

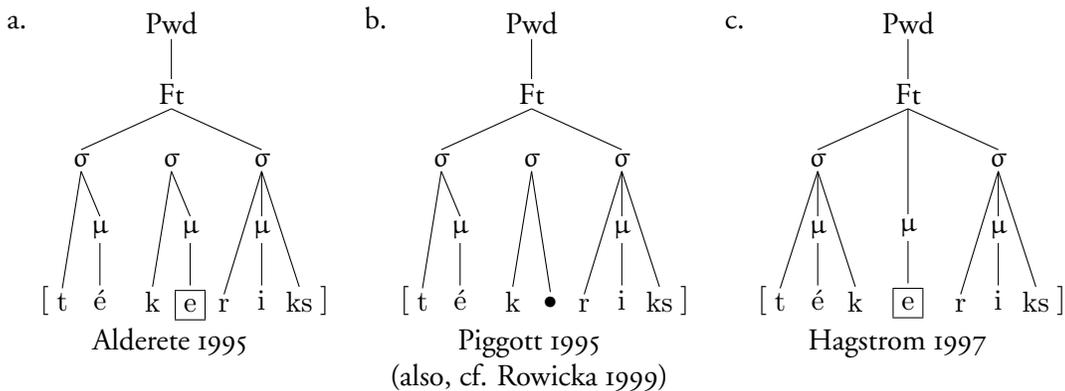
I INTRODUCTION

Mohawk (Lake Iroquoian: New York/Quebec) has simple stress system, which interacts with epenthetic vowels in a complex manner. Some epenthesis is invisible to stress assignment – in the terminology of Lounsbury 1942, this epenthesis is “weightless”. The traditional rule-based analysis of the facts (Postal 1968; Michelson 1988, and see also the classic Mohawk problem set in Halle and Clements 1983) crucially involves an opaque rule ordering. Forms not involving epenthesis look like [kha.rá:tats] (case 1), with penultimate stress and lengthening (if needed). Forms with one instance of epenthesis either look either like [té.k[e].riks] (case 2) with antepenultimate stress and penultimate epenthesis into an open syllable (marked with a e), or like [wa.k[é]n.yaks] (case 3) with penultimate stress and epenthesis into a penultimate closed syllable. The derivational analysis is that vowels in case 3 are inserted before stress assignment, so act like the underlying vowels in case 1, but vowels in case 2 are inserted after stress assignment. In standard Optimality Theory (Prince and Smolensky 1993) there is no cycle, and so apparent cyclic behavior must receive some alternative explanation.

In the present paper I provide a non-opaque explanation of the stress-epenthesis interaction that is rooted in a new understanding of the Mohawk stress system. In particular, I argue that it is moraic trochaic, and that many of the odd facts follow from this. Traditionally, this system has been taken (tacitly or otherwise) to be a syllabic trochaic system, with stressed-syllable lengthening. In that respect, it has been understood as one of the few counterexamples to a consequence of the Iambic/Trochaic law – iambic languages only should have stressed-syllable lengthening. Another consequence of the syllabic trochaic assumption is that it drives analyses to assume quite non-standard prosodic structures (Piggott 1995; Alderete 1995; Hagstrom 1997). Some samples are given in (1):

(1) /te-k-rik-s/

DU-1A-put.together-HAB  
 ‘I put them next to each other’



• = empty nucleus  
V = epenthetic V

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Both Alderete 1995 and Piggott 1995 and propose that feet can be discontinuous – spanning an unparsed syllable, as in the (a) and (b) trees above. Under Alderete’s analysis, this syllable is normal but unparsed, because of positional faithfulness requirements on prominent positions. Piggott proposes that it is unparsed because at the level of phonological derivation, there is no nucleus (borrowing Government Phonology and Lexical Phonology assumptions), though the nucleus is filled in post-lexically. In each case, epenthesis drives the lack of parsing. Hagstrom 1997 proposes another unusual structure, shown in (c). Here, there is a mora attached directly to a foot, in the middle of an otherwise binary trochee. This mora could be thought of as a semi-syllable or minor syllable (cf. Kiparsky 2002 and references therein). The foot is not discontinuous, but the structural nature of the analysis is quite similar. The vowel prefers to be in a semi-syllable because it is epenthetic.

Some non-standard assumption along these lines is more or less necessary, given the assumption that feet in Mohawk involve syllabic trochees, and the general account of stress and epenthesis proposed by Alderete 1995, 1999. However, I show that if Mohawk has moraic trochaic feet (alternating between a single heavy syllable and a light-light trochee), the Mohawk stress-epenthesis interaction falls into place with no unusual prosodic structures. This includes the lack of lengthening that correlates with (some) stress shift – a fact that has previously been extremely difficult for analyses to deal with.

The situation in Mohawk is interesting to a theory of stress systems because without looking at the epenthesis interaction, there is simply no evidence as to what the basic stress system is. It is compatible with syllabic trochaic (the usual assumption), moraic trochaic, and even iambic assumptions. I argue that the interaction of stress and epenthesis provides strong support for moraic trochaicity – under no other assumptions does the stress system fall into place so cleanly.

The paper is structured as follows. In §2 I discuss the basic stress system of Mohawk, independent of cases of epenthesis. In this section I show how the stress system could be accounted for under all three foot-types. In §3 I introduce the epenthesis systems of Mohawk, and following that in §4, I introduce the interaction of stress and epenthesis. In §5 I spell out the details of how this data could be accounted for assuming syllabic trochaic feet, and demonstrate some empirical problems for such an account. In §6 I show how it could be accounted for assuming moraic trochaic feet, and argue that this account provides much better coverage, and requires far few assumptions about unusual prosodic structure. In 7 I tie up the loose ends of the moraic trochaic analysis, accounting for the behavior of the two other epenthetic vowels, the joiner vowel, and prothetic [i].

All data, unless otherwise noted, are from Michelson 1988.

## 2 MOHAWK: THE BASIC STRESS SYSTEM

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Primary stress in Mohawk (in cases not involving epenthesis) is penultimate<sup>1</sup>, and there is no solid indication of secondary stress. There is also lengthening in some stressed syllables, though vowels never lengthen in unstressed syllables. Lengthening happens only when the stressed syllable is open. Several examples are given in (2).

- |   |  |
|---|--|
| (2) a. /wak-haratat-u-hatyε-ø/ ↗ [wa.kha.ra.ta.tu.hát.ye] | iP-lift-STAT-PROG-STAT<br>‘I go along lifting it up’     |
| b. /k-haratat-s/ ↗ [kha.rá:tats]                          | iA-lift-HAB ‘I am lifting it up a little (with a lever)’ |
| c. /k-kawe-s/ ↗ [kká:wes]                                 | iA-paddle-HAB ‘I paddle’                                 |
| d. /wak-yaʔk-u/ ↗ [wa.kyá:ku]                             | iP-blow-STAT ‘I have blown’                              |

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<sup>1</sup>This is not true of some uninflected particles, and some loan words.

I will start off entertaining three hypotheses about the prosodic structure in this basic set of data. The first, and perhaps most obvious (given previous literature), is that Mohawk has syllabic trochaic feet, with the head of a prosodic word to the left. For the data in (2), this would give the parses in (3).

- (3) PARSES ASSUMING SYLLABIC TROCHAIC FEET
- a. /wak-haratat-u-hatye-ø/ ↗ [wa.kha.ra.ta.tu.(hát.ye)]
  - b. /k-haratat-s/ ↗ [kha.(rá:tats)]
  - c. /k-kawe-s/ ↗ [(kká:wes)]
  - d. /wak-yaʔk-u/ ↗ [wa.(kyá:ku)]

This hypothesis is, in various forms, what much previous research on the prosodic structure of Mohawk has assumed (Michelson 1988; Alderete 1995; Piggott 1995; Hagstrom 1997).

The second hypothesis is that feet in Mohawk are iambic, and that the final syllable in a prosodic word is extrametrical – not parsed into a foot. This would result in the examples in (2) being parsed as in (4).

- (4) PARSES ASSUMING IAMBIC FEET WITH EXTRAMETRICALITY
- a. /wak-haratat-u-hatye-ø/ ↗ [wa.kha.ra.ta.(tu.hát).ye]
  - b. /k-haratat-s/ ↗ [(kha.rá:tats)]
  - c. /k-kawe-s/ ↗ [(kká:wes)]
  - d. /wak-yaʔk-u/ ↗ [(wa.kyá:ku)]

Finally, we can suppose that Mohawk might have moraic trochaic feet, with final syllable extrametricality. This would give the following parses:

- (5) PARSES ASSUMING MORaic TROCHAIC FEET WITH EXTRAMETRICALITY
- a. /wak-haratat-u-hatye-ø/ ↗ [wa.kha.ra.ta.tu.(hát).ye]
  - b. /k-haratat-s/ ↗ [(kha.rá:tats)]
  - c. /k-kawe-s/ ↗ [(kká:wes)]
  - d. /wak-yaʔk-u/ ↗ [wa.(kyá:ku)]

All of these are clearly viable possibilities for the basic stress system, though to my knowledge, the second or third possibilities have never been seriously considered. In the following sections I show how each would be analyzed in OT.

## 2.1 Syllabic trochaic feet

Syllabic trochaic feet consist of two syllables, the left of which is stressed (Hayes 1995)TODO. In OT, this can be derived by the relative ranking of two alignment constraints:  $F_{T}H_{DL} \gg F_{T}H_{DR}$ .

- (6)  $ALIGN-L(HD(\Sigma), \Sigma)$  ( $F_{T}H_{DL}$  for short)  
The head of a foot ( $\Sigma$ ) is aligned to the left edge of the foot.
- (7)  $ALIGN-R(HD(\Sigma), \Sigma)$  ( $F_{T}H_{DR}$  for short)  
The head of a foot ( $\Sigma$ ) is aligned to the right edge of the foot.

This ranking is illustrated in tableau 1, using the form /hra-kw-as/ MA-pick-HAB ‘he picks it’.<sup>2</sup>

<sup>2</sup>Underlying word-initial initial [h] deletes; cf. Michelson 1988 §2.3.8.

		/hra-kw-as/	FtHdL	FtHdR
☞	a.	[(rák.was)]		*
	b.	[(rak.wás)]	*!	

Tableau 1: Trochaicity

This ranking guarantees that feet will be trochaic, but we must also ensure that they consist of two syllables, and not just two moras – a foot consisting of a single heavy syllable would satisfy both alignment constraints. To accomplish this, FtBIN must be ranked over FtHdR, as shown in tableau 2.

- (8) FtBIN  
Feet must consist of two syllables.

		/hra-kw-as/	FtBIN	FtHdR
☞	a.	[(rák.was)]		*
	b.	[(rak).(wás)]	*!	
	c.	[(rák).(was)]	*!	

Tableau 2: Foot Binariness at the syllable level

The input forms so far have been two-syllable words, and so the only foot is aligned to both edges of the prosodic word. As seen from earlier data, when we look at larger words, the foot with a stress-bearing syllable is aligned to the right of a prosodic word. In rule-based phonology, this would mean that there is a “right end rule” (Hayes 1995). In OT, this can be accomplished directly by the relative ranking of two alignment constraints, which I will refer to as REND and LEND for short.

- (9) ALIGN-R(Hd(PWD), PWD) (= Right end constraint, REND for short)  
The head (foot) of a prosodic word is aligned to the right edge of the prosodic word.
- (10) ALIGN-L(Hd(PWD), PWD) (= Left end constraint, LEND for short)  
The head (foot) of a prosodic word is aligned to the left edge of the prosodic word.

In a trisyllabic word, we can see that REND outranks LEND. Tableau 3 shows this using the form /ohru?ke/ ‘in.the.morning’ ‘in the morning’.

		/ohru?ke/	REND	LEND
☞	a.	[oh.(rú?.ke)]		*
	b.	[(óh.ru?.ke)]	*!	

Tableau 3: Right end effects

At this point we can also obtain a ranking of LEND relative to FtBIN (assuming the “exactly two syllables” reading of that constraint), and for similar reasons, offFtBIN relative to PARSE- $\sigma$ . These are shown in tableaux 4 and 5 respectively.

		/ohru?ke/	FtBIN	LEND
☞	a.	[oh.(rú?.ke)]		*
	b.	[(óh.ru?.ke)]	*!	

Tableau 4: A lack of left end effects

		/ohru?ke/	FtBIN	PARSE- $\sigma$
☞	a.	[oh.(rú?.ke)]		*
	b.	[(óh.ru?.ke)]	*!	

Tableau 5: A lack of parsing effects

In the preceding examples, stress always falls on a syllable that is heavy due to a coda in correspondence to an input consonant. When the stressed syllable does not have a coda, the vowel lengthens. I assume that this is to achieve a heavy syllable – in OT terms, *STRESSToWEIGHT* is active in the grammar of Mohawk. I also assume that moras are present in input consonants. This means that *STRESSToWEIGHT* dominates a constraint against inserting extra moras, *DEP<sub>μ</sub>*. This is shown in tableau 6.

(11) *STRESSToWEIGHT*

If a syllable is stressed, it should be heavy. (*SToW* for short)

(12) *DEP<sub>μ</sub>*

Moras in the output must belong to a segment in correspondence with a segment in the input which also possesses a mora.

	/wak-yaʔk-u/	<i>STRESSToWEIGHT</i>	<i>DEP<sub>μ</sub></i>
☞	a. wak.(yá:ku)		*
	b. wak.(yá.ku)	*	

*Tableau 6: Lengthening of the stressed syllable*

A number of the constraints already given also have to be ranked against *DEP<sub>μ</sub>*, since the resolution of *STRESSToWEIGHT* involves lengthening, as opposed to moving the stress to a heavy syllable in some way. This is shown in tableau 7.

	/wak-yaʔk-u/	<i>REND</i>	<i>FTBIN</i>	<i>DEP<sub>μ</sub></i>
☞	a. wak.(yá:ku)			*
	b. (wák.ya).ku	*		
	c. (wák.ya.ku)		*	

*Tableau 7: No stress shift for weight, pt. 1*

Similarly, *FTHDl* must dominate *DEP<sub>μ</sub>*. This can't be seen in the form used in tableau 7, but in a form with a light penultimate syllable and heavy final syllable, we don't find stress shift.

	/k-haratat-s/	<i>FTHDl</i>	<i>DEP<sub>μ</sub></i>
☞	a. [kha.(rá:tats)]		*
	b. [kha.(ra.táts)]	*!	

*Tableau 8: No stress shift for weight, pt. 2*

This concludes the treatment of the basic stress system under syllabic trochaic assumptions. In (13) are the rankings and a summary ranking graph.

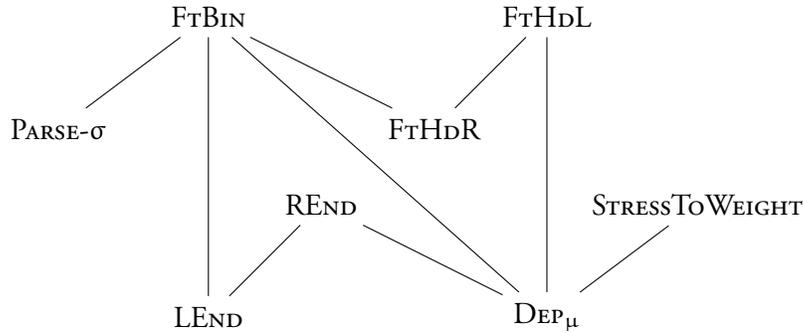
(13) **Syllabic trochaic current rankings:**

*FTHDl*, *FTBIN* » *FTHDR*

*REND*, *FTBIN* » *LEND*

*FTBIN* » *PARSE-σ*

*FTHDl*, *REND*, *FTBIN*, *STRESSToWEIGHT* » *DEP<sub>μ</sub>*



The prosodic system illustrated here is so far quite straightforward, and not all that interesting. If this were all there is to Mohawk, then this hypothesis might well be the obvious choice, and there wouldn't be much reason to spill more ink. As we'll see in §4, there is much more to worry about in the prosodic structure of Mohawk. Before we get there, however, I'll present two competing hypotheses.

## 2.2 Systems with extrametricality

In the previous section, the force behind penultimate stress came from foot structure – the feet were always word-final, but were also disyllabic with first-syllable stress. There are other ways of getting penultimate stress, and for the next two hypotheses we start with the idea that the reason stress is penultimate is not because of foot structure, but because of final-syllable extrametricality. The idea of extrametricality itself does not require deciding between an iambic and a moraic trochaic system, but we will need to fix our assumptions differently for each system.

Final-syllable extrametricality can follow straightforwardly from the NONFINALITY constraint being active in the grammar (Prince and Smolensky 1993). The version of NONFINALITY that I use is given in (14).

(14) NONFINALITY

The head of a prosodic word is not aligned to the right edge of the prosodic word.

This can be thought of as an anti-alignment constraint (cf. Ito and Mester 1999 fn. 4), and in later sections of this paper it will become clear that I rely on the anti-alignment nature of the formulation.

Right-headedness of prosodic words in this system is determined by the right-end constraint, introduced earlier:

(15) ALIGN-R(HD(PWD), PWD) (= Right end constraint, REnd for short)

The head (foot) of a prosodic word is aligned to the right edge of the prosodic word.

This constraint must be ranked under NONFINALITY, since we never see completely final stress. This is shown in tableau 9.<sup>3</sup>

	/hra-kw-as/	NONFINALITY	REnd
☞	a. [(rák).was]		*
	b. [rak.(wás)]	*!	
	c. [(rak.wás)]	*!	
	d. [(rák.was)]	*!	

Tableau 9: Penultimate stress via extrametricality

<sup>3</sup>Underlying word-initial initial [h] deletes; cf. Michelson 1988 §2.3.8.

The (c) and (d) candidates will not be predicted under every assumption – (c) gives an iambic parse and (d) a trochaic parse, but no matter what, these forms are not allowed.

The right-end constraint is ranked over the left end constraint, and this can be seen in longer words.

- (16) ALIGN-L(HD(PWD), PWD) (= Left end constraint, LEND for short)

The head (foot) of a prosodic word is aligned to the left edge of the prosodic word.

This ranking (NONFINALITY » REND » LEND) gives the result in tableau 10, which illustrates (almost) right-headedness in a 7-syllable word. Again, perfect right-headedness is blocked by NONFINALITY. It is better to move the stress window to the left, than have it final, but moving it more than one syllable away is harmonically bounded.

	/wak-haratat-u-hatye-ø/	NONFINALITY	REND	LEND
	a. wa.kha.ra.ta.tu.hat.(yé:)	*!		*****
☞	b. wa.kha.ra.ta. tu.(hát).ye		*	****
	c. wa.kha.ra.ta.(tú:).hat.ye		**!	***
	d. wa.kha.ra.(tá:).tu.hat.ye		**!*	**
	e. wa.kha.(rá:).ta.tu.hat.ye		**!***	*
	f. wa.(khá:).ra.ta.tu.hat.ye		**!****	
	g. (wá:).kha.ra.ta.tu.hat.ye		**!****	

Tableau 10: Right end constraint effects

At this point, there is no reason to choose between an iambic and a moraic trochaic system. It is also at this point that the analyses would start to diverge, even though no empirical predictions are made. The main difference is left- vs. right-headedness: iambic feet are right headed, and trochaic feet, left-headed. This will follow from the ranking of FtHdR and FtHdL. The other difference will be the reason for lengthening: iambic lengthening occurs because of STRESSToWEIGHT, just like in the syllabic trochaic system. A moraic trochaic system will lengthen for somewhat different reasons: to satisfy foot binarity. In §2.2.1 and §2.2.2, I spell out the differences.

### 2.2.1 Iambic assumptions

If FtHdR dominates FtHdL, we get iambic stress. But it is not clear that the data can tell us whether this is what we find. If the stress window consists of one-syllable feet, there is no evidence either way. If the stress window consists of two-syllable feet (assuming extrametricality), they must be iambs. Nothing yet can tell us which it is, but I will demonstrate the second case, to illustrate iambicity.

If the feet were not iambic but were two syllables we would expect antepenultimate stress in words longer than two syllables, but we find penultimate stress. This is illustrated using the form /k-o-har-ha?/ IA-attach-HAB ‘I attach it’ in tableau 11. I have lengthened the vowel on the hypothetical (b) form, but this is simply because we seldom find light stressed syllables in Mohawk, and is independent of the actual ranking.

	/k-o-har-ha?/	FtHdR	FtHdL
☞	a. [(ko.hár).ha?]		*
	b. [(kó:.har).ha?]	*!	

Tableau 11: Iambicity

Finally, lengthening (as in the syllabic trochaic account) is derived via STRESSToWEIGHT. This is shown in tableau 12.

	/wak-yaʔk-u/	STRESSToWEIGHT	DEP <sub>μ</sub>
☞	a. (wak.yá:).ku		*
	b. (wak.yá).ku	*	

Tableau 12: Lengthening of stressed syllable

Because this system is iambic, I am assuming that single syllable feet are possible as long as they contain two moras. Ideally, this difference from the syllabic trochaic system would be expressed by some reranking of constraints, but here I will simply reword the FTBIN constraint.

(17) FTBIN

A foot consists of either two syllables or a single syllable with two moras.

There are no crucial rankings with respect to this version of FTBIN – I simply assume that it is active.

Just like with hypothesis A we don't see stress shift to satisfy weight requirements. There are several potential ways that stress shift could go, given the constraints in play, and we must block them all. The first is to shift stress to the left when a heavy syllable can be found, increasing the violation of the right end constraint. This is illustrated in tableau 13 using the form /ye-hro-hrek-u/ 'TRANS-MP-push-STAT 'he has pushed'.

	/ye-hro-hrek-u/	REND	DEP <sub>μ</sub>
☞	a. [ye.hoh.(ré:).ku]	*	*
	b. [ye.(hóh).re.ku]	**!	

Tableau 13: No stress shift for weight, pt. 1

The second possible way of shifting stress to satisfy STRESSToWEIGHT would be to violate non-finality, and we don't see this either. This is illustrated in tableau 14.

	/k-haratat-s/	NONFINALITY	DEP <sub>μ</sub>
☞	a. [(kha.rá:).tats]		*
	b. [kha.(ra.táts)]	*	

Tableau 14: No stress shift for weight, pt. 2

Finally, we could imagine violating FTHDR, and making an exceptional trochaic foot in order to satisfy STRESSToWEIGHT. This also we don't find.

	/wak-yaʔk-u/	FTHDR	DEP <sub>μ</sub>
☞	a. [wak.(yá:).ku]		*
	b. [(wák.ya).ku]	*	

Tableau 15: No stress shift for weight, pt. 3

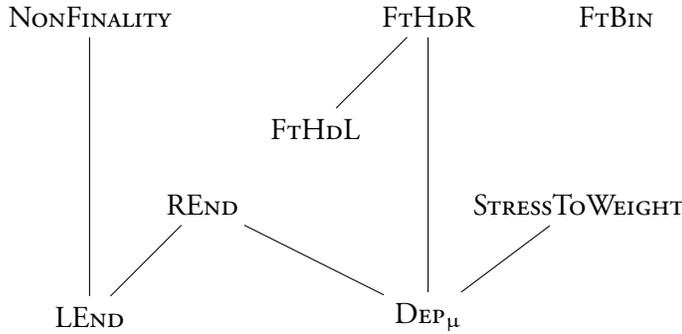
This concludes the basic stress system given iambic assumptions. The complete rankings and a summary chart are given in (18). The rest of this paper will not develop the iambic assumption further (some reasons are discussed in §6), but it is clear that this is a viable starting assumption.

(18) Iambic rankings:

FTHDR » FTLDL

NONFINALITY » REND » LEND

FTHDR, REND, STRESSToWEIGHT » DEP<sub>μ</sub>



### 2.2.2 Moraic trochaic feet with extrametricality

This section develops an analysis where feet in Mohawk are moraic trochaic, but a heavy one-syllable foot surfaces by default. Though no evidence for this can be adduced from the stress system alone, I will argue in the remainder of the paper that the interaction with epenthesis provides strong support for this structure.

Moraic trochaic feet can consist of a single heavy stressed syllable, or two light syllables, the first of which is stressed. Since heavy-light trochees are quite rare in systems of this sort, I will assume that they aren't present in Mohawk. (We will see later that this derives exactly the right result.) In this case, what we see in normal forms without epenthesis is a heavy stressed syllable making up a foot, with an extrametrical final syllable. The general rankings for the extrametrical approach guarantee this result.

If the system is moraic trochaic, feet are left-headed. This can be derived by ranking FtHdL over FtHdR. However, we have yet to see such a foot surface. An interesting feature of the Mohawk stress system (on this approach) is that heavy one-syllable feet are preferred, over light-light trochees. More generally, it is a central claim of this paper is that light light trochees emerge only in cases of epenthesis; this claim will be developed in following sections.

The preference for one-syllable feet follows straightforwardly from the presence of both of these constraints in the grammar, and ranked relatively high. A one-syllable foot satisfies both FtHdL and FtHdR, whereas a two-syllable foot can only satisfy one of these constraints. This is seen in tableau 16. In this tableau I have ranked the headedness constraints (as per assumption) despite the lack of a ranking argument.

		/wak-haratat-u-hatye-ø/	FtHdL	FtHdR
☞	a.	wa.kha.ra.ta.tu.(hát).ye		
	b.	wa.kha.ra.ta.(tú(:).hat).ye		*!
	c.	wa.kha.ra.ta.(tu.hát).ye	*!	

*Tableau 16: Heavy syllable foot preferred*

Under both previous hypotheses, stressed vowels lengthen to satisfy STRESSToWEIGHT. This need not be so under moraic trochaic assumptions, as foot binarity can drive lengthening.<sup>4</sup> The foot binarity constraint needed is the same as in the previous section, and is repeated here from earlier.

(17) FTBIN

A foot consists of either two syllables or a single syllable with two moras.

The analysis works by ranking this over DEP<sub>μ</sub>. That is, lengthening of an underlying short vowel is preferable to violating FTBIN (FTBIN » DEP<sub>μ</sub>).

<sup>4</sup>This idea was suggested to me by David Teeple.

Heavy syllable trochees still must be preferred, however, and therefore even though the system is trochaic, we must have FT HDR ranked over the faithfulness constraint: FT HDR » DEP<sub>μ</sub>.

Both of these effects are shown in tableau 17.

		/k-haratat-s/	FTBIN	FT HDR	DEP <sub>μ</sub>
☞	a.	[kha.(rá:).tats]			*
	b.	[kha.(rá).tats]	*!		
	c.	[(khá.ra).tats]		*!	

Tableau 17: Lengthening of stressed vowels

We only ever see penultimate stress, but given the ranking so far we might expect stress shift to satisfy foot binarity. That is, stress might shift off of a light penultimate syllable in some way. It could shift either by moving the stress window (therefore violating REND), or by making a two-syllable foot. This second case I take to involve a violation of a constraint like FT MAX, given in (19).

(19) FT MAX

A foot may maximally contain two moras.

This constraint bans heavy-light trochees, and such feet are extremely uncommon. See Mester 1994 for discussion of such a maximality restriction. Some languages can resolve foot maximality by shortening, by Mohawk never needs to go so far – the preference for heavy one-syllable feet sees to this. This constraint is basically a ramification of the “Iambic/Trochaic Law” (cf. Hayes 1995 for discussion and references). A H L trochee would involve initial prominence by stress and length, but final prominence is generally preferred for length.

The rankings needed to block stress shift to antepenultimate position are shown in tableau 18.

		/hs-at-hw-atase-ø/	FT MAX	REND	DEP <sub>μ</sub>
☞	a.	[sat.(snó:).rat]		*	*
	b.	[(sát).sno.rat]		**!	
	c.	[(sát.sno).rat]	*!	*	

Tableau 18: No stress shift for weight, pt. 1

We might also expect stress shift onto a final heavy syllable, but this would violate NONFINALITY:

		/k-haratat-s/	NONFINALITY	DEP <sub>μ</sub>
☞	a.	[kha.(rá:).tats]		*
	b.	[kha.ra.(táts)]	*!	

Tableau 19: No stress shift for weight, pt. 2

This concludes the treatment of Mohawk’s basic stress system, assuming moraic trochaic feet. Mohawk can be spelled out as a fairly straightforward moraic trochaic language – the only twist is the default preference for one-syllable feet, something we have yet to see overridden.

### 2.3 Mohawk’s basic stress system: conclusions

We have seen that there are at least three different ways of analyzing the basic stress system of Mohawk. Without further evidence, there is no obvious way of deciding between the analyses. There are certain predictions that the analyses differ on, but Mohawk simply doesn’t have the right kinds of forms to verify



that feet are binary and syllabic. On an iambic system, even though a foot can consist only of two moras, there must be at least one syllable that is extrametrical and one that is parsed, so again there could be some kind of minimal word effect. The same pattern should arise under the moraic trochaic analysis that I have presented – since final-syllable extrametricality is crucial there as well.

What we find in Mohawk, when a word consists only of one syllable is initial epenthesis of the vowel /i/ to form a minimal word. The vowel bears stress, saving the penultimate generalization. It also lengthens in a regular fashion. Thus we find forms like (22) and (23).

(22) /k-kʌ-s/ ↗ [í.k.kʌs] ɪA-see-HAB ‘I see’

(23) /w-e-ʔs/ ↗ [í.weʔs] ZA-walk-HAB ‘She/it is walking around’

These facts can be explained in a reasonably straightforward way under each hypothesis, by ranking the constraints leading to the minimal word effect over DEP.

### 3.1.1 Prothesis and syllabic trochees

On a syllabic trochaic account, the minimality effect comes about due to FTBIN. More specifically, it comes about from the part of FTBIN that requires feet to contain two syllables. This can be seen in tableau 20.

	/k-kʌ-s/	FTBIN	DEP
☞ a.	[[í.k.kʌs]]		*
b.	[(kkʌs)]	*	

Tableau 20: Epenthesis via foot binarity

We would also need CONTIGUITY or some similar constraint to force prothesis – to prevent, in the case of inputs like that in the above tableau, a much less marked syllable structure from emerging.

	/k-kʌ-s/	CONTIGUITY	*CODA	ONSET
☞ a.	[[í.k.kʌs]]		*	*
b.	[(kí.kʌs)]	*		

Tableau 21: Contiguity effects forcing prothesis

In a syllabic trochaic system, the minimal word effect can be accounted for straightforwardly.<sup>5</sup>

### 3.1.2 Prothesis and iambs; prothesis and moraic trochees

On both the iambic account, and the moraic trochaic account, it is NONFINALITY that is driving the minimality effect. If there were no prothesis, the head of the prosodic word would also be final in the prosodic word. The crucial ranking is shown in tableau 22.

	/k-kʌ-s/	NONFINALITY	DEP
☞ a.	[(ík).kʌs]		*
b.	[(kkʌs)]	*	

Tableau 22: Epenthesis via extrametricality

Recall that both of these hypotheses use a different wording of FTBIN, which would not come into play here – the head foot would have two moras either way. We again need CONTIGUITY to force prothesis, and the ranking is the same as seen in tableau 21 above.

<sup>5</sup>There is the question of why epenthesis is word-initial, especially given what I later say about HEADDEP. I do not have an answer for this question yet.

### 3.2 Driving [e]-epenthesis

Epenthetic [e] breaks up certain sequences of consonants. Much previous work has characterized the purpose of this kind of epenthesis as preventing bad consonant clusters. This doesn't provide a sufficient explanation for all the positions where the epenthetic vowel appears, as we will see.

The generalization about [e]-epenthesis, as characterized by Michelson 1988, is as follows. Epenthetic [e] breaks up oral-resonant CC sequences except where the 2nd C is [y]. It also breaks up CCC sequences except when the 2nd C is [h] or [s] or when the 2nd and 3rd C form an (oral?) stop-glide sequence. Finally, it breaks up word-final C[ʔ] clusters. Here are some examples to illustrate:

- (24) /wak-ruhyak $\Lambda$ - $\emptyset$ /  $\mapsto$  [wa.k $\square$ [e].ruh.yá:.k $\Lambda$ ] iP-suffer-STAT 'I suffer'  
 (25) /s-wa-nuhweʔ-s/  $\mapsto$  [s $\square$ [e].wa.nú:.weʔs] 2-p-like-HAB 'You.pl like it'  
 (26) /wak-nyak-s/  $\mapsto$  [wa.k $\square$ [é].n.yaks] iP-get.married-HAB 'I get married'  
 (27) /hs-theʔt-haʔ/  $\mapsto$  [s $\square$ [e].thé:.thaʔ] 2A-pound-HAB 'You're pounding'  
 (28) /te-k-hsaʔkt-s/  $\mapsto$  [tek.hsá:.k $\square$ [e]ts]<sup>6</sup> DU-1A-bend-HAB 'I bend it'

Obviously this kind of epenthesis blocks complex consonant sequences, but the generalization does not explain why it should. In fact, when we consider the details in the data, it does not appear that cluster restrictions can always be at issue. For instance, in (24), the epenthetic vowel does not resolve a potential bad cluster, but merely prevents a syllable structure like [wak.ruh.yá:.k $\Lambda$ ]. Some cases, such as that in (28), clearly are preventing bad clusters – there we would unavoidably have a coda cluster kts. This cluster never surfaces as a coda in Mohawk, so we can take a constraint like \*COMPLEX to be blocking this output. The traditional OT epenthesis pattern seen in tableau 23 explains data of this sort quite straightforwardly.

		/te-k-hsaʔkt-s/	*COMPLEX	DEP	*OTHERV	*i	*e
☞	a.	[tek.hsá:.k $\square$ [e]ts]		*	*		**
	b.	[tek.hsákts]	*		*		*
	c.	[tek.hsá:.k $\square$ [a]ts]			**!		*
	d.	[tek.hsá:.k $\square$ [i]ts]			*	*!	*

Tableau 23: Traditional epenthesis pattern

There are two parts to the traditional epenthesis pattern – the selection of the epenthetic vowel, and the motivation for epenthesis. The selection of the vowel I will return to, but the motivation for epenthesis works straightforwardly in this case – the (b) form violates \*COMPLEX. This ranking can't explain data like (28), as we'd incorrectly predict the form suggested above:

		/wak-ruhyak $\Lambda$ - $\emptyset$ /	*COMPLEX	DEP
☞	a.	[wa.k $\square$ [e].ruh.yá:.k $\Lambda$ ]		*
	b.	[wa.kruh.yá:.k $\Lambda$ ]	*	
	c.	[wakr.uh.yá:.k $\Lambda$ ]	*	
✗	d.	[wak.ruh.yá:.k $\Lambda$ ]		

Tableau 24: Traditional epenthesis pattern, failure

Outputs where the /kr/ sequence is syllabified into a coda or onset do not survive, of course, but the point is that these are really pathological forms. The (d) form involves neither problem. The (d) form does

<sup>6</sup>The syllabification on the first syllable is a little unclear.

violate \*CODA, but we do see codas in this language, and in fact we see [k] as a valid coda (cf. (28) for instance). So this form, given just a constraint militating against complex clusters, should be the output.

The solution is that epenthesis is driven not just by bans on complex clusters, but also by restrictions on **syllable contact**. Syllable contact laws (Murray and Vennemann 1983; Davis and Shin 1999; Gouskova 2001, 2004 and many others) describe patterns of consonant sequences that are acceptable at syllable boundaries. Many languages have a restriction where the sonority of an onset needs to be higher than that of its preceding offset, and Mohawk appears to be no exception. One form of this generalization is stated in (29).

- (29) **Syllable Contact Law (sonority version)** (Davis and Shin 1999)  
 “A syllable contact A\$B is the more preferred, the greater the sonority of the offset A and the less the sonority of the onset B.”

This can be translated directly into a constraint (and in fact, the formulation in Murray and Vennemann 1983 was already quite constraint-like):

- (30) **SYLLCON** (Davis and Shin version)  
 Avoid rising sonority over a syllable boundary.

This constraint, working in tandem with a fairly strict \*COMPLEX, can explain the restrictions we see on consonant sequences.

	/wak-ruhyak $\Lambda$ - $\emptyset$ /	*COMPLEX	SYLLCON	DEP
☞ a.	[wa.k $\square$ e.ruh.yá:k $\Lambda$ ]			*
b.	[wa.kruh.yá:k $\Lambda$ ]	*!		
c.	[wakr.uh.yá:k $\Lambda$ ]	*!		
d.	[wak.ruh.yá:k $\Lambda$ ]		*!	

Tableau 25: Syllable contact effects

We still need a strict \*COMPLEX constraint, not just to block coda sequences like that in tableau 23, but to prevent onset clusters like that in candidate (b) of tableau 25. We do not even find these kinds of onset clusters. The coda cluster in (c) is of course pathological, but needs to be blocked similarly.

C-glide sequences must be licensed across syllable boundaries. The most obvious explanation is that consonants (in particular, oral/nasal stops) palatalize or labialize preceding glides, forming a complex segment that can be ambisyllabic. No complex cluster constraint or syllable contact constraint would be violated by such a complex segment. The presence of a complex cluster is known to happen in at least some dialects (in fact the precise character of the complex segment varies across dialects). More phonetic work would be needed to establish the generality of this phenomenon and the presence of ambisyllabicity in these cases. In general, evidence from lengthening suggests that ambisyllabicity does not happen with non-complex segments.

### 3.3 Driving [a]-epenthesis

Michelson 1988 states that the joiner vowel appears to break up any CC sequences at the edges of adjacent derivational morphemes. This includes verb stems and incorporated noun stems, and also stems and derivational affixes. The fact is, however, that I have no forms that couldn't be explained by the combination of a prohibition on complex onsets and codas, and syllable contact effects. Here are a few examples:

- (31) /te-hs-aʔar-a-rik- $\emptyset$ /  $\leftrightarrow$  [teh.sa.ʔá:r $\square$ a.rik]      DU-2A-curtain-JOIN-put.together-IMP  
 ‘Put the curtains together!’

The epenthetic vowel breaks up an /r-r/ sequence. To account for this we simply need to change SYLLCON to ban flat sonority contours:

- (32) SYLLCON (revised version)  
 Avoid rising or flat sonority over a syllable boundary.

This new version is applied to the form in (31) in tableau 26.

	/te-hs-aʔar-rik-ø/	*COMPLEX	SYLLCON	DEP
☞	a. [teh.sa.ʔá:r[ <u>a</u> ].rik]			*
	b. [teh.sa.ʔár.rik]		*!	

Tableau 26: Joiner vowel example

We would need to block coalescence in this form as well – we do not find an ambisyllabic [r] at this morpheme boundary.

Here's another example that shows \*COMPLEX effects:

- (33) /k-r-a-kw-as/ → [k[e].r[á]k.was] ɪA-fill.in-JOIN-UN-HAB  
'I take it out'

The form in (33), if there were no joiner vowel, would inevitably have a horrible complex onset:

	/k-r-kw-as/	*COMPLEX	SYLLCON	DEP
☞	a. [k[e].r[á]k.was]			**
	b. [kr[á]k.was]	*!		*
	c. [k[e]r.kwas]	*!		*
	d. [krkwás]	*!		

Tableau 27: Joiner vowel, example 2

More data is needed – though I don't know of any, it is still possible that there are CC sequences which wouldn't trigger [e]-epenthesis, but trigger [a]-epenthesis.

Without such data, though, it seems clear that the apparent distribution of one vowel per process is mistaken. Under the present analysis, the motivation for [a]-epenthesis is really the same as the motivation for [e]-epenthesis. What is different is the domain in which epenthesis occurs. With this observation in mind, I will turn to the issue of how the epenthetic vowel is chosen.

### 3.4 Vowel choice in epenthesis

A central mystery about epenthesis in Mohawk is why there are different epenthetic vowels. This is a mystery in OT, at least – in a traditional rule-based analysis, there is at first glance no mystery. We would have one epenthetic vowel per process. This kind of explanation won't work in OT, as there is no way to directly connect choice of vowel with the motivation for epenthesis in each case. Actually, it is worth noting that this explanation (one vowel per process) is also not present in any formal sense in the best rule-based account of epenthesis (Michelson's). On that account, several rules of [e] epenthesis are needed (to capture the stress/epenthesis interaction), and as a result, it is not so easy to define any single process that is associated with that vowel. There are similarities between the rules associated with e.g. [e], but no formal connection beyond the rules' names. A similar problem arises for epenthetic [a] on the rule-based account.

In OT the problem of vowel-choice appears quite distinct from the problem of epenthesis-motivation. Traditionally, the least marked vowel is the one that will be chosen for epenthesis. That is, there is a hierarchy of markedness constraints against vowel qualities, and a TETU ranking results in the least marked vowel being chosen in cases where a vowel isn't in correspondence with an input vowel. That can't work straightforwardly for Mohawk, because there can only be one least marked vowel, but here we have three epenthetic vowels.

The solution that I propose is that vowel markedness constraints are parameterized to morphological domains. Outside of a morphological word (Mwd), the vowel [i] is the least marked. Within an Mwd but outside a stem, the vowel [a] is the least marked. Thus we get the appearance of a joiner vowel. Finally, inside stems, the vowel [e] is the least marked – and we find it at inflectional-morpheme boundaries and morpheme-internally.

We can see that the positional markedness constraints can't be given relative to prosodic domains by the simple fact that any of these vowels can be the stressed vowel - the head vowel of the head syllable of the head foot of the prosodic word. Words in Mohawk (including incorporation structures) are one prosodic word, with one head. In this situation there can be no difference in prosodic domain, yet we see a difference in vowel quality. If the morphological domain is what's relevant, however, we might expect a difference – there can be mismatches between morphological domains and prosodic domains.

The rankings that explain the vowel choice in this way are given in (34):

- (34) a. \*I/STEM,\*A/STEM » \*E/STEM  
 b. \*I/MWD,\*E/MWD » \*A/MWD  
 c. \*E,\*A » \*I

“Stem” here includes verbal and nominal complexes, but I have to assume that incorporation structures form recursive morphological words rather than recursive stems. This assumption may lead to problems that I am still considering. Derivational affixes also need to be considered “stems” – we find epenthetic [e] inside a derivational (non-lexical) affix in a few cases. At the moment, I can't see any general way to derive these rankings – they are just language-particular facts.

A final piece of evidence for part of this breakdown comes from syncope processes that occur at morpheme boundaries, discussed by Hopkins 1987. At morpheme boundaries, a complex syncope process occurs with VV sequences. A vowel in this sequence deletes if it is the lowest of the two on a strength scale (following Hooper 1976). The strength scale necessary for explaining the syncope makes [a] lowest – if either of a two-vowel sequence at a morpheme is [a], that is the vowel that will delete. It is in fact a problem for Hopkins' analysis that [a] is not the most common kind of epenthetic vowel, as Hooper had suggested that the vowel that is epenthesized is the weakest vowel in a language (or takes its features from nearby segments). This leads Hopkins to suggest that Hooper's generalization (really a proto-statement of the emergence of the unmarked pattern in epenthesis) does not work for all languages, but given my account of vowel choice it can be seen in a new light.

The syncope process happens at morpheme boundaries, and as far as I can tell from the data in the literature, at morpheme boundaries which are either between derivational morphemes or boundaries which we have no evidence aren't between derivational morphemes. If these boundaries all involve derivational morphemes, this is exactly the domain where we find epenthetic [a] – within an Mwd but not within a stem. So relative to this domain, [a] is the least marked, and expected for epenthesis, and also expected to delete preferentially in syncope.

This is also evidence that [a] is truly an epenthetic vowel – if it were a morpheme, we'd have no expectation at all (even less than Hopkins did) that [a] should preferentially delete in syncope processes in this morphological domain.



The generalization is that stress moves as far to the left as it needs to in order to avoid appearing on an epenthetic [e] or joiner vowel, but no further. We never find stress on epenthetic [e] in an open syllable, and we never find penultimate stress when the word ends in epenthetic [e] followed by [ʔ].

Table 1 summarizes the situation. The word “tonic” refers to the position where stress ends up falling, and epenthesis position is where the epenthesis ends up happening. The table crosses the closed/open status of the tonic position with the closed/open status of the epenthesis position. A subscript “c” marks a closed syllable, and a subscript “o” an open syllable. A  $\sigma$  marks a syllable with a non-epenthetic nucleus, and with no subscript it can be either open or closed. An “e” marks syllable containing epenthetic [e].

epenthesis	closed tonic pattern	open tonic pattern
none	$\acute{\sigma}_c \sigma \#$	$\acute{\sigma}_o : \sigma \#$
penultimate closed	$\acute{e}_c \sigma \#$	–
final closed	$\acute{\sigma}_c e_c \#$	$\acute{\sigma}_o : e_c \#$
penultimate open	$\acute{\sigma}_c e_o \sigma \#$	$\acute{\sigma}_o e_o \sigma \#$
final open	$\acute{\sigma}_c \sigma e \text{ʔ} \#$	$\acute{\sigma}_o : \sigma e \text{ʔ} \#$

Table 1: Stress and epenthesis summary

## 4.1 Derivational analyses

### 4.1.1 Rule-based analyses

Michelson 1988 gives a rule-based analysis of these facts, building on analyses of a subset of the data due to Postal 1968 and Postal 1969. I won't present the details of the analysis here, but I will give the highlights. The rule-based account relies crucially on derivational opacity. A rule inserting epenthetic [e] into closed syllables is ordered before the rule placing accent, and a rule doing epenthesis into open syllables is ordered after the accent placement rule. The outlines are given in (40).

- (40)
1. [e]-epenthesis I
  2. Mohawk Accent Rule (places accent on penultimate syllable)
  3. Tonic Lengthening (lengthens accented syllable)
  4. [e]-epenthesis II
  5. [e]-epenthesis III

[e]-epenthesis I does epenthesis for only the cases where the resulting syllable will be closed, and this is determined simply by the number of consonants following the epenthesis site. [e]-epenthesis II and III take care of the other cases – II is basically I without the closedness requirement, and III inserts [e] between a consonant and a word-final /ʔ/. This analysis does not capture the fact that [e]-epenthesis I and II effectively target the same environment – they break up the same clusters, but it does very effectively capture the generalizations about stress shift. [e]-epenthesis I feeds the accent/tonic rules, so epenthesis into a closed syllable will be visible to stress assignment. [e]-epenthesis II and III counterfeed the stress assignment rules – epenthesis as a result of these rules will happen after stress is placed on the penultimate syllable, and possibly add an extra syllable between the stressed one and the end of the word. Here are two sample derivations, one of weighted epenthesis, and one of weightless epenthesis:

(41) **Derivation of (26)**

form	rule
/wak-nyak-s/	(input)
↗ wak.nyaks	
↗ wa.ken.yaks	([e]-epenthesis I)
↗ [wa.kén.yaks]	(accent rule)

(42) **Derivation of (39):**

form	rule
/waʔ-t-k-atat-nak-ʔ/	(input)
↗ waʔ.tka.tat.nakʔ	
↗ waʔ.tka.tát.nakʔ	(accent rule)
↗ waʔ.tka.tá.te.nakʔ	([e]-epenthesis II)
↗ [waʔ.tka.tá.te.na.keʔ]	([e]-epenthesis III)

The use of opaque rule-orderings makes the pattern challenging to translate into OT. These rule orderings accomplish many things, but the main 3 are as follows. First, one kind of epenthesis (epenthesis into open syllables) is invisible to stress, because of the rule ordering. Second, the other kind of epenthesis (into closed syllables) is visible, also because of the rule ordering. This rule ordering also captures the exceptional lack of lengthening with stress shift. It does this because at the level of derivation where stress is assigned, there is a not-yet-broken cluster following the stressed vowel, so at least some of this cluster is guaranteed to be in the coda (at that level). Therefore, the lengthening rule doesn't apply. Later, the cluster is broken up, and the previously coda consonant becomes the onset of the new syllable, resulting in an unlengthened stressed open syllable. [e]-epenthesis II counterfeeds the lengthening rule in these cases. Another derivation demonstrating this is given in (43).

(43) **Derivation of (36a):**

form	rule
/te-k-rik-s/	(input)
↗ tek.riks	(initial syllabification)
↗ ték.riks	(accent rule, lengthening does not apply)
↗ [té.ke.riks]	([e]-epenthesis II)

Michelson's account remains the most complete analysis of stress and epenthesis in Mohawk. However, it suffers from a range of problems with respect to explanatory adequacy. In earlier sections, I explored the factors driving epenthesis. In an OT account, epenthesis (word-internally) happens for exactly two reasons – to break up complex clusters, and to prevent bad syllable contacts. In fact, both factors are potentially involved in any instance of epenthesis. This is a complete accident under a rule-ordering analysis. The environments in Michelson's particular formulations of [e]-epenthesis are not exactly the same, but the differences are mainly in order to capture the difference in output syllable structure. The environments are effectively the same, with respect to actually conditioning the epenthesis. The rules driving epenthetic [a], though I do not give them here, have effectively the same problem – the conditioning of the epenthesis (regardless of what it actually is) is clearly the same regardless of the shape of the surface syllable, and the rule-based analysis makes this a complete accident.

A further problem involves the treatment of stress placement. At some level of derivation, on this kind of analysis, Mohawk has trochees. However, Mohawk forms often will not have trochees at the surface. If the surface forms involving epenthesis have any footing or larger prosodic structure at all, it will look something like the structure proposed by Alderete 1995, with a discontinuous foot. If the theoretical assumption is that surface forms have prosodic structure, the rule-based analysis also brings in all the

problems of assuming discontinuous feet, along with the problems about conditioning epenthesis. But assuming that there is surface prosodic structure seems quite desirable.

Michelson 1988 crucially relies on rule-ordering to explain the effect of weightless vowels. Without rule-ordering on a derivational account, there is no explanation for any of them – in fact, a subset of this data was one of the arguments from Postal 1968 that phonological rules had to be ordered as part of the grammar. The challenge for an OT account is to explain these puzzles in a non-cyclic way – coming a full 360 degrees (in some sense) from Postal.

#### 4.1.2 Strata-based analyses

In this section I briefly discuss approaches to the problem of opacity that rely on different lexical strata. Piggott 1995 is one approach to Mohawk that makes use of different levels of derivation, but the arguments against such an approach are quite general. On this kind of approach, as Kiparsky 2000 puts it, the goal is to reduce opacity to interlevel constraint masking. The cycle is preserved, in a limited and principled way, even in OT-like frameworks.

The basic idea would have to be that weightless epenthesis happens at a different level of derivation than weighted epenthesis, and that constraints on prosodic structure applied in between. This, on the face of it, seems quite parallel to the case of Arabic stress and epenthesis interaction, as analyzed by Kiparsky 2000. To further the analogy, Arabic has epenthesis for prosodic minimality (parallel to Mohawk [i]-epenthesis), which is visible to stress.

This type of analysis does not extend so easily to Mohawk. The determination of whether epenthetic vowels are visible or invisible seems to be largely determined by output syllable structure. Information about output syllable structure should only be available to a lexical phonology analyses at the stage of post-lexical phonology. However, stress assignment (at least for Arabic) has to happen before this, making it difficult to see how the grammar is going to order epenthesis into a weighted syllable at the stem or word stage of the phonology.

Such an analysis might be subject to the same criticisms of explanatory adequacy that the rule-based analysis is. We do not want it to be a complete coincidence that weighted and weightless epenthesis have the same motivations – but if the motivations are the same, why wouldn't both kinds of epenthesis happen as early in the derivation as possible? That is, the same kinds of clusters will be present to be broken up from the start. Again, it is a generalization about the output syllable structure that would have to determine the ordering, not anything intrinsic to the particular kind of epenthesis.

Finally, there are two conceptual problems. First, The levels of lexical phonology are associated loosely with different kinds of processes – stem-based, word-based, and post-lexical. Roughly, the morphophonology should happen first, and the pure phonology later. This is not the kind of ordering that the Mohawk data suggests, if it is to be analyzed derivationally. Epenthetic [a] is (at least traditionally) a morphophonological process – it has both morphological and phonological conditions. Epenthetic [e] happens for “purely” phonological reasons – bad clusters, and bad syllable contacts. From this we might expect epenthetic [a] to happen earlier, and we don't find this. There must be an earlier stage where both happen, and also a later stage. My analysis of epenthesis in §3 turns the problem on its head – [e] should happen stem-internally, and [a] at the word level, predicting the opposite ordering. We don't find this either.

The second conceptual problem involves the number of levels in a lexical phonology – Kiparsky 2000 argues for three, and this seems to be standard. The three levels that Kiparsky presents certainly make intuitive sense. However, if opacity is really to be analyzed as constraint masking, Mohawk presents a serious problem for this assumption. A full analysis of epenthesis in Mohawk in a purely rule-based system involves a sequence of at least 9 completely ordered rules (cf. Michelson 1988 p.160), in which there are at least 6 counterfeeding or counterbleeding orders (Michelson in fact has ordering arguments for a total ordering of these rules, as well as additional minor rules, but many of the pairwise orderings are not

opaque). None of the individual processes can be cleanly identified with any level, and it is clear that a lexical phonology approach would not desire this many levels of derivation. A simple recapitulation of opaque rule-orderings into lexical phonology would not work.

Of course none of this argues against a strata-based phonology. It simply argues against the treatment of opacity in Mohawk by locating processes at different strata. It may even be possible to reduce the opacity to certain crucially different processes that occur at different strata, though I won't address this task in much detail here.<sup>8</sup> Piggott 1995 has the best attempt at this, but that analysis faces certain problems discussed in detail in Hagstrom 1997, and Rowicka 1999. On the face of it, trying to use lexical strata in OT to account for the stress-epenthesis interaction in Mohawk is at best no easier than trying to analyze it in OT at all, and faces certain daunting problems. Therefore, I will focus on a pure OT analysis.

The preceding discussion of derivational treatments of Mohawk raises several puzzles for an OT analysis, which I will use to focus the discussion in the following sections:

(44) **Core puzzles of Mohawk**

- a. Why does stress avoid (some) epenthetic segments?
- b. Why does stress only avoid epenthetic segments in open syllables?
- c. Why does lengthening depend on the epenthetic status of the following nucleus?

Next, I consider how each hypothesis fares in light of the data.

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## 5 OT ANALYSIS ASSUMING SYLLABIC TROCHAIC FEET

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In this section I spell out an analysis of the stress-epenthesis interaction in OT assuming syllabic trochaic feet, showing how far we can get. This analysis largely builds on the analysis of a subset of this data presented in Alderete 1995.

### 5.1 The first puzzle: avoidance of epenthetic segments

Other languages show similar stress shift patterns to Mohawk, and work by Alderete 1995, 1999 has provided a general account of these patterns. Alderete argues for what amounts to a positional faithfulness (Beckman 1997, 1998) account. Prosodic domains in prominent positions, such as the head of a foot, can be privileged, with respect to faithfulness - in some languages, faithfulness constraints limited to a prominent position can outrank general faithfulness constraints. This can explain stress shift off of epenthetic segments in a range of languages, including Dakota, Yimas, and potentially Mohawk. Alderete 1995 provides an analysis of the first two puzzles in Mohawk assuming this kind of positional faithfulness, and this section largely follows that analysis.

The relevant faithfulness constraint is DEP, relativized to heads of prosodic words, or of feet. HEADDEP needs to outrank the general DEP constraint - epenthesis does not trigger any surprising effects except when stress could fall on it (or it is in final position; see the following sections for discussion of final epenthesis). HEADDEP also looks like it might outrank REND, as does \*COMPLEX - otherwise stress couldn't shift at all.

The version of HEADDEP needed for the syllabic trochaic account is given in (45).

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<sup>8</sup>One area that would be simplified greatly would be the treatment of epenthetic [i], which is exactly parallel to epenthesis for minimal word requirements in Arabic. In both languages this kind of epenthesis is entirely regular with respect to stress assignment. Kiparsky analyzes this epenthesis by taking it to be happening at the word level - earlier in the derivation. The current analysis, without resorting to such strata, would seem to have to parameterize almost every constraint to some domain, to get the effect that epenthetic vowels act completely weighted outside of any morphological domain (as well as being pronounced [i]).

(45) HEADDEP(PWD)

Every segment in the head of prosodic word (the entire foot) must have a correspondent in the input.

In a syllabic trochaic system feet are disyllabic; this version of HEADDEP will be violated if either the strong or the weak syllable has an epenthetic nucleus. This allows us to capture two stress shift effects at once – the effect of final epenthesis to break up C?, and the effect of penultimate epenthesis into an open syllable. First we will deal with a case of final epenthesis.

	/waʔ-k-yerit-ʔ/	*COMPLEX	HEADDEP	REND
☞ a.	[waʔ.(kyé:ri).t[e]ʔ]			*
b.	[(waʔ.kye).(rí:t[e]ʔ)]		*!	
c.	[waʔ.(kyé:ritʔ)]	*!		

Tableau 28: Stress shift: basic ranking under hypothesis A

From this word we can also see that HEADDEP dominates PARSE-σ:

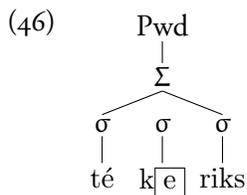
	/waʔ-k-yerit-ʔ/	*COMPLEX	HEADDEP	PARSE-σ
☞ a.	[waʔ.(kyé:ri).t[e]ʔ]			**
b.	[(waʔ.kye).(rí:t[e]ʔ)]		*!	
c.	[waʔ.(kyé:ritʔ)]	*!		*

Tableau 29: Stress shift: basic ranking under hypothesis A

This ranking works admirably on the case of final epenthesis. There is a consequence for penultimate epenthesis, however. Note that in a form like (36a) repeated below from earlier, we get an epenthetic nucleus in the syllable to the immediate right of the stressed syllable.

(36a) /te-k-rik-s/ ↗ [té.k[e].riks] DU-IA-put.together-HAB ‘I put them next to each other’

On a syllabic trochaic system, the second syllable would typically be treated as the weak member of the syllable, and therefore violate HEADDEP as formulated above. There is another way of interpreting this data, however, one that has been embraced by Piggott 1995 and Alderete 1995 – the foot is discontinuous and skips over the syllable with the epenthetic nucleus. That is, we have the structure in (46), with the middle syllable not connected at the foot level (though conceivably it could connect to the prosodic word node).



For the form in (36a), the result is illustrated in tableau 30. This foot structure presumably violates some structure constraint that is highly ranked in most languages - Alderete takes the relevant constraint to say roughly that syllables dominated by the same foot should be adjacent. I will refer to this constraint as σ-CONTIG. This constraint can be thought of as part of the family of constraints accomplishing the “strict layering” of Selkirk 1995. It is a part usually considered inviolable (perhaps as part of Gen), but in a framework with ranked constraints it does not seem completely crazy to reconsider this.

	/te-k-rik-s/	*COMPLEX	HEADDEP	$\sigma$ -CONTIG
 a.	$\Sigma$ $\sigma$ $\sigma$ $\sigma$ t $\acute{e}$ k[e] rik $s$			*
b.	$\Sigma$ $\sigma$ $\sigma$ $\sigma$ te k[ $\acute{e}$ :] rik $s$		*!	
c.	$\Sigma$ $\sigma$ $\sigma$ $\sigma$ t $\acute{e}$ : k[e] rik $s$		*!	
d.	$\Sigma$ $\sigma$ $\sigma$ t $\acute{e}$ : kriks	*!		

Tableau 30: Stress shift: basic ranking

This kind of discontinuous foot structure is predicted to occur any time a constraint driving epenthesis outranks both  $\sigma$ -CONTIG and PARSE- $\sigma$ , as long as HEADDEP is active.

One reason that this sort of account seems to be driven to a discontinuous foot is by the need to account for word-final epenthesis and subsequent stress shift in the same way as penultimate epenthesis and stress shift. This observation will play a key role in the development of the moraic trochaic account later, but for now I will take it for granted that this is a positive property of the present account.

## 5.2 Puzzle 2: stress, epenthesis and closed syllables

The rankings in the previous section, without further modification, predict epenthesis into any potential head to trigger stress shift. This is not so, as we saw in §4. When a syllable with an epenthetic nucleus is heavy, the nucleus can bear stress. The incorrectly predicted output is shown with the  $\times$  symbol in tableau 31 (assuming a discontinuous foot structure branching around the middle syllable). What we actually find, assuming syllabic trochaic parses, is candidate (b).

	/wak-nyak-s/	HEADDEP	REND	PARSE- $\sigma$
$\times$ a.	[(w $\acute{a}$ .k[e]n).yaks]			*
 b.	[wa.(k[ $\acute{e}$ n].yaks)]	*!		*
c.	[(w $\acute{a}$ .k[e]n).(yaks)]	*!	*	

Tableau 31: Penultimate weighted epenthesis, failure

An obvious starting point is the account of this puzzle in Alderete 1995, which assumes roughly the same background that I have presented here. However, that solution only accounts for a subset of the data, and doesn't explain the asymmetry between epenthetic and non-epenthetic light syllables.

Alderete 1995 proposes that WEIGHTTOSTRESS is active in the grammar of Mohawk. A penultimate epenthetic nucleus can be stressed if in a heavy syllable, because WEIGHTTOSTRESS will be satisfied in that case. However, as far as I can tell, this provides no way to differentiate between open epenthetic syllables and open non-epenthetic syllables. When a penultimate syllable is not epenthetic but open, it

consistently lengthens, and WEIGHTTOSTRESS will be satisfied, but Alderete provides no reason that an epenthetic nucleus won't lengthen. Reasons can be found (and in fact I will discuss them shortly), so this is not an argument against this kind of approach, just against the formulation in Alderete 1995. A more serious problem is that we **always** see lengthening preferred over stress shift to heavy syllables, but lengthening will never reduce WEIGHTTOSTRESS violations. To block stress shift, some constraint(s) need to be above WEIGHTTOSTRESS, but it is far from clear what they would be on the account as I've developed it. The generalization that WEIGHTTOSTRESS has no effects when epenthesis isn't in the picture is an absolute generalization, so any potential effect in non-epenthetic situations has to be blocked entirely. This makes it conceptually problematic that there are even WEIGHTTOSTRESS effects in Mohawk.

These complaints might be resolved by fine-tuning the analysis, but at this point I would like to suggest a different approach that is simpler.

The solution I develop in this section is entirely different. Recall that coda consonants must have moras in Mohawk in order to explain the basic lengthening facts. If an open syllable with an epenthetic nucleus isn't parsed into the foot, there is one mora that is not part of the larger prosodic structure, that of the epenthetic vowel. If a closed syllable is not parsed, however, there are two moras, because of the presence of the coda consonant, and I suggest that it is much worse to have two moras unparsed than one. That is, an unparsed heavy syllable is intolerable in Mohawk, whereas an unparsed light syllable is not so bad.

I implement this intuition using local constraint self-conjunction. First, PARSE- $\sigma$  must be replaced with PARSE- $\mu$ :<sup>9</sup>

- (47) PARSE- $\mu$   
Moras must be part of a syllable that is parsed into a foot.

This constraint is somewhat problematic in that, unlike the typical PARSE constraint, it makes reference to a level of structure two steps away from the level being parsed – it really enforces moras being parsed into feet. I have nothing more to say about this issue, however. Self-conjoining this constraint in the domain of the syllable gives us the following constraint:

- (48) PARSE- $\mu$  & PARSE- $\mu$   
Violated if there are two moras in an unparsed syllable.

The ranking of PARSE- $\mu$  is the same as the ranking of PARSE- $\sigma$  given previously, though in some cases the violation marks might look different. The self-conjoined version must be ranked higher, as shown in tableau 32. Candidate (a) in this tableau has a discontinuous foot structure.

	/wak-nyak-s/	P $\mu$ & PARSE- $\mu$	HEADDEP	REND	PARSE- $\mu$
a.	[(wá.k[e]n.yaks)]	*!			**
b.	[wa.(k[é]n.yaks)]		*		*
c.	[(wá.k[e]n).(yaks)]		*	*!	

Tableau 32: Penultimate weighted epenthesis

### 5.3 Puzzle 3: stress, epenthesis, and weight

When stress shift due to penultimate epenthesis pushes stress onto an open syllable, this syllable typically does not lengthen. This is almost the only case in Mohawk where a stress open syllable does not involve lengthening, and as such is quite mysterious. Alderete 1995 does not address this problem, and it is a major problem for any syllabic trochaic approach.

<sup>9</sup>I assume temporarily that there is maximal parsing; there is really no evidence either way.

Under the assumptions laid out so far in this section, I do not know of any easy way to solve this puzzle. One possible solution is to say that the discontinuous foot structure satisfies STRESS-TO-WEIGHT in some way without needing lengthening. This is intuitively plausible, given that the unparsed syllable has an extra mora that isn't participating in foot structure otherwise. This syllable could perhaps be thought of as a "semisyllable" in the sense of Kiparsky 2002, though it is crucial for this account that it be an actual syllable, as opposed to lose moras. The use of something like a semisyllable is in fact a crucial component of the account of weightless epenthesis in Hagstrom 1997 (though that differs significantly from Alderete's proposal). But there does not seem any concrete way of stating this idea with the present system, or any real independent evidence for believing this to be possible. Even if we could state it, it is not clear what phonetic evidence for such a proposal would look like, and it would seem to conflict significantly with reported native speaker judgements about syllabification.

Michelson's generalization about these cases is that any syllable lengthens which, at some level of derivation, is open and stressed and is followed by a closed syllable. It is crucial that this generalization does not hold at the surface, because while it often does, there are exceptions. Two of these are given in (49a) and (49b).

- (49) a. /t-a-w-aresr-ʔ/ ↗ [tu.ré:s[e].r[e]ʔ]      CIS-FACT-NA-boil.over-PUNCT 'It boiled over'  
 b. /te-wak-ahsutr-ʔ/ ↗ [te.wa.kah.sú:t[e].r[e]ʔ]      DU-1P-splice-STAT 'I've already spliced it'

Both of these, on Michelson's analysis, have the crucial property of ending in a CCʔ cluster, where the first two Cs form an impermissible sequence. Both pairs will be broken up by the end of the derivation, but because of the ordering, the way in which this happens may be surprising. First, epenthesis I, which feeds stress placement, fires, because that rule has no knowledge that the second cluster will eventually get broken up. This inserts an [e] between the first two consonants, one that is visible to stress placement. In (49a), for example, the word ends now in .../re.serʔ/. Stress is placed on what will be the antepenultimate syllable, re. At this level of derivation the final Cʔ cluster hasn't been broken up, and so the final syllable appears heavy – the conditioning environment for the lengthening rule. The stressed syllable lengthens, resulting in /ré:serʔ/. Finally, epenthesis III breaks up the final cluster, incidentally resulting in resyllabification into a penultimate open syllable. This gives in (49a) the surface form /ré:se.reʔ/, with the surprising antepenultimate lengthening.

Under Michelson's rule ordering account this situation will only come about under one situation – when the final and penultimate syllable are both epenthetic. All of the forms that I know of with this exceptional length pattern match this situation, and so I will take this to be the correct surface generalization about when epenthesis into an open syllable doesn't prevent tonic lengthening.

Under the syllabic trochaic hypothesis, this is exactly the situation where a discontinuous foot structure isn't possible, as there is no later non-epenthetic syllable to be the weak member of the foot. In this case, we could take the lengthening as a way of satisfying a constraint like FTBRANCH (Ussishkin 2000), requiring feet to minimally involve a branch somewhere. Right now this is rolled into the version of FTBIN that I am using, but could be separated out.

The real problem, however, is that under hypothesis A, I see no way to make the actual output form optimal compared to the hypothetical output [(te.wa).(káh.su).te.reʔ]. That is, given the assumption that feet are syllabic, why wouldn't stress just shift further, in order to be able to build a true syllabic trochaic foot? The problem is demonstrated in tableau 33, where the correct candidate is harmonically bounded by the incorrect candidate, via both FTBIN and PARSE-μ.

	/t-a-w-aresr-ʔ/	FTBIN	PARSE-μ
☞	a. [tu.(ré:).s[e].r[e]ʔ]	*	***
✗	b. [(tú:re).s[e].r[e]ʔ]		**

Tableau 33: Problem case for hypothesis A

This can't possibly be a REND effect because final epenthesis already triggers REND violations without difficulty – REND has to be low enough to allow this. Even if we found a different explanation for C? epenthesis (and I will argue for one in the following sections) allowing for epenthetic vowels to be in the dependent member of a foot (the parse would be [tu.(ré:s[e]).r[e]ʔ]) the presence of lengthening is extremely difficult to understand. We would really expect this to pattern with other cases of antepenultimate stress with penultimate epenthesis. I do not see any obvious way to explain this data on the assumption that feet can be trochaic and consist of two syllables. The foot here just doesn't look like a foot of the sort we expect, and there is no reason why it couldn't have been one.

## 5.4 Syllabic trochaic feet: conclusions

There is a certain attraction to this account – the highlight is the uniform treatment of final and penultimate epenthesis. There are two costs, however, and I consider them high. We are forced to assume discontinuous feet, a structure for which there is little independent evidence. And there is no obvious way to explain the lack of lengthening of antepenultimate stressed syllables, with penultimate epenthesis.

The final rankings for this analysis, as far as it goes, are shown in (50). These rankings don't account for the blocking of lengthening, or the special cases noted in the previous section.

(50) **Syllabic trochaic final rankings:**

FTHDl, FTBIN » FTHDR

REND, FTBIN » LEND

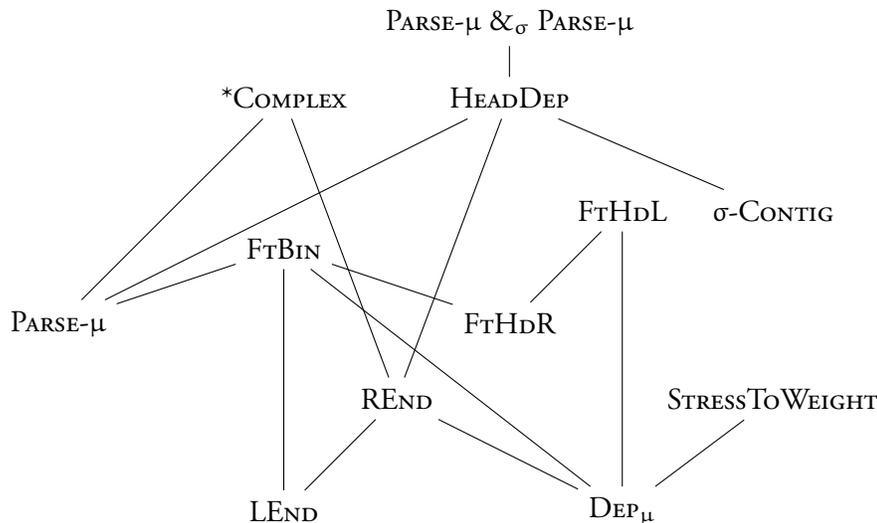
FTBIN » PARSE-μ

FTHDl, REND, FTBIN, STRESSToWEIGHT » DEP<sub>μ</sub>

**New:**

\*COMPLEX, HEADDEP » PARSE-μ, σ-CONTIG

PARSE-μ &<sub>σ</sub> PARSE-μ » HEADDEP



## 6 MORAIC TROCHAIC FEET: OT ANALYSIS

The syllabic trochaic account has two major problems – we are forced to accept discontinuous feet, and we are left with no account of the lengthening patterns. At this point I will go back to the drawing board, and develop a new account of Mohawk stress and epenthesis that avoids both of these problems.

In this paper I do not try to develop a third competing iambic hypothesis, though I showed earlier that the basic stress system might well be iambic. An iambic account can avoid some of the problems of the syllabic trochaic account, but it shares with it the inability to account for the lengthening patterns (or at least, it is just as hard to account for them in both systems). Additionally, an iambic account faces difficulties with forms like [té.ke.riks] where we'd have to assume a degenerate iamb. The iambic account, despite these problems, is very similar to what is developed in this section.

### 6.1 Puzzle I

In this section I return to the question of why stress avoids epenthesis at all. On a moraic trochaic account, there is an obvious problem with final epenthesis – it can't trigger stress shift for the same reasons as under a syllabic trochaic account. I will postpone this problem until §6.1.1, and look at cases of penultimate epenthesis first.

The HEADDEP constraint is equally applicable to this analysis, at least as a starting point. Here we only want to penalize epenthesis into the heads of syllables. The relevant version is given in (51):

(51) HEADDEP(Ft)

Every segment in the head of foot must have a correspondent in the input.

Because we have moraic trochees, there is as yet no ranking of HEADDEP with REND, as normal forms all incur one violation of REND. The effect of the relevant constraints are shown in tableau 34, unranked.

	/t-k-atawyaʔt-s/	*COMPLEX/SYLLCON	HEADDEP	REND
☞	a. [tka.(tá.w <sup>̄</sup> e).yaʔts]			*
	b. [tka.ta.(w <sup>̄</sup> é).yaʔts]		*!	*
	c. [tka.ta.(w <sup>̄</sup> é:).yaʔts]		*!	*
	d. [tka.(tá:).wyaʔts]	*!		*

*Tableau 34: Stress shift: a basic case (version 1)*

Candidate (a) wins because it involves violations of nothing except REND, and one violation of this constraint is forced by NONFINALITY. Any way of getting penultimate stress (regardless of vowel length) would involve a violation of HEADDEP, which of course isn't allowed.

In order to get a ranking for HEADDEP, we'd need to consider forms where stress might shift further than the antepenultimate syllable. For reasons to be discussed in the next section, these forms can't involve final epenthesis (which often in combination with other epenthesis results in pre-antepenultimate stress). I don't have any forms of this sort, and in consequence don't need to rank REND low. I strongly suspect that forms like this will exist (for reasons to become clear they will involve the joiner vowel), but they have not ever been elicited by a linguist. So I leave REND unranked with respect to REND, but reserve the option to rank it low.

We will need to rank HEADDEP relative to FTHDR in order to allow light light trochees in this case. This is shown in tableau 35 below.

	/t-k-atawyaʔt-s/	HEADDEP	REND	FTHdR
☞	a. [tka.(tá.w[e]).yaʔts]		*	*
	b. [tka.(tá:).w[e].yaʔts]		**!	
	c. [tka.ta.(w[é:]).yaʔts]	*!	*	

Tableau 35: Stress shift: a basic case (version 1)

So far HEADDEP seems promising, but it will face the same challenge as it did previously: stressed closed syllables with epenthetic nuclei. Before we look at this, I will give a different account of final epenthesis.

### 6.1.1 Final epenthesis

Final epenthesis to break up Cʔ triggers stress shift to the antepenultimate syllable. This syllable under no analysis is a candidate to be the stressed syllable, which makes it an interesting case for any analysis. For a syllabic trochaic system, this has a natural explanation, as the final syllable is still a candidate to be the weak member of the syllabic trochee. A constraint like HEADDEP can be parameterized to refer to the entire head foot of a prosodic word, instead of just the head syllable (and in fact, this is Alderete’s 1995 analysis). For a system like Hagstrom 1997, the epenthetic status can give rise to a semisyllable, instead of the full syllable needed to be the dependent member of a foot. However, in a moraic trochaic system as I’ve presented it, this explanation won’t fly – the final syllable is never going to be part of the stressed foot. There must be some other reason to shift stress.

The apparent problem is illustrated in tableau 36, where (a) is the output, but (b) is the candidate predicted incorrectly to win.

	/waʔ-k-yerit-ʔ/	*COMPLEX/SYLLCON	HEADDEP	REND
☞	a. [waʔ.(kyé:).ri.t[e]ʔ]			*
✗	b. [waʔ.kye.(rí:).t[e]ʔ]			
	c. [waʔ.(kyé:).ritʔ]	*!		

Tableau 36: Apparent incorrect predictions of moraic trochaicity

There is a fairly natural explanation for these facts that also goes a long way towards explaining some other puzzles. I take stress shift to be occurring in these cases for a different reason – so that certain morphemes can suffix to a prosodic word (McCarthy and Prince 1993a,b). This creates a recursive prosodic word structure, where in a form like that in tableau 36 above, the output syllable [.ri.] is final in a prosodic word structure. I first discuss a number of problems for the competing syllabic trochaic analysis, and then elaborate on the new proposal.

Word-final epenthesis to break up Cʔ sequences does not pattern with other stress-shift-triggering epenthesis in at least two ways. It is the only case of epenthesis triggering stress shift that does not result in stress immediately to its left. We find other cases of epenthesis into final position, but they create what are taken to be heavy syllables (cf. (38) [skáh.k[e]ʔts]).

It also does not involve epenthesis into a light syllable – the syllable always has a coda [ʔ]. This has led to proposals such as Hagstrom’s 1997, where this segment “shares a mora” with its preceding vowel (that is, they are both daughters of the same mora node), and Rowicka 1999 is forced to call upon Government Phonology’s “magic licensing” principle. We can see that ʔ codas usually count towards weight by considering their behavior in stressed syllables. Normally, when the syllable is stressed, the glottal stop deletes, with compensatory lengthening as well as a sharp falling tone on the vowel. This tone is not found elsewhere in the language. If such syllables counted as light in word-internal positions, we’d expect simple stress shift off of them. There are also some forms where [ʔ] does not delete (for somewhat unclear reasons), and here we also do not see stress shift (this form also conveniently illustrates that there are surface final Ceʔ sequences that don’t involve stress shift):

(52) /wak-yoʔt-eʔ/ ⇨ [wak.yóʔ.teʔ]

ɪP-work-HAB ‘I work’

Word-final epenthesis to break up Cʔ has some interesting behavior across Mohawk dialects. Michelson reports that some speakers do not actually pronounce the final [ʔ], yet stress shift is still triggered. On a derivational system, this is not a technical problem (though the necessary assumptions are very reminiscent of a Duke of York gambit, cf. Pullum 1976). Michelson, for example, claims that there is some level of derivation at which [ʔ] is present in these derivations, and at that level of derivation, epenthesis is conditioned. The final glottal stop simply doesn’t surface in these dialects. In OT, however, this explanation is clearly not adequate, and it would be very difficult to motivate epenthesis into this position. This suggests that the stress-shift in this position is not actually associated with epenthesis in all dialects.

There is also a piece of typological evidence for a different analysis of this case of stress shift. In Oneida, there is regular [e] epenthesis to break up clusters, in a pattern very similar to Mohawk. Only final epenthesis to break up Cʔ clusters triggers stress shift in this language – all other epenthesis is regularly counted regardless of weight.

These arguments add up to the conclusion that the effect of a final Ceʔ sequence, whatever it is, is not the same thing as the effect of a penultimate epenthetic [e]. One way of capturing this is to say that the idiosyncratic behavior of word-final C/ʔ/ sequences has been lexicalized somehow. This is of course only possible if the behavior can be associated with particular lexical items, and in fact it can. There are very few morphemes(/allomorphs) that trigger this kind of stress shift: /-ʔ/ (meaning stative or punctual aspect, and marking nouns), /hkwʔ/ meaning former past, and /nʔ/, also marking punctual aspect. The particular behavior I associate with these allomorphs is that they must suffix to a prosodic word, forming a recursive prosodic word structure. Following McCarthy and Prince 1993b, I state this in alignment constraints. These alignment constraints must violate something like Selkirk’s 1995 strict layering constraint.

$$(53) \left\{ \begin{array}{l} \text{ALIGN}(/-ʔ/,L,PWD,R) \\ \text{ALIGN}(/-hkwʔ/,L,PWD,R) \\ \text{ALIGN}(/-nʔ/,L,PWD,R) \end{array} \right\} \gg \text{STRICTLAYERING}$$

The resulting structure is illustrated below using the form in (54). The appearance of stress shift is caused by the fact that NONFINALITY requires a syllable to the right of the stressed one in the local prosodic word. The basic ranking can be seen in tableau 37, with the former past suffix. The recursive Pwd structure is shown in the tree to the right of the tableau – this is the winning output.

(54) /k-nuhweʔ-s-hkwʔ/ ⇨ [k<sup>◻</sup>e.nú:.weʔs.kw<sup>◻</sup>eʔ]

ɪA-like-HAB-FORM ‘I used to like it’





	/wak-nyak-s/	*COMPLEX/SYLLCON	HEADDEP	REND
✗	a. [(wá:).k[e]n.yaks]			**
☞	b. [wa.(k[é]n).yaks]		*	*
	c. [(wák).nyaks]	*!		*

Tableau 39: Penultimate weighted epenthesis: failure

We want to predict penultimate stress, but expect instead antepenultimate stress. One potential problem with using WEIGHTTOSTRESS here can be made very concrete – it would have to outrank HEADDEP in order to prevent stress shift off of heavy epenthetic syllables. Since HEADDEP seems very likely to outrank REND (we just don't have the data to see), this would predict stress shift in certain cases. In particular, with light penultimate syllables and heavy antepenultimate syllables, or heavy epenthetic penultimate syllables with heavy antepenultimate syllables. An instance of the second case is shown in tableau 40:

	/warhhoʔ/	WEIGHTTOSTRESS	HEADDEP	REND
✗	a. [(wár).h[e]r.hoʔ]	**		**
☞	b. [war.(h[é]r).hoʔ]	**	*	*

Tableau 40: Penultimate weighted epenthesis: failure pt. 2

WEIGHTTOSTRESS will have two violations no matter where the stress is – all three syllables are heavy, and only one can be stressed. So it can't determine the position of stress, and therefore HEADDEP must. HEADDEP makes the wrong predictions, as we want penultimate stress.

The reason Alderete can afford to rank HEADDEP lower than REND is exactly because of the discontinuous foot – in any structures that would provide a ranking argument for REND under this account, the right member of a discontinuous foot can be across the epenthetic syllables from the left member, and there is no ranking argument.

If I am incorrect about what the ranking of HEADDEP and REND is likely to be, then an account using WEIGHTTOSTRESS might be usable. But for now I will assume that it is preferable to have some account of the weight alternation.

The account I gave under hypothesis A was that local constraint conjunction of a PARSE- $\mu$  constraint makes it intolerable to leave a heavy syllable unparsed. This can't work either, as it relies crucially on the discontinuous foot. In particular, the epenthetic syllable would have been in the middle of a discontinuous foot, and therefore either parsed into the head foot, or not parsed at all. On a moraic trochaic account, the epenthetic syllable need not be parsed into the head foot, and therefore there is no reason to block stress shift. The problem candidates are (b) and possibly (c) in tableau 41.

	/wak-nyak-s/	P $\mu$ & $\sigma$ P $\mu$	HEADDEP	PARSE- $\mu$
	a. [(wá:).k[e]n.yaks]	*!		**
✗	b. [(wá:).(k[e]n).yaks]			**
✗	c. [(wá:).k[e]n).yaks]			**
☞	d. [wa.(k[é]n).yaks]		*!	*

Tableau 41: Penultimate weighted epenthesis: underparsing

Though this can't be imported directly, I will frame the moraic trochaic analysis along similar lines. The basic observation is that we never see a long epenthetic [e] or [a] in Mohawk. In fact, it is a strong typological generalization that epenthetic vowels don't lengthen. Therefore, what is actually the marked element is a long epenthetic vowel. If stress were to fall on an epenthetic vowel, it would have to be lengthened, and this isn't allowed.<sup>12</sup> I will treat this formally by local conjunction of DEP $\mu$ :

<sup>12</sup>Hagstrom 1997 reports a similar idea in an unpublished 1995 manuscript by Hajime Ikawa. I have not seen this manuscript, but Hagstrom reports that it does not account for the lack of antepenultimate lengthening.



		/te-k-riks/	REND	FtHdR
☞	a.	[(té.k[e]).riks]	*	*
	b.	[(té:).k[e].riks]	**!	

Tableau 44: Stress shift: heavy-light trochee is pathological, part 1

The second way of getting antepenultimate lengthening involves a pathological  $\acute{H} \acute{L}$  trochee. Such trochees are quite uncommon typologically, and are predicted to be uncommon by the Iambic/Trochaic law. Languages even will resolve such situations by “trochaic shortening” (Mester 1994). In §2.2.2 I’ve already introduced the FtMAX constraint to cover this, and it comes back here. The following tableau demonstrates the effect of FtMAX to prevent lengthening. (We need not assume that STRESSToWEIGHT is even active, but if it is, the following ranking is what we’d find.)

		/te-k-riks/	FtMAX	STRESSToWEIGHT
☞	a.	[(té.k[e]).riks]		*
	b.	[(té:).k[e].riks]	*!	

Tableau 45: Stress shift: heavy-light trochee is pathological, part 2

This is the key point: Mohawk is a moraic trochaic language, but a heavy one-syllable foot is preferred, so a real trochee never surfaces except in the case of stress shift. When we do have stress shift, we find a  $\acute{L} \acute{L}$  trochee.

Analytically, this is a direct consequence of triggering lengthening by FtBIN, instead of STRESSToWEIGHT – the key difference between syllabic and moraic trochaic system in OT. In a system where lengthening is triggered by STRESSToWEIGHT (either trochaic or iambic), the lack of lengthening is completely inexplicable, and it was basically this concern that led to Hagstrom 1997’s treatment of epenthetic vowels as semisyllables. On the present analysis I address this concern without resorting to non-standard prosodic structures, and in fact the situation in Mohawk is something that is clearly predicted by straightforward assumptions about what kind of stress systems there can be.

Finally, the problem cases for the syllabic trochaic hypothesis can now be explained straightforwardly. These involve final and penultimate epenthesis, with antepenultimate stress. The surprise, for other approaches, is that there is lengthening on the stressed syllable. On the present account this lengthening is straightforwardly predicted. Final epenthesis involves suffixation to a small prosodic word, and so stress is actual Pwd-penultimate. This is entirely unsurprising despite the Pwd-final epenthesis; NONFINALITY ensures stress no later than the third syllable from the end, and the Pwd-final epenthesis is irrelevant. The result is shown in tableau 46, assuming satisfaction of NONFINALITY.

		/t-a-w-aresr-ʔ/	FtBIN	REND	FtHdR
☞	a.	[{{tu.(ré:).s[e].r[e]ʔ}}		*	
	b.	[{{(tú:).re.s[e].r[e]ʔ}}		**!	
	c.	[{{(tú.re).s[e].r[e]ʔ}}		*	*!

Tableau 46: Problem cases for syllabic trochees explained

At this point, it is clear that the moraic trochaic account of Mohawk stress and epenthesis is a very successful one. The patterns of both weightlessness and lengthening are straightforwardly accounted for, and no new assumptions about prosodic structure are required. The analysis is almost complete, but there are two loose ends I would like to tie up first.

In this section I deal with two loose ends: the joiner vowel, and the fact that prothetic [i] is traditionally taken to act as if it's underlying with respect to stress assignment.

## 7.1 Joiner vowel

The joiner vowel behaves almost like epenthetic [e] with respect to stress shift – it is stressed in penultimate closed syllables, and not stressed in penultimate open syllables. The major difference is in the presence of lengthening in this second case. Two such examples are given in (61):

- (61) a. /te-hs-aʔar-rik-ø/ ↦ [teh.sa.ʔá:r[a].rik] DU-2A-curtain-put.together-IMP  
 ‘Close the curtains (lit. put the curtains together)’  
 b. /waʔ-k-wʌn-r-hkw-ʔ/ ↦ [waʔ.k[e].wá:n[a].r[a].h.kw[e]ʔ] FACT-1A-voice-fill.in-INST-PUNC  
 ‘I obey’

The expected stress pattern, given the behavior of epenthetic [e], would be for the stressed vowel in each case to lengthen. This is shown for (61a) in tableau 47. We want to predict candidate (a), but unfortunately it is (b) that is currently predicted.

	/te-hs-aʔar-rik-ø/	DEP <sub>μ</sub> & σ DEP <sub>μ</sub>	REND	FTHDR
✓	a. [teh.sa.(ʔá:r[ <u>a</u> ].rik]		*	*
✗	b. [teh.sa.(ʔá:r[ <u>a</u> ].rik]		**!	
	c. [teh.sa.ʔa.(r[ <u>á:</u> ].rik]	*!	*	

Tableau 47: Stress shift: joiner vowel problems

It is clear that the joiner vowel behaves almost, but not quite, homogeneously with epenthetic [e]. In the analysis developed here, this can't be because it is a different process – in fact, I have argued that it is really the same process. The major difference between the two epentheses, in my account, is that there is a larger morphological category break in positions where we find the joiner vowel. This difference I will also use to derive the lengthening effects above.

There are two converse ways of looking at the problem. The simplest is that stems, in Mohawk, prefer to align to the right edges of feet. Since the joiner vowel appears in a no-man's-land between stems, it is preferentially going to not be footed with the stressed syllable, because increasing the foot's size would increase alignment violations. The other way of looking at the problem is that feet prefer not to span stem breaks – they have to consist of material entirely from one stem. I will go with the first one.

- (62) ALIGN-R(FT, STEM)

Assess a violation mark for every foot boundary that is not at the right edge of a stem.

It is immediately clear that this constraint must be outranked NONFINALITY. What is less obvious at first glance is that it need not be outranked by REND.<sup>13</sup> We certainly want to block stress shift to final position to satisfy this constraint, but NONFINALITY is all that's needed to do so, not REND. Tableau 48 shows this ranking.

<sup>13</sup>Thanks to Jesse Kirchner for discussion on this point.

	/hra-kw-as/	NONFINALITY	ALIGN-R(F <sub>T</sub> , STEM)
☞	a. [(rák).was]		*
	b. [rak.(wás)]	*!	

Tableau 48: Extrametricality

The interaction of this constraint with stress shift is shown in tableau 49. Note that there is no ranking of ALIGN-R(F<sub>T</sub>, STEM) with DEP<sub>μ</sub> & σ DEP<sub>μ</sub> – it is simply shown as ranked here for notational convenience.<sup>14</sup>

	/te-hs-aʔar-rik-ø/	ALIGN-R(F <sub>T</sub> , STEM)	DEP <sub>μ</sub> & σ DEP <sub>μ</sub>	REND	F <sub>T</sub> HDR
☞	a. [teh.sa.(ʔá:).r[ <u>a</u> ].rik]			**	
	b. [teh.sa.(ʔá.r[ <u>a</u> ]).rik]	*!		*	*
	c. [teh.sa.ʔa.(r[ <u>á:</u> ]).rik]	*!	*	*	
	d. [teh.(sá.ʔa).r[ <u>a</u> ].rik]			**	*!

Tableau 49: Stress shift: joiner vowel solutions

This tableau basically exploits an emergence of the unmarked effect, heavy syllable feet being the least marked foot structure in Mohawk.

This explanation of lengthening in joiner-vowel stress shift reduces the effect to the same difference that drives the vowel choice in epenthesis – the presence of a major morphological category break. When a vowel is epenthesized outside a stem, it becomes [a], and it also can't be footed with a stressed vowel inside a preceding stem.

## 7.2 Prothesis, stress, and lengthening

Prothetic [i] can bear stress, and even more surprisingly, it can lengthen. Recall from §3.1 that this vowel appears to prevent subminimal words – in the present account, in order for NONFINALITY to be satisfied. This can be derived straightforwardly given only a few more assumptions.

When prothetic [i] appears in a heavy syllable, there is no problem, and it doesn't lengthen. This is shown in tableau 50 – no candidate violates DEP<sub>μ</sub> & σ DEP<sub>μ</sub>.

	/k-kʌ-s/	NONFINALITY	DEP <sub>μ</sub> & σ DEP <sub>μ</sub>	DEP
☞	a. ([ <u>i</u> ].k).kus			*
	b. (kkús)	*!		

Tableau 50: Prothesis: closed syllable

The moraic trochaic account also works well when prothesis is triggered by epenthetic penultimate [e] in a short word. This is shown in tableau 51. The winning candidate involves a light-light trochee, with both vowels epenthetic. The real competitor is (c), with penultimate lengthening of a stressed vowel. We don't find this, because prothesis is preferred.

	/hs-ri-ht-ø/	NONFINALITY	DEP <sub>μ</sub> & σ DEP <sub>μ</sub>	DEP
☞	a. ([ <u>i</u> ].s[ <u>e</u> ]).riht			**
	b. (s[ <u>e</u> ]).riht	*!		*
	c. (s[ <u>e:</u> ]).riht		*!	*

Tableau 51: Prothesis and stress shift

<sup>14</sup>However, if a reason were found to rank ALIGN-R(F<sub>T</sub>, STEM) higher, we would also now have a ranking argument for REND being below DEP<sub>μ</sub> & σ DEP<sub>μ</sub>. If it is the other direction, there is no ranking argument.

The case where we need more assumptions comes in with prothesis resulting in an open syllable. Here we find lengthening, and this is somewhat unexpected. A form like /w-e-ʔs/ ('she/it is walking around') surfaces as [(<sup>í</sup>i).weʔs]. The candidate [(<sup>í</sup>i).weʔs] can be straightforwardly blocked by NONFINALITY, but the real competitor on this analysis is the pathological looking [(<sup>í</sup>i).i].weʔs]. The most obvious ways of ruling out this double epenthesis are not available, given the ranking we already have. I will rule it out using a constraint \*V.V against hiatus. Some vowel-vowel sequences do surface in Mohawk, but in general most (which appear at morpheme boundaries) are resolved by syncope (Hopkins 1987), so it seems quite plausible that such a constraint is active and relatively high-ranked in Mohawk. Such sequences are never resolved by epenthetic consonants, crucially. The effect can be seen in tableau 52 (NONFINALITY is not ranked relative to the conjoined constraint, though \*V.V is).

	/w-e-ʔs/	NONFINALITY	*V.V	DEP <sub>μ</sub> & <sub>σ</sub> DEP <sub>μ</sub>	DEP
a.	[( <sup>í</sup> i).weʔs]			*	*
b.	[( <sup>í</sup> i).weʔs]	*!			*
c.	[( <sup>í</sup> i).i].weʔs]		*!		**

Tableau 52: Prothesis: open syllables

Even if this isn't the right way to block candidate (c), it seems clear that we'd want to somehow – there are many cases of epenthetic vowels which resolve minimal word requirements, but I know of no cases of epenthetic trochees to do so. Also, to capture the fact that we don't get an epenthetic consonant to resolve hiatus, we'd need to split DEP into DEP-C and DEP-V, and rank DEP-C much higher than where it appears now. At this point a question appears about what the difference between DEP-V and DEP<sub>μ</sub> might be. The difference shows up primarily when conjoined, as long vowels would not trigger a self-conjoined DEP-V violation. If DEP-V were simply replaced with DEP<sub>μ</sub> everywhere, I do not see any problems.

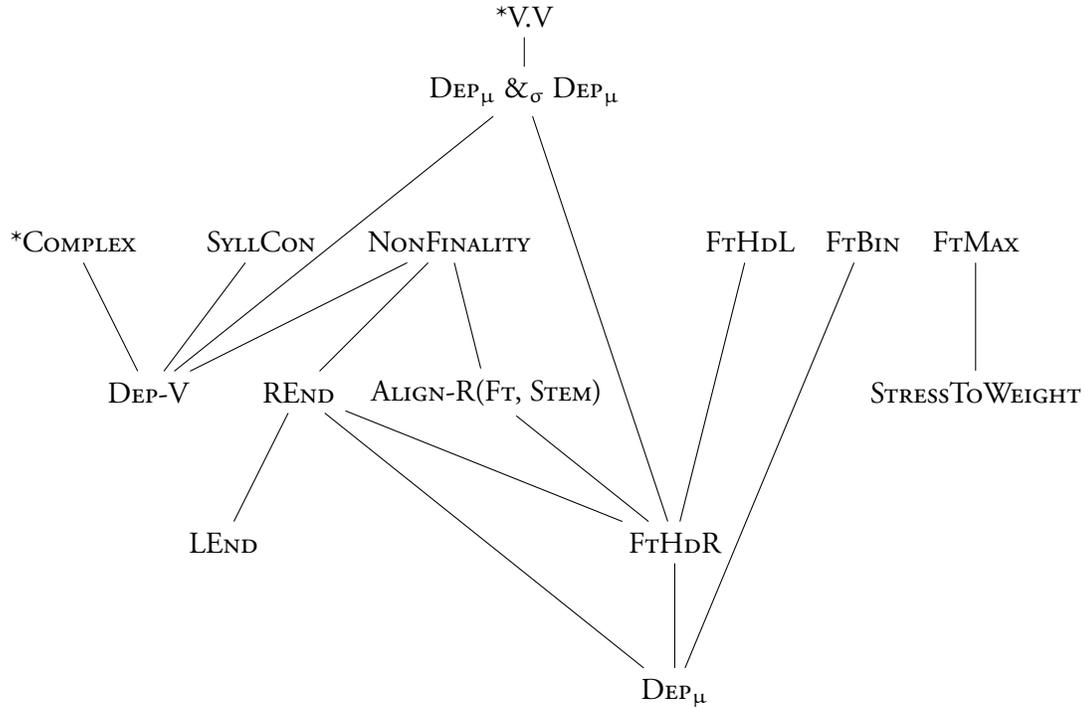
The appearance of prothetic [i] as an underlying vowel requires only one further assumption – that candidate (c) in tableau 52 is pathological and should be blocked somehow. Otherwise, the length alternations of this vowel are entirely expected on the moraic trochaic account.

### 7.3 Final Rankings

The final rankings for this analysis are given in (63). I haven't included the suffixation-to-Pwd rankings, as they are morpheme specific and straightforward, and I haven't included the vowel choice rankings, which are also straightforward.

(63) **Moraic Trochaic final rankings**

- NONFINALITY » RE<sub>ND</sub>, ALIGN-R(F<sub>T</sub>, STEM)
- RE<sub>ND</sub>, ALIGN-R(F<sub>T</sub>, STEM), DEP<sub>μ</sub> &<sub>σ</sub> DEP<sub>μ</sub>, FT<sub>HDL</sub> » FT<sub>HDR</sub>
- RE<sub>ND</sub> » LE<sub>ND</sub>
- RE<sub>ND</sub>, FT<sub>HDR</sub>, FT<sub>BIN</sub> » DEP<sub>μ</sub>
- FT<sub>MAX</sub> » STRESS<sub>TO</sub>WEIGHT
- \*COMPLEX, SYLLCON, NONFINALITY, DEP<sub>μ</sub> &<sub>σ</sub> DEP<sub>μ</sub> » DEP



## 8 CONCLUDING REMARKS

I have developed an analysis of Mohawk as a moraic trochaic language, with an interesting property: two-syllable trochees don't normally surface. It is only in the interaction with epenthesis that we see them surface, in forms like [(t<sup>é</sup>.ke).riks]. This is the explanation for the lack of lengthening preceding an epenthetic vowel – no lengthening is needed, as a perfectly good trochee has already been constructed. The moraic trochaic account is extremely successful in accounting for the length alternations in Mohawk, alternations which have previously been an extremely difficult fact to deal with. No unusual prosodic structures are required. Hagstrom 1997 required semisyllables to deal with the length facts, but we have seen from this analysis that only regular syllables are necessary. Alderete 1995 and Piggott 1995 required discontinuous feet to account for word-final weightless vowels, but I have argued that these are better accounted for via suffixation to prosodic words.

Previously, Mohawk has been taken to be a syllabic trochaic language with stressed-syllable lengthening. As such, it was one of only a few exceptions to a strong typological generalization: stressed syllables lengthen in iambic languages. (cf. Hayes 1995 §4.5.3). However, the prevalence of long stressed vowels is an illusion, and follows simply from the rarity of  $\bar{L}L$  trochees under normal circumstances. Mohawk is an exception no longer. Though the interaction with epenthesis is complicated, Mohawk now looks like a relatively normal moraic trochaic language – a significant improvement in our understanding of stress systems in Iroquoian languages.

## BIBLIOGRAPHY

- John Alderete. Faithfulness to prosodic heads. Manuscript, UMass Amherst, 1995.  
 John Alderete. Faithfulness to prosodic heads. In Ben Hermans and Marc van Oostendorp, editors, *The Derivational Residue in Phonological Optimality Theory*, pages 29–50. John Benjamins Publishing Company, 1999.

- Jill Beckman. Positional faithfulness, positional neutralization, and Shona height harmony. *Phonology*, 14 (1):1–46, 1997.
- Jill Beckman. *Positional Faithfulness*. Doctoral dissertation, University of Massachusetts, Amherst, 1998.
- Stuart Davis and Seung-Hoon Shin. The syllable contact constraint in Korean: An optimality-theoretic analysis. *Journal of East Asian Linguistics*, 8:285–312, 1999.
- Maria Gouskova. Falling sonority onsets, loanwords, and syllable contact. In *CLS 37*, pages 175–185. Chicago Linguistics Society, 2001.
- Maria Gouskova. Relational hierarchies in OT: the case of syllable contact. *Phonology*, 21(2):201–250, 2004.
- Paul Hagstrom. Contextual metrical invisibility. In *MITWPL 30*. MIT Press, 1997.
- Morris Halle and George Clements. *Problem Book in Phonology*. The MIT Press, 1983.
- Bruce Hayes. *Metrical Stress Theory*. The University of Chicago Press, 1995.
- Joan Hooper. *An Introduction to Natural Generative Phonology*. Academic Press, New York, 1976.
- Alice Hopkins. Vowel dominance in Mohawk. *International Journal of American Linguistics*, 53(4):445–459, 1987.
- Junko Ito and Armin Mester. Realignment. In R. Kager, H. v.d. Hulst, and W. Zonnefeld, editors, *Proceedings of the Utrecht Workshop on Prosodic Morphology*, pages 188–217. Mouton, 1999.
- Paul Kiparsky. Opacity and cyclicity. *The Linguistic Review*, 17:351–367, 2000.
- Paul Kiparsky. Syllables and moras in Arabic. In C. Fery and R. Vijver, editors, *The Syllable in Optimality Theory*. Cambridge University Press, 2002.
- Floyd Lounsbury. *Phonology of the Oneida Language*. M.A. thesis, University of Wisconsin, 1942.
- John McCarthy and Alan Prince. Generalized alignment. In G. Booij and J. van Marle, editors, *Yearbook of Morphology 1993*, pages 79–153. Kluwer, 1993a.
- John McCarthy and Alan Prince. Prosodic morphology: Constraint interaction and satisfaction, 1993b. Technical Report #3 of the Rutgers University Center for Cognitive Science.
- Armin Mester. The quantitative trochee in Latin. *Natural Language and Linguistic Theory*, 12(1):1–62, 1994.
- Karin Michelson. *A Comparative Study of Lake-Iroquoian Accent*. Studies in Natural Language and Linguistic Theory. Kluwer Academic Publishers, 1988.
- Robert Murray and Theo Vennemann. Sound change and syllable structure in Germanic phonology. *Language*, 59(3):514–528, 1983.
- G. L. Piggott. Epenthesis and syllable weight. *Natural Language and Linguistic Theory*, 13(2):283–326, 1995.
- Paul Postal. *Aspects of Phonological Theory*. Harper and Row, 1968.
- Paul Postal. Mohawk vowel doubling. *International Journal of American Linguistics*, 35:291–298, 1969.
- Alan Prince and Paul Smolensky. Optimality theory: constraint interaction in generative grammar. Technical Report 2, Rutgers University Center for Cognitive Science, 1993.
- Geoffrey K. Pullum. The Duke of York gambit. *Journal of Linguistics*, 12:83–102, 1976.
- Grazyna Rowicka. *On Ghost Vowels: A strict CV approach*. PhD dissertation, Universiteit Leiden, 1999.
- Elisabeth Selkirk. The prosodic structure of function words. In James Morgan and Katherine Demuth, editors, *Signal to Syntax: Bootstrapping from Speech to Grammar in Early Acquisition*, pages 187–214. Erlbaum Associates, 1995.
- Adam Ussishkin. *The emergence of fixed prosody*. PhD thesis, UC Santa Cruz, 2000.