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Stress-Epenthesis Interactions in Harmonic Serialism

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1 Introduction

In many languages, epenthetic vowels disturb an otherwise regular stress pattern. In Dakota (Shaw 1976, 1985), for example, stress regularly falls on the second syllable, except when the second syllable contains an epenthetic vowel. In these forms, stress falls instead on the first syllable. This can be seen by comparing the data in (1), which show the basic stress pattern, and (2), which show initial stress for a class of verb and noun stems that predictably end in the epenthetic vowel /a/:[1]

(1) Regular second-syllable stress in Dakota (Shaw 1985: 31)

a.	/č^{h}i-kte/	č^{h}i.kté	'I kill you'
b.	/ma-ya-kte/	ma.yá.kte	'You kill me'
c.	/wičha-ya-kte/	wi.čhá.ya.kte	'You kill them'

(2) Initial-syllable stress (Shaw 1985: 32)

a.	/čap/	čá.pa̱	'beaver'
b.	/šuk/	šú.ka̱	'to stagger'
c.	/šič/	ší.ča̱	'to be bad'

Contrasting data can be found in Swahili, where the placement of stress is not affected by epenthetic vowels, as in loanwords (Alderete 1995, Ashton 1944, Broselow 1982, Polomé 1967). This can be seen by comparing the data in (3), which show the regular penultimate stress pattern, and (4), which show an optional process of [i]-epenthesis following coda consonants in loan words:

(3) Penultimate stress in Swahili

a.	jíko	'kitchen'
	jikóni	'in the kitchen'
b.	nilimpíga	'I hit him'
	nitakupíga	'I should hit him'

(4) Penultimate stress in words with epenthetic vowels

a.	tíket ~ tikéti	'ticket'
b.	rátli ~ ratíli	'pound'

The pattern in languages like Dakota presents a problem for Classic OT (Prince and Smolensky 1993/2004) because it shows a type of opaque interaction that cannot be adequately described in a strictly parallel framework. In Classic OT, faithfulness constraints govern input-output relations and markedness constraints militate against marked output forms. In languages where epenthetic vowels differ from their non-epenthetic counterparts only in their lack of input correspondents, there is no simple markedness constraint that can derive the opaque pattern: in Dakota, stress is expected to fall on the second syllable, whether or not the vowel is epenthetic.

Within Classic OT, Alderete (1995, 1999) argues that such patterns arise from a dispreference for epenthetic vowels to be contained in the heads of prosodic constituents, and he proposes to augment the tools of Classic OT with the positional faithfulness constraint

HEAD-DEP. However, while this constraint can be used to capture the basic patterns, as in the contrast between languages like Dakota and Swahili, it can be shown to lead to pathological typological predictions of a type that are also found with other positional faithfulness constraints, as discussed in Jesney (2011b) and in section 2 of this paper, as well as to make incorrect predictions with respect to attested data.

In this paper, I propose that the interactions exhibited by stress and epenthesis are best captured using Harmonic Serialism (HS; among others, McCarthy 2000, 2002: 159-163, 2008a, b: et. seq., Prince and Smolensky 1993/2004: 94-95), a version of OT that combines constraint interaction with serial derivation. HS is like Classic OT, except for a restriction on GEN that requires that candidates differ from their input by no more than a single operation. Each step in the derivation is an OT evaluation, and the derivation continues to pass through GEN and EVAL until the output is identical to the input, at which point it converges. Unlike other serial implementations of OT such as Stratal OT (Bermúdez-Otero to appear, Kiparsky 2003, to appear) and OT-with-Candidate-Chains (OT-CC; McCarthy 2007), the order of operations in HS is controlled solely by the ranking and interaction of basic OT constraints.

In HS, stress assignment and epenthesis are separate operations in GEN whose order of application is controlled by the relative ranking of those markedness constraints responsible for driving epenthesis (syllable structure markedness constraints) and by a constraint punishing stressless words. Because epenthesis and stress are separate operations, they must be applied sequentially rather than concurrently, as they would in Classic OT. As in Classic OT, factorial typology predicts that languages will differ with respect to whether epenthesis or stress is prioritized by the constraint ranking. This prediction appears to hold. In languages like Dakota, stress markedness outranks syllable structure markedness, requiring stress to precede epenthesis. Stress ignores the epenthetic vowel because the vowel is not yet present, resulting in the opaque pattern. In languages with transparent interactions like Swahili, the constraints are ranked in the opposite order, with the result that epenthesis precedes stress. The stress pattern is not disturbed in this case because the epenthetic vowel is present at the point in the derivation where stress is assigned. The HS analysis shares many of the properties of other serial analyses of epenthesis including rule-based ones (Broselow 1982, Farwaneh 1995, Michelson 1983, 1988, 1989, Selkirk 1981), but it derives the serial interactions through constraint ranking rather than rules. Moreover, HS retains many of the advantages of Classic OT by deriving output forms through constraint interaction and by making clear typological predictions based on factorial typology.

This paper is organized as follows. Section 2 provides an overview of the difficulties associated with an account of stress-epenthesis interactions in Classic OT using HEAD-DEP. Section 3 presents the HS analysis of the basic contrast between languages with opaque stress-epenthesis interactions (Dakota) and transparent interactions (Swahili). Section 4 develops analyses of 'mixed' languages in HS, those with both transparent and opaque interactions, including Mohawk (4.1) and Levantine Arabic (4.2). Section 4.3 discusses the typological predictions of the HS analysis, and section 4.4 provides a comparison between the HS account of stress-epenthesis interactions and that of other serial implementations of OT, including Stratal OT and OT-CC. Section 5 concludes the paper.

2 Parallelism versus Serialism in Stress-epenthesis Interactions

Alderete (1995, 1999) proposes to augment the tools of Classic OT with the constraint HEAD-DEP, a version of the anti-epenthesis faithfulness constraint DEP. HEAD-DEP is a positional faithfulness constraint violated by epenthetic vowels that are the heads of prosodic constituents. Alderete (1995: 8) defines this constraint as below using the formal characterization of correspondence given in McCarthy and Prince (1995, 1999):

(5) HEAD-DEP: Every segment contained in a prosodic head in S_2 has a correspondent in S_1. If β is contained in a prosodic head in S_2, then $\beta \in \text{Range}(\Re)$.

This constraint is violated by every epenthetic vowel that is contained within a prosodic head. This would include, for example, the head syllable of a foot or the head foot of the prosodic word.

When HEAD-DEP is added to the constraint set, Classic OT can account for the contrast between languages with an opaque stress-epenthesis interaction like Dakota and a transparent interaction like Swahili. In Dakota, HEAD-DEP is ranked above FT=IAMB, the constraint that militates against feet that are not right-headed, resulting in a non-iambic stress pattern when the second syllable contains an epenthetic vowel:[2]

(6) Opacity in Classic OT (Dakota)

/čap/	HEAD-DEP	FT=IAMB
a. → (čá.pa)		1
b. (ča.pá)	1 W	L

In Swahili, HEAD-DEP is ranked below stress constraints such as ALIGNHDR, which calls for the head foot to be right-aligned. This ranking prevents stress from being assigned to the antepenultimate syllable when the penultimate syllable contains an epenthetic vowel:

(7) Transparency in Classic OT (Swahili)

/ratli/	ALIGNHDR	HEAD-DEP
a. → ra(tí.li)		1
b. (rá.ti)li	1 W	L

It is clear from the above analysis that Classic OT with the constraint HEAD-DEP is capable of dealing with the basic contrast between transparent and opaque systems.

Adding the constraint HEAD-DEP to the constraint set in Classic OT is not without its problems. One problem with HEAD-DEP arises from consideration of factorial typology. HEAD-DEP is a positional faithfulness constraint which militates against epenthesis in prominent prosodic positions. In each of the cases examined by Alderete (1995, 1999) and others, opaque interactions arise because stress constraints are violated to accommodate the constraints driving epenthesis. In OT terms, this occurs because syllable structure markedness constraints dominate the constraints governing stress assignment. This can be seen in a more complete analysis of opaque stress assignment in Dakota, where the tableau is expanded to include the syllable structure markedness constraint NOCODA, which drives epenthesis, and a candidate where epenthesis does not occur. In order for candidate (a) to be optimal, both NOCODA and HEAD-DEP must dominate the stress constraint FT=IAMB:

(8) Opacity in Classic OT (Dakota)

/čap/	HEAD-DEP	NOCODA	FT = IAMB	DEP
a. → (čá.pa)			1	1
b. (ča.pá)	1 W		L	1
c. (čáp)		1 W	L	L

However, if the ranking between NOCODA and FT = IAMB were to be reversed, the candidate without epenthesis would win:

(9) Predicted language (Dakota'): epenthesis blocked in prominent positions

/čap/	HEAD-DEP	FT = IAMB	NOCODA	DEP
a. → (čáp)			1	
b. (čá.pa)		1 W	L	1 W
c. (ča.pá)	1 W		L	1 W

Under this ranking, NOCODA, as the lower-ranked constraint, is violated to avoid epenthesis in a prominent position, showing an alternative strategy to avoid violating HEAD-DEP. However, because HEAD-DEP is a positional-faithfulness constraint, epenthesis will only be blocked under this ranking when a vowel would be epenthesized into a prominent position. If a vowel were to be epenthesized into a syllable other than the second, epenthesis would not be blocked:

(10) Epenthesis not blocked in non-prominent positions (hypothetical)

/čapat/	HEAD-DEP	FT = IAMB	NOCODA	DEP
a. → (čá.pa)ta				1
b. (ča.pát)			1 W	L
c. (čá.pa)ta		1 W		1
d. (čá.pat)		1 W	1 W	L

The HEAD-DEP analysis thus predicts the existence of a language where epenthesis is avoided in positions that would be prominent, but occurs freely in non-prominent positions. To the best of my knowledge, such languages are unattested. This is part of a more general typological problem with positional faithfulness constraints; see Jesney (2011b)) for discussion.

Conversely, the HEAD-DEP account also appears to be overly restrictive in its typological predictions. Alderete (1995: 16) draws attention to a prediction made by the account, namely that extrametrical epenthetic vowels will never affect stress assignment. This prediction appears to be explicitly contradicted in data from Levantine and Iraqi Arabic (Abu-Salim 1982, Broselow 2008, Farwaneh 1995, Kiparsky to appear), where extrametrical epenthetic vowels do result in irregular stress patterns. In these dialects, final syllables are extrametrical, as can be evidenced by a regular pattern of antepenultimate stress when the penult is a light syllable (Broselow 2008: 140):

(11) Iraqi Arabic, Antepenultimate stress: light penult

a. (ʃá.ri)ka ‘company’
b. (ʕáː.la)mi ‘my world’
c. mu(máθ.θi)la ‘actress’

However, when a word underlyingly ends in certain final sequences of two consonants, stress falls on the light penultimate syllable rather than the antepenult, as expected from the pattern in (11):

(12) Iraqi Arabic, Opaque Pattern: Final CC clusters
/kitab-t/ kitábi̱t 'I wrote' *kítabi̱t

This pattern presents a problem for HEAD-DEP because the epenthetic vowel is in the final syllable, which is extrametrical. The shift of stress rightward cannot be attributed to HEADDEP, because the transparent form, *[(kí.ta)bit], would not include the epenthetic vowel in the head of any prosodic constituent. HEAD-DEP predicts that epenthetic vowels can only affect stress assignment when they would be placed in prosodically prominent positions, and therefore cannot account for the data in (12) (Alderete 1995: 16).[3]

These data, as well as the arguments presented above relating to typological predictions, present serious challenges to the HEAD-DEP account of stress-epenthesis interactions, and suggest that alternatives should be considered. This paper develops an analysis of these and other patterns using Harmonic Serialism, a serial framework whose derivations are driven by the ranking and interaction of violable OT constraints. This framework provides a way of preserving many of the insights of Classic OT without the need to rely exclusively on surface patterns.

3 HS and Stress-epenthesis Interactions[4]

As in Classic OT, unfaithful operations in HS are motivated by the satisfaction of markedness constraints that outrank relevant faithfulness constraints. For instance, epenthesis occurs when a constraint on syllable structure markedness such as NOCODA or *COMPLEX outranks DEP. Similarly, feet are built when a constraint such as PROSODICWORDHEAD (PWDHD, which is violated by words without a head foot) outranks a constraint against the insertion of prominences that are not present in the input (DEPPROMINENCE).

In this paper, I follow the proposal in McCarthy (2007) that the notion of gradualness in HS is tied to faithfulness constraints, such that a single change in HS is equivalent to an unfaithful mapping. This can be defined as follows:

(13) Gradualness Requirement on GEN:
Candidates differ from their input only by the application of one phonological operation, where an operation incurs a violation of a basic faithfulness constraint.

For example, epenthesis and deletion, as well as segmental changes such as assimilation are all distinct operations in GEN because they violate basic faithfulness constraints (i.e. DEP, MAX, IDENT). Prosodic structure is less clearly defined, and in this, I follow this line of reasoning and most closely the proposals in McCarthy (2008b, 2010) and Pruitt (2010), where stress, but not syllabification, constitutes a separate operation.[5] Syllabification, which is claimed not to be contrastive in any language (Blevins 1995, Clements 1986, Hayes 1989, McCarthy 2003), does not violate any faithfulness constraints, and therefore does not constitute a separate operation in an HS derivation, under the definition in (13). However, other prosodic constituents, like stress as defined by foot assignment, can be contrastive among languages, indicating that the building of foot structure differs from syllabification by being an unfaithful act, violating

DEPPROMINENCE. In other words, syllables can be built or modified at any time as segments are deleted or epenthesized. Foot structure requires a separate operation to build and undo that cannot be applied concurrently with any other operation. Most importantly for the current proposal, stress and epenthesis cannot apply in the same step, as both are faithfulness-violating operations.

In languages with both stress and epenthesis, each of the relevant markedness constraints will outrank the corresponding faithfulness constraint. However, in Classic OT, with its parallel evaluation of stress and epenthesis, it is never possible to determine the relative ranking of undominated markedness constraints with respect to each other. For example, as discussed above, Swahili is a language with predictable penultimate stress (PWDHD » DEPPROM) and epenthesis to avoid codas (NOCODA » DEP). This language shows a transparent interaction between stress and epenthesis because penultimate epenthetic vowels may be stressed (e.g. /ratli/ > [ratíli] 'pound').

In Classic OT, both possible rankings of PWDHD and NOCODA will result in the same transparent interaction between stress and epenthesis attested in Swahili. As can be seen in the following tableau, the opaque form (candidate b) is harmonically bounded by the transparent form:

(14) Classic OT: PWDHD and NOCODA are equally satisfied by winning candidate

/ratli/	NOCODA	PWDHD	ALIGNHDR	DEPPROM	DEP
a. → ra(tí.li)				1	1
b. (rá.ti)li			1 W	1	1

In HS, however, the markedness constraints responsible for motivating stress and epenthesis conflict with each other, and as such, must be ranked. It is this ranking that will determine the order in which operations are applied. More specifically, if NOCODA outranks PWDHD, epenthesis will precede stress because the ranking indicates a preference for satisfying NOCODA before PWDHD. The opposite ranking would indicate instead a preference for stress to be assigned before epenthesis. Languages thus differ with respect to whether or not the epenthetic vowel is present at the moment of stress assignment. In transparent languages, epenthesis precedes stress and stress can fall on the epenthetic vowel. In opaque languages, stress is applied before epenthesis occurs and cannot fall on the epenthetic vowel because it is not yet present. The basic typology of transparent and opaque interactions in this way follows from one of the fundamental properties of OT: constraint permutation and factorial typology.

The HS analysis of this basic contrast can again be illustrated with Swahili and Dakota. In Swahili, a transparent language, epenthesis precedes stress, as captured by ranking NOCODA over PWDHD. The following two tableaux illustrate the derivation. In Step 1, epenthesis occurs to satisfy higher-ranked NOCODA:

(15) Swahili, Step 1: Epenthesis

/ratli/	NOCODA	PWDHD	DEPPROM	DEP	*Operations*
a. → ra.ti.li		1		1	*epenthesis*
b. (rát.li)	1 W	L	1 W	L	*stress*
c. rat.li	1 W	1		L	*no change*

High-ranked NOCODA eliminates all candidates that do not epenthesize a vowel, including candidate (b), which assigns stress to satisfy PWDHD. The gradualness requirement ensures that there is no candidate that can satisfy both NOCODA and PWDHD.

The output of Step 1, *ra.ti.li*,[6] then becomes the input to Step 2. Now that the input satisfies NOCODA, the derivation turns to the next-highest ranked constraint, PWDHD. The optimal candidate, then, is *ra(tí.li)*, which assigns stress transparently to the penultimate syllable and satisfies PWDHD. Candidates with alternative stress patterns, such as *(rá.ti)li*, are eliminated based on the ranking of constraints generally responsible for stress assignment in the language; in this case, for example, ALIGNHDR outranks ALIGNHDL.

(16) Swahili, Step 2: Stress

ra.ti.li	NOCODA	PWDHD	DEPPROM	DEP	*Operations*
a. → ra(tí.li)			1		*stress*
b. ra.ti.li		1 W	L		*no change*

Finally, the derivation will converge in Step 3, because there is no operation that can be applied that will produce a candidate that is more harmonic with respect to the constraint hierarchy.

In contrast, the opaque pattern in languages such as Dakota can be derived by assuming the opposite ranking of syllable structure markedness and PWDHD. In Dakota, PWDHD outranks NOCODA. Because stress will be assigned before epenthesis occurs, stress falls on the initial syllable rather than the second syllable. Step 1 is shown in the following tableau:[7]

(17) Dakota, Step 1: Stress

/čap/	PWDHD	NOCODA	DEPPROM	DEP	*Operations*
a. → (čáp)		1	1		*stress*
b. ča.pa	1 W	L	L	1 W	*epenthesis*
c. čap	1 W	1	L		*no change*

The epenthesis candidate in the above tableau is initially eliminated by high-ranked PWDHD. Because PWDHD is satisfied in Step 1, the epenthesis candidate can now win in Step 2. Once epenthesis occurs, the stress pattern becomes opaque, because the surface form violates the stress constraints that are normally satisfied in the language, including the preference for iambic feet governed by the constraint FT=IAMB. However, provided that NOCODA (the epenthesis-driving constraint) outranks FT=IAMB, the opaque form *(čá.pa)* emerges as optimal, as shown in the following tableau:

(18) Dakota, Step 2: Epenthesis

(čáp)	PWDHD	NOCODA	FT=IAMB	DEPPROM	DEP	*Operations*
a. → (čá.pa)			1		1	*epenthesis*
b. (čáp)		1 W	L		L	*no change*

In order for the form with opaque stress to surface, the derivation must converge on this form. This means that when the output of Step 2 is fed into the next step, the *no change* candidate must be the most harmonic. In other words, the transparent form *(ča.pá)* cannot be among the candidates considered in Step 3 because it would be more harmonic than opaque *(čá.pa)*, given the constraint hierarchy. This follows from the assumptions regarding GEN in HS: if stress assignment is itself a faithfulness-violating operation, any further changes to stress placement must also be faithfulness-violating operations. Under this hypothesis, stress shift requires the application of two operations, one to remove the foot, and another one to reassign it.[8] In the case of *(čá.pa)*, we would first have to demote the first syllable from head status by removing the foot (> *ča.pa*) and then by parsing an iambic foot, which assigns head status to the second syllable (> *(ča.pá*)). However, this chain of events would require an intermediate step where stress is removed from the word. Because stress assignment itself was a harmony-improving operation, its removal cannot be harmonically improving. The intermediate candidate without word stress cannot win without decreasing the harmony of the derivation, and will not be chosen as the optimal candidate. In Dakota, stress will therefore remain stranded on the initial syllable, even though it violates the basic stress constraints in the language.

This is illustrated in the tableau for Step 3 of the above derivation. This step considers, alongside the faithful candidate *(čá.pa)*, the candidate *ča.pa* (which deletes the foot). The candidate *(ča.pá)* (which both deletes a foot and adds a foot), on the other hand, is not considered because it is not produced as a candidate at this step. As can be seen below, *ča.pa* incurs a violation of high-ranked PWdHd, and for this reason, loses to the *no change* candidate. The derivation instead converges on the opaque form *(čá.pa)*, even though it violates Ft = iamb. This is illustrated in the following tableau for Step 3:

(19) Dakota, Step 3: Convergence

(čá.pa)	PWdHd	NoCoda	Ft = iamb	Dep	***Operations***
a. → (čá.pa)			1		*no change*
b. ča.pa	1 W		L		*stress deletion*

The above discussion of Swahili and Dakota illustrate how HS can be used to account for opaque and transparent stress-epenthesis interactions. This account assumes only constraint ranking and the HS assumptions regarding the gradualness requirement on Gen. While the analysis shares with rule-based serialism the idea that the ordering of stress and epenthesis operations is responsible for deriving opacity in stress-epenthesis interactions, the HS analysis differs from the rule-based one because it assumes that ordering derives from the ranking and interaction of violable constraints, as in Classic OT.

4 Mixed Languages

In addition to this basic contrast, some languages show "mixed" systems, where epenthetic vowels are stressed in some environments but not others. These languages are important because they show that epenthesis processes are independent from one another, and may interact differently with respect to stress assignment. In this section, I show how the complex array of data in two of these languages, Mohawk (Michelson 1983, 1988, 1989) and Levantine Arabic (Abu-Salim 1982, Farwaneh 1995) can be accounted for using HS.

4.1 Mohawk

4.1.1 CCC and CR epenthesis

Mohawk (Michelson 1983, 1988, 1989) has several epenthesis processes that interact in different ways with stress. The language is described as having three epenthetic vowels, [e], [i] and [a]. Of these, [e]-epenthesis is the only one that is clearly phonological in nature and arises in three contexts to break up certain consonant clusters. The other epenthetic vowels are less clearly motivated by syllable structure markedness constraints: [i]-epenthesis occurs only to fulfil a disyllabic word minimality requirement, while [a]-epenthesis patterns as a type of "joiner" morpheme that surfaces to avoid consonant sequences when morphemes are concatenated. Because this paper is concerned with epenthesis as motivated by syllable structure, I will not discuss [i]-epenthesis or [a]-epenthesis, but leave a full analysis of Mohawk to future research. For more details on these other processes, see Michelson (1983, 1988, 1989).

In Mohawk, the epenthetic vowel [e] interacts non-uniformly with respect to stress assignment, in contrast with Swahili and Dakota: [e] can be stressed when it breaks up an underlying three-consonant cluster but not when it breaks up a consonant-sonorant sequence (CR, where C is an oral consonant and R is a sonorant from the set /n, r, w/). This can be seen in the following data: (20) shows the regular pattern of penultimate stress, (21) shows that epenthetic [e] is stressed when it is inserted to break up a CCC cluster and falls in penultimate position, and (22) shows that stress avoids epenthetic [e] when its origin is a CR cluster, and falls instead on the antepenultimate syllable:[9, 10, 11]

(20) Regular penultimate stress (Michelson 1989: 44)

a.	k-ketskwas	[kkétskwas]	'I raise it'
b.	k-ataʔkerahkw-haʔ	[kataʔkeráhkwaʔ]	'I float'
c.	k-atirut-haʔ	[katirútha?]	'I pull it'
d.	k-riht-haʔ	[keríhthaʔ]	'I cook'
e.	wak-ashet-u	[wakashé:tu]	'I have counted it'
f.	k-akʌʔrokew-as	[kakʌʔroké:was]	'I'm dusting'

(21) CCC [e]-epenthesis ("Type II", Michelson 1989: 42)

a.	wak-nyak-s	[wakényaks]	'I get married'
b.	s-rho-s	[sérhos]	'you coat it with something'
c.	ak-tshe-ʔ	[akétsheʔ]	'my container, jar'
d.	ʌ-k-theʔt-ʔ	[ʌkétheʔteʔ]	'I will pound'
e.	w-at-ʔskut-ʔ	[watè:skuteʔ]	'a roast'

(22) CR [e]-epenthesis ("Type I", Michelson 1989: 40-41)

a.	w-akr-as	[wákeras]	'it smells'
b.	ʌ-k-r-ʌʔ	[ʌ́kerʌʔ]	'I will put it into a container'
c.	ʌ-k-rahkw-ʔ	[ʌ́kerahkweʔ]	'I will use it as a container'
d.	waʔ-k-riht-ʔ	[wà:kerihteʔ]	'I will cook it'
e.	t-ʌ-k-rik-ʔ	[tʌ́kerikeʔ]	'I will put together side by side'
f.	waʔ-t-k-atat-nak-ʔ	[waʔtkatátenakeʔ]	'I scratched myself'

The rule-based serial analysis in Michelson (1983, 1988, 1989) accounts for this difference by assuming the existence of two epenthesis rules, where CCC epenthesis (Vowel Insertion I) precedes stress assignment and CR epenthesis (Vowel Insertion II) follows stress assignment. In HS, the two types of epenthesis are instead motivated by two different markedness constraints. More specifically, epenthesis occurs in CCC clusters in order to avoid the creation of a complex onset or coda (a violation of *COMPLEX), while epenthesis in CR clusters occurs in order to avoid either a sequence of rising sonority across a syllable boundary (with syllabification C.R) or to avoid a complex onset (with syllabification .CR). Consonant sequences which show rising sonority across a syllable boundary violate the markedness constraint SYLLABLECONTACT (Davis and Shin 1999, Gouskova 2004, Murray and Vennemann 1983, Rose 2000). I assume the following definition of the constraint; see the cited references for refinements and further discussion:

(23) SYLLABLECONTACT (SYLLCON): assign one violation mark for every sequence of two heterosyllabic consonants A.B, where A is less sonorous than B.

Because each type of epenthesis is motivated by a different markedness constraint, it is possible to rank PWDHD between the two constraints. Because CCC epenthesis is transparent to stress assignment, *COMPLEX must outrank PWDHD so that the epenthetic vowel will be visible when stress is assigned in Step 2 of the derivation. The proposed derivation for CCC epenthesis is illustrated in the following tableaux:[12]

(24) a. Mohawk CCC cluster, Step 1: Epenthesis

/wak-nyak-s/	*COMPLEX	PWDHD	*Operations*
a. → wa.ken.yaks		1	*epenthesis*
b. (wák.nyaks)	1 W	L	*stress*
c. (wákn.yaks)	1 W	L	*stress*
d. wak.nyaks	1 W	1	*no change*
e. wakn.yaks	1 W	1	*no change*

b. Mohawk CCC cluster, Step 2: Stress

wa.ken.yaks	*COMPLEX	PWDHD	*Operations*
a. → wa(kén.yaks)			*stress*
b. wa.ken.yaks		1 W	*no change*

As in Swahili, the derivation for /wak-nyak-s/ will converge on Step 3 with stress falling transparently on the epenthetic vowel.

The constraint motivating CR epenthesis, SYLLCON, is ranked below PWDHD. This means that stress will be assigned before epenthesis occurs to satisfy PWDHD. Because the epenthetic vowel is not yet present, stress falls on the first syllable of the word, which is then the penultimate syllable and the preferred syllable for main word stress:

(25) Mohawk CR cluster, Step 1: Stress

/w-akr-as /	*COMP	PWDHD	SYLLCON	*Operations*
a. → (wák.ras)			1	*stress*
b. (wá.kras)	1 W		L	*stress*
c. wa.ke.ras		1 W	L	*epenthesis*
d. wak.ras		1 W	1	*no change*
e. wa.kras	1 W	1 W	L	*no change*

Note that candidate (b) in the above tableau is eliminated because it violates high-ranking *COMPLEX, even though it avoids violating both PWDHD and SYLLCON. This is one way in which constraint ranking is important in HS beyond merely inducing ordering: here, constraint ranking is also responsible for choosing among the candidates that apply stress, in a way familiar from Classic OT.

As in Dakota, epenthesis occurs in the next step, this time to satisfy SYLLCON. Stress assignment becomes opaque, resulting in a violation of the stress constraint ALIGNHDR, which is ranked below SYLLCON: [13]

(26) Mohawk CR cluster, Step 2: Epenthesis

(wák.ras)	*COMP	PWDHD	SYLLCON	ALIGNHDR	*Operations*
a. → (wá.ke)ras				1	*epenthesis*
b. (wák.ras)			1 W	L	*no change*

Owing to the gradualness requirement on GEN, stress cannot be altered without violating higher-ranked constraints, and the derivation converges on the opaque form in Step 3:

(27) Mohawk CR cluster, Step 3: Convergence

(wá.ke)ras	*COMP	PWDHD	SYLLCON	ALIGNHDR	*Operations*
a. → (wá.ke)ras				1	*no change*
b. wa.ke.ras		1 W		L	*stress deletion*

As in Swahili and Dakota, HS derives the two epenthesis patterns found in Mohawk by ranking the syllable structure constraints independently with respect to PWDHD.

4.1.2 Stressed [e] in an open syllable

The HS analysis derives the difference in behavior of epenthetic [e] from the markedness constraints driving epenthesis. In this way, the HS analysis differs fundamentally from the HEAD-DEP analysis argued for in Alderete (1995, 1999), which aims to account for the above patterns using a surface-based explanation. More specifically, Alderete argues that epenthetic [e] is stressed when it occurs in a closed syllable (CCC clusters) and unstressed when it occurs in an open syllable (CR clusters), making it possible to account for the two patterns by ranking HEAD-DEP between two markedness constraints: HEAD-DEP is outranked by WSP (the Weight-to-Stress principle), which is violated by unstressed heavy syllables, but outranks ALIGNHDR. The ranking arguments can be seen in the following two tableaux:

(28) a. WSP » HEAD-DEP

/wak-nyak-s/	WSP	HEAD-DEP
a. → wa(ké̲n.yaks)		1
b. (wá.ke̲n)yaks	1 W	L

b. HEAD-DEP » ALIGNHDR

/w-akr-as/	HEAD-DEP	ALIGNHDR
a. → (wá.ke̲)ras		1
b. wa(ké̲.ras)	1 W	L

The following example, however, which shows a stressed epenthetic vowel in an open syllable, suggests that the generalization that stressed [e] is only found in a heavy syllable is not always true in Mohawk (Michelson 1988: 58):

(29) k-rʔok-s [ké̲roʔks] ‘I chop with an axe’

In this form, epenthetic [e] is epenthesized to break up an underlying CCC cluster, but ends up in an open syllable in the output because epenthesis interacts with metathesis, which occurs to eliminate sequences of [Cʔ] in the output (Michelson 1988: 56-58).[14] The epenthetic vowel in this case ends up being stressed, even though it does not surface in a closed syllable, and provides a counterexample to the predictions of the HEAD-DEP analysis.

Because the HS analysis relies on the ordering of epenthesis operations rather than surface generalizations, it can account for the stress pattern in words like [ké̲roʔks] without any additional assumptions. In /k-rʔok-s/ 'I chop with an axe', epenthesis occurs to avoid the creation of a complex onset rather than to avoid a syllable contact violation, and as such, will precede stress assignment in order to avoid violating high-ranked *COMPLEX. Metathesis follows epenthesis, rendering stress assignment opaque:[15]

(30) a. Mohawk CCC/metathesis, Step 1: Epenthesis

/k-rʔok-s/	*COMP	PWDHD	*Cʔ	SYLLCON	*Operations*
a. → ker.ʔoks		1	1		*epenthesis*
b. (krʔóks)	1 W	L	1		*stress*
c. kroʔks	1 W	1	L		*metathesis*
d. krʔoks	1 W	1	1		*no change*

b. Mohawk CCC/metathesis, Step 2: Stress

ker.ʔoks	*COMP	PWDHD	*Cʔ	SYLLCON	*Operations*
a. → (kér.ʔoks)			1		*stress*
b. ker.oʔks		1 W	L		*metathesis*
c. ker.ʔoks		1 W	1		*no change*

c. Mohawk CCC/metathesis, Step 3: Metathesis

(kér.ʔoks)	*COMP	PWDHD	*Cʔ	SYLLCON	*Operations*
a. → (ké.roʔks)					*metathesis*
b. (kér.ʔoks)			1 W		*no change*

The derivation will converge in Step 4 with stress correctly falling on the epenthetic vowel, even though it occurs in an open syllable. The HS analysis therefore derives the correct pattern for free, while the HEAD-DEP analysis cannot account for this pattern without additional assumptions regarding the interaction of the metathesis process with epenthesis and stress.

4.1.3 Final Cʔ epenthesis

The vowel [e] is also epenthesized into sequences of word final consonant-glottal stop (Cʔ) sequences. Like CR epenthesis, Cʔ epenthesis is opaque to stress assignment, but the way it affects stress is different: instead of pushing back stress by one syllable, as in CR clusters, stress is instead pushed back two syllables:

(31) Cʔ# [e]-epenthesis ("Type III", Michelson 1989: 43)

a. ʌ-k-arat-ʔ [ʌkáːrate̲ʔ] ‘I lay myself down’

b. ro-kut-ot-ʔ [rokú:tote̲ʔ] 'he has a bump on his nose'
c. o-hnyʌʔtskwir-ʔ [ohnyʌ́:tskwire̲ʔ] 'small branch'

As before, the HS analysis can account for this pattern by ensuring that stress assignment precedes the constraint responsible for Cʔ epenthesis. Unlike the rule-based analysis proposed by Michelson (1989), however, CR and Cʔ# epenthesis cannot be motivated by the same epenthesis rule: I have argued that SYLLABLECONTACT is responsible for CR epenthesis, but as the final /ʔ/ is not in a different syllable, this constraint cannot motivate epenthesis here.

Instead, I propose to make use of a distinction between word-final and word-medial consonants. This distinction is attested cross-linguistically in languages such as English, where sequences of word-final consonants (restricted to coronals in English) are permitted, but where medial clusters are much more restricted in nature (for English, see Hayes 1982, on other languages that exhibit final-consonant extrametricality, see Hayes 1995). I attribute this distinction to the existence of two versions of the constraint PARSESEGMENT (PARSESEG) that exist in a stringency relationship, as defined below, where PARSESEGMENT-NONFINAL is a specific version of the general PARSESEGMENT constraint:

(32) PARSESEGMENT: assign one violation mark for every segment that is not associated with a syllable.

(33) PARSESEGMENT-NONFINAL (PARSESEG-NONFIN): assign one violation mark for every non-PWd-final segment that is not associated with a syllable.

In Mohawk, PARSESEG-NONFIN outranks PWDHD, and eliminates candidates that would leave medial consonants unparsed, as in CCC clusters like in *(wák<n>yaks).* The general constraint, PARSESEG, however, is ranked below PWDHD, meaning that final consonants such as /ʔ/ may be left unparsed while stress is assigned (unparsed segments are set aside with < >):

(34) a. Mohawk Cʔ# cluster, Step 1: Stress

/ʌ-k-arat-ʔ/	*COMP	PWDHD	PRSSEG	ALIGNHDR	***Operations***
a. → ʌ(ká.rat)<ʔ>			1		*Stress*
b. ʌ(ká.ratʔ)	1 W		L		*Stress*
c. ʌ.ka.ra.teʔ		1 W	L		*epenthesis*
d. ʌ.ka.ratʔ		1 W	L		*no change*

Note how, once again, high-ranking *COMPLEX intervenes to help decide between two candidates that equally satisfy PWDHD.

In Step 2, epenthesis occurs to eliminate the PARSESEG violation, rendering stress assignment opaque:

(35) Mohawk Cʔ# cluster, Step 2: Epenthesis

ʌ(ká.rat)<ʔ>	*COMP	PWDHD	PRSSEG	ALIGNHDR	***Operations***
a. → ʌ(ká.ra)teʔ				1	*epenthesis*
b. ʌ(ká.rat)<ʔ>			1 W	L	*no change*

Finally, the derivation converges in Step 3 on the form with antepenultimate stress:

(36) Mohawk Cʔ# cluster, Step 3: Convergence

ʌ(ká.ra)teʔ	*COMP	PWDHD	PRSSEG	ALIGNHDR	*Operations*
a. → ʌ(ká.ra)teʔ				1	*no change*
b. ʌ.ka.ra.teʔ		1 W		L	*stress deletion*

The different behavior of final Cʔ epenthesis and medial CR epenthesis with respect to stress assignment can be accounted for derivationally in a straightforward way.

Once again, the HS analysis can be compared to the Classic OT analysis using HEAD-DEP. Alderete (1995) analyzes the forms in (31) using a version of the HEAD-DEP constraint, HEAD(F)-DEP, that is violated by epenthetic vowels that are contained within the head foot of the word, whether or not they are the stressed vowel. For instance, in [ʌ(káː.ra)te̲ʔ], the foot is built such that it avoids containing the epenthetic vowel in the final syllable:

(37) Head(F)-Dep » AlignHdR

/ʌ-k-arat-ʔ/	HEAD(F)-DEP	ALIGNHDR
a. → ʌ(káː.ra)teʔ		1
b. ʌka(rá.teʔ)	1 W	L

However, this analysis of final epenthesis makes predictions regarding the behavior of other epenthetic vowels in the language that do not appear to be generally true. First, in order to affect stress assignment in words with final epenthesis, HEAD(F)-DEP must outrank the relevant stress constraints in Mohawk (e.g. ALIGNHDR), meaning that it is expected that other epenthetic vowels should also avoid being parsed as part of the head foot. Alderete (1995) proposes that such forms are excluded on the basis of a three-syllable stress window which blocks forms where stress is more than three syllables from the right edge of the word; however, as the following examples show, stress falls outside of this window when the antepenultimate syllable contains an epenthetic vowel that is opaque to stress assignment (as from CR epenthesis):

(38) Cʔ# [e]-epethesis: Pre-antepenultimate stress (Michelson 1989: 40-43)

a. ʌ-k-rahkw-ʔ [ʌ́ke̲rahkwe̲ʔ] 'I will use it as a container'
b. waʔ-k-riht-ʔ [wàːke̲rihte̲ʔ] 'I will cook it'
c. t-ʌ-k-rik-ʔ [tʌ́ke̲rike̲ʔ] 'I will put together side by side'

Further, as can be seen in the following example, while epenthetic vowels from CR epenthesis avoid being stressed, they do not avoid being part of the head foot. Because there is no three-syllable stress-window in Mohawk, there does not appear to be any constraint that would disfavor stressing the fifth-to-last syllable in the following word, as would be predicted by high-ranking HEAD(F)-DEP:

(39) HEAD(F)-DEP is violated gratuitously

waʔ-t-k-atat-nak-ʔ [waʔtka(táte̲)nake̲ʔ] 'I scratched myself'

*[waʔt(káta)te̲nake̲ʔ] (satisfies HEAD(F)-DEP)

The HS account does not require the assumption of a three-syllable stress-window, nor does it predict that stress will shift to avoid footing an epenthetic vowel, as in (39). In this form, the HS analysis correctly predicts that stress will fall on the pre-antepenultimate syllable, as can be illustrated by considering the derivation for this word. In Step 1, stress is assigned before epenthesis because there are no violations of *COMPLEX:[16]

(40) Mohawk CR/Cʔ epenthesis, Step 1: Epenthesis

/waʔ-t-k-atat-nak-ʔ/	*COMP	PWDHD	SYLLCON	PRSSEG	*Operations*
a. → waʔt.ka(tát.nak)<ʔ>			1	1	*stress*
b. waʔt.ka.ta.te.nak<ʔ>		1 W	L	1	*epenthesis*
c. waʔt.ka.tat.na.keʔ		1 W	1	L	*epenthesis*
d. waʔt.ka.tat.nak<ʔ>		1 W	1	1	*no change*

When CR and Cʔ epenthesis occur, stress will remain stranded on the syllable *(tá)*, which will eventually end up in pre-antepenultimate position. Based on the data considered so far, there is no ranking argument for SYLLCON and PARSESEG, such that the two epenthesis operations can occur in either order; however, both orders will result in an output consistent with the attested form.

As shown in this section, the HS analysis of various stress-epenthesis interactions found in Mohawk captures the contrast between transparency and opacity in epenthesis operations by assuming that epenthesis occurs in response to three markedness constraints, *COMPLEX, SYLLCON, and PARSESEG, which are ranked independently with respect to PWDHD. In the language's constraint hierarchy, *COMPLEX outranks PWDHD, with the result that epenthesis will precede stress assignment when it is necessary to avoid the creation of a complex onset or coda. This was seen to be true both for medial CCC clusters and for the initial underlying CCC cluster in /k-rʔok-s/. In these environments, the epenthetic vowel is present when stress is assigned, and stress falls transparently on the epenthetic vowel when is in the penultimate syllable. However, SYLLCON and PARSESEG are ranked below PWDHD, with the result that epenthesis to avoid CR clusters and final Cʔ clusters follows stress assignment. Epenthetic vowels in these environments are thus not visible when stress is assigned, resulting in opaque stress. This was seen to be true both for medial and initial CR clusters, as well as final Cʔ clusters and words with both CR and Cʔ epenthesis. This analysis provides a clear advantage over the HEAD-DEP analysis because it is able to account for a wider range of data, including those cases which are problematic for the HEAD-DEP account.

4.2 Levantine Arabic

Another language with a complex array of transparent and opaque stress-epenthesis interactions is Levantine Arabic, a subset of which were discussed in section 2 as they apply to closely-related Iraqi Arabic.[17] The basic pattern of stress assignment is Latin-like, where stress falls on the penultimate syllable if it is heavy or if the word contains only two syllables, but on the antepenultimate syllable if the penult is light (Abu-Salim 1982):

(41) Penultimate stress: heavy penult
  a. darásna ‘we studied’
  b. samá:na ‘our sky’
  c. katáblak ‘he wrote to/for you (m.sg)’
  d. maká:tib ‘offices’
  e. maktábna ‘our office’
  f. katabú:ha ‘they wrote it (f.)’

(42) Initial stress: disyllabic word
  a. ʔána ‘I’
  b. kátab ‘he wrote’

(43) Antepenultimate stress: light penult
  a. kátabu ‘they wrote’
  b. mádrasa ‘school’
  c. ʕálamat ‘she taught’
  d. ʕallámato ‘she taught him’

Epenthetic vowels are inserted to avoid violations of *COMPLEX in both CCC and CCCC clusters; however, the epenthetic vowels differ with respect to whether or not they are stressed when in penultimate position. More specifically, a penultimate epenthetic vowel is only stressed if it is inserted to break up a CCCC cluster. If it instead breaks up a CCC cluster, stress falls on the antepenultimate syllable even though the penult is heavy:

(44) Opaque Pattern: Medial CCC clusters
  /katab-l-ha/ ka.tá.bi̱l.ha ‘he wrote to her’ *ka.ta.bí̱l.ha

  cf. /katab-na/ ka.táb.na ‘we wrote’

(45) Transparent Pattern: Medial CCCC clusters
  /katab-t-l-ha/ ka.tab.tí̱l.ha ‘I wrote to her’

A third pattern, mentioned previously in section 2, shows opaque stress assignment when a vowel is epenthesized to break up a final CC cluster. In this case, stress falls on the penult even though it is light:

(46) Levantine Arabic, Opaque Pattern: Final CC clusters
  /katab-t/ katábi̱t ‘I wrote’ *kátabi̱t

  cf. /katab-u/ kátabu ‘they wrote’

This analysis will first consider the contrast between CCC and CCCC clusters, and then move on to account for final CC clusters.

4.2.1 CCC and CCCC clusters

While epenthesis in both CCC and CCCC clusters occurs to avoid violating *COMPLEX, it is possible to distinguish the two types of epenthesis by assuming that the medial consonants are left unparsed in an intermediate step, rather than parsed into complex onsets or codas (for an analysis using Stratal OT, see Kiparsky 2003). For example, in words with CCC clusters, if stress were to precede epenthesis in the first step, this would result in a single unparsed segment because there would be no way to syllabify the middle consonant in the sequence without violating high-ranked *Complex. If ParseSeg is ranked below PWdHd, stress will be assigned before epenthesis, and will fall on what will eventually become the antepenultimate syllable.

(47) Levantine Arabic CCC cluster, Step 1: Stress

/katab-l-ha/	*Comp	PWdHd	PrsSeg	***Operations***
a. → ka(táb)<l>ha			1	*stress*
b. ka.ta.bil.ha		1 W	L	*epenthesis*
c. ka(tábl)ha	1 W		L	*stress*
d. ka(táb)lha	1 W		L	*stress*
e. ka.tab<l>ha		1 W	1	*no change*

When epenthesis occurs to eliminate the violation of ParseSeg, stress becomes opaque because it is now antepenultimate, and violates constraints responsible for stress assignment in the language (for instance, FootBinμ, which is violated by feet which do not dominate exactly two moras):

(48) Levantine Arabic CCC cluster, Step 2: Epenthesis

ka(táb)<l>ha	*Comp	PWdHd	PrsSeg	FtBinμ	***Operations***
a. → ka(tá)bil.ha				1	*epenthesis*
b. ka(táb)<l>ha			1 W	L	*no change*

Finally, the derivation converges on the opaque form because, as in Dakota and Mohawk, foot deletion is not harmonically improving:

(49) Levantine Arabic CCC cluster, Step 3: Convergence

ka(tá)bil.ha	*Comp	PWdHd	PrsSeg	FtBinμ	***Operations***
a. → ka(tá)bil.ha				1	*no change*
b. ka.ta.bil.ha		1 W		L	*stress deletion*

In contrast, the cost of not epenthesizing a vowel in a word with a CCCC cluster is a sequence of two unparsed consonants, rather than one (*ka.tab<l>ha* vs. *ka.tab<tl>ha*). We can conjecture that while epenthesis to avoid a single unparsed segment follows stress assignment, epenthesis to avoid a sequence of two unparsed segments, precedes stress assignment. As proposed in Kiparsky (2003), there is reason to believe that sequences of two unparsed segments are more marked than single unparsed segments, and that this is reflected in the preference for early epenthesis in words with CCCC clusters. This dispreference for sequences of two unparsed consonants may be captured by assuming the existence of a specific version of ParseSeg which is violated by sequences of two or more unparsed segments:

(50) ParseCC: Assign one violation mark for every sequence of two or more unparsed consonants.

This constraint can be thought of as a segment-level counterpart of the Parse-2 constraint proposed in Kager (1999), which punishes sequences of two unparsed syllables.

If ParseCC is ranked above PWdHd, we will correctly derive the transparent interaction found in words with CCCC sequences: epenthesis will precede stress in order to satisfy the higher-ranked markedness constraint that is not violated in CCC clusters:

(51) Levantine Arabic CCCC cluster, Step 1: Epenthesis

/katab-t-l-ha/	*Comp	ParseCC	PWdHd	PrsSeg	*Operations*
a. → ka.tab.til.ha			1		*epenthesis*
b. ka(táb)<tl>ha		1 W	L	2 W	*stress*
c. ka.tab<tl>ha		1 W	1	2 W	*no change*

When stress is assigned in Step 2, it is assigned transparently to the heavy penultimate syllable containing the epenthetic vowel:

(52) Levantine Arabic CCCC cluster, Step 2: Stress

ka.tab.til.ha	*Comp	ParseCC	PWdHd	PrsSeg	*Operations*
a. → ka.tab(tíl)ha					*stress*
b. ka.tab.til.ha			1 W		*no change*

The derivation will converge in Step 3. Note that ParseCC and ParseSeg are in a stringency relationship with one another: violations of ParseCC are also violations of ParseSeg, while the reverse is not true. The HS analysis makes a typological prediction here, namely that when two constraints are in a stringency relation, regardless of their ranking, there is no language in which the less marked structure (here, forms with a single unparsed segment) will interact transparently with stress assignment while the more marked structure (forms which violate ParseCC) will interact opaquely. The range of opaque interactions that are predicted to occur cross-linguistically are in this way grounded in the relationships between markedness constraints, a characteristic that distinguishes HS from rule-based serial frameworks. This topic is taken up again in the discussion of typology in section 4.3.

While descriptively adequate, the ParseCC constraint has the disadvantage of being stipulative in nature because it encodes in its definition the observation that two unparsed segments are more marked than one, something that should ideally arise from the system rather than be encoded in the constraint itself. A different solution is to use weighted rather than ranked constraints, as in Harmonic Grammar (HG, Jesney 2011a, Legendre, Miyata and Smolensky 1990, Pater 2009a, b, Potts et al. 2010, Smolensky and Legendre 2006), which can be implemented in a serial framework like HS (Serial HG, Pater 2012).[18] For an introduction to HG, see Pater (this volume).

For example, the first step in a Serial HG analysis of the stress-epenthesis interaction in a CCC cluster can be represented in the following tableau, where I have assumed weight settings for PWdHd and PrsSeg consistent with the present analysis. In this tableau, the stress candidate has a higher overall H score than its competitors because it violates only PrsSeg, the constraint with a relatively lower weight. The epenthesis and *no change* candidates both incur a violation of PWdHd, and have correspondingly lower H scores. The stress candidate is therefore the winner in this step:

(53) Serial HG, Levantine Arabic CCC cluster, Step 1: Stress

Weights	1.5	1	H	
/katab-l-ha/	PWdHd	PrsSeg		***Operations***
a. → ka(táb)<l>ha		-1	-1	*Stress*
b. ka.ta.bil.ha	-1		-1.5	*epenthesis*
c. ka.tab<l>ha	-1	-1	-2.5	*no change*

One consequence of assuming that constraints are weighted rather than ranked is that it predicts the existence of "gang effects" where there are asymmetric trade-offs in constraint violations, which occur when violations of two constraints can be avoided by a single violation of a conflicting constraint (Pater 2009b). A gang effect occurs when multiple violations of one or more lower-weighted constraints result in a lower overall H score for a candidate as compared to a single violation of a higher-weighted constraint for a different candidate. In Levantine Arabic, we can use a gang effect to model the distinction between a single ParseSeg violation and two ParseSeg violations. Here, a word with two unparsed consonants will violate ParseSeg twice. Given the right weightings, the sum of the two violations will result in a lower H score than the epenthesis candidate, which incurs a single violation of PWdHd:

(54) Serial HG, Levantine Arabic CCCC cluster, Step 1: Epenthesis

	1.5	1	H	
/katab-t-l-ha/	PWdHd	PrsSeg		***Operations***
a. → ka.tab.til.ha	-1		-1.5	*Epenthesis*
b. ka(táb)<tl>ha		-2	-2	*Stress*
c. ka.tab<tl>ha	-1	-2	-3.5	*no change*

In this way, HG coupled with HS can provide an alternative way of accounting for the increased dispreference for two unparsed segments as opposed to one. The advantage of this analysis is that it derives the difference in markedness between one and two unparsed segments through the tools of the framework, without need for a constraint where that markedness relation is built-in.

Another alternative is to analyse the dispreference for sequences of two unparsed consonants in CCCC clusters using local constraint conjunction (Smolensky 2006). An analysis using constraint conjunction would rank the self-conjoined version of ParseSeg (ParseSeg&ParseSeg) above PWdHd, and the simple version below PWdHd, with the result that two (or more) violations of ParseSeg would be satisfied before stress assignment, and a single violation would be resolved after stress assignment.

Local constraint conjunction, however, requires the assumption that the conjoined constraint applies within a specific domain. In the above example, the two unparsed segments are adjacent, but because they are not yet syllabified, do not both occupy any phonologically-motivated sub-domain smaller than the prosodic word. McCarthy (1999) argues that when constraint conjunction is used to account for opaque processes, locally conjoined constraints specifying a domain which is too large run the risk of eliminating non-local transparent patterns along with the opaque process. The following sketch shows that this is true of a hypothetical analysis of the Levantine Arabic epenthesis patterns using local constraint conjunction.

For instance, if we assume the domain of PARSESEG&PARSESEG to be the prosodic word, we correctly predict the transparent behavior of CCCC clusters. In addition, however, we incorrectly predict the existence of a language where words with two non-adjacent unparsed segments (hypothetical *katab<l>hab<l>ha*) would eliminate the violation of the conjoined constraint by eliminating one of the PARSESEG violations before stress is assigned. As shown in the following HS tableau for Step 1 of the derivation of this word, epenthesis is predicted to precede stress assignment, but the constraint ranking equally prefers either site for epenthesis.

(55) HS with constraint conjunction, hypothetical word with two non-adjacent violations of PARSESEG, Step 1: Stress

/katablhablha/	(PRSSEG&PRSSEG)$_{PWd}$	PWDHD	PRSSEG	*Operations*
a. → ka.ta.bil.hab<l>ha		1	1	*epenthesis*
b. → ka.tab<l>ha.bil.ha		1	1	*epenthesis*
c. ka.tab<l>(háb)<l>ha	1 W	L	2 W	*Stress*
d. ka.tab<l>hab.<l>ha	1 W	1	2 W	*no change*

If we assume that ties in HS are resolved by randomly selecting one of the tied candidates,[19] we predict that this language will show transparent stress in one of the vowels but opaque stress in the other. More specifically, if candidate (a) is chosen, stress (motivated by the next-highest-ranked constraint PWDHD) will be assigned in Step 2 to the heavy penultimate syllable as in *ka.ta.bil(háb)<l>ha*, while Step 3 will see epenthesis of the second vowel, *ka.ta.bil(há)bil.ha*, which renders the placement of stress on the antepenultimate syllable opaque. On the other hand, if candidate (b) is chosen, Step 2 will assign stress transparently to the penultimate syllable, as in *ka.tab<l>ha(bíl)ha*. Epenthesis in Step 3 will not affect the positioning of stress assignment in this case.

Interestingly, neither the HS analysis assuming PARSECC nor the serial HG analysis share this typological prediction. In the former case, PARSECC will not be violated by non-adjacent PARSESEG violations, and we predict that stress assignment will precede epenthesis of both vowels:

(56) HS with PARSECC, hypothetical word with two non-adjacent violations of PARSESEG, Step 1: Stress

/katablhablha/	PRSCC	PWDHD	PRSSEG	*Operations*
a. → ka.tab<l>(háb)<l>ha			2	*Stress*
b. ka.ta.bil.hab<l>ha		1 W	1 L	*Epenthesis*
c. ka.tab<l>ha.bil.ha		1 W	1 L	*Epenthesis*
d. ka.tab<l>hab.<l>ha		1 W	2	*no change*

After epenthesis occurs in Steps 2 and 3, stress will be stranded on the antepenultimate syllable. This result holds regardless of which epenthetic vowel is inserted first.

Similarly, the non-local interaction described above is impossible to derive in Serial HG under any possible weighting of the constraints PWDHD and PARSESEG.[20] In the hypothetical word with two non-adjacent unparsed consonants, the choice in the first step will be between epenthesis to eliminate one of the violations of PARSESEG, and stress, which will leave both violations intact. Because harmony is calculated cumulatively, any candidate that shows epenthesis will violate both PARSESEG and PWDHD. Under the weighting assumed here, the cumulative weight of one violation of each of these constraints would result in a lower H-score than two violations of PARSESEG, resulting in stress assignment in the first step:

(57) Serial HG, hypothetical word with two non-adjacent violations of PARSESEG, Step 1: Stress

	1.5	1	H	
/katablhablha/	PWDHD	PRSSEG		***Operations***
a. → ka.tab<l>(háb)<l>ha		-2	-1.5	*stress*
b. ka.ta.bil.hab<l>ha	-1	-1	-2.5	*epenthesis*
c. ka.tab<l>ha.bil.ha	-1	-1	-2.5	*epenthesis*
d. ka.tab<l>hab.<l>ha	-1	-2	-3.5	*no change*

This tableau shows that each of the violations of PARSESEG, when non-adjacent, will be satisfied after stress assignment, meaning that either epenthesis order will have the same effect on stress assignment: stress is predicted to be consistently opaque.

While I do not have access to data that would bear on this question, it is interesting to observe that HS with constraint conjunction differs in its predictions from both the HS analysis assuming PARSECC and the Serial HG analysis, and that these are the least restrictive accounts in this particular case. Further empirical work is needed to determine which analysis is preferable. See Pater (2009b) and Potts et al. (2010) for further discussion of HG as compared to OT frameworks with respect to traditional constraint ranking and local constraint conjunction.

4.2.2 Final CC Clusters

The analysis developed above may be extended to account for the opaque stress assignment in final CC clusters, as is found in both the Levantine and Iraqi dialects of Arabic. In these forms, stress falls on the penultimate syllable even though it is light:

(58) Opaque Pattern: Final CC clusters (Levantine Arabic)

/katab-t/ ka.tá.biṯ ‘I wrote’ *ká.ta.biṯ

cf. /katab-at/ ká.ta.bat ‘she wrote’

While these patterns posed a direct problem for HEAD-DEP and Classic OT (see discussion in section 2), these patterns can be accounted for straightforwardly under an HS framework using the analysis developed above.

As in medial consonant clusters, epenthesis occurs to avoid a violation of *COMPLEX; however, syllabification without epenthesis leaves only a single segment unparsed, which violates the constraint PARSESEG. Since this constraint is also ranked below PWDHD, the stress candidate will win in Step 1, as shown below. Stress is assigned to the final syllable, which is heavy and non-final, owing to the extrametricality of the final consonant (McCarthy 2007):

(59) Levantine Arabic CC cluster, Step 1: Stress

/katab-t/	*COMP	PWDHD	PRSSEG	ALIGNHDR	*Operations*
a. → ka(táb)<t>			1		*stress*
b. ka.ta.bit		1 W	L		*epenthesis*
c. ka(tábt)	1 W		L		*stress*
d. ka.tabt	1 W	1 W	L		*no change*
e. ka.tab<t>		1 W	1		*no change*

As for CCC clusters, epenthesis occurs in Step 2, making stress assignment opaque, and the derivation converges in Step 3:

(60) a. Levantine Arabic CC cluster, Step 2: Epenthesis

ka(táb)<t>	*COMP	PWDHD	PRSSEG	ALIGNHDR	*Operations*
a. → ka(tá)bit				1	*epenthesis*
b. ka(táb)<t>			1 W	L	*no change*

b. Levantine Arabic CC cluster, Step 3: Convergence

ka(tá)bit	*COMP	PWDHD	PRSSEG	STRESS	DEP	*Operations*
a. → ka(tá)bit				1		*no change*
b. ka.ta.bit		1 W		L		*stress deletion*

The HS analysis derives the final CC patterns using the same constraint ranking necessary to account for medial clusters.

The analysis can also be extended to account for a difference between Iraqi Arabic and Levantine Arabic. Iraqi Arabic behaves like Levantine Arabic with respect to medial CCCC and final CC clusters, but epenthesis in medial CCC clusters is transparent rather than opaque to stress assignment (Farwaneh 1995):

(61) Opaque stress: final CC clusters:
/kitab-t/ kitáb<u>i</u>t 'I wrote'
(as in Levantine Arabic)

(62) Transparent stress: medial CCC clusters
/kitab-l-ha/ kitab<u>í</u>lha 'he wrote to her'
(*cf.* Levantine Arabic katábilha)

(63) Transparent stress: medial CCCC clusters
/kitab-t-l-ha/ kitabt<u>í</u>lha 'I wrote to her'
(as in Levantine Arabic)

This contrast can be accounted for by assuming the distinction between the specific constraint PARSESEG-NONFIN and the general constraint PARSESEG that was assumed above for Mohawk. In Levantine Arabic, both versions of the constraint are ranked below PWDHD, resulting in opaque interactions except when PARSECC is violated. In Iraqi Arabic, however, PARSESEG-NONFIN is ranked above PWDHD, which derives transparent interactions in all medial clusters. PARSESEG, on the other hand, is ranked below PWDHD, as in Levantine Arabic, resulting in an opaque interaction only in word-final clusters.

4.3 Typological Predictions

Like Classic OT, HS makes clear typological predictions that can be derived from constraint permutation. In this paper, I have shown that the contrast between epenthetic vowels that are transparent to stress assignment with those that are opaque results from the ranking of the constraints driving epenthesis with respect to the constraint driving stress assignment: when a syllable structure markedness constraint outranks PWDHD, epenthesis precedes stress and the vowel is transparent for the purpose of stress assignment, while when the opposite ranking is true, stress precedes epenthesis and the stress pattern is opaque.

The HS analysis predicts that any constraint driving epenthesis may interact opaquely with stress in some language, and that different syllable structure markedness constraints can be independently ranked above or below PWDHD within a single language, leading to "mixed" languages like Mohawk and Levantine Arabic. Further, as pointed out in the discussion of Levantine Arabic, markedness constraints that are in a stringency relationship (such as PARSECC and PARSESEG) are predicted to behave differently with respect to factorial typology as compared to markedness constraints that are not in a stringency relationship. For example, the markedness constraints responsible for CCC and CR epenthesis in Mohawk (*COMPLEX and SYLLCON) are not in a stringency relationship with one another. Thus, while Mohawk has the ranking *COMPLEX » PWDHD » SYLLCON, factorial typology predicts the existence of four distinct languages with epenthesis to avoid violations of *COMPLEX and SYLLCON, as follows:

(64) Factorial typology for *COMPLEX, PWDHD, and SYLLCON
- (a) Language 1: *COMPLEX, SYLLCON » PWDHD (completely transparent pattern)
- (b) Language 2: *COMPLEX » PWDHD » SYLLCON (Mohawk pattern)
- (c) Language 3: SYLLCON » PWDHD » *COMPLEX (CR transparent, CCC opaque)
- (d) Language 4: PWDHD » *COMPLEX, SYLLCON (completely opaque pattern)

On the other hand, the permutation of markedness constraints that are in a stringency relationship, such as PARSECC and PARSESEG, predicts only three distinct patterns:

(65) Factorial typology for PARSESEG, PARSECC, and PWDHD
- (a) Language 1: PARSECC, PARSESEG » PWDHD (completely transparent pattern)
- (b) Language 2: PARSECC » PWDHD » PARSESEG (Levantine Arabic pattern)
- (c) Language 3: PARSESEG » PWDHD » PARSECC (completely opaque pattern)
- (d) Language 4: PWDHD » PARSESEG, PARSECC (completely opaque pattern)

The typology above that results from the permutation of PARSESEG and PARSECC appears to be at least partially justified based on attested Arabic dialects: Palestinian Arabic optionally stresses epenthetic vowels, exhibiting the transparent pattern (Gouskova and Hall 2009). No dialect shows the completely opaque pattern, but this is justified typologically by the existence of languages like Dakota where stress-epenthesis interactions are consistently opaque. Notably, however, no dialect appears to show a pattern where CCC clusters are transparent but CCCC clusters are opaque, as predicted from the typology in (65).

In this way, HS differs from rule-based serialism because it makes specific predictions regarding factorial typology based on how markedness constraints are related to each other.

Rules that make reference only to the environment triggering epenthesis miss this generalization.

Finally, the HS analysis avoids the pathological prediction of HEAD-DEP discussed in section 2, where it was shown that HEAD-DEP predicts the existence of languages that avoid epenthesizing vowels in the heads of prosodic constituents, but not in non-heads. The HS analysis obviates the need for a positional faithfulness constraint of this type by deriving the language contrasts derivationally, using only basic markedness and faithfulness constraints. Based on the above discussion, the typological predictions of the HS analysis are reasonable, and appear to be an improvement on the predictions of both rule-based serialism and HEAD-DEP.

4.4 Comparison with other serial OT frameworks

In this paper, I have argued that the array of possible interactions between stress and epenthesis can be captured using Harmonic Serialism, a derivational variant of OT that retains many of the advantages of OT. Like Classic OT, the HS account provides clear typological predictions while capturing a range of data that were problematic for the HEAD-DEP account.

HS can also be compared with other serial variants of OT, including Stratal OT (Bermúdez-Otero to appear, Kiparsky 2003, to appear) and OT-with-Candidate-Chains (McCarthy 2007, Wolf 2008, this volume). Like HS, Stratal OT and OT-CC provide a constraint-based alternative to rule ordering and a serial alternative to Classic OT. Analyses of opaque and mixed systems of stress-epenthesis interactions have been developed in Stratal OT (Kiparsky 2003, to appear) and OT-CC (McCarthy 2007).

Stratal OT is a constraint-based framework that adopts many of the assumptions of Lexical Phonology (among others, Kiparsky 1982, Mohanan 1986). There are assumed to be three distinct levels of representation, stem-level, word-level, and phrase-level (also referred to as stem/lexical/postlexical). A parallel OT evaluation occurs at each of these levels; however, unlike HS, each level can have a different constraint ranking. Thus, a language may rank DEP over NOCODA at the word level, but have the opposite ranking at the phrase level. As proposed by Kiparsky (2003), when stress is a word-level process, epenthesis is predicted to interact transparently with stress if it occurs at the word or stem level, but opaquely if it occurs at the phrase level. In this way, the same principle of ordering stress and epenthesis operations can be used in Stratal OT to achieve many of the same results.

As far as the data discussed in this paper, Stratal OT can also provide an account of the patterns. However, the two frameworks are quite different in their architecture and make different predictions with respect to the types of interactions that are expected to occur. For instance, Stratal OT makes the strong prediction that there are exactly three levels of representation, and that opaque interactions are expected to occur between processes that apply at different levels, and never among processes that apply at the same level. This property of Stratal OT has been criticized as overly restrictive, as there are opaque processes that appear to occur within one of the levels assumed by the theory (McCarthy 2007). More specifically with respect to the data discussed in this paper, McCarthy (2007) shows that Arabic dialects show different patterns with respect to whether or not epenthetic vowels in CCC clusters are opaque:

provided that these languages show the same process of CCC epenthesis, there is no reason to believe that the process should be active in different strata in different dialects. HS, on the other hand, does not set any specific limit with respect to the number of possible steps in a derivation, nor that the steps are tied to specific strata. A derivation may have anywhere from one step (a faithful input to output mapping) upwards to the number of possible operations that may be applied to a given input in a harmonically-improving manner.

Another difference between the two theories relates to constraint ranking. In Stratal OT, each level has a distinct ranking, and therefore, its own different grammar. HS, on the other hand, retains from Classic OT the assumption that each language has a single ranking. In HS, this constraint ranking remains constant throughout the derivation. This aspect of Stratal OT has also been criticized because it makes overly-powerful typological predictions. In this respect, with only a single ranking per language, the types of opaque interactions that are predicted by HS are greatly reduced. See McCarthy (2007) for discussion.

HS also differs from closely-related OT-CC (McCarthy 2007, Wolf 2008, this volume). Like HS, OT-CC assumes that derivations are built by a series of single operations that are applied to an input. Unlike HS, OT-CC compares possible derivations for optimality, rather than intermediate steps. One of the main innovations of OT-CC is a family of PREC constraints that impose precedence relationships on unfaithful mappings. Each step in the derivation is limited to a single unfaithful mapping, which is analogous to the use of operations as a check on gradualness as assumed in HS. PREC(A,B) constraints take as their argument any two faithfulness constraints (A and B). The typological predictions of these constraints are kept in check by a requirement on harmonic improvement and a meta-constraint that requires the faithfulness constraint B to outrank a corresponding constraint PREC(A,B). As shown in the above analysis, HS can account for stress-epenthesis interactions using only constraint ranking, without PREC constraints. As well, harmonic improvement is an integral part of HS, as each step in the derivation represents an output form that is locally optimal.

It must be taken into consideration, however, that HS is limited with respect to the types of opaque processes that it can account for. McCarthy (2000) argues that HS fares no better than Classic OT in its ability to account for counter-feeding opacity and most types of counter-bleeding opacity: in HS, as in Classic OT, constraint ranking is durable (i.e. does not change throughout the derivation, as in Stratal OT). This means that non-optimal candidates cannot result in convergence of the derivation because the derivation will continue to proceed until no further harmonic improvement is possible. Because counter-feeding opacity by definition allows non-optimal forms to surface, such derivations cannot be captured using HS. Further, as argued in this paper, stress-epenthesis interactions, a type of counter-bleeding opacity, can indeed be accounted for using HS provided that stress assignment and epenthesis are assumed to be independent operations: forms with opaque stress assignment were able to surface only because stress-shift was assumed to be a two-step operation involving stress deletion and reassignment. This same assumption must be true in order to derive other opaque processes using HS. However, as McCarthy (2000) argues, this is not necessarily the case with other types of counter-bleeding opacity, particularly cases where the processes in question may be reversed in a single step. While this paper shows that HS is indeed capable of accounting for certain types of opaque processes, it does not provide a solution for the larger array of opaque processes. For further discussion of specific and hypothetical examples, see McCarthy (2000).

In all, while more research remains to be done comparing the predictions of HS with Stratal OT and OT-CC, this paper has shown that HS is capable of accounting for the array of stress-epenthesis interactions that are found cross-linguistically, including languages with mixed systems. The analyses presented here require only the assumption of serialism, and does so using a single constraint ranking per language. As noted by Ito and Mester (2003), there is no reason to believe that there needs to be a single solution to opacity within OT, and other types of opaque processes will require solutions beyond the theory proposed in this paper.

5 Conclusion

This paper provides an analysis of stress-epenthesis interactions using the framework of Harmonic Serialism, a serial variant of OT that combines constraint interaction and serial derivation. I showed that HS can be used to account for a range of attested interactions between stress and epenthesis, including transparent, opaque, and mixed languages and patterns that cannot be accounted for using the strictly parallel HEAD-DEP account. Because the order of operations is determined by constraint ranking, it becomes possible in these frameworks to account for typological variation using constraint permutation, just as in Classic OT. Languages differ in the ranking of constraints, and this ranking is responsible for determining whether stress and epenthesis interact transparently or opaquely. In addition, this paper shows that the framework differs fundamentally from rule-based serialism by deriving patterns using the interaction of violable constraints.

This paper illustrates that HS can be used to account for attested stress-epenthesis interactions which show a type of counter-bleeding opacity, and does so with only the assumptions of serialism under the framework of HS. HS presents a viable alternative to other accounts of opaque stress-epenthesis interactions within OT, including the HEAD-DEP account and serial alternatives like Stratal OT and OT-CC. HS differs from other approaches to opacity within OT because serialism is an integral part of the theory, rather than a mechanism introduced to account solely for opacity, as HS has been used to account for a range of phonological patterns aside from opacity (for examples and citations, see the other papers in this volume). As shown in this paper, the account of stress-epenthesis interactions proposed here derives naturally from the assumptions of the framework, and its potential to account for other types of patterns that are difficult to analyze in Classic OT deserves further attention.

Notes

[1] As Shaw (1985: 32, 116-120) notes, there is evidence for the underlying representations in (2) from phonotactic distribution (the final consonant is limited to voiceless unaspirated stops and affricates, and voiced fricatives), as well as morphological alternations.

[2] The tableaux in this paper are in the comparative format (Prince 2002). Violations are represented by integers. *W*s and *L*s appear in the rows with losing candidates and compare the performance of the losing candidate to that of the winner. A *W* indicates that a constraint

favors the winner over the loser, while an *L* indicates that a constraint favors the loser over the winner. A well-formed tableau has no *L*s to the left of a *W* in a given row; this indicates that the winner performs better than all competing candidates with respect to the constraint hierarchy.

[3] Broselow (2008) proposes an alternative analysis of the Iraqi Arabic pattern that relies on morphological constraints desiring contrast and paradigm uniformity rather than HEAD-DEP. For reasons of space, I do not discuss this alternative in detail here.

[4] For an introduction to HS, see McCarthy (this volume).

[5]See Elfner (2009), Pater (2012), Moore-Cantwell (this volume) and Torres-Tamarit (this volume) for discussion of treating syllabification as a distinct operation.

[6] Here and elsewhere, I use italics to refer to intermediate forms when cited in the text of the paper. Slanted brackets / / are reserved for underlying forms, and square brackets [ ] for surface forms. For example: /pat/ > *pati* > [patʃi]. "No change" candidates are those which are syllabified, but show no other change.

[7] Another possible candidate for this intermediate step is that the final consonant is left unparsed rather than parsed as a coda consonant. For simplicity, I will not consider this candidate here. See section 4 for further discussion of unparsed segments in other languages.

[8] Another possibility is that the head status of one of the vowels would be removed in one step, and that the reassignment of head status would occur in the following step. I do not distinguish between these two possibilities here, as they both require the application of two distinct operations.

[9] There is a regular process of stressed vowel lengthening, in which all stressed vowels in open syllables are long. As seen in (22), stressed vowel lengthening also does not occur when the stressed vowel precedes epenthetic [e] in a CR cluster. I will not discuss this process in this paper, though a complete analysis of Mohawk would need to take this process into account.

[10] As can be seen in (21)d-e and (22)b-f, the final syllable is extrametrical in words which end in a sequence [eʔ]. This [e] is also epenthetic, and occurs to break up a final underlying consonant-/ʔ/ sequence. This epenthetic vowel also avoids stress, but I will not discuss it at present in order to keep the presentation relatively simple. See Michelson (1983, 1988, 1989) and section 4.1.3 below for discussion and more examples.

[11] Note that some lengthened stressed vowels are marked with a grave accent as in [watè̲:skute̲ʔ] 'a roast'. This preserves the notation in Michelson (1983, 1988, 1989), which indicates that the vowel is both stressed and has a falling tone resulting from coalescence with a following [ʔ] or [h].

[12] For simplicity, I will not include the faithfulness constraints DEP and DEPPROM in the tableaux from this point on. In all of the languages that will be considered here, they are low-ranked.

[13] I have arbitrarily chosen the candidate [(wá.ke)ras] as the winner; however, a parse where the foot is trisyllabic, as in [(wá.ke.ras)], is also possible. I know of no ranking argument in Mohawk that would distinguish between these two candidates. Note that cost-free resyllabification also applies with epenthesis in these forms

[14] Michelson (1988) analyses the metathesis process as a series of two processes, vowel copy and syncope. For ease of presentation, I will assume that that the operation is simply metathesis, a single operation in HS.

[15] The relative ordering of PWDHD and *Cʔ is not possible to determine if we continue with the simplifying assumption that the metathesis operation is a single operation.

[16] This form contains a CCC sequence that is not broken up by epenthesis (/ʔtk/), indicating that *COMPLEX is too broad to capture all of the data. However, for the purposes of this analysis, I will simply assume that these forms do not violate *COMPLEX rather than explore other formulations of this constraint.

[17] Levantine and Iraqi Arabic show the same basic stress pattern and share the opaque stress-epenthesis interaction in final CC clusters (see section 2 and discussion below). They differ in their treatment of open syllables with low vowels, where such vowels are raised to [i] in Iraqi Arabic (e.g. [kítab] 'he writes') but not in Levantine Arabic ([kátab] 'he writes'). They also differ with respect to their treatment of the stress-epenthesis interaction in CCC versus CCCC clusters; this will be discussed later in this section. See Farwaneh (1995) for further details.

[18] It should be noted that any of the above arguments provided for HS may also be analyzed in Serial HG, as basic ranking arguments in OT with strict ranking may also be made using weighted constraints.

[19] An alternative hypothesis is that ties are always resolved by constraint ranking, such that low-ranked constraints may emerge to play a role in determining the winner. For example, in the case of epenthesis, the make-up of the consonant cluster triggering epenthesis might be expected to play a role in such cases. However, this attention to segmental detail is atypical of epenthesis processes (e.g. Blumenfeld 2006, Broselow 1982).

[20] The HG typology was checked using OT-Help2 (Staubs et al. 2010).

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