as an epenthetic segment, and it is superfluous. Swahili's disyllabic minimal word requirement would just as easily be filled with a vowel only. Furthermore, [ku-] has the same phonological shape as Swahili's infinitive morpheme. I propose that this epenthetic material *is* the infinitive morpheme being recruited for a purely phonological purpose. Another clear example of this is epenthetic *yi-* in Navaho, which Young and Morgan (1987) have argued is a semantically null morpheme, and which is recruited to repair minimal words.

Cases that look more like segmental epenthesis do exist – examples include Lardil (Piggott, 2010) and Choctaw (Lombardi and McCarthy, 1991). My proposal is that even in these cases, the material epenthesized for word-minimality is really a semantically vacuous morpheme. This makes two predictions. First, it should never, or only very rarely, be the case that what is epenthesized for word-minimality requirements matches what is epenthesized for other types of markedness in the same language. Second, the typology of epenthetic material used to repair word-minimality should look different from the typology of epenthetic vowels in general.[4] Both of these predictions remain to be tested.

4 Thanks to Paul de Lacy for pointing this out to me.

Providing a fully worked-out account for morpheme-epenthesis in HS is a job for future work. However, such an account, if it is to allow morpheme-epenthesis to repair word-subminimality, must allow morphemes to be epenthesized at least partially prosodified. For example, the Swahili epenthetic morpheme –ku- must be already syllabified before it is epenthesized. The ability to insert already-prosodified morphemes will be necessary independently to model prosodically conditioned allomorphy, in which the choice of allomorphs depends on how they will be prosodified into the existing string (for example, Kager, 1996).

If the epenthetic morpheme is inserted already syllabified, then according to the Exhaustivity condition in (28), it can be inserted into an existing foot. This means that after the formation of a subminimal prosodic word, the material inside the prosodic word must be footed first, after which a syllabified morpheme can be epenthesized into that foot, thereby eliminating the word minimality violation. In Swahili, these two derivational stages would go something like this:

(46) Word-minimality epenthesis in Swahili, step 1

	{(la)}	Parse-Syll	WordMin	Dep-M(FS)
a. →	{[(la)]}		1	
b.	{(la)}	1W	1	

(47) Word-minimality epenthesis in Swahili, step 2

	{(la)}	Parse-Syll	WordMin	Dep-M(FS)
a. →	{[(ku)(la)]}			1
b.	{[(la)]}		1W	L

8.5 Conclusion

In this paper, I've proposed a hypothesis about the content of Harmonic Serialism's Gen, namely that it contains an operation of epenthesis which is separate from subsequent operations of prosodic structure building, and which obeys absolutely the Exhaustivity constraint of Selkirk (1981, 1984), and Nespor and Vogel (1986). I've argued that under this hypothesis, epenthesis of a segment can be used to resolve syllable-structure markedness and segmental phonotactic markedness, but will never be used to resolve violations of *Clash, *Lapse, *Nonfinality, and FtBin. This is because epenthesis before prosodic structure building is harmonically bounded, since it cannot immediately remove the markedness violation, but incurs an additional faithfulness violation.

This paper is a contribution to the general effort to discover what kinds of too-many-repairs problems can be solved in a serial framework like Harmonic Serialism. As I have shown here, restricting Gen restricts the space of possible repairs to any markedness constraint. This paper also contributes to the research program of finding reasonable (typologically sensible) constraints on the space of possible operations in HS's Gen.

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