Syllabification and Stress-Epenthesis Interactions in Harmonic Serialism*

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Abstract

In some languages, epenthetic vowels act as though they are invisible to stress assignment. There are many proposals for addressing this problem in various languages; however, the challenge is particularly acute in Classic OT because the markedness constraints responsible for stress only evaluate surface forms. This paper presents a new proposal within the framework of Harmonic Serialism, a version of OT that combines constraint interaction with serial derivation. This proposal accounts for opaque stress-epenthesis interactions using only traditional constraint ranking, with no machinery beyond the adoption of a serial, rather than parallel, framework. This paper shows that Harmonic Serialism retains many of the advantages of Classic OT, including factorial typology by constraint permutation and the use of constraint ranking to account for non-uniform interactions, as evidenced from analyses of stress-epenthesis interactions in Egyptian Arabic, Dakota, and Levantine Arabic.

1. Introduction

Harmonic Serialism (HS, Prince & Smolensky 1993/2004:94-95; McCarthy 2000, McCarthy 2002:159-163, 2008a, 2008b, 2009; Kimper 2008; Pruitt 2008; Jesney 2009)[1] is a version of Optimality Theory (Classic OT, Prince & Smolensky 1993/2004) that combines serial derivation with constraint interaction. HS is like Classic OT, except that it imposes a requirement on GEN which allows candidates to differ from their input only by the application of a single operation. Multiple passes through GEN and EVAL create a derivation-like sequence of harmonically-improving candidates. The derivation terminates when the input is identical to the output, indicating that no further harmonic improvement is possible. HS differs from OT-with-Candidate-Chains (OT-CC, McCarthy 2006, 2007a; Wolf 2008), another single-grammar serial variant of OT, because it does not evaluate whole derivations: instead, HS builds a single derivation through a series of gradual optimizations.

In this paper, I examine interactions between syllabification, stress, and epenthesis in a number of languages under a theory of the grammar where prosodic structure is applied serially. I develop a theory of syllabification which

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[1] See also Pater 2008 on serial Harmonic Grammar.

parses syllables in a gradual fashion using a small set of basic syllabification operations (see also Pater 2008). I show that this theory provides typological coverage of the range of syllable types found cross-linguistically, and argue that epenthesis, as a syllable-based process, arises from intermediate steps which contain vowel-less minor syllables, in a way similar to some rule-based serial analyses of epenthesis (e.g. Selkirk 1981; Itô 1986, 1989).

I propose that this theory can account for opaque stress-epenthesis interactions among languages where epenthetic vowels appear to avoid stress (Alderete 1995, 1999). In HS, the order that operations are applied is determined by constraint ranking. The ranking of syllable-structure markedness constraints with respect to the stress-assigning constraint PARSEσ can determine whether epenthetic vowels interact transparently with stress assignment (epenthesis precedes stress) or opaquely (stress precedes epenthesis). As in Classic OT, other markedness constraints can interact with the constraints governing epenthesis, such that epenthesis can be blocked or delayed until after stress is assigned in some contexts. This can result in non-uniform interactions between stress and epenthesis within a single language, as in Levantine Arabic (Abu-Salim 1982, Farwaneh 1995).

This paper is organized as follows. Section 2 provides background on HS and develops a theory of gradualness in syllabification. Section 3 discusses how serialism and constraint ranking can be used to account for transparent and opaque stress-epenthesis interactions in Egyptian Arabic and Dakota. Section 4 provides an HS analysis of stress-epenthesis interactions in Levantine Arabic, including a discussion of typology. Section 5 compares HS to alternative accounts of stress-epenthesis interactions in OT. Section 6 concludes the paper.

2. Harmonic Serialism

2.1. Theoretical Background

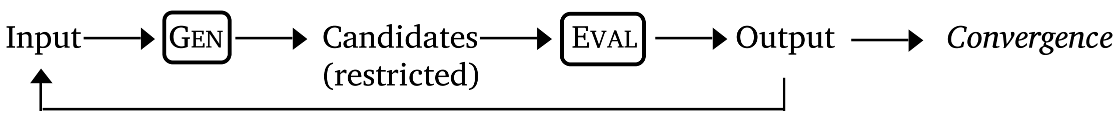
In Classic OT (Prince & Smolensky 1993/2004), the generative component GEN produces the candidate set. The set of candidates is infinite because candidates can differ from the input in any number of different ways: one or more operations can be applied to a given input to produce each candidate. For example, among the candidates compared to an input /pat/ are [pat] (the faithful candidate), [pati] (a candidate which differs from the input by the application of an epenthesis operation), and [patʃi] (a candidate which differs by the application of two operations, epenthesis and palatalization). The candidate set is evaluated by EVAL, the language-specific ranking of constraints. The most harmonic candidate is chosen from among the candidate set produced by GEN. If the constraint hierarchy prefers the candidate [patʃi] over more faithful [pat] or [pati], this candidate becomes the output.

HS differs from Classic OT because GEN is limited by a condition allowing "a certain single modification" to be made to candidates (Prince & Smolensky 1993/2004:94); to apply more than one modification to an input, the pass through GEN and EVAL must be repeated such that the optimal candidate is arrived at through a gradual series of changes. On the first pass, EVAL (as in

Classic OT) chooses the most harmonic candidate through a language-specific hierarchy of ranked constraints. This candidate becomes the input to the next step in the derivation, which makes its own pass through GEN and EVAL. This "loop" from input to output continues until the optimal candidate is identical to its input. This indicates that no further harmonic improvement is possible, and the derivation converges. The following diagram schematically illustrates the contrast between Classic OT, with its single pass through GEN and EVAL, and HS, where multiple passes are possible:

(1) Classic OT

(2) HS



For example, in the first step in the HS derivation of the input /pat/, [pat] and [pati] will be among the candidates produced by GEN. The candidate [patʃi] is not produced, because it requires the application of two operations, epenthesis and palatalization. As illustrated in the following tableau, the first pass in the derivation chooses the epenthesis candidate [pati] because it does better than [pat] with respect to NOCODA:[2]

(3) Step 1 /pat/: Epenthesis

Original Input:	/pat/	NOCODA	*ti	DEP	***Operations***
☞	a. pati		1	1	*Epenthesis*
	b. pat	W1	L	L	*No change*

In the next pass, [pati], the output of Step 1, becomes the input. In this step, GEN produces candidates that differ from [pati] by only a single modification. The candidate [patʃi] now becomes a candidate, because it applies only a single operation of palatalization to the input ([pati] > [patʃi]). The constraint

[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 favours the winner over the loser, while an *L* indicates that a constraint favours 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.

hierarchy prefers [patʃi] over [pati], and [patʃi] is chosen as the optimal candidate in the second step:

(4) Step 2 /pat/: Palatalization

Input to Step 2:	pati	NoCoda	*ti	Ident	Dep	***Operations***
☞	a. patʃi			1	1	*Palatalization*
	b. pati		W1	L	1	*No change*

The output [patʃi] then becomes the input to Step 3. However, with these constraints and operations, no candidate is generated that better satisfies the constraint hierarchy. The derivation therefore converges on [patʃi] because this candidate is both the input and the output of the same step:

(5) Step 3 /pat/: Convergence

Input to Step 3:	patʃi	NoCoda	*ti	Ident	Dep	***Operations***
☞	a. patʃi			1	1	*No change*
	b. pati		W1	L	1	*Depalatalization*

The derivation can be summarized using a Harmonic Improvement tableau (McCarthy 2008a, 2008b), which shows that each step in the HS derivation is more harmonic than the step that immediately precedes it:

(6) Harmonic Improvement Tableau: /pat/

Original Input:	/pat/	NoCoda	*ti	Dep	***Operations***
Step 1	pati *is less harmonic than*		1	1	*Epenthesis*
Step 2	patʃi *is equally harmonic to*			1	*Palatalization*
Step 3	patʃi			1	*Convergence*

Harmonic improvement is an integral part of the theory because the derivation will terminate as soon as harmonic improvement is no longer possible.

The gradualness requirement on Gen is such that candidates differ from their input only by “a certain single modification”. The exact nature of this restriction is a matter of debate. In this paper, I will assume that the notion of a single change is not related to faithfulness violations (as in McCarthy 2007a), but instead refers broadly to the application of phonological operations:

(7) **Gradualness Requirement on GEN:**
Candidates differ from their input only by the application of one phonological operation.

Phonological operations can therefore include changes that violate faithfulness constraints (such as epenthesis, which violates DEP), as well as prosodic structure-building operations (including syllabification and foot assignment), which are not as clearly tied to faithfulness constraints. In this paper, I will be concerned with three types of operations: syllabification (composed of several basic syllable-building operations), foot-assignment, and epenthesis, and the interactions between these operations.

2.2. Serial Syllabification

2.2.1. Operations

It has been claimed that no language uses syllabification contrastively in tautomorphemic sequences (Blevins 1995, Clements 1986, Hayes 1989, McCarthy 2003). Under a faithfulness-based theory of gradualness such as that assumed in McCarthy (2007a) for OT-CC, syllabification is not applied serially because it is cost-free, and is instead evaluated in parallel. However, I will argue in this paper that syllabification and resyllabification should be considered distinct phonological operations that apply in a step-wise manner, and find support for this claim from an investigation of stress-epenthesis interactions in Egyptian Arabic, Dakota, and Levantine Arabic. The data provide evidence in favour of an operation-based theory of gradualness, rather than a faithfulness-based one.

There are several ways to derive syllabification through a series of operations. For example, syllables could be parsed one-syllable-at-a-time or one-segment-at-a-time (as in Pater 2008). In this paper I will assume a theory of syllabification where syllables are created through a combination of three basic syllable creation and adjunction operations, as follows: (i) *Project Syllable* forms a syllable that can be either headed (moraic nucleus) or headless (non-moraic minor syllable); (ii) *Adjunction* adds a segment to an existing syllable, in either moraic or non-moraic position; and (iii) *Core Syllabification* (Steriade 1982, Dell & Elmedlaoui 1985, 1988) creates a binary syllable, consisting of a head (moraic nucleus) and a dependent non-moraic onset. The operations are defined below:

(8) **Syllabification Operations:**

(i) **Project syllable**

a. With mora:

From a segment X, create a syllable (X_μ), where X is moraic (indicated by the subscript μ).

```
           σ
           |
           μ
           |
X    →     X
```

b. Without mora (minor syllable creation):[3]

From a segment X, creation of a minor syllable (X), where X is non-moraic (indicated by the absence of subscript μ).

```
           σ
           |
X    →     X
```

(ii) **Adjunction:**[4]

a. With mora:

Takes a segment X and adjoins it to a syllable[5] to the left or the right. X is moraic.

Mora Adjunction (right)

```
   σ          σ
   |         /|
  (μ)      μ (μ)
   |       |  |
X  Y  →    X  Y
```

Mora Adjunction (left)

```
 σ          σ
 |          |\
(μ)        (μ) μ
 |          |  |
 Y  X  →    Y  X
```

[3] I use the term *minor syllable* to refer to mora-less syllables. My assumptions about the structure of minor syllables will be discussed in section 2.3.

[4] Four adjunction operations are included for completeness. However, in general, I will not specify the moraicity of coda consonants except when necessary.

[5] Adjunction may apply either to syllables that are headed by a mora, or to minor syllables, which are moraless.

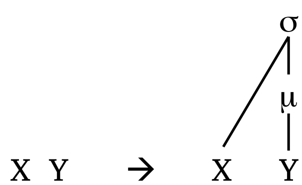
b. Without mora:

Takes a segment X and adjoins it to a syllable to the left or the right. X is non-moraic.

Adjunction (right) Adjunction (left)

(iii) **Core Syllabification:**

From a sequence of unparsed segments X Y, creation of a binary syllable (XY_μ), where Y is the head (indicated by the subscript μ) and X is the dependent (Steriade 1982, Dell & Elmedlaoui 1985, 1988, cf. Pater 2008). Core syllabification cannot create single segment syllables.



These operations allow for the gradual syllabification of a string of unparsed segments. For example, in languages that allow codas, an input /pat/ will be syllabified in a series of two steps: Step 1 creates a core syllable [**(pa)**t][6] and Step 2 adjoins a coda to the core syllable [(pa**t**)]. This derivation can be illustrated by assuming that PARSESEG, the syllabification-driving constraint, outranks NOCODA:

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

Step 1 yields the core syllable [(pa)t]; the /t/ cannot be parsed in this step because the syllable [(pat)] is larger than a single core syllable:

[6] Here and elsewhere, I use parentheses to indicate syllable boundaries.

(10) Step 1/pat/: Core syllabification[7]

Original Input:	/pat/	PARSESEG	NOCODA	***Operations***
☞	a. (pa)t	1		*Core syllabification*
	b. pat	W3		*No change*

Step 2 adjoins the coda to the core syllable:

(11) Step 2 /pat/: Coda adjunction

Input to Step 2:	(pa)t	PARSESEG	NOCODA	***Operations***
☞	a. (pat)		1	*Adjunction (coda)*
	b. (pa)t	W1	L	*No change*

Finally, Step 3 leads to convergence, because having a coda is more harmonic than unparsing the coda segment:

(12) Step 3 /pat/: Convergence

Input to Step 3:	(pat)	PARSESEG	NOCODA	***Operations***
☞	a. (pat)		1	*No change*
	b. (pa)t	W1	L	*Unparsing*

If the ranking had been reversed (NOCODA » PARSESEG), the candidate [(pa)t] would have emerged as optimal in Step 2, and the derivation would have converged at that step with the final segment left unparsed. The ranking of syllable structure markedness constraints with respect to PARSESEG determines which syllable types are allowed: languages that allow codas rank NOCODA below PARSESEG, while languages that avoid codas by not parsing coda consonants have the opposite ranking. Another possibility is to avoid marked syllable structures such as codas through deletion or epenthesis. As will be discussed below, these possibilities also derive through constraint ranking and interaction.

Allowing an operation of core syllabification has several consequences. For example, in a CVCV sequence, the core syllabification theory will always prefer

[7] For simplicity, the tableaux in this section do not contain an exhaustive candidate set because I do not include the single segment syllables that would be produced by *Project Syllable*. Single-segment syllables are discussed later in this section and minor syllables in section 2.3.

the syllabification (CV)(CV) to any other alternative, including (CVC)(V). If there was no operation of core syllabification, and syllabification proceeded serially one-segment-at-a-time, we would predict that [(pat)(a)] for an input /pata/ would be a possible intermediate stage. The constraints ONSET and NOCODA would be in direct competition because the creation of every new syllable would violate ONSET. This can be seen in steps 1 and 2 of the hypothetical derivation for /pata/, where a core syllable is parsed in two steps rather than one. An onsetless syllable is created in Step 1 and then eliminated in Step 2 through an adjunction operation:[8]

(13) One-segment-at-a-time syllabification (no core syllabification)

(a) Step 1 /pata/: Project syllable

Original Input:	/pata/	PARSESEG	ONSET	NOCODA	***Operations***
☞	a. p(a)ta	3	1		*Project syllable*
☞	b. pat(a)	3	1		*Project syllable*
	c. pata	W4	L		*No change*

(b) Step 2 /pata/: Onset adjunction

Input to Step 2:	p(a)ta	PARSESEG	ONSET	NOCODA	***Operations***
☞	a. (pa)ta	2			*Adjunction (onset)*
	b. p(a)t(a)	2	W1		*Project syllable*
	c. pata	W3			*No change*

In a language that ranks ONSET over NOCODA, Step 3 produces the parse [(pat)a] because parsing a coda is preferable to creating an onsetless syllable:

[8] Candidates (a) and (b) are tied in tableau (13)(a). When two candidates are tied, I indicate the tie by choosing two winners in the tableau, and I arbitrarily choose one of the candidates as the input to the next step. In this particular case, and in all of the ties that are found in tableaux in this paper, the tie converges in the next step, such that it does not matter which order the tied candidates are chosen as winners. In this case, both candidates converge on [(pat)(a)]. The best way to deal with ties of this type in HS remains an important research question, but will not be discussed further in this paper.

(14) Step 3 /pata/: Coda adjunction (no core syllabification)

Input to Step 3:	(pa)ta	PARSESEG	ONSET	NOCODA	***Operations***
☞	a. (pat)a	1		1	*Adjunction (coda)*
	b. (pa)t(a)	1	W1	L	*Project syllable*
	c. (pa)ta	W2		L	*No change*

Finally, Step 4 parses the final vowel as an onsetless syllable:

(15) Step 4 /pata/: Project syllable

Input to Step 4:	(pat)a	PARSESEG	ONSET	NOCODA	***Operations***
☞	a. (pat)(a)		1	1	*Project syllable*
	b. (pat)a	W1	L	1	*No change*

The derivation does not necessarily converge at this point because the coda consonant can be resyllabified to serve as an onset to give [(pa)(ta)]. However, the presence of the intermediate parse [(pat)(a)] predicts that stress might fall on the heavy syllable if it is assigned before resyllabification occurs, as in [(pat)(a) > (pát)(a) > (pá)(ta)]. This has some unexpected consequences with respect to stress assignment because it predicts the existence of a language where the placement of stress is sensitive to the presence of onset consonants. For instance, in a language that has final stress except in the presence of a heavy syllable, /pata/ might be stressed as [(pá)(ta)] and /paa/ as [(pa)(á)] if stress is assigned to the intermediate form [(pat)(a)] (*cf.* [(pa)(a)]).[9] This type of stress system does not seem to occur.

This prediction does not arise under the assumption that a core syllabification operation exists. This is illustrated in the following derivation of /pata/, where, in Step 2, the parse [(pat)a], a necessary intermediate step toward the parse [(pat)(a)], is harmonically bounded (indicated by ☠):

[9] See sections 3 and 4 for more detailed discussion of stress-syllabification interactions.

(16) Core syllabification: /pata/

(a) Step 1 /pata/: Creation of core syllable

Original Input:	/pata/	PARSESEG	NOCODA	*Operations*
☞	a. (pa)ta	2		*Core syllabification*
☞	b. pa(ta)	2		*Core syllabification*
	c. pata	W4		*No change*

(b) Step 2 /pata/: Creation of second core syllable

Input to Step 2:	(pa)ta	PARSESEG	NOCODA	*Operations*
☞	a. (pa)(ta)			*Core syllabification*
☠	b. (pat)a	W1	W1	*Adjunction (coda)*
	c. (pa)ta	W2		*No change*

A theory of serial syllabification that assumes core syllabification cannot syllabify CVCV as (CVC)(V) under the current constraint set,[10] and this theory thus appears to avoid a potential problem connected with other theories of serial syllabification. I will therefore assume the existence of a core syllabification operation in this paper, and leave further discussion of this theoretical decision to future research.

2.2.2. Sonority and Core Syllables

The segments X and Y in (8) can be replaced by segments of any sonority, either vowels or consonants. However, following the work of Zec (1988, 1995, 2003), Morén (1999), and de Lacy (2002), among others, I assume that moras, as well as other prosodic units, impose sonority restrictions on the segments that can function as their heads. In OT, these effects can be captured using sonority-based families of constraints that exist in a fixed ranking following the sonority hierarchy. I will assume a set of *σ/X constraints (analogous, but not identical, to the *NUC/X constraints of Prince & Smolensky 1993/2004) that can be defined as follows:

(17) *σ/X: assign one violation mark for every syllable whose head mora is associated with a segment of sonority X.

The fixed ranking can be represented as follows:

[10] This does not mean that this syllabification is impossible. For example, a language which prefers stressed syllables to be heavy might resyllabify an onset as a coda to satisfy this constraint as in [(pa)(ta) > (pá)(ta) > (pát)(a)].

(18) Fixed ranking for *σ/X constraints (where O represents obstruents, R represents sonorants, and V represents vowels)[11]
*σ/O » *σ/R (» *σ/V)

Under the serial theory of syllabification pursued here, GEN will produce candidates with core syllables in every possible configuration, including those where a consonant is dominated by the head mora. Because core syllabification does better on PARSESEG than any other syllabification operation (it parses two segments at once as opposed to just one), core syllabification can only be blocked if the relevant *σ/X constraint outranks PARSESEG. For example, English is a language that allows core syllables to be formed from sonorants but not from obstruents. A word like [bʌfɹ̩] *buffer* will consist of two core syllables, which arises from ranking PARSESEG over *σ/R:

(19) English: Syllabification of [bʌfɹ] *buffer*
(a) Step 1 /bʌfɹ/: Creation of core syllable

Original Input:	/ bʌfɹ /	PARSESEG	*σ/R	*Operations*
☞	a. $(bʌ_{μ})fɹ$	2		*Core syllabification*
	b. $bʌ(fɹ_{μ})$	2	W1	*Core syllabification*
	c. bʌfɹ	W4		*No change*

(b) Step 2 /bʌfɹ/: Creation of a second core syllable

Input to Step 2:	$(bʌ_{μ})fɹ$	PARSESEG	*σ/R	*Operations*
☞	a. $(bʌ_{μ})(fɹ_{μ})$		1	*Core syllabification*
	b. $(bʌ_{μ}f_{μ})ɹ$	W1	L	*Adjunction (coda)*
	c. $(bʌ_{μ})fɹ$	W2	L	*No change*

(c) Step 3 /bʌfɹ/: Convergence

Input to Step 3:	$(bʌ_{μ})(fɹ_{μ})$	PARSESEG	*σ/R	*Operations*
☞	a. $(bʌ_{μ})(fɹ_{μ})$		1	*No change*
	b. $(bʌ_{μ})(f)ɹ$	W1	L	*Unparsing*

[11] Some languages may require the sonority hierarchy to be broken down into finer units. However, the distinction between obstruents, sonorants, and vowels is sufficient for the present illustration, and will be further collapsed into a contrast between consonants and vowels later in the paper. As well, I will ignore the possible existence of the lowest-ranked constraint in the hierarchy (*σ/V) following Gouskova (2003).

On the other hand, the final obstruent sequence in a word like [bʌfs] *buffs* will not be syllabified as a core syllable. Instead, the final two consonants will be syllabified as a complex coda. This arises from ranking *σ/O over PARSESEG:

(20) English: Syllabification of [bʌfs] *buffs*

(a) Step 1 /bʌfs/: Creation of core syllable

Original Input:	/ bʌfs /	*σ/O	PARSESEG	NOCODA	*COMPLEX	***Operations***
☞	a. $(bʌ_{\mu})fs$		2			*Core syllabification*
	b. $bʌ(fs_{\mu})$	W1	2			*Core syllabification*
	c. bʌfs		W4			*No change*

(b) Step 2 /bʌfs/: Coda adjunction

Input to Step 2:	$(bʌ_{\mu})fs$	*σ/O	PARSESEG	NOCODA	*COMPLEX	***Operations***
☞	a. $(bʌ_{\mu}f)s$		1	1		*Adjunction (coda)*
	b. $(bʌ_{\mu})(fs_{\mu})$	W1	L	L		*Core syllabification*
	c. $(bʌ_{\mu})fs$		W2	L		*No change*

(c) Step 3 /bʌfs/: Adjunction of second coda consonant

Input to Step 3:	$(bʌ_{\mu}f)s$	*σ/O	PARSESEG	NOCODA	*COMPLEX	***Operations***
☞	a. $(bʌ_{\mu}fs)$			1	1	*Adjunction (coda)*
	b. $(bʌ_{\mu}f)(s_{\mu})$	W1		1	L	*Core syllabification*
	c. $(bʌ_{\mu}f)s$		W1	1	L	*No change*

(d) Step 4 /bʌfs/: Convergence

Input to Step 4:	$(bʌ_{\mu}fs)$	*σ/O	PARSESEG	NOCODA	*COMPLEX	***Operations***
☞	a. $(bʌ_{\mu}fs)$			1	1	*No change*
	b. $(bʌ_{\mu}f)s$		W1	1	L	*Unparsing*

In general, the ranking of *σ/X constraints with respect to PARSESEG will determine whether or not core syllables can contain a segment of sonority X as their head. The following illustrates the typology:

(21) Typology: Core syllables using *σ/X constraints
 (a) Vowels only (Finnish, Lithuanian): *σ/O, *σ/R » PARSESEG
 (b) Vowels and sonorants only (English): *σ/O » PARSESEG » *σ/R
 (c) All segments (Imdlawn Tashlhiyt Berber): PARSESEG » *σ/O, *σ/R

Other possibilities including epenthesis and deletion, may be used to avoid violating either *σ/X or PARSESEG, as will be discussed below.

2.3. Minor Syllables and Epenthesis

2.3.1. Epenthesis as a two-step process

Under the serial theory of syllabification developed above, syllabification operations are applied one-at-a-time to a string of unparsed segments in such a way as to best respect the language-specific ranking of syllable structure markedness constraints. Because syllabification is gradual, epenthesis and resyllabification cannot occur in a single step because these constitute two separate operations under the gradualness restriction placed on GEN in (7). As such, epenthesis into a syllable with a coda will not immediately resolve the NOCODA violation, even if NOCODA outranks DEPV. For example, if the candidate [(pati)] is added to the derivation of /pat/ started in (12), the derivation will continue to converge on [(pat)] because it is less marked:

(22) An impossible path to coda epenthesis
 Step 3: /pat/ (convergence)

Input to Step 3:	$(pa_\mu t_\mu)$	PARSESEG	NOCODA	DEPV	*Operations*
☞	a. $(pa_\mu t_\mu)$		1		*No change*
	b. $(pa_\mu t_\mu i_\mu)$		1	W1	*Epenthesis*
	c. $(pa_\mu)t$	W1	L		*Unparsing*

Crucially, the candidate $[(pa_\mu)(ti_\mu)]$ is not made available from this input because it would require both epenthesis and resyllabification to apply in a single step. In [(pati)], the epenthesized vowel is not the head of the syllable (/a/ is the head, as the most sonorous moraic segment), and epenthesis does nothing except make the syllable coda more complex.[12]

The remainder of this paper is devoted to the argument that vowel epenthesis is a two-step process; specifically, that epenthesis occurs as a response to the creation of a minor syllable. In the syllabification process, consonants can be syllabified as minor (headless/non-moraic) syllables in order to avoid the creation of a marked syllable structure like a coda or a complex onset. In order

[12] Intrusive vowels, on the other hand, which arise from the imperfect timing of gestures in consonant sequences, would not need to pass through an intermediate step because these vowels are not syllabic (Hall 2003, 2006).

to satisfy SYLL-HEAD, a constraint against minor syllables, a vowel is inserted to eliminate the minor syllable. Epenthesis is thus a two-step process, as can be illustrated schematically as follows:

(23) A path to vowel epenthesis: Minor syllable creation and elimination

$$\text{CCV} \rightarrow \text{C}(\text{CV}_{\mu}) \rightarrow (\text{C})(\text{CV}_{\mu}) \rightarrow (\text{C}\underline{\mathbf{v}}_{\mu})(\text{CV}_{\mu})$$

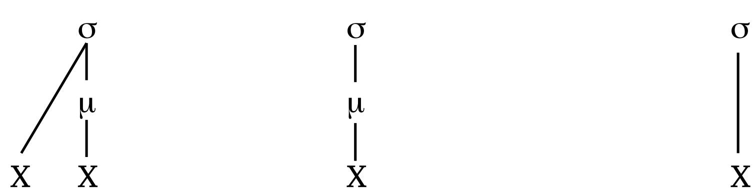
In subsequent sections, I will show that the assumption of an intermediate step in vowel epenthesis can be used to account for opaque interactions between stress and epenthesis. This section presents background on minor syllables and illustrates the two-step theory of epenthesis with data from the North Wakashan languages Oowekyala (Wilson 1978, Howe 2000) and Kwak'wala (Boas 1947, Grubb 1977, Wilson 1978, Bach *et al.* 2005).

2.3.2. Minor syllables

Minor syllables have also been termed consonantal syllables, headless syllables, degenerate syllables, semisyllables (Cho & King 2003), and anuclear syllables (Shaw 1993, 1995, 1996). I assume that minor syllables differ from true syllables because they lack a mora, as shown in the following representations:

(24) Syllable representations, where X is a segment

a. Core syllable b. Onsetless syllable c. Minor syllable



Under the operation set defined in (8), the three syllable types are created by distinct operations: *Core Syllabification*, *Project Syllable* (with mora), and *Project Syllable* (without mora). Core syllables, onsetless syllables, and minor syllables also differ in the constraints that they violate. For instance, no matter the sonority of X, syllables of the form (X_{μ}), as in (24)b, lack an onset and violate the constraint ONSET, as defined below:

(25) ONSET: assign one violation mark for every mora that is aligned with the left edge of a syllable.

Minor syllables of the form (X), on the other hand, lack a mora, and therefore do not violate ONSET. Instead, they violate SYLL-HEAD, a constraint against headless syllables, which is defined here as any syllable which lacks a mora:

(26) SYLL-HEAD: assign one violation mark for every syllable that does not dominate at least one mora.

Core syllables of the form (XX_μ) violate neither of these constraints, and represent the maximally unmarked syllable type for CV sequences. Therefore, sequences of segments will always be parsed as core syllables, except when, as discussed above, *σ/C blocks the creation of a core syllable with a consonant as its head.

When the creation of a core syllable is not possible, as in a CC sequence, there are a number of options: the consonants may be parsed as a core syllable (CC_μ), an onsetless syllable (C_μ), as an adjoined segment to a pre-existing syllable (either as moraic or non-moraic), or as a minor syllable (C). The choice among these options depends on the ranking of markedness constraints, and, as such, the creation of a minor syllable depends on the ranking of SYLL-HEAD with respect to syllable structure markedness constraints. For example, in a language in which *COMPLEX and PARSESEG outrank SYLL-HEAD, minor syllables can be created as a means of avoiding both complex onsets and unparsed segments. This appears to be the ranking in Oowekyala (North Wakashan: British Columbia; Wilson 1978, Howe 2000, Bach *et al.* 2005), a language that does not tolerate complex onsets but allows obstruents to form minor syllables:[13]

(27) Single obstruent minor syllables in Oowekyala (Howe 2000:12)

a.	√p'ɬ-	(p')(ɬá)	'to blink'
b.	√k'^{w}q-	(k'^{w})(qá)	'daylight, to dawn, to become light in the morning'
c.	√t'k^w-	(t')(k^{w}á)	'to scrape, scratch, claw; to open a fish with the fingers'
d.	√ƛ'k-	(ƛ')(ká)	'to put something round and/or bulky somewhere'
e.	√ɬq^w-	(ɬ)(q^{w}á)	'to eat the insides of sea eggs (urchins)'
f.	√k's-	(k')(sá)	'wrinkled'

In the syllabification of a word like /p'ɬa/ 'to blink', the first step will syllabify the final CV sequence as a core syllable. Other options, including the creation of a core syllable with /ɬ/ as the head, or the projection of minor syllables from the obstruents, are harmonically bounded because they do worse on PARSESEG or violate an additional markedness constraint:

[13] The references for Oowekyala (Wilson 1978, Howe 2000, Bach *et al.* 2005) provide evidence from phonotactics, reduplication, coda spirantization, and speaker judgements to support the claim that these consonants are syllabified as minor syllables rather than complex onsets.

(28) Oowekyala: Syllabification of /p'ɬa/ 'to blink'[14]
Step 1 /p'ɬa/: Creation of core syllable

Original Input:	/p'ɬa/	*σ/O	*Complex	ParseSeg	DepV	Syll-Head	*Operations*
☞	a. p'(ɬa$_\mu$)			1			*Core syllabification*
	b. (p'ɬ$_\mu$)a	W1		1			*Core syllabification*
	c. (p')ɬa			W2		W1	*Project minor syllable*
	d. p'(ɬ)a			W2		W1	*Project minor syllable*
	e. p'ɬa			W3			*No change*

In Step 2, the initial obstruent will be parsed as a minor syllable, because *Complex and ParseSeg outrank Syll-Head. Further, obstruents cannot act as syllable heads in the language, indicating that *σ/O outranks ParseSeg.[15] This ranking eliminates the candidate (p'$_\mu$)(ɬa$_\mu$). The choice of [(p')(ɬa)] in Step 2 leads to convergence in Step 3:

(29) Oowekyala: Syllabification of /p'ɬa/ 'to blink'
(a) Step 2 /p'ɬa/: Creation of minor syllable[16]

Input to Step 2:	p'(ɬa$_\mu$)	*σ/O	*Complex	ParseSeg	DepV	Syll-Head	*Operations*
☞	a. (p')(ɬa$_\mu$)					1	*Project minor syllable*
	b. (p'ɬa$_\mu$)		W1			L	*Adjunction (onset)*
	c. (p'$_\mu$)(ɬa$_\mu$)	W1				L	*Core syllabification*
	d. p'(ɬa$_\mu$)			W1		L	*No change*

(b) Step 3 /p'ɬa/: Convergence

Input to Step 3:	(p')(ɬa$_\mu$)	*σ/O	*Complex	ParseSeg	DepV	Syll-Head	*Operations*
☞	a. (p')(ɬa$_\mu$)					1	*No change*
	b. (p'ə$_\mu$)(ɬa$_\mu$)				W1	L	*Epenthesis*
	c. p'(ɬa$_\mu$)			W1		L	*Unparsing*

[14] I do not show an exhaustive list of harmonically bounded candidates. I assume that candidates such as [p'ɬ(a$_\mu$)] are available but will never win.
[15] Though not shown here, sonorants can form the head of a syllable: an input such as /ɬnta/ 'to blow the nose' is syllabified as [(ɬń$_\mu$)(ta)] (Bach *et al.* 2005:4). In addition, the syllabic sonorant bears word stress in this case. Interestingly, single sonorants cannot form minor syllables: /npa/ 'to break through a surface, to collapse' is pronounced [(nə)(pá)], not *[(ń)(pa)].
[16] In this example, the constraint Onset can also be used to eliminate the parse [(p'$_\mu$)(ɬa$_\mu$)] if it outranks Syll-Head.

In Oowekyala, the derivation converges on the form with the minor syllable [(p’)(ɬa$_{\mu}$)] because there is no single operation that can eliminate the violation of SYLL-HEAD that does not also violate a higher-ranked constraint.

2.3.3. Epenthesis

In tableau (29)(b) for Oowekyala in the previous section, the set of failed candidates for the input /p’ɬa/ ‘to blink’ include a candidate [(p’ə$_{\mu}$)(ɬa$_{\mu}$)], where a vowel is epenthesized to eliminate the minor syllable and improve satisfaction of the constraint SYLL-HEAD. In Oowekyala, this candidate is eliminated by ranking DEPV over SYLL-HEAD, as shown above.[17] However, if the ranking of DEPV and SYLL-HEAD were reversed, we would expect candidate (b) in the above tableau to win, meaning that the derivation would not converge in Step 3. This may be the ranking in Kwak’wala (North Wakashan: British Columbia; Boas 1947, Grubb 1977, Wilson 1978, Bach *et al.* 2005), a closely related language. Cognates indicate that forms with minor syllables in Oowekyala correspond to forms which contain schwa in Kwak’wala:

(30) Oowekyala-Kwak’wala cognates (Grubb 1977; Bach *et al.* 2005:2)

	Oowekyala	Kwak’wala	
a.	p’ɬa	p’ə̲ɬa	‘to blink’
b.	k’ʷs	k’ʷə̲s	‘light’
c.	qʷχʷ	qʷə̲χ	‘powder’
d.	pk’ʷs	bə̲kʷə̲́s	‘Sasquatch’
e.	ƛxχs	λə̲xə̲́χs	‘thwart’
f.	txʷʔít	də̲xʷʔíd	‘to jump’
g.	c’ɬc’kʷ	c’ə̲ɬc’ə̲́kʷ	‘short (pl.)’
h.	qʷsqʷs	χʷə̲sχʷə̲́s	‘blueberry’
i.	txtxəní	də̲xdə̲xlíɬ	‘owl’

Schwa is generally predictable in Kwak’wala and evidence from alternations and phonotactics suggest that at least some instances of schwa are epenthetic (Grubb 1977:236-241). Assuming Richness of the Base (Prince & Smolensky 1993/2004), a possible input for Kwak’wala [p’əɬá] ‘to blink’ may be /p’ɬa/, the same input form as in Oowekyala. If SYLL-HEAD outranks DEPV while keeping the rest of the constraint hierarchy the same, schwa will be epenthesized into the

[17] The data are in actuality more complicated than presented here: Oowekyala appears to tolerate minor syllables that contain obstruents but not minor syllables that contain sonorants, suggesting that minor syllables also impose sonority preferences on their contents. See Howe (2000) for a more complete account of the data.

minor syllable in Step 3 of the above derivation, and the derivation will not converge until Step 4:[18]

(31) Epenthesis in a minor syllable: Kwak'wala /p'ɬa/ [p'əɬa] 'to blink'

(a) Step 3 /p'ɬa/: Epenthesis

Input to Step 3:	(p')(ɬa$_\mu$)	*σ/O	*COMPLEX	PARSESEG	SYLL-HEAD	DEPV	*Operations*
☞	a. (p'ə$_\mu$)(ɬa$_\mu$)					1	*Epenthesis*
	b. (p')(ɬa$_\mu$)				W1	L	*No change*
	c. p'(ɬa$_\mu$)			W1		L	*Unparsing*

(b) Step 4 /p'ɬa/: Convergence

Input to Step 4:	(p'ə$_\mu$)(ɬa$_\mu$)	*σ/O	*COMPLEX	PARSESEG	SYLL-HEAD	DEPV	*Operations*
☞	a. (p'ə$_\mu$)(ɬa$_\mu$)					1	*No change*
	b. (p')(ɬa$_\mu$)				W1	L	*Deletion*
	c. (p')ə(ɬa$_\mu$)			W1		L	*Unparsing*

The above example illustrates the proposed two-step path to epenthesis through the means of a minor syllable. The minor syllable is created to avoid a complex onset, and the minor syllable is then eliminated by vowel epenthesis.

I will argue in this paper that epenthesis always occurs in response to an intermediate step which creates a minor syllable.[19] The remainder of this paper will discuss how this theory can account for stress-epenthesis interactions in Egyptian Arabic (Farwaneh 1995), Dakota (Shaw 1976, 1985), and Levantine Arabic (Abu-Salim 1982, Farwaneh 1995).

3. Stress-epenthesis Interactions I: Egyptian Arabic and Dakota

3.1. Stress and Epenthesis

The previous section developed a theory of serial syllabification and epenthesis under the HS framework. Under this theory, epenthesis follows syllabification: vowel insertion occurs in response to the creation of a vowel-less minor syllable, which violates the markedness constraint SYLL-HEAD. Similarly,

[18] Bach *et al.* (2005) argue that schwa is non-moraic in the North Wakashan languages. If this is the case, the definition of SYLL-HEAD would need to be revised to account for syllable headedness in terms of sonority rather than weight. This possibility is not pursued here.

[19] A possible second path to vowel epenthesis passes through a consonant-only core syllable, as in CCCV → CC(CV$_\mu$) → (CC$_\mu$)(CV$_\mu$) → (C**v$_\mu$**C$_\mu$)(CV$_\mu$). This possibility is not discussed here, but it is in principle available as a means to improve the sonority of the head segment.

stress also follows syllabification because foot-building is motivated by the constraint PARSESYLLABLE, defined as below:

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

I follow Pruitt (2008) in the assumption that feet are built serially, and can be maximally binary.

In this section, I show that while both stress and epenthesis follow syllabification, the relative ordering of these two operations is not fixed and depends on constraint ranking: if PARSEσ outranks SYLL-HEAD, stress will precede epenthesis, while if SYLL-HEAD outranks PARSEσ, epenthesis will precede stress. If the former ranking holds, the presence of a minor syllable can disrupt the regular stress patterns of the language because mora-less syllables cannot be the heads of feet. To illustrate both possible rankings, I discuss two languages: Egyptian Arabic (Farwaneh 1995), in which epenthetic vowels can be stressed, and Dakota (Shaw 1976, 1985), where epenthetic vowels disrupt stress assignment.

3.2. Egyptian Arabic

In Egyptian Arabic (Farwaneh 1995), stress falls on the antepenultimate syllable:

(33) Egyptian Arabic (Farwaneh 1995:134): Penultimate stress

a.	/madrasa/	(mad)**(rá)**(sa)	‘school’
b.	/martaba/	(mar)**(tá)**(ba)	‘mattress’

In words with sequences of three medial consonants (CCC), a vowel is epenthesized following C_2. If the epenthetic vowel is penultimate, it is stressed just like an underlying vowel:

(34) Egyptian Arabic: Epenthesis in medial CCC clusters (Farwaneh 1995:135)

a.	/bint-na/	(bin)**(tí̲)**(na)	‘our daughter’
b.	/ʔarD-na/	(ʔar)**(Dí̲)**(na)	‘our land’
c.	/katabt-lu/	(ka)(tab)**(tí̲)**(lu)	‘I wrote to him’

Following the theory of epenthesis described above, epenthesis must pass through an intermediate stage where the medial consonant is parsed as a minor syllable. This is achieved by ranking *COMPLEX and PARSESEG over SYLL-HEAD. The initial syllabification of the word /bint-na/ ‘our daughter’ produces the form [(bin)(t)(na)], where the medial consonant is syllabified as a mora-less minor syllable in order to avoid the creation of a complex onset or coda.

The syllabification of /bint-na/ is illustrated by the following series of tableaux. The first two steps see the creation of two core syllables:[20]

(35) Syllabification: /bint-na/

(a) Step 1 /bint-na/: Creation of core syllable

Original Input:	/bint-na/	ParseSeg	*Complex	Syll-Head	NoCoda	***Operations***
☞	a. (bi)ntna	4				*Core syllabification*
☞	b. bint(na)	4				*Core syllabification*
	c. (b)intna	W5		W1		*Project minor syllable*
	d. bi(n)tna	W5		W1		*Project minor syllable*
	e. bin(t)na	W5		W1		*Project minor syllable*
	f. bint(n)a	W5		W1		*Project minor syllable*
	g. bintna	W5				*No change*

(b) Step 2 /bint-na/: Creation of a second core syllable

Input to Step 2:	(bi)ntna	ParseSeg	*Complex	Syll-Head	NoCoda	***Operations***
☞	a. (bi)nt(na)	2				*Core syllabification*
	b. (bin)tna	W3			W1	*Adjunction (coda)*
	c. (bi)(n)tna	W3		W1		*Project minor syllable*
	d. (bi)n(t)na	W3		W1		*Project minor syllable*
	e. (bi)nt(n)a	W3		W1		*Project minor syllable*
	f. (bi)ntna	W4				*No change*

Step 3 adjoins a coda to the first core syllable, because the ranking Syll-Head » NoCoda prefers codas to minor syllables:

[20] From this point on, I will not indicate the moraicity of segments by the subscript μ, except when this is directly relevant to the discussion at hand.

(36) Step 3 /bint-na/: Coda adjunction[21]

Input to Step 3:	(bi)nt(na)	PARSESEG	*COMPLEX	SYLL-HEAD	NOCODA	*Operations*
☞	a. (bin)t(na)	1			1	*Adjunction (coda)*
	b. (bi)(n)t(na)	1		W1	L	*Project minor syllable*
	c. (bi)n(t)(na)	1		W1	L	*Project minor syllable*
	d. (bi)n(tna)	1	W1		L	*Adjunction (onset)*
	e. (bi)nt(na)	W2			L	*No change*

Finally, Step 4 parses the remaining consonant as a minor syllable. The ranking *COMPLEX » SYLL-HEAD makes the creation of a minor syllable preferable to parsing the medial consonant as a complex onset or coda:

(37) Step 4: Minor syllable creation

Input to Step 4:	(bin)t(na)	PARSESEG	*COMPLEX	SYLL-HEAD	NOCODA	*Operations*
☞	a. (bin)(t)(na)			1	1	*Project minor syllable*
	b. (bint)(na)		W1	L	1	*Adjunction (coda)*
	c. (bin)(tna)		W1	L	1	*Adjunction (onset)*
	d. (bin)t(na)	W1		L	1	*No change*

However, the derivation does not converge at this point because two operations remain to be applied: epenthesis into the minor syllable (indicating that SYLL-HEAD » DEPV) and stress assignment (governed by PARSEσ). The ranking of SYLL-HEAD and PARSEσ will determine the order that the operations are applied: if SYLL-HEAD outranks PARSEσ, epenthesis will apply first, while under the opposite ranking, stress will apply first.

We know from the output form [bintína] that stress falls on the epenthetic vowel. If stress were applied in Step 4 on the input [(bin)(t)(na)], we would expect that stress would avoid the penultimate syllable because it contains a mora-less minor syllable. Minor syllables are headless because they do not contain a mora, and headlessness on this level precludes them from being possible heads of higher prosodic categories.

If, on the other hand, epenthesis precedes stress, the penultimate syllable will become a possible foot head because it will contain the epenthetic vowel. As shown in the following tableaux, ranking SYLL-HEAD over PARSEσ derives this

[21] The candidate [(bi)(nt$_{\mu}$)(na)] is also included in the candidate set for Step 3. I assume that this is eliminated by *σ/C, which disprefers syllable heads of low sonority. For simplicity, I do not include this candidate in this tableau; however, this possibility is discussed further in relation to Levantine Arabic in section 4.

ordering, which correctly captures the transparent interaction between epenthesis and stress:

(38) Epenthesis precedes stress: /bint-na/

(a) Step 5 /bint-na: Vowel epenthesis

Input to Step 5:	(bin)(t)(na)	ParseSeg	Syll-Head	Parseσ	DepV	*Operations*
☞	a. (bin)(ti)(na)			3	1	*Epenthesis*
	b. [(bín)(t)](na)		W1	L1	L	*Stress*
	c. (bin)(t)(na)		W1	3	L	*No change*

(b) Step 6 /bint-na/: Stress assignment

Input to Step 6:	(bin)(ti)(na)	ParseSeg	Syll-Head	Parseσ	DepV	*Operations*
☞	a. (bin)[(tí)(na)]			1	1	*Stress*
	b. (bin)(ti)(na)			W3	1	*No change*

(c) Step 7 /bint-na/: Convergence

Input to Step 7:	(bin)[(tí)(na)]	ParseSeg	Syll-Head	Parseσ	DepV	*Operations*
☞	a. (bin)[(tí)(na)]			1	1	*No change*
	b. (bin)(ti)(na)			W3	1	*Unparsing*

Ranking Syll-Head over Parseσ produces a transparent interaction between stress and epenthesis because the epenthetic vowel will be present at the point in the derivation where stress is assigned. The next section looks at a language where the reverse ranking appears to hold true, and epenthetic vowels disrupt stress assignment.

3.3. Dakota

In Dakota (Shaw 1976, 1985), stress regularly falls on the second syllable of the word:

(39) Second-syllable stress in Dakota (Shaw 1985:31)

a.	č^{h}i-kte	[č^{h}ikté]	‘I kill you’
b.	ma-ya-kte	[mayákte]	‘You kill me’
c.	wičha-ya-kte	[wičháyakte]	‘You kill them’

However, when the second syllable contains an epenthetic vowel, stress falls instead on the initial syllable. This is seen in a class of verb and noun stems that predictably end in the vowel /a/:[22]

(40) Initial-syllable stress in Dakota (Shaw 1985:32)

a.	čap	[čápa̲]	'beaver'
b.	šuk	[šúka̲]	'dog'
c.	ček	[čéka̲]	'to stagger'
d.	šič	[šíča̲]	'to be bad'
e.	puz	[púza̲]	'to be dry'

For simplicity, I will assume that stem-final epenthesis is motivated by NoCoda, and that medial clusters are syllabified as complex onsets.

I assume that the ranking NoCoda » Syll-Head results in the creation of minor syllables in Dakota's consonant-final stems. The syllabification for /čap/ 'beaver' is illustrated in the following sequence of two tableaux:

(41) Syllabification: /čap/

(a) Step 1 /čap/: Creation of core syllable

Original Input:	/čap/	ParseSeg	NoCoda	Syll-Head	*Operations*
☞	a. (ča)p	1			*Core syllabification*
	b. ča(p)	W2		W1	*Project minor syllable*
	c. čap	W3			*No change*

(b) Step 2 /čap/: Creation of minor syllable

Input to Step 2:	(ča)p	ParseSeg	NoCoda	Syll-Head	*Operations*
☞	a. (ča)(p)			1	*Project minor syllable*
	b. (čap)		W1	L	*Adjunction (coda)*
	c. (ča)p	W1		L	*No change*

In the previous section, I argued that the transparent stress-epenthesis interactions in Egyptian Arabic can be accounted for by assuming that Syll-Head outranks Parseσ, causing epenthesis to apply before stress in the derivation. This ordering eliminated the minor syllable by replacing it with a core syllable, an eligible foot head. If the ranking had been reversed, such that Parseσ outranked Syll-Head, stress would have been assigned to a different syllable.

[22] As Shaw (1985:32, 116-120) notes, there is evidence for the underlying representations in (40) from phonotactic distribution (the final consonant is limited to voiceless unaspirated stops and affricates, and voiced fricatives), as well as morphological alternations.

In Dakota, stress is assigned opaquely in consonant-final roots with an epenthetic vowel. If PARSEσ outranks SYLL-HEAD in Dakota, stress will be assigned before the epenthetic vowel is introduced. Stress would normally fall on the second syllable (creating an iambic foot), but when the second syllable is a minor syllable, stress will fall instead on the initial syllable, creating a trochaic foot. This sequence of steps is illustrated in the following tableaux which continue the derivation in (41):

(42) Stress and epenthesis: /čap/

(a) Step 3 /čap/: Stress assignment

Input to Step 3:	(ča)(p)	PARSESEG	PARSEσ	SYLL-HEAD	FT = IAMB	DEPV	***Operations***
☞	a. [(čá)(p)]			1	1		*Stress*
	b. (ča)(pa)		W2	L	L	W1	*Epenthesis*
	c. (ča)(p)		W2	1	L		*No change*

(b) Step 4 /čap/: Epenthesis

Input to Step 4:	[(čá)(p)]	PARSESEG	PARSEσ	SYLL-HEAD	FT = IAMB	DEPV	***Operations***
☞	a. [(čá)(pa)]				1	1	*Epenthesis*
	b. [(čá)(p)]			W1	1	L	*No change*

In Step 5, the derivation will converge even though the second syllable is now a valid foot head. The gradualness requirement on GEN would require that the foot be deleted before it can be reassigned because stress shift would require the application of two operations (foot deletion and foot assignment). Under the current ranking, this would increase the number of violations to PARSEσ, causing the derivation to converge on [(čá)(pa)]:

(43) Stress and epenthesis: /čap/

Step 5 /čap/: Convergence

Input to Step 5:	[(čá)(pa)]	PARSESEG	PARSEσ	SYLL-HEAD	FT = IAMB	DEPV	***Operations***
☞	a. [(čá)(pa)]				1	1	*No change*
	b. (ča)(pa)		W2		L	1	*Unparsing*

This section has demonstrated that constraint ranking in HS controls the order that operations are applied. In this example, the relative ordering of stress and epenthesis operations determined whether stress was assigned transparently (as in Egyptian Arabic) or opaquely (as in Dakota). In the next section, I discuss how the interaction of other markedness constraints with SYLL-HEAD and PARSEσ can account for non-uniform stress-epenthesis interactions within a single language, as occurs in Levantine Arabic. In this language, epenthetic vowels interact both transparently and opaquely with respect to stress assignment, depending on the environment for epenthesis.

4. Stress-epenthesis Interactions II: Levantine Arabic

4.1. Data

The basic pattern of stress in Levantine Arabic is like Latin: stress falls on the penultimate syllable if it is heavy or if the word is disyllabic, and on the antepenultimate syllable if the penultimate syllable is light (Abu-Salim 1982):

(44) 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.)'

(45) Initial stress: disyllabic word

a.	ʔána	'I'
b.	kátab	'he wrote'

(46) Antepenultimate stress: light penult

a.	kátabu	'they wrote'
b.	mádrasa	'school'
c.	ʕálamat	'she taught'
d.	ʕallámato	'she taught him'

I assume the following stress constraints and ranking:

(47) Stress Constraints

a. ALIGNHDR/ALIGNHDL: assign one violation mark for every syllable that intervenes between the right/left edge of the word and the head foot.
b. FOOTBINARITYμ (FTBIN): assign one violation mark for every foot that does not dominate exactly two moras.
c. NONFINALITY (NONFIN): assign one violation mark for every foot that includes the final syllable in the word.

(48) Ranking for Stress Constraints

(ka)(ta)(bu)	NonFin	FtBin	AlignHdR	AlignHdL
a. ☞[(ká)(ta)](bu)			1	
b. (ka)[(tá)(bu)]	W1		L	W1
(ka)(tab)(lak)				
a. ☞(ka)[(táb)](lak)			1	1
b. (ka)(tab)[(lák)]	W1		L	W2
c. [(ká)(tab)](lak)		W1	1	L
(mak)(tab)(na)				
a. ☞(mak)[(táb)](na)			1	1
b. [(mák)](tab)(na)			W2	L
(mad)(ra)(sa)				
a. ☞[(mád)](ra)(sa)			2	
c. (mad)[(rá)](sa)		W1	L1	W1

Deviations from the normal stress pattern occur when epenthesis breaks up illicit consonant clusters (Abu-Salim 1982, Farwaneh 1995), resulting in both opaque and transparent stress patterns.[23] The first opaque pattern arises from epenthesis into a final two-consonant (CC) cluster, where stress falls on the penultimate syllable, even though it is light:

(49) **Opaque Pattern 1: Final CC clusters**

/katab-t/	(ka)**(tá)**(bi̲t)	'I wrote'	*(ká)(ta)(bi̲t)
cf. /katab-u/	(ká)(ta)(bu)	'they wrote'	

A second opaque pattern occurs in medial three-consonant (CCC) clusters, where stress appears to skip over a heavy penult to fall on the antepenultimate syllable:

(50) **Opaque Pattern 2: Medial CCC clusters**

/katab-l-ha/	(ka)(tá)**(bi̲l)**(ha)	'he wrote to her'	*(ka)(ta)(bí̲l)(ha)
cf. /katab-na/	(ka)(táb)(na)	'we wrote'	

However, in medial four-consonant (CCCC) clusters, stress falls transparently on the heavy penult:

(51) **Transparent Pattern: Medial CCCC clusters**

/katab-t-l-ha/ (ka)(tab)**(tí̲l)**(ha) 'I wrote to her'

[23] Some consonant clusters are tolerated. For the purposes of the analysis, I abstract away from this point and assume that the clusters are dispreferred under pressure from high-ranking *Complex.

Following the analysis in the previous section, I will argue that transparent stress results when epenthesis precedes stress, and opaque stress when stress precedes epenthesis. However, unlike the analysis of Egyptian Arabic and Dakota, this must be done using a single ranking of SYLL-HEAD and PARSEσ because the interaction takes place within a single language. I will show that this is possible in HS because, just as in Classic OT, the interaction between constraints can result in non-uniform patterns. I will show that this occurs in Levantine Arabic when high-ranked markedness constraints intervene to block epenthesis in the opaque environments (medial CCC and final CC clusters) but do not block epenthesis in the transparent environment (medial CCCC clusters). Levantine Arabic thus fulfils an implicit prediction of HS in this account for stress-epenthesis interactions: constraint interaction can result in a type of derivational non-uniformity.

4.2. Syllabification

I will assume that Levantine Arabic allows simple codas but not complex ones, as derived from ranking *COMPLEX over SYLL-HEAD and SYLL-HEAD over NOCODA. The syllabification of a word like /katab/ 'he wrote' will proceed as illustrated in the following series of tableaux, with the final consonant parsed as a coda rather than as a minor syllable:

(52) Syllabification: /katab/

(a) Step 1 /katab/: Creation of core syllable

Original Input:	/katab/	PARSESEG	SYLL-HEAD	NOCODA	***Operations***
☞	a. (ka)tab	3			*Core syllabification*
☞	b. ka(ta)b	3			*Core syllabification*
	c. (k)atab	W4	W1		*Project minor Syllable*
	d. ka(t)ab	W4	W1		*Project minor Syllable*
	e. kata(b)	W4	W1		*Project minor Syllable*
	f. katab	W5			*No change*

(b) Step 2 /katab/: Creation of second core syllable

Input to Step 2:	(ka)tab	PARSESEG	SYLL-HEAD	NOCODA	***Operations***
☞	a. (ka)(ta)b	1			*Core syllabification*
	b. (kat)ab	W2		W1	*Adjunction (Coda)*
	c. (ka)(t)ab	W2	W1		*Project minor Syllable*
	d. (ka)ta(b)	W2	W1		*Project minor Syllable*
	e. (ka)tab	W3			*No change*

(c) Step 3 /katab/: Adjunction of coda consonant

Input to Step 3:	(ka)(ta)b	PRSSEG	SYLL-HEAD	NOCODA	***Operations***
☞	a. (ka)(tab)			1	*Adjunction (Coda)*
	b. (ka)(ta)(b)		W1	L	*Project minor Syllable*
	c. (ka)(ta)b	W1		L	*No change*

As will be seen in the next section, complex clusters trigger epenthesis, and pass through an intermediate step which contains a minor syllable. This is derived from ranking *COMPLEX over SYLL-HEAD.

4.3. Transparent Stress-epenthesis Interaction: CCCC clusters

An epenthetic vowel in a CCCC cluster attracts stress, just like any other vowel in a heavy, penultimate syllable:

(53) **Transparent Pattern: Medial CCCC clusters**

/katab-t-l-ha/	(ka)(tab)**(tí̱l)**(ha)	'I wrote to her'
/katab-na/	(ka)(táb)(na)	'we wrote'

In section 3, I argued that transparent stress-epenthesis interactions arise when epenthesis precedes stress in the derivation, the result of the ranking SYLL-HEAD » PARSEσ. I will show that just as in Egyptian Arabic, this ranking will also account for the transparent interaction in Levantine Arabic, and that the opaque interactions can be accounted for under this same ranking using constraint interaction.

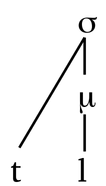
In words with medial CCCC clusters, the first four steps will produce the syllabification [(ka)(tab)tl(ha)], which follows from the ranking given in the previous section. The first four steps in the derivation are summarized in the following Harmonic Improvement tableau:

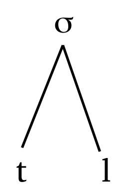
(54) Harmonic Improvement summary tableau: /katab-t-l-ha/ 'I wrote to her'

Original Input:	/katab-t-l-ha/	PARSESEG	NOCODA	***Operations***
Step 1 *is less harmonic than*	**(ka)**tabtlha	7		*Core syllabification*
Step 2 *is less harmonic than*	(ka)**(ta)**btlha	5		*Core syllabification*
Step 3 *is less harmonic than*	(ka)(ta)btl**(ha)**	3		*Core syllabification*
Step 4	(ka)(ta**b**)tl(ha)	2	1	*Adjunction (Coda)*

Syllabification is not yet complete, because two segments must still be accounted for. Because complex onsets and codas are not tolerated in the language, the consonants must be parsed into a vowel-less syllable, either as a consonant-headed core syllable or a complex minor syllable, as illustrated below:

(55) Two representational options for the vowel-less syllable in /katab-t-l-ha/
a. Core syllable b. (Complex) minor syllable[24]





Both possibilities represent possible paths to epenthesis in Levantine Arabic, as neither syllable type is tolerated in output forms. However, for reasons that will become clear in the next section, I will assume that structure (b) is correct. The crucial difference between structures (a) and (b) is that structure (a) is produced by the application of a single operation (core syllabification), and structure (b) by the application of two operations: first a minor syllable is projected /tl/ > [(t)l], and then the second consonant is adjoined to the minor syllable [(t)l] > [(tl)]. I will argue in the next section that the two step process of minor syllable creation is essential for arriving at the intermediate forms that will allow stress to be assigned to the correct syllable in words with opaque stress. I will therefore assume that the *σ/C constraints are undominated in Levantine Arabic, while SYLL-HEAD is ranked below *COMPLEX and PARSESEG.

The derivation in (54) will continue as follows, with steps 5 and 6 creating a two-consonant minor syllable:

[24] This type of complex minor syllable can be interpreted as a type of adjunction structure, with an onset and a final appendix. This representation has been used to represent minor syllables in Oowekyala (Howe 2000; Bach *et al.* 2005), as well as Georgian and Polish (Cho & King 2003).

(56) Syllabification: /katab-t-l-ha/

(a) Step 5 /katab-t-l-ha/: Creation of minor syllable[25]

Input to Step 5:	(ka)(tab)tl(ha)	*σ/C	*COMPLEX	PARSESEG	SYLL-HEAD	NOCODA	*Operations*
☞	a. (ka)(tab)t(l)(ha)			1	1	1	*Project minor Syllable*
☞	b. (ka)(tab)(t)l(ha)			1	1	1	*Project minor Syllable*
	c. (ka)(tab)(tl_μ)(ha)	W1		L	L	1	*Core syllabification*
	d. (ka)(tabt)l(ha)		W1	1	L	1	*Adjunction (Coda)*
	e. (ka)(tab)t(lha)		W1	1	L	1	*Adjunction (Onset)*
	f. (ka)(tab)tl(ha)			W2	L	1	*No change*

(b) Step 6 /katab-t-l-ha/: Adjunction to minor syllable

Input to Step 6:	(ka)(tab)t(l)(ha)	*COMPLEX	PARSESEG	SYLL-HEAD	NOCODA	*Operations*
☞	a. (ka)(tab)(tl)(ha)			1	1	*Adjunction*
	b. (ka)(tabt)(l)(ha)	W1		1	1	*Adjunction (Coda)*
	c. (ka)(tab)(t)(l)(ha)			W2	1	*Project minor Syllable*
	d. (ka)(tab)t(l)(ha)		W1	1	1	*No change*

Step 6 fully satisfies PARSESEG. As discussed above, the transparent relation between stress and epenthesis in this example is derived by ranking SYLL-HEAD over PARSEσ, which will result in epenthesis applying before stress assignment. Note that if stress were to apply at this point in the derivation, we would expect stress to fall on the antepenultimate syllable, skipping over the light penultimate syllable. However, epenthesis here makes penultimate syllable heavy, such that stress will fall transparently on this syllable in Step 8.[26] This leads to convergence in Step 9, as illustrated by the following series of tableaux:

[25] Once again, candidates (a) and (b) are tied in this tableau. I arbitrarily choose (a) here: in this case, the split in the derivation will re-converge on [(tl)] no matter which candidate is syllabified first.

[26] I assume that mora insertion is not a separate operation, but occurs concurrently with syllabification in such a way as to best satisfy syllable structure constraints such as WEIGHT-BY-POSITION (Hayes 1989) or *μ/C. This assumption requires more research, but may be supported by the apparent absence of languages which contrast moras in coda position (Bermudez-Otero 2001, Campos-Astorkiza 2004, *cf.* Elfner 2006). Thus, in Levantine Arabic where coda consonants contribute weight, the consonant in [(tl)] becomes moraic upon insertion of the vowel [($ti_\mu l_\mu$)], because it is now in coda position.

(57) Epenthesis and stress: /katab-t-l-ha/

(a) Step 7 /katab-t-l-ha/: Epenthesis (creation of heavy penult)

Input to Step 7:	(ka)(tab)(tl)(ha)	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	***Operations***
☞	a. (ka)(tab)(ti$_{\mu}$l$_{\mu}$)(ha)			4	1	2	*Epenthesis*
	b. (ka)[(táb)](tl)(ha)		W1	L3	L	L1	*Stress*
	c. (ka)(tab)(tl)(ha)		W1	4	L	L1	*No change*

(b) Step 8 /katab-t-l-ha/: Stress assignment (falls on the heavy penult)

Input to Step 8:	(ka)(tab)(ti$_{\mu}$l$_{\mu}$)(ha)	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	***Operations***
☞	a. (ka)(tab)[(tí$_{\mu}$l$_{\mu}$)](ha)			3	1	2	*Stress*
	b. (ka)(tab)(ti$_{\mu}$l$_{\mu}$)(ha)			W4	1	2	*No change*

(c) Step 9 /katab-t-l-ha/: Convergence[27]

Input to Step 9:	(ka)(tab)[(tí$_{\mu}$l$_{\mu}$)](ha)	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	***Operations***
☞	a. (ka)(tab)[(tí$_{\mu}$l$_{\mu}$)](ha)			3	1	2	*No change*
	b. (ka)(tab)(ti$_{\mu}$l$_{\mu}$)(ha)			W4	1	2	*Unparsing*

Just as in Egyptian Arabic, constraint ranking derives the transparent interaction between stress and epenthesis: when SYLL-HEAD outranks PARSEσ, epenthesis precedes stress, meaning that the epenthetic vowel is present when stress is assigned. In the next section, I show that opaque interactions between stress and epenthesis can arise under this same ranking when a markedness constraint blocks the application of epenthesis. This can result in epenthesis being delayed until after stress assignment, creating an opaque stress pattern as found in Dakota.

4.4. Opaque Stress 1: Final CC clusters

Words with final illicit CC clusters are stressed on the light penultimate syllable:

[27] I assume that PARSEσ is as satisfied as it can be. I do not consider the assignment of secondary stress in this analysis.

(58) **Opaque Pattern 1: Final CC clusters**

/katab-t/	(ka)**(tá)**(bi̱t)	'I wrote'	*(ká)(ta)(bit)
cf. /katab-u/	(ká)(ta)(bu)	'they wrote'	

Normally, stress falls on the penultimate syllable only when it is heavy. This suggests that the penultimate syllable is heavy at the point in the derivation when stress is assigned to [katábit]. However, because the ranking SYLL-HEAD » PARSEσ has already been established to account for the transparent interaction in medial CCCC clusters, this ranking cannot be reversed to account for the opaque interaction in final CC clusters. I will show that the above assumptions regarding serial syllabification and the representation of minor syllables produce an intermediate form, [(ka)(tab)(t)], where the penultimate syllable is heavy and the final minor syllable consists of one rather than two consonants. If stress is applied to this intermediate form, stress will fall on the penultimate syllable, the correct result.

As before, syllabification operations are sequentially applied to /katab-t/ 'I wrote'. The first two steps yield [(ka)(ta)bt] from the creation of two core syllables. This is summarized in the following Harmonic Improvement tableau:

(59) Harmonic Improvement summary tableau: /katabt/ 'I wrote'

Original Input:	/katab-t/	PARSESEG	PARSEσ	***Operations***
Step 1 *is less harmonic than*	**(ka)**tabt	4	1	*Core syllabification*
Step 2	(ka)**(ta)**bt	2	2	*Core syllabification*

As before, there is a choice between parsing the /b/ as a coda and forming a vowel-less core syllable containing [(bt$_\mu$)]. Above, I assumed that sequences of two consonants are syllabified as a complex minor syllable [(bt)] rather than a core syllable, a preference that can be derived by ranking *σ/C over PARSESEG. The reason for this decision is clear from stress assignment in words like /katab-t/: if /bt/ was parsed as a core syllable ([(ka)(ta)(bt$_\mu$)]), the penultimate syllable would not be heavy at any point in the derivation, and thus be unable to attract stress.

Step 3 in the derivation, as above, therefore syllabifies /b/ as a coda consonant, and Step 4 syllabifies /t/ as a final minor syllable. This gives the syllabification [(ka)(tab)(t)]:

(60) Syllabification: /katab-t/

(a) Step 3 /katab-t/: Coda adjunction

Input to Step 3:	(ka)(ta)bt	*σ/C	*COMPLEX	PARSESEG	SYLL-HEAD	NOCODA	***Operations***
☞	a. (ka)(tab)t			1		1	*Adjunction (Coda)*
	b. (ka)(ta)(b)t			1	W1	L	*Project minor syllable*
	c. (ka)(ta)b(t)			1	W1	L	*Project minor syllable*
	d. (ka)(ta)(bt$_{\mu}$)	W1		L		L	*Core syllabification*
	e. (ka)(ta)bt			W2		L	*No change*

(b) Step 4 /katab-t/: Minor syllable creation

Input to Step 4:	(ka)(tab)t	*σ/C	*COMPLEX	PARSESEG	SYLL-HEAD	NOCODA	***Operations***
☞	a. (ka)(tab)(t)				1	1	*Project minor syllable*
	b. (ka)(tabt)		W1		L	1	*Adjunction (Coda)*
	c. (ka)(tab)t			W1	L	1	*No change*

The fully syllabified candidate [(ka)(tab)(t)] is the input to Step 5. Note that the output of Step 5 is [(ka)(tab)(t)], a form which is arguably more marked than [(ka)(ta)(bt)], where [(bt)] is a mora-less minor syllable and not a core syllable. The former is the outcome at Step 4 because the decision leading to [(ka)(tab)(t)] is made before [(ka)(ta)(bt)] is even part of the candidate set. This illustrates one of the differences between the HS evaluation and a parallel evaluation as made in Classic OT: if decisions about syllabification had been evaluated in parallel, the candidate [(ka)(tab)(t)] would have lost to [(ka)(ta)(bt)], and the penultimate syllable would never have been heavy. The candidate [(ka)(tab)(t)] is crucial in order to achieve the correct placement of stress.

Step 5 takes as its input the output of Step 4, [(ka)(tab)(t)]. The constraint hierarchy, in which SYLL-HEAD outranks PARSEσ, would prefer epenthesis to precede stress, in order to eliminate the violation of SYLL-HEAD incurred by the minor syllable. However, this cannot be the correct order of operations: epenthesis would render the penultimate syllable heavy, and the correct output sees stress falling on the antepenultimate syllable instead. This pattern can be derived if stress is applied to the current form, suggesting that epenthesis is blocked at this step in the derivation.

There are two possible sites for epenthesis that would satisfy SYLL-HEAD at this point: the vowel could precede the stray consonant as in [(ka)(tab)($\underline{\text{i}}$t)], or it could follow the consonant as in [(ka)(tab)(t$\underline{\text{i}}$)]. Each of these forms violates a markedness constraint: [(ka)(tab)(i̠t)] violates ONSET,[28] and [(ka)(tab)(ti̠)] violates ALIGNR(Stem, Word), a constraint that is violated when the right edge of the stem and the right edge of the word do not coincide, and which appears to be active in all Arabic dialects (Farwaneh 1995:61-66, McCarthy & Prince 1993:126-127, McCarthy 2007a:155). The form that would satisfy both of these constraints, [(ka)(ta)(bi̠t)], is not produced by GEN because it would require the simultaneous application of two operations, epenthesis and resyllabification. The absence of this candidate combined with the ranking ONSET, ALIGNR(Stem, Word) » SYLL-HEAD effectively block epenthesis at Step 5 of the derivation.

Since SYLL-HEAD cannot be satisfied without violating these higher-ranked constraints, the stress candidate wins because it best satisfies the next highest constraint, PARSEσ. Stress falls on the penultimate syllable rather than the antepenult because the penult is heavy at this point in the derivation. The following tableau illustrates how the two epenthesis candidates lose to the stress candidate under the proposed constraint ranking:

(61) Step 5 /katab-t/: Stress assignment (ONSET and ALIGNR(St,Wd) block epenthesis)

Input to Step 5:	(ka)(tab)(t)	ONSET	ALIGNR (St,Wd)	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	***Operations***
☞	a. (ka)[(táb)](t)				1	2		1	*Stress*
	b. (ka)(tab)(it)	W1			L	W3	W1	W2	*Epenthesis*
	c. (ka)(tab)(ti)		W1		L	W3	W1	1	*Epenthesis*
	d. (ka)(ta)(bt)				1	W3		L	*Adjunction*
	e. (ka)(tab)(t)				1	W3		1	*No change*

In Step 6, epenthesis is still blocked by ONSET and ALIGNR(Stem, Word). However, harmonic improvement is still possible. Low-ranked NOCODA prefers the candidate which resyllabifies the coda consonant as part of the final minor syllable, even though resyllabification violates FOOTBIN: [29]

[28] Crucially, the minor syllable in the form [(ka)(tab)(l)(ha)] does not violate ONSET. As discussed in section 2.2, I redefine the constraint ONSET such that it refers to the left alignment of moras and syllable boundaries ("assign one violation mark for every mora that is aligned with the left edge of a syllable"). This constraint disprefers syllables with heads that are not preceded by a non-moraic segment, independent of the sonority of the head segment.

[29] Because FOOTBIN and NOCODA do not otherwise conflict, this assumption is not problematic. FOOTBIN also outranks ALIGNHEADR, meaning that this constraint is also dominated by NOCODA and cannot block resyllabification.

(62) Step 6 /katab-t/: Resyllabification of coda consonant as an onset (result of adjunction operation)

Input to Step 6:	(ka)[(táb)](t)	ONSET	ALIGNR (St, Wd)	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	FOOTBIN	***Operations***
☞	a. (ka)[(tá)](bt)				1	2			1	*Adjunction*
	b. (ka)[(táb)](it)	W1			L	2	W1	W2	L	*Epenthesis*
	c. (ka)[(táb)](ti)		W1		L	2	W1	W1	L	*Epenthesis*
	d. (ka)[(táb)](t)				1	2		W1	L	*No change*

Inadvertently, this process of resyllabification has created a possible site for epenthesis that does not violate ONSET. Epenthesis can now apply between the two consonants in Step 7, because this site for epenthesis no longer violates ONSET. This leads to convergence in Step 8:

(63) Epenthesis: /katab-t/

(a) Step 7 /katab-t/: Epenthesis

Input to Step 7:	(ka)[(tá)](bt)	ONSET	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	FOOTBIN	***Operations***
☞	a. (ka)[(tá)](bit)				2	1	1	1	*Epenthesis*
	b. (ka)[(tá)](bt)			W1	2	L	L	1	*No change*

(b) Step 8 /katab-t/: Convergence

Input to Step 8:	(ka)[(tá)](bit)	ONSET	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	FOOTBIN	***Operations***
☞	a. (ka)[(tá)](bit)				2	1	1	1	*No change*
	b. (ka)(ta)(bit)				W3	1	1	L	*Foot Deletion*

Stress is stranded on the light penultimate syllable. The stress constraints FOOTBIN and ALIGNHEADR are powerless to shift stress, because they are ranked below NOCODA and PARSEσ. Unparsing the foot would increase the number of violations to PARSEσ, causing a decrease in harmony. The candidate with opaque stress is therefore chosen as optimal, leading to convergence.

The difference between stress-epenthesis interactions in CCCC clusters and final CC clusters lies in their syllabification, which affects the application of epenthesis and stress operations. Just as in Egyptian Arabic and Dakota, the contrast between transparent and opaque stress-epenthesis interactions lies in the order that stress and epenthesis are applied in the derivation: in the transparent interaction, epenthesis precedes stress, while in the opaque interaction, stress precedes epenthesis. As discussed above, this can be achieved by a single ranking in Levantine Arabic using constraint interaction. The default ordering sees epenthesis preceding stress because SYLL-HEAD outranks PARSESEG. However, the order can be reversed, such that stress precedes epenthesis, when higher-ranked markedness constraints that disprefer epenthesis succeed in blocking the application of the epenthesis operation, meaning that the operation applies late in the derivation after stress has been assigned. The next section illustrates that this ranking also accounts for the opaque interaction in medial CCC clusters.

4.5. Opaque Stress 2: Medial CCC clusters

In words with medial CCC clusters, stress is assigned opaquely: it falls on the antepenultimate syllable, even though the penultimate syllable is heavy:

(64) **Opaque Pattern 2: Medial CCC clusters**

/katab-l-ha/	(ka)(tá)**(bi̲l)**(ha)	'he wrote to her'	*(ka)(ta)(bíl)(ha)
cf. /katab-na/	(ka)(táb)(na)	'we wrote'	

In words without epenthetic vowels, stress falls on the antepenultimate syllable only when the penultimate syllable is light. In serial terms, this suggests that the penultimate syllable must be light at the point in the derivation when stress is assigned. As shown in the previous section, this analysis is possible in HS if epenthesis can be blocked by high-ranked markedness constraints such that it is applied after stress assignment, as was the case in final CC clusters.

As before, syllabification operations are applied one-at-a-time to /katab-l-ha/ 'I wrote' to satisfy PARSESEG. The first three steps produce the syllabification [(ka)(ta)bl(ha)], creating three core syllables:

(65) Harmonic Improvement tableau: /katab-l-ha/ 'He wrote to her'

Original Input:	/katab-l-ha/	PARSESEG	PRSσ	***Operations***
Step 1 *is less harmonic than*	**(ka)**tablha	6	1	*Core syllabification*
Step 2 *is less harmonic than*	(ka)**(ta)**blha	4	2	*Core syllabification*
Step 3	(ka)(ta)bl**(ha)**	2	3	*Core syllabification*

As before, there is a choice between parsing the /b/ as a coda and forming a vowel-less core syllable containing [(bl$_{\mu}$)]. This assumption was necessary to account for the placement of stress in words with final CC clusters, as discussed in the previous section. This analysis is supported by stress assignment in words like /katab-l-ha/: if C_1 and C_2 of the medial sequence were syllabified as a core syllable, there would be no reason to block epenthesis from applying before stress. Stress would then fall on the heavy penultimate syllable rather than the antepenultimate, just as in /katab-t-l-ha/ ([(ka)(ta)(bl)(ha)] > [(ka)(ta)(bi̲l)(ha)]). However, if /katab-l-ha/ receives the parse [(ka)(tab)(l)(ha)], with /l/ occupying a minor syllable, epenthesis can be blocked by high-ranked markedness constraints, and stress will fall on the antepenultimate syllable as expected from the output form.

The derivation in (65) continues as follows, where /b/ is syllabified as a coda and /l/ as a minor syllable:

(66) Syllabification: /katab-l-ha/

(a) Step 4 /katab-l-ha/: Coda adjunction

Input to Step 4:	(ka)(ta)bl(ha)	*σ/C	*COMPLEX	PARSESEG	SYLL-HEAD	NOCODA	***Operations***
☞	a. (ka)(tab)l(ha)			1		1	*Adjunction (coda)*
	b. (ka)(ta)(b)l(ha)			1	W1	L	*Project minor syllable*
	c. (ka)(ta)b(l)(ha)			1	W1	L	*Project minor syllable*
	d. (ka)(ta)(bl$_\mu$)(ha)	W1		L		L	*Core syllabification*
	e. (ka)(ta)b(lha)		W1	1		L	*Adjunction (onset)*
	f. (ka)(ta)bl(ha)			W2		L	*No change*

(b) Step 5 /katab-l-ha/: Creation of minor syllable

Input to Step 5:	(ka)(tab)l(ha)	*σ/C	*COMPLEX	PARSESEG	SYLL-HEAD	NOCODA	***Operations***
☞	a. (ka)(tab)(l)(ha)				1	1	*Project minor Syllable*
	b. (ka)(tabl)(ha)		W1		L	1	*Adjunction (Coda)*
	c. (ka)(tab)(lha)		W1		L	1	*Adjunction (Onset)*
	d. (ka)(tab)l(ha)			W1	L	1	*No change*

As before, the output of Step 5, [(ka)(tab)(l)(ha)], contains a minor syllable consisting of a single consonant. The gratuitous coda consonant, as in words with final CC clusters, will be resyllabified as [(ka)(ta)(bl)(ha)] in a later step, and create an unmarked environment for epenthesis. However, because PARSEσ outranks NOCODA, this resyllabification will take place after stress is assigned, meaning that epenthesis will once again be blocked, provided that the relevant markedness constraints outrank SYLL-HEAD.

As before, epenthesis can either precede the stray consonant, as in [(ka)(tab)(i̲l)(ha)], or follow it, as in [(ka)(tab)(li̲)(ha)]. ONSET eliminates [(ka)(tab)(i̲l)(ha)], as in [(ka)(tab)(i̲t)]. Epenthesis following the consonant in medial clusters is blocked by a constraint that disprefers open, unstressed, non-final ("weak") syllables with high vowels, termed WEAK<*i* in McCarthy

(2007a:169). As discussed in McCarthy (2007a), this constraint is undominated in Levantine Arabic:

(67) WEAK<*i*: assign one violation mark for every weak syllable with a nucleus whose sonority is equal to or greater than that of a [+high] vowel.

Levantine Arabic belongs to a class of Arabic dialects which systematically epenthesize vowels before rather than after a stray consonant (Broselow 1992, Farwaneh 1995, among others). Thus, in Levantine Arabic, forms such as /katab-l-ha/ will consistently epenthesize vowels between C_1 and C_2 in a CCC cluster ([kata**bi̲l**ha]) rather than between C_2 and C_3 (*[katab**li̲h**a]) in order to avoid the creation of a weak syllable with [i] as its nucleus. These dialects contrast with the 'onset' dialects (including Egyptian, Saudi, and Sudanese varieties; see sections 3.2 above and 4.6.2 below for some discussion), where forms such as [katab**li̲h**a] are preferred over *[kata**bi̲l**ha]. I follow McCarthy (2007a) and assume that this constraint blocks epenthesis after C_2 in forms such as *[katab**li̲h**a] in Levantine Arabic.

As in final CC clusters, stress precedes epenthesis in Step 6 of the present derivation. Stress is assigned because epenthesis is blocked by high-ranking ONSET and WEAK<*i*: the form [(ka)(ta)(bi̲l)(ha)], which satisfies both markedness constraints, is not produced by GEN because it requires the application of both an epenthesis and a resyllabification operation in a single step. The tableau for Step 6 is given below:

(68) Step 6 /katab-l-ha/: Stress assignment (ONSET and WEAK<*i* block epenthesis)

Input to Step 6:	(ka)(tab)(l)(ha)	ONSET	WEAK<*i*	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	***Operations***
☞	a. (ka)[(táb)](l)(ha)				1	3		1	*Stress*
	b. (ka)(tab)(il)(ha)	W1			L	W4	W1	W2	*Epenthesis*
	c. (ka)(tab)(li)(ha)		W1		L	W4	W1	1	*Epenthesis*
	d. (ka)(ta)(bl)(ha)				1	W4		L	*Adjunction*
	e. (ka)(tab)(l)(ha)				1	W4		1	*No change*

Under this ranking, stress precedes epenthesis just as in final CC clusters, and falls on the antepenult because the penult is light.

In Step 7, epenthesis will still be blocked by high-ranking ONSET. However, low-ranked NOCODA will trigger resyllabification of the coda consonant into the minor syllable, even though this creates a violation of FOOTBIN:

(69) Step 7 /katab-l-ha/: Resyllabification of coda consonant as an onset (result of adjunction operation)

Input to Step 7:	(ka)[(táb)](l)(ha)	ONSET	WEAK<i	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	FOOTBIN	*Operations*
☞	a. (ka)[(tá)](bl)(ha)				1	3			1	*Adjunction*
	b. (ka)[(táb)](il)(ha)	W1			L	3	W1	W2	L	*Epenthesis*
	c. (ka)[(táb)](li)(ha)		W1		L	3	W1	W1	L	*Epenthesis*
	d. (ka)[(táb)](l)(ha)				1	3		W1	L	*No change*

As before, this process of resyllabification has created a possible site for epenthesis that does not violate ONSET. Step 8 therefore sees epenthesis emerge as the optimal candidate because it satisfies SYLL-HEAD without violating ONSET, a step which leads to convergence in Step 9:

(70) Epenthesis and convergence: /katab-l-ha/

(a) Step 8 /katab-l-ha/: Epenthesis

Input to Step 8:	(ka)[(tá)](bl)(ha)	ONSET	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	FOOTBIN	*Operations*
☞	a. (ka)[(tá)](bil)(ha)				3	1	1	1	*Epenthesis*
	b. (ka)[(tá)](bl)(ha)			W1	3	L	L	1	*No change*

(b) Step 9 /katab-l-ha/: Convergence

Input to Step 9:	(ka)[(tá)](bil)(ha)	ONSET	PARSESEG	SYLL-HEAD	PARSEσ	DEPV	NOCODA	FOOTBIN	*Operations*
☞	a. (ka)[(tá)](bil)(ha)				3	1	1	1	*No change*
	b. (ka)(ta)(bil)(ha)				W4	1	1	L	*Foot Deletion*

Stress is stranded on the light antepenultimate syllable, even though the penultimate syllable is heavy. As before, the candidate with opaque stress is chosen as optimal, leading to convergence: deleting the foot only increases the number of violations to PARSEσ, which outranks FOOTBIN.

This section has accounted for non-uniform stress-epenthesis interactions in Levantine Arabic using constraint interaction in a single constraint hierarchy, much as in a Classic OT analysis of non-uniform patterns where constraint ranking can result in markedness constraints being satisfied in a variety of ways within a single language. In HS, however, non-uniform effects can be derivational and constraint interaction can change the order that operations are applied. This can result in an opaque interaction if subsequent steps are unable to undo the opaque process. In Levantine Arabic, constraint ranking determines which syllabification operations are applied, as well as the order that epenthesis and stress operations are applied to the derivation. The initial syllabification is crucial to the current analysis because the form produced by syllabification operations is not always the globally optimal form, but proves to be an essential intermediate step for stress assignment: in CCC and final CC clusters, the opaque interaction arises because the initial syllabification produces a single-consonant minor syllable (C), which cannot be eliminated at first because epenthesis is blocked by undominated markedness constraints. In CCCC clusters, on the other hand, no resyllabification is necessary and epenthesis precedes stress, resulting in a transparent interaction. As in Egyptian Arabic and Dakota, constraint ranking in Levantine Arabic determines the order that operations are applied: when epenthesis precedes stress, the interaction is transparent, and when stress precedes epenthesis, the interaction is opaque.

4.6. Typology: Other Arabic dialects

4.6.1. Iraqi and Gulf dialects

Iraqi and Gulf varieties of Arabic show identical patterns to Levantine Arabic stress-epenthesis interactions, except that medial CCC clusters show transparent rather than opaque stress (Farwaneh 1995):

(71) Opaque stress: final CC clusters:
/katab-t/ (ka)**(tá)**(bi̱t) 'I wrote'
(as in Levantine Arabic)

(72) Transparent stress: medial CCC clusters
/katab-l-ha/ (ka)(ta)**(bí̱l)**(ha) 'he wrote to her'
(*cf.* Levantine Arabic (ka)**(tá)**(bil)(ha))

(73) Transparent stress: medial CCCC clusters
/katab-t-l-ha/ (ka)(tab)**(tí̱l)**(ha) 'I wrote to her'
(as in Levantine Arabic)

The Iraqi pattern can be derived by assuming that the language is identical to Levantine Arabic with respect to syllabification, stress, and epenthesis, except that ONSET is ranked low enough that it does not block epenthesis from preceding stress assignment in the derivation. I will not provide the details of the analysis here; however, the contrast between the Levantine and Iraqi dialects can be accounted for schematically as below:

(74) Levantine Arabic (top): *COMPLEX, PRSSEG, **ONSET** » SYLL-HEAD » PRSσ » NOCODA
Iraqi Arabic (bottom): *COMPLEX, PRSSEG » SYLL-HEAD » PRSσ » **ONSET**, NOCODA

a. /katablha/ ‘he wrote to her’

(ka)[(táb)](l)(ha) > (ka)[(tá)](bl)(ha) > (ka)[(tá)](bil)(ha)

↗

/katablha/… > (ka)(tab)(l)(ha)

↘

(ka)(tab)(il)(ha) > (ka)(tab)[(íl)](ha) > (ka)(ta)[(bíl)](ha)

b. /katabt/ ‘I wrote’

(ka)[(táb)](t) > (ka)[(tá)](bt) > (ka)[(tá)](bit)

↗

/katabt/… > (ka)(tab)(t)

↘

(ka)(tab)(it) > (ka)[(táb)](it) > (ka)[(tá)](bit)

c. /katabtlha/ ‘I wrote to her’ (convergent derivations)

/katabtlha/ … > (ka)(tab)(tl)(ha) > (ka)(tab)(til)(ha) > (ka)(tab)[(tíl)](ha)

In Iraqi Arabic, ONSET does not block epenthesis, and epenthesis applies before stress in all three clusters. In CCC clusters, epenthesis produces a transparent interaction because the epenthetic vowel precedes the consonant, creating a heavy penult that can be stressed transparently, as in [(ka)(tab)[(íl)](ha)]. CCCC clusters behave identically in both dialects because epenthesis in both cases precedes stress and produces a heavy penult that attracts stress transparently. In final CC clusters, epenthesis also precedes stress. However, the opaque stress pattern arises because resyllabification, a separate operation, follows stress: epenthesis produces the form [(ka)(tab)(it)], whose heavy penultimate syllable attracts stress just as in Levantine Arabic. The stress placement in this form is rendered opaque by resyllabification, which follows stress assignment, also as in Levantine Arabic. This pattern illustrates that the relative ordering between stress and epenthesis is not the only crucial ordering relationship in the Arabic dialects. Resyllabification is also an operation and like epenthesis, it affects stress by changing the weight of the syllable. This analysis therefore predicts that any phonological process that can potentially affect stress assignment (i.e. any operation that alters syllable weight or changes the number of syllables) can interact opaquely with stress. This appears to be true of syncope processes in Levantine Arabic (see McCarthy 2007a for discussion); however, further investigation is beyond the scope of this paper and is left to future research.

4.6.2. Onset dialects

Dialects of Arabic vary systematically with respect to the placement of the epenthetic vowel (Broselow 1992, Farwaneh 1995, and others). Coda dialects, including Levantine and Iraqi Arabic, consistently epenthesize a vowel following C_1 in a cluster: /katab-l-ha/ > [katabi̲lha] and /katab-t/ > [katabi̲t]. Onset dialects, including Egyptian, Saudi, and Sudanese varieties, epenthesize the vowel following C_2 in CCC clusters. This is illustrated in the following data from Egyptian Arabic, repeated below from section 3.2:

(75) Egyptian Arabic: medial CCC clusters (Farwaneh 1995:135)

d.	/bint-na/	(bin)**(tí̲)**(na)	'our daughter'
e.	/ʔarD-na/	(ʔar)**(Dí̲)**(na)	'our land'
f.	/katabt-lu/	(ka)(tab)**(tí̲)**(lu)	'I wrote to him'

Following McCarthy (2007a), I assume that the difference in the site for epenthesis results from a difference in constraint ranking: WEAK<*i* is ranked low enough in the onset dialects that it does not block epenthesis following C_2.

The analysis presented here says that opaque stress-epenthesis interactions in Levantine Arabic result from an interaction between ONSET and SYLL-HEAD, where the ranking of ONSET can block epenthesis in certain environments and delay its application until later in the derivation. The opaque interactions in Levantine Arabic also derive as a result of the preference for pre-consonantal epenthesis: if epenthesis following the consonant were not blocked by WEAK<*i* (*[katabl**i̲**ha]), epenthesis would precede stress assignment, and would not interact opaquely with stress.

This prediction is borne out in the onset dialects, where stress and epenthesis never interact opaquely. As discussed above, stress in Egyptian Arabic falls on a light penult if the antepenult is heavy, as illustrated in the examples below:

(76) Egyptian Arabic (Farwaneh 1995:134): Stress

c.	/madrasa/	(mad)**(rá)**(sa)	'school'
d.	/martaba/	(mar)**(tá)**(ba)	'mattress'

The examples with epenthesis in (75) above follow this stress pattern: stress falls on a light penult even when the penult contains an epenthetic vowel. This connection between the transparent patterns in onset dialects and the opaque patterns in coda dialects provides additional support for the serial analysis, which uses syllabification to derive the opaque effects.

4.6.3. Factorial Typology

As in Classic OT, typology in HS can be calculated by constraint permutation. Because constraint ranking affects the order that operations are applied, constraint permutation in HS creates a typology of possible derivations. Manipulating the ranking of ONSET and PARSEσ in the above analysis of

Levantine Arabic gives a typology of four language types (assuming that the languages also rank SYLL-HEAD over NOCODA, as in Levantine and Iraqi Arabic): [30]

(77) Factorial typology (manipulating the ranking of ONSET and PARSEσ)

a. All transparent ("stress last"):

Constraint Ranking	SYLL-HEAD » NOCODA » PARSEσ
Order of Operations	epenthesis → resyllabification → stress
Language	Palestinian Arabic (optional; Hall & Gouskova 2007); also Egyptian Arabic (Farwaneh 1995)
Forms	/katabt/ > [kátabit] /katablha/ > [katabílha] /katabtlha/ > [katabtílha]

b. Opacity in final CC but not medial CCC:

Constraint Ranking	SYLL-HEAD » PARSEσ, ONSET » NOCODA
Order of Operations	epenthesis → stress → resyllabification (no blocking)
Language	Iraqi and Gulf varieties of Arabic
Forms	/katabt/ > [katábit] /katablha/ > [katabílha] /katabtlha/ > [katabtílha]

c. Opacity in both final CC and medial CCC:

Constraint Ranking	ONSET » SYLL-HEAD » PARSEσ » NOCODA
Order of Operations	epenthesis → stress → resyllabification (blocked by ONSET)
Language	Levantine Arabic
Forms	/katabt/ > [katábit] /katablha/ > [katábilha] /katabtlha/ > [katabtílha]

[30] The ranking NOCODA over SYLL-HEAD would result in a language like Fijian, with no codas whatsoever and epenthesis following every consonant not followed by a vowel.

d. Opacity in final CC, medial CCC, and medial CCCC ("stress first"):

Constraint Ranking	Parseσ » Syll-Head » NoCoda
Order of Operations	stress → epenthesis → resyllabification
Language	Unattested in Arabic, but present crosslinguistically (e.g. Dakota; Shaw 1976, 1985, and discussion above)
Forms	/katabt/ > [katábit] /katablha/ > [katábilha] /katabtlha/ > [katábtilha]

Implicit in this typology are a number of implicational relationships between the three types of consonant clusters: final CC clusters interact transparently only if both CCC and CCCC clusters interact transparently, CCC clusters interact transparently only if CCCC clusters interact transparently, and CCCC clusters interact opaquely only if the other two clusters interact opaquely:

(78) Predicted Typological Patterns

Language	Final CC	Medial CCC	Medial CCCC
A	Transparent	Transparent	Transparent
B	Opaque	Transparent	Transparent
C	Opaque	Opaque	Transparent
D	Opaque	Opaque	Opaque

Missing, then, are a number of other possible patterns that violate these implicational relationships. For example, the present analysis does not predict a pattern that would see an opaque interaction in CCCC clusters ([ka**táb**ti̲lha]) and transparent interactions in CCC and final CC clusters ([kata**bí̲l**ha], [**ká**tabi̲t]). This pattern would require epenthesis to precede stress in CCC and final CC clusters, but to follow stress in CCCC clusters. This cannot be derived under the current analysis because there is no constraint that would block epenthesis in a (CC) minor syllable but not in a (C) minor syllable, nor is there any constraint that sees simple minor syllables as inherently more marked than complex minor syllables, such that it would be violated by (C) but not by (CC). Similarly, there is no way to allow for an opaque interaction in CCC but not final CC clusters ([ka**tábi̲**lha], [**ká**tabi̲t]). This would require resyllabification to precede stress in final CC clusters but to follow stress in CCC clusters. This language is blocked in the current analysis because the constraint ranking must stay constant: resyllabification must precede or follow stress in both word types, unless blocked. However, there is no constraint that would block resyllabification in CCC clusters but not in final CC clusters, meaning that they must pattern together in this respect. Given the attested patterns in the Arabic coda dialects, the typology generated by the HS analysis appears to be sufficiently restrictive and permissive.

5. Discussion and Alternatives

The analysis presented in this paper adopts HS, a serial framework that uses a single constraint hierarchy and derives a single derivation through a series of optimizations. This account can be compared to analyses of stress-epenthesis interactions under alternative OT frameworks, including Classic OT and other derivational variants of OT such as Stratal OT (Kiparsky 2003) and OT-CC (McCarthy 2007a).

The predominant approach to stress-epenthesis interactions in Classic OT uses the positional faithfulness constraint HEAD-DEP, a constraint that is violated by epenthetic vowels that are prosodic heads (Alderete 1995, 1999; Kager 1999). While this constraint targets epenthetic vowels (an I-O mapping), the constraint incorrectly predicts that extrametrical vowels in words like /katab-t/ [katábi̲t] 'I wrote' should not interact with stress assignment, an argument made in Kiparsky (in preparation). The epenthetic vowel in this example is not a prosodic head either at the foot level or the word level, yet causes stress to be assigned opaquely. The present analysis predicts that even extrametrical epenthesis can have an affect stress assignment, because final consonant clusters can affect the syllabification of intermediate forms.

Kiparsky (2003) develops an analysis of stress-epenthesis interactions in Arabic using Stratal OT, a serial version of OT that assumes the existence of lexical strata. Constraints can be reranked between strata such that each stratum has its own OT grammar. Kiparsky's (2003) analysis resembles the present analysis because it assumes that opaque interactions arise from intermediate stages where stray consonants are parsed as minor syllables.[31] However, the Stratal OT analysis differs in its representational assumptions regarding minor syllables as well as in its assumption regarding lexical strata and constraint re-ranking.

In Stratal OT, intermediate stages correspond to strata with different constraint rankings and therefore different grammars, while in HS, constraint ranking remains constant throughout and intermediate stages are not tied to strata. McCarthy (2007a) argues that Stratal OT is both too restrictive and too powerful to account for the range of opaque processes found cross-linguistically. It is too restrictive because some opaque phenomena occur within a single stratum, and too powerful because the reranking of constraints at different strata is without limit, leading to an overly permissive typology.

In this paper, I have shown that HS appears to make good typological predictions with respect to typology in stress-epenthesis interactions among Arabic dialects and cross-linguistically. HS allows an infinite number of intermediate stages that are not tied to specific strata, and thus appears to avoid some of the problems of Stratal OT while achieving similar results.

[31] Kiparsky (2003) assumes that minor syllables consist of unsyllabified moras, in contrast to the representational assumptions made here. The difference in predictions between the two representational possibilitis is not pursued in this paper.

Finally, OT-CC (McCarthy 2007a, Wolf 2008) is another derivational variant of OT. In OT-CC, possible derivations are compared for optimality, rather than possible intermediate steps in a single derivation. 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 here. 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 opaque stress-epenthesis interactions without PREC constraints, and shows a sufficiently restrictive typology without the need for constraints on ranking conditions. Further, harmonic improvement is an integral part of HS, as each step in the derivation represents an output form that is locally optimal. While it remains to be seen whether HS can be used to account for the full range of opaque processes, it is a promising alternative to approaches to stress-epenthesis interactions using Classic OT, Stratal OT, and OT-CC.

6. Conclusion

The proposal in this paper accounts for opaque stress-epenthesis interactions among a variety of languages using only traditional constraint ranking under HS, a serial, rather than parallel, framework where prosodic structure, including syllable structure, is assigned serially. The analysis keeps in tact many of the advantages of Classic OT, including factorial typology by constraint permutation and the use of constraint ranking to account for non-uniform interactions. I have shown that constraint ranking to some extent controls the order that stress and epenthesis operations are applied, but that interaction among markedness constraints, including those related to the application of syllabification operations, can also affect the order of operations. This analysis was used to account for languages with transparent stress-epenthesis interactions, where minor syllables are eliminated by epenthesis prior to stress assignment (SYLL-HEAD » PARSEσ, as in Egyptian Arabic), as well as languages with opaque interactions, where stress is assigned before epenthesis (PARSEσ » SYLL-HEAD, as in Dakota). Constraint ranking and interaction were also used to derive non-uniform stress-epenthesis patterns within a single language: in Levantine Arabic, high-ranked markedness constraints were shown to intervene and block epenthesis in certain environments but not others, resulting in non-uniformity.

This analysis illustrates that HS can be used to account for stress-epenthesis interactions, a type of counter-bleeding opacity, and does so with no added machinery beyond the assumption of a gradualness requirement on GEN. HS therefore presents a viable alternative to present approaches to opacity within OT. Its ability to account for opaque processes other than stress-epenthesis interactions deserves further research, despite its superficially limited ability to account for certain types of counter-bleeding opacity involving allophony and for counter-feeding opacity (see McCarthy 2000, 2007a for discussion). Further research will determine the extent to which analyses of other opaque processes can be accounted for using HS.

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