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Contextual metrical invisibility[*]

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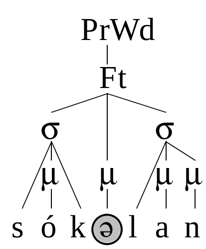
This paper investigates a stress phenomenon which I refer to as "contextual metrical invisibility" in several languages, the primary examples being from Mohawk and Passamaquoddy. In each of these languages, there is a class of vowels which are, in certain contexts but not in others, invisible to syllable-sensitive processes. The proposal I make is that such vowels, which I refer to as "weak vowels," are invisible to syllable-sensitive processes by virtue of not being dominated by a syllable node in the prosodic structure. For illustration, consider the Passamaquoddy word in (1a).[1] In Passamaquoddy, the penultimate syllable of a word is generally stressed, yet in (1a), it is the antepenultimate vowel which surfaces with stress. If the structure of this word is as shown in (1b), however, it is still true that the penultimate *syllable* is stressed, due to the fact that the word-medial vowel is not dominated by a syllable node. That is, stress assignment is a syllable-sensitive process to which the weak vowel ə is invisible in this structure.

(1) a. sókəlan 'it pours (rain).' [Passamaquoddy]

b.



I will propose in section 3 that configurations such as that shown in (1b) arise from a pressure to avoid having weak vowels as syllable heads, which I suggest ultimately derives from pressure to avoid adding structure to the representation not present in the underlying form. This means that a vowel is weak if it is not underlyingly associated to a syllable.

[*] The material in this paper expands a subset of my MIT Phonology Generals paper (from which much of section 2 on Passamaquoddy was derived). I wish to thank Phil LeSourd particularly for his extensive commentary (and skepticism). Thanks also to Benjamin Bruening, San Duanmu, Morris Halle, Michael Kenstowicz, David Pentland, David Pesetsky, Ken Wexler, Cheryl Zoll, the Fall 1994 Phonology/Morphology workshop, the Fall 1996 Topics in Phonology course, the MIT Phonology Circle, and the Post-Generals Workshop attendees for helpful suggestions, comments, and discussions at all stages of this project. Any errors which remain are my own.

[1] Data sources are listed at the end of the paper.

We will formulate the analysis by looking in detail at metrical invisibility in Mohawk (section 1) and Passamaquoddy (section 2), later considering alternative proposals in the literature (section 4), and then finishing with extensions of this approach to Dutch, Indonesian, and Winnebago (section 6).

1 Mohawk

We begin our investigation with Mohawk, a Northern Iroquoian language, spoken mainly in New York, Ontario, and Québec. Our interest in the Mohawk stress system lies in the fact that epenthetic vowels are taken into consideration for stress placement only in certain contexts.[2]

1.1 Normal stress pattern of Mohawk

In (2), I list three generalizations about Mohawk prosody which I take to be correct. We will work through these generalizations in order, but notice at the outset that each is sensitive to syllables.

(2) Mohawk: Prosodic generalizations
- a. Stress falls on the penultimate syllable (not quantity sensitive)
- b. A stressed syllable must be heavy (CV: or CVC).
- c. A word must consist of two syllables.

The first generalization (2a) is that Mohawk words have only a single stress, which surfaces on the penultimate syllable. This pattern is shown by the examples in (3-4).[3,4]

(3)	a.	wakharatatuhátye	/wak-haratat-u-hatye/	‘I go along lifting up’
	b.	rákwas	/hra-kw-as/	‘He picks it’
	c.	katirúthaʔ	/k-atirut-haʔ/	‘I pull it’
	d.	kohárhaʔ	/k-ohar-haʔ/	‘I attach it’
	e.	kataʔkeráhkwaʔ	/k-ataʔkerahkw-haʔ/	‘I float’
	f.	kóʔkwats	/k-oʔkwat-s/	‘I dig’
	g.	tékyaʔks	/te-k-yaʔk-s/	‘I break it in two’

[2] This aspect of Mohawk phonology has received some attention in the literature. Bonvillain 1973 and Beatty 1974 provide a descriptive view of Mohawk grammar. Michelson (1988) gives a very detailed overview of the stress systems of a range of Lake-Iroquoian languages. Postal 1969, Broselow 1982, Michelson 1988, 1989, Piggott 1995, Potter 1994, Alderete 1995b, and Pizer 1997 all contain alternative analyses of the Mohawk stress patterns. Comparisons to alternative accounts will be postponed until section 4.

[3] Long vowels in the Mohawk examples are indicated by a colon. Epenthetic vowels are indicated by italics, and a grave accent indicates a falling tone.

[4] A small number of cases have final stress, including *takó:s* ‘cat’, *istá* ‘mother’ (Beatty 1974:21), and *aplám* ‘Abraham’ (Bonvillain 1973:39). I assume that the stress pattern of these forms is lexically specified, and I disregard such examples from here on.

(4)	a.	wakashé:tu	/wak-ashet-u/	'I have counted it'
	b.	kakʌʔroké:was	/k-akʌʔrokew-as/	'I am dusting'
	c.	khyá:tus	/k-hyatu-s/	'I write'
	d.	khará:tats	/k-haratat-s/	'I am lifting it up a little (with a lever)'

The second generalization (2b) states that a stressed syllable must be heavy (TONIC LENGTHENING). We can see this in the examples in (4), where the stressed syllable is open and the vowel is lengthened. Only the stressed vowel is ever long in Mohawk. Notice that in (3), the stressed vowel does not lengthen, indicating that closed syllables count as heavy.[5]

Stress placement itself does not appear to be quantity-sensitive. The examples given above were chosen to illustrate that stress falls on the penultimate syllable regardless of whether the final syllable is open (3a, 4a), closed (3b-e, 4b-c), or even closed by two (3f, 4d) or three (3g) consonants.

Another aspect of Mohawk phonology which is sensitive to syllables is the minimal word requirement (2c). Wherever a word would otherwise have surfaced with fewer than two syllables, a prothetic *i* is inserted, as we see in (5). Again, notice that the number of final consonants has no effect.[6]

(5)	a.	*í*kyʌs	/k-yʌ-s/	'I put it'
	b.	*í*ktats	/k-tat-s/	'I offer it'
	c.	*í*:keks	/k-ek-s/	'I eat'
	d.	*í*kyaʔks	/k-yaʔk-s/	'I cut it'

1.2 Epenthetic e

Mohawk has two epenthetic vowels which appear to disobey the prosodic generalizations discussed above. We will begin by looking at the epenthetic *e*, which is inserted in the contexts listed below in (6).[7,8]

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[5] Beatty (1974:21) notes rare exceptions to tonic lengthening before a single consonant, including *ísiʔ* 'there' (cf. *í:seʔ* 'you').

[6] Michelson explicitly refers to verb forms when describing prothesis, which suggests that other categories may not necessarily meet the bisyllabic requirement (thanks to Phil LeSourd for bringing this to my attention). I have come across a very few monosyllabic words, including *jíks* 'fly', *wísk* 'five', and *hʌ́* 'yes' (Bonvillain 1973:31-34). The proper way to limit "minimal word" requirements to the verb paradigm is not my concern here, however, since we will use prothesis mainly as a diagnostic for syllable structure.

[7] Michelson writes of epenthetic *e* that its "phonetic realization is identical to the phonetic realization of underlying /e/" (1989:40) and that "(1) the [epenthetic] *e* is never reduced to a schwa, and it is certainly never deleted; (2) speakers consistently write the *e* and have always done so." (1989:68). The epenthetic "joiner vowel" *a* (to be discussed later) is similarly phonetically indistinguishable from underlying /a/ (Michelson 1988:132).

[8] Michelson (1989:57) notes that not all vowels which disobey the prosodic generalizations are convincingly epenthetic. This will be an important observation later (section 4.1); epenthetic vowels can disrupt the prosody, but not all disruptions of prosody are attributable to epenthesis.

(6) Contexts in which epenthetic *e* is inserted (MOHAWK)
- a. Between a consonant and a single sonorant (C*e*{*nrw*})
- b. Between a consonant and a word-final glottal stop.
- c. After a consonant when followed by a consonant cluster (except *h*C and *s*C).

In the first context (6a), *e* is inserted to break up underlying consonant-sonorant sequences, as shown in (7).[9] Notice that in each of these examples, stress surfaces not on the penultimate vowel, but earlier in the word, on the antepenultimate (7a-d) or even on the preantepenultimate (7e) vowel. For the purposes of stress assignment, the epenthetic *e* is invisible; stress surfaces on the penultimate *underlying* vowel. The examples in (8) make the same point for epenthetic *e* in the second insertion context (6b), which interrupts word-final consonant-glottal stop sequences.

(7)	a.	ʌ́k*e*rʌʔ	/ʌ-k-r-ʌ-ʔ/	'I will put it into a container'
	b.	ték*e*riks	/te-k-rik-s/	'I put them together'
	c.	tʌkahsút*e*rʌʔ	/t-ʌ-k-ahsutr-ʌʔ/	'I will splice it'
	d.	wák*e*ras	/w-akra-s/	'it smells'
	e.	waʔtkatát*e*nak*e*ʔ	/waʔ-t-k-atat-nak-ʔ/	'I scratched myself'

(8)	a.	ʌká:rat*e*ʔ	/ʌ-k-arat-ʔ/	'I lay myself down'
	b.	rokú:tot*e*ʔ	/ro-kut-ot-ʔ/	'he has a bump on his nose'
	c.	waʔtkatát*e*nak*e*ʔ	/waʔ-t-k-atat-nak-ʔ/	'I scratched myself'
	d.	tʌ́k*e*rik*e*ʔ	/t-ʌ-k-rik-ʔ/	'I'll put together side by side'
	e.	ón*e*raht*e*ʔ	/o-nraht-ʔ/	'leaf'
	f.	tʌ́:k*e*hkw*e*ʔ	/t-ʌ-k-hkw-ʔ/	'I'll lift it'

The third context in which epenthetic *e* appears (6c) is different. Here, *e* is inserted in order to permit proper syllabification of underlying sequences of three or more consonants. As we see in (9), the epenthetic vowel is metrically *visible* in this context; it acts just like an underlying vowel, both stressable and counted in the determination of penultimate position.

(9)	a.	wak*é*nyaks	/wak-nyak-s/	'I get married'
	b.	s*é*rhos	/s-rho-s/	'you coat it with something'
	c.	tekahsut*é*rhaʔ	/te-k-ahsutr-haʔ/	'I splice it'
	d.	skáhk*e*ts	/s-k-ahkt-s/	'I got back'
	e.	sasáhk*e*t	/sa-s-ahkt/	'go back!'

[9] In these and all future examples, a vowel is underlined to indicate that it is metrically invisible.

Where an epenthetic *e* is invisible for stress placement, it is also invisible with respect to other syllable-sensitive effects, such as the minimal word requirement and tonic lengthening. Recall from (5) that a prothetic *i* appears where necessary to ensure a word of at least two syllables. However, in (10) we find a prothetic *i* despite the fact that two (10a) or even three (10b, c) other surfacing vowels are present.

(10)	a.	*íseriht*	/hs-ri-ht-Ø/	‘cook!’
	b.	*ítenehreˀ*	/t-n-ehr-ˀ/	‘you and I want’
	c.	*ítewehreˀ*	/t-wa-ehr-ˀ/	‘you and I want to’

Importantly, where an epenthetic *e* counts for stress placement, it counts for the minimal word requirement as well. We can see this by comparing (10a) *íseriht* with (9b) *sérhos*. In (9b), where the epenthetic *e* is metrically visible, no prothetic *i* is inserted: **íserhos*.[10]

The same correlation holds between visibility for stress placement and the ability to syllabify neighboring consonants. Recall from (4) that because stressed syllables must be heavy, vowels lengthen in stressed open syllables. As we can see in (11), however, where a metrically invisible epenthetic *e* follows the stressed syllable, the stressed vowel fails to lengthen. This failure to lengthen indicates that the stressed syllable is already heavy by virtue of being closed. In these cases, then, the consonant preceding the metrically invisible *e* is a coda to the stressed syllable, indicating that the *e* is also invisible for the purposes of syllabifying neighboring consonants.

(11)	a.	ték*e*riks	/te-k-rik-s/	‘I put them together’
	b.	tʌkahsút*e*rʌˀ	/t-ʌ-k-ahsutr-ʌˀ/	‘I will splice it’
	c.	wák*e*ras	/w-akra-s/	‘it smells’
	d.	waˀtkatát*e*nak*e*ˀ	/waˀ-t-k-atat-nak-ˀ/	‘I scratched myself’
	e.	tʌ́k*e*rik*e*ˀ	/t-ʌ-k-rik-ˀ/	‘I’ll put together side by side’
	f.	ón*e*raht*e*ˀ	/o-nraht-ˀ/	‘leaf’

*1.3 “Weak vowels” and *WEAKPEAK*

The analysis of Mohawk which I advocate here takes the invisibility of certain vowels to syllable-sensitive processes as an indication that such vowels are not in fact part of a syllable.[11] I formalize this as a constraint on the prosodic repre-

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[10] Notice that this argues against an interpretation of prothesis as “insert[ing] an *i* initially in verb forms which have fewer than two underlying vowels” (Michelson 1981:317); this would predict **íserhos* for (9b).

[11] Potter (1994:354) independently reaches a similar conclusion, based also on the Mohawk data. He tentatively states that “assuming that stress is the result of incorporation into foot structure, ... my informal hypothesis is that in the absence of mitigating factors, the moraic node of [an epenthetic] vowel is not dominated by a syllable node, and only syllables are incorporated into foot structure.” The proposal which I advocate here, while differing from Potter’s in various crucial ways, can still be considered to be a formalization of his idea.

sentation which discourages the use of a "weak vowel," such as the Mohawk epenthetic *e*, as a syllable nucleus. The constraint, called *WEAKPEAK, is given in (12).[12]

(12) *WEAKPEAK — A weak vowel is prohibited from being a syllable peak.

I take *WEAKPEAK to be one of a set of several constraints on the prosodic structure, all ranked with respect to one another within a system where satisfaction of a higher ranked constraint may force violations of conflicting but lower-ranked constraints. Specifically, I will formalize these interactions in the terminology of Optimality Theory (Prince & Smolensky 1993, and much subsequent literature). I also assume that prosodic structure is organized in a hierarchy of prosodic categories, shown in (13), essentially following Selkirk (1984).[13] Stress is taken to be an interpretive reflex, appearing on syllables which head a foot in the prosodic structure.

(13)

Prosodic Word (PrWd)
|
Foot (Ft)
|
Syllable (σ)
|
Mora (μ)
|
Melodic/segmental material

One thing we know about *WEAKPEAK from the discussion above is that it can be violated in certain circumstances. In particular, where an epenthetic *e* breaks up an underlying cluster of three consonants, it heads a syllable, in violation of *WEAKPEAK. This tells us that constraints which ensure proper syllabification take priority over *WEAKPEAK. The syllabification constraints which I take to be active are given in (14-15).

(14) PROPERSYLL — No complex onsets or codas—except *kw* or if they contain *s* or *h*. (MOHAWK)

(15) PARSE-C — An underlying consonant must be parsed in the output.

The first of the syllabification constraints, PROPERSYLL, requires syllables to be from the inventory of allowable syllables in Mohawk.[14] The other syllabifica-

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[12] In section 3, *WEAKPEAK will be replaced by more basic constraints, but until then we will continue to use *WEAKPEAK for presentational purposes.

[13] I do not, however, adopt the "Strict Layering Hypothesis," as will be discussed in detail shortly; I assume that prosodic structure is "weakly layered" (Itô & Mester 1992).

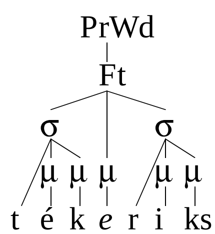
[14] To adequately describe the constraints and issues involved in deriving the "cover constraint" PROPERSYLL from better motivated and more fundamental constraints would require a lengthy digression which is irrelevant to the issues at hand. I therefore leave

tion constraint, PARSE-C, requires that all underlying consonants be incorporated into the prosodic structure in the output.

To see how the three constraints introduced so far interact, consider the two words illustrated in (16).[15] The word in (16a) contains an epenthetic *e*, a weak vowel subject to the *WEAKPEAK constraint. Because the consonants flanking *e* can be incorporated into the surrounding syllables, all of the constraints discussed so far—including *WEAKPEAK—can be satisfied by a prosodic structure in which *e* is not dominated by a syllable node.

By contrast, the fact that a consonant cluster follows the weak vowel in (16b) sets up a conflict between *WEAKPEAK and the syllabification constraints. There are three relevant possibilities in this situation. If *WEAKPEAK is to be satisfied, one of the syllabification constraints must be violated, either by deleting one of the consonants—in violation of PARSE-C—or by forming a complex onset with the consonants *ny*—in violation of PROPERSYLL. Empirically, we see that in this situation, *WEAKPEAK gives way, resulting in a metrically visible epenthetic vowel. This means that the syllabification constraints take priority over *WEAKPEAK, as I indicate by ranking them in (17).

(16) a. ték*e*riks

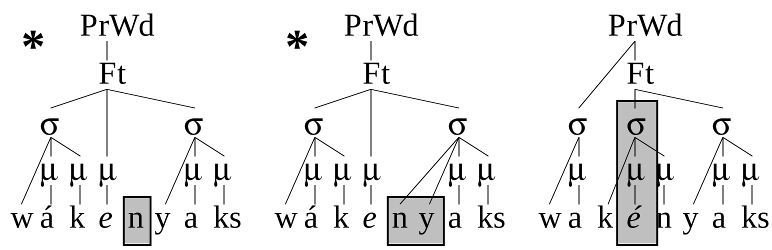


√: *WEAKPEAK
√: PROPERSYLL
√: PARSE-C

PROPERSYLL as a statement of the syllabification restrictions. Michelson (1981) provides evidence that *kw* and *ts* sequences can be syllable onsets, citing *rú:kwe* 'man' and *onú:tsiʔ* 'head' (Michelson 1981:315); the fact that the stressed vowel is lengthened indicates that it is in an open syllable. Michelson (1989:42) notes that *ChC* and *CsC* clusters are not broken up by epenthetic *e*, further indicating the special properties of *s* (and *h*) with respect to syllabification. Words ending in *Cs* sequences (e.g. (11a) *tékeriks*) suggest that *Cs* can be a coda as well as an onset (cf. *onú:tsiʔ*).

[15] In the diagrams in (16), I have depicted the final *Cs* cluster as a single complex segment, but I do not intend by this depiction to be making any strong claims about how the *s* is incorporated into the prosodic structure in these exceptional instances. It will turn out to be crucial later (in (64)) that *s* not be represented as a syllable appendix, but how *Cs* clusters are properly represented remains an open question. One possibility is that *Cs* actually represents a complex segment, like the analysis of English *s*-stop clusters argued for in some detail by Lamontagne (1993, ch. 6). This special status may result from constraints based on phonetic salience, along the lines explored by Côté (1997).

b. wak*é*nyaks



√ : *WeakPeak	√ : *WeakPeak	(*): *WeakPeak
√ : ProperSyll	(*): ProperSyll	√ : ProperSyll
(*): Parse-c	√ : Parse-c	√ : Parse-c

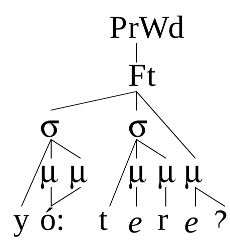
(17) Parse-c, ProperSyll >> *WeakPeak

Consider what this means for a consonant trapped between two weak vowels, as in (18). Because the trapped consonant must be incorporated into a syllable, only one of the weak vowels can be metrically invisible.

(18) b. yó:t*ere̲*ʔ /yo-t-r-ʔ/ 'it's in the dish/glass'
a. tewakahsú:t*ere̲*ʔ /te-wak-ahsutr-ʔ/ 'I have spliced it'

Taking the example in (18a), the *r* trapped between the two epenthetic *e*'s must become either an onset or a coda if it is to be prosodified. Thus, not both epenthethic vowels can satisfy *WeakPeak, since one must head a syllable in order to prosodify the *r*. The surface prosodification of (18a) is shown in (19), where the first epenthetic *e* heads a syllable taking the trapped *r* as its coda.[16]

(19)



For now, let us assume that *e*-epenthesis is motivated by the *BadSeq constraint given in (20), a surface filter for prohibited consonant sequences (we will return to this in section 1.5). Superfluous epenthesis is assumed to be discouraged by the Fill constraint in (21). The rankings in (22) and (23) follow from the fact that epenthesis occurs both to break up disallowed consonant sequences and to permit proper syllabification of all underlying consonants.

[16] The representation of the word-final glottal stop is the subject of section 1.6.

(20) *BADSEQ No prohibited consonant sequences (Cʔ#, C*r*, ...)

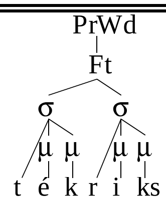
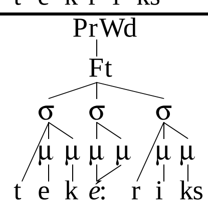
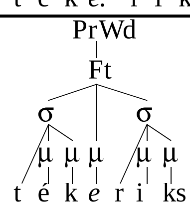
(21) FILL No epenthetic vowels in the output.

(22) *BADSEQ >> FILL

(23) PROPERSYLL, PARSE-C >> FILL

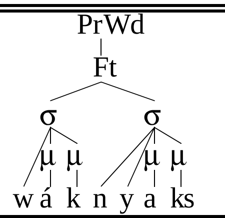
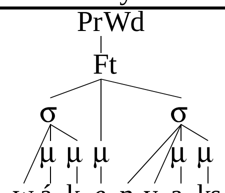
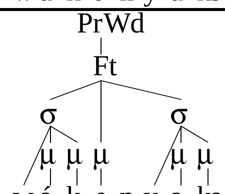
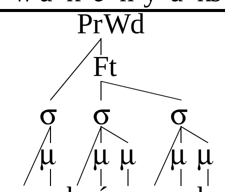
The tableau in (24) illustrates how these constraints interact to yield the correct output. Candidates which violate the syllabification constraints are not shown. Candidate (24a), the simplest syllabification of the underlying form, contains an illicit *kr* sequence, violating the high-ranked *BADSEQ. The remaining candidates satisfy the high-ranked constraints by inserting an epenthetic vowel, violating FILL. The crucial decision is thus left to *WEAKPEAK. Candidate (24b) violates *WEAKPEAK, because the epenthetic vowel is syllabified. Candidate (24c), satisfies *WEAKPEAK, thereby winning.

(24)

/ te-k-rik-s /	*BAD SEQ	PROPER SYLL	PARSE-C	*WEAK PEAK	FILL
a. 	*!	√	√	√	√
b. 	√	√	√	*!	*
c. ☞ 	√	√	√	√	*

The tableau in (25) formalizes the case from (16), where we see *e* inserted for syllabification. Recall that no candidate can satisfy both PROPERSYLL and PARSE-C without violating both FILL and *WEAKPEAK. The winning candidate, (25d), has syllabified the epenthetic *e* in order to prosodify all underlying consonants.

(25)

/ wak-nyak-s /	*BAD SEQ	PROPER SYLL	PARSE-C	*WEAK PEAK	FILL
a.  wá k n y a ks	*!	*!	√	√	√
b.  wá k *e* n y a ks	√	*!	√	√	*
c.  wá k *e* n y a ks	√	√	*!	√	*
d. ☞  w a k *é* n y a ks	√	√	√	*	*

Epenthetic *e* is also inserted between a consonant and a word-final glottal stop, but we will postpone discussion of epenthesis in this context until section 1.6. Summarizing this section, epenthetic *e* is a weak vowel, inserted to avoid illicit surface sequences arising at syllable junctures, but there is conflicting pressure to realize all underlying consonants as part of well-formed syllables.[17]

[17] There is one word which I have found that is unexpected under this view, namely /wak-attr-u/ *wakátteru* 'I'm dangerous' (Michelson 1988:141, Michelson 1989:46). What is unusual about this word is that the epenthetic vowel is preceded by an apparent geminate, which under the principles that I have been outlining should force the epenthetic vowel to be metrically visible. I leave this word without an explanation, although it is clear that under the analysis proposed here, the *tt* sequence cannot be associated with the epenthetic *e*. Phil LeSourd (p.c.) has called my attention to the fact that, according to Michelson (1988:12), "*tt* and *kk* clusters are not pronounced as long segments but as sequences of stops; the first stop is released." Note also that such sequences appear to be possible word-initially, as in *kká:wes* 'I paddle' (Michelson 1981:321), where I have also found *tk* sequences, as in *tkatáweyaʔ*ts 'I enter' (Michelson 1981:323). These facts may indicate

1.4 Theoretical background

Having outlined the basic idea, we now turn to consider technical aspects of the theoretical framework in which the analysis is set. First, because I have argued that syllable nodes are forced into prosodic structure (sometimes violating *WEAKPEAK) by an overriding pressure to syllabify all underlying consonants, it is important that consonants (in Mohawk) may *only* be prosodified as part of a syllable. As highlighted in (26), this will be true if (*a*) a consonant cannot be immediately dominated in prosodic structure by anything hierarchically above a syllable, and (*b*) a consonant dominated by a mora is necessarily also dominated by a syllable. I assume that both conditions hold in Mohawk, for the following reasons.

(26) Consonants in Mohawk may only be prosodified as part of a syllable.
  a. Consonants must be immediately dominated by a mora or a syllable.
  b. Only a mora dominated by a syllable may dominate a consonant.

First, I take property (26a) to hold of prosodic structure generally. In particular, I assume that prosodic structure conforms to "weak layering," which I state in (27).

(27) WEAK LAYERING — A prosodic node of category *i* is immediately dominated by a node of category *i*+1, preferably, or *i*+2 (at least word-internally).

Weak Layering dictates that, to the greatest extent possible, each node in a prosodic structure is dominated by a node from the immediately higher category in the prosodic hierarchy. In certain circumstances, one prosodic level may be skipped—allowing, for example, an onset to be immediately dominated by a syllable node, or a syllable to be immediately dominated by a Prosodic Word—but never are *two* prosodic levels skipped, at least word-internally.[18] Weak Layering therefore entails (26a); no consonant can be prosodified except through immediate domination by either a mora or a syllable.

The Weak Layering I adopt here is a slightly stronger version of Itô & Mester's (1992), who proposed that Weak Layering derives from the interaction of the more basic constraints given in (28), PROPER HEADEDNESS (probably inviolable), and MAXIMAL PARSING.[19]

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that *tt* in *wakátteru* is not in fact a structural geminate, although the implications of this are far from clear.

[18] See fn. 21 below regarding the qualification concerning word-peripheral elements.

[19] In Itô & Mester (1992), Weak Layering follows from Proper Headedness, Maximal Parsing, and a MORA CONFINEMENT constraint. The Mora Confinement constraint, which is an absolute requirement that moras be immediately dominated by a syllable, is not only at odds with the proposals I make here, but does not actually figure into Itô & Mester's analysis. Bagemihl (1991) provides evidence from Bella Coola which argues against the

(28) PROPER HEADEDNESS — Every (nonterminal) prosodic category of level *i* must have a head, that is, it must immediately dominate a category of level *i*-1.

MAXIMAL PARSING — Prosodic structure is maximally parsed, within the limits imposed by other (universal and language-particular) constraints on prosodic form.

These constraints allow for prosodic structures in which any number of prosodic levels can be skipped in a given dominance relation. By themselves, they are too weak to ensure (26a). Another crucial component of Weak Layering, also introduced by Itô & Mester (1992), is the HIERARCHICAL LOCALITY constraint defined in (29).[20]

(29) HIERARCHICAL LOCALITY — A condition operating at prosodic level *i* has access only to structural information at *i* and at the subjacent level *i*-1.

In Itô & Mester's analysis of Japanese clippings, the Hierarchical Locality constraint ensured that a word-level constraint on derived words does not have access to structural information below the syllable. This follows from Hierarchical Locality if the structural information (in this case, branchingness) is available only from the word level (branching to two feet) and the foot level (branching to two syllables). The information at the syllable level (branching to two moras) would be inaccessible to of a word-level condition.

If we interpret Hierarchical Locality as a constraint on structural well-formedness, on a par with the constraints in (28), we can derive (26a). Suppose that the well-formedness of a category (e.g., a foot) in a prosodic structure were being evaluated. If that category immediately dominated a node whose category was two levels lower in the prosodic hierarchy (e.g., a segment), the dominated node would be invisible for the purposes of evaluating the well-formedness of the dominating node. This dominance relation would therefore be either ill-formed or simply superfluous, and the structure would be ruled out in favor of a structure where the intermediate prosodic node (e.g., a syllable or a mora) is

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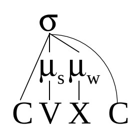
Mora Confinement constraint (assuming the existence of Stray Erasure), and the data discussed in this paper also points to this conclusion.

[20] Itô & Mester (1992) credit Liberman & Pierrehumbert (1984:231) for the idea. Liberman & Pierrehumbert made a much more general suggestion, proposing the existence of an "accessibility condition" for phonological objects which restricts computation of phonological properties to allow reference only to the preceding phonological object of the same type. The example they use is a pitch accent, the computation of which may look back to a property of the immediately preceding pitch accent but no further. Itô & Mester are responsible for carrying this principle into the domain of the prosodic hierarchy.

present in the structure. This now entails (26a) that a segment may not be directly dominated by a foot, but may only be dominated by a syllable or a mora.[21]

Property (26b) follows from the assumption that there is a language-particular threshold which constrains the sonority of segments a mora may dominate, following proposals made by Zec (1988, 1995a). We suppose that the maximal syllable has the structure shown in (30), where there is an asymmetry between the two moras of a bimoraic syllable. The first mora (μ_s) is the STRONG MORA and heads the syllable. The second mora (μ_w) is a WEAK MORA. The particular definitions which I adopt in (31) determine mora type contextually.

(30)



(31) Weak mora (μ_w): A mora preceded by a strong mora within the same syllable.
Strong mora (μ_s): All moras which are not weak.

Zec proposes that each type of mora is separately constrained in terms of the sonority of the segments the mora is permitted to dominate. These constraints are subject to language-particular paramaterization. In Zec's terminology, the constraint on the weak mora is the MORAICITY CONSTRAINT, and the constraint on the strong mora is the SYLLABICITY CONSTRAINT.[22]

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[21] There is an issue which remains concerning the applicability of Hierarchical Locality to word-peripheral elements. Itô & Mester (1992:33-34) note that the facts "clearly demand" the existence of rules that directly affect segmental material at the edges of prosodic domains, which should be in violation Hierarchical Locality. Furthermore, I will later adopt a proposal from Spaelti (1994) which, in his analysis of word-final geminates in a dialect of Swiss German, calls for segments which are actually directly dominated by the PrWd at the right edge of the prosodic structure. It seems fairly evident that the main force of Hierarchical Locality is limited to word-internal contexts, although why that would be is not entirely clear. We may be able to capture the effect through ranking of Hierarchical Locality within the system of constraints on prosodic structure, although a full investigation of this must await future research. An example we see later, (44a), suggests that in Mohawk even word-final consonants require a syllable.

[22] Zec (1995a) claims that moraicity constraints are universally less restrictive than syllabicity constraints. Because she takes the syllabicity constraint to be a constraint on syllables regulating the allowable sonority of syllable nuclei, this follows because for a segment to be a syllable nucleus, it must also be moraic. For her, it then follows that a syllable nucleus must satisfy both the moraicity and syllabicity constraint. I have reinterpreted the syllabicity constraint as a constraint on the strong mora, rather than on the syllable, which destroys the entailment of diminished restrictiveness for the moraicity constraint. I leave this as an open issue. Notice that it is important for this analysis that the syllabicity constraint also apply to moras which are not part of a syllable, which is the reason for my reinterpretation of the domain of the syllabicity constraint.

In Mohawk, tonic lengthening occurs only in open stressed syllables, indicating that coda consonants can be moraic. Thus, Mohawk is governed by the moraicity constraint in (32b). We also know that only vowels can head a syllable, which translates into the syllabicity constraint in (32a).

(32) Mohawk syllabicity and moraicity constraints
 a. μ_s constraint: A μ_s may only dominate segments at least as sonorous as vowels
 b. μ_w constraint: A μ_w may dominate segments of any sonority.

If we interpret the constraints in (32) properly, we can now derive (26b). A consonant may not be immediately dominated by a strong mora, given the syllabicity constraint (32a). Therefore, if a consonant is dominated by a mora, it must be dominated by a weak mora. However, although a strong mora can exist independent of a syllable node, a weak mora is defined only in opposition to a strong mora (31), entailing that a weak mora cannot exist outside of a syllable.[23] Thus we arrive at (26b): any consonant dominated by a mora must also be dominated by a syllable.

We have thus provided a foundation for the claim that consonants in Mohawk may only be prosodified as part of a syllable. We thus have an explanation for how pressure to prosodify all underlying consonants, can force syllables to be added to the prosodic representation.[24]

1.5 Formalizing Mohawk stress assignment and epenthesis

Since it is somewhat peripheral to the main issue, I will sketch only briefly the analysis of stress placement and tonic lengthening, and then turn to the motivations for *e*-epenthesis. I take the penultimate stress pattern to reflect a single word-final syllabic trochee. The constraints listed in (33) (Prince & Smolensky 1993, McCarthy & Prince 1993), ranked as in (34), derive the result that the optimal metrical structure has one final, trochaic, and bisyllabic foot.

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[23] Clearly, this is the crucial step in this chain of reasoning. This argument works because a weak mora is explicitly *defined* as being dominated by a syllable. While this may not be the most satisfactory state of affairs, it does capture the intuitive idea that a weak mora is defined in opposition to a strong mora within its immediate constituent. It is possible that a definition of weak mora which mentions only “immediate constituent” may be empirically tenable, but this turns on whether two moras directly dominated by a foot show a strong/weak asymmetry. Even finding a plausible example of such a structure is tricky, although a good place to begin looking might be Salish languages such as Bella Coola and Spokane Salish, which are argued to have long sequences of moraic segments outside of syllables (Bagemihl 1991, Bates & Carlson 1992).

[24] As for the source of the pressure to prosodify, the most natural explanation is some form of the “Stray Erasure” hypothesis (Steriade 1982) that unprosodified material does not receive any phonetic interpretation. That is, the pressure is to *realize* all underlying consonants, and prosodification is the means to that end. The discussion of Passamaquoddy syncope in section 2.2 gives further support to this interpretation, but what is crucial at this point is just that there is pressure to *prosodify*, for whatever reason.

(33) PARSE-SYLL Syllables must be parsed into feet.
FTBIN Feet must contain two syllables.
FTFORM(L) Feet are left-headed.
ALIGN-FT-R ALIGN (Foot, R; PrWd, R).

(34) ALIGN-FT-R >> FTMAX, FTMIN >> PARSE-SYLL
FTFORM(L) undominated

To account for tonic lengthening, I assume that a constraint which requires stressed syllables to be heavy (*STRESSEDLIGHT),[25] dominates the prohibition against adding moras to the representation (FILL-μ). These constraints are defined in (35).[26]

(35) *STRESSEDLIGHT Stressed syllables are bimoraic.
FILL-μ A mora in the output structure must be projected by an underlying segment ("Don't lengthen vowels").

(36) *STRESSEDLIGHT >> FILL-μ

The tableau in (37) demonstrates how the basic constraints interact to derive the stress pattern and the tonic lengthening in a word without epenthetic vowels.

(37)

/CVCVCVCV/	ALIGN-FT-R	FTBIN	PARSE-SYLL	*STRESSED LIGHT	FILL-μ
a. ☞ σσ(σ́:σ)	√	√	σσ	√	*
b. σσ(σ́σ)	√	√	σσ	*!	√
c. (σ́σσσ)	√	*!	σ	*	√
d. (σ́σ)(σ́σ)	σσ!	√	σ	**	√

We now turn to consider the motivations for *e*-epenthesis. Earlier we dodged the issue by attributing *e*-epenthesis to the influence of the *BADSEQ constraint. Let us take a moment to try to understand the more basic constraints which yield this effect, considering in turn each of the three contexts (from (6)) where epenthetic *e* is inserted.

The first context in which epenthetic *e* appears is between a consonant and a single sonorant (context (6a)). Where there is an underlying *CR* sequence,

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[25] *STRESSEDLIGHT appears under many names in the literature (e.g., Sprouse's (1996) IAMBIC LENGTH, Kager's (1996) STRESS-TO-WEIGHT), but I continue to use the name *STRESSEDLIGHT for clarity.
[26] At this point, I remain intentionally vague about what it means for a mora to be "projected by an underlying segment." This issue will be discussed in more depth in section 2.2. For now, FILL-μ should be interpreted as a constraint against lengthening underlyingly short vowels.

there are three possible syllabifications without epenthesis, shown in (38), each of which must be ruled out.

(38)	a.	*CR* as an onset	$[_\sigma$CR
	b.	*CR* split by syllable boundary	$C_\sigma][$R
	c.	*CR* as a coda	$CR_\sigma]$

We can assume that (38a) and (38c) can be ruled out by the constraints on syllable structure represented by PROPERSYLL; (38a) being ruled out by a constraint against complex onsets (e.g., *COMPLEX, Prince & Smolensky 1993), and (38c) being ruled out by the Sonority Sequencing Principle (Clements 1990). The question which remains is what rules out (38b), clearly not under the jurisdiction of an intrasyllabic constraint like PROPERSYLL.

The suggestion I will make is that (38b) is ruled out by a constraint on syllable contact (Hooper 1976, Murray & Vennemann 1983, Alderete 1995a). The facts indicate that in Mohawk, this constraint must allow syllable junctures between obstruents and between sonorants, but not between an obstruent and a sonorant. The specific constraint I assume is stated in (39), making reference to the language-specific sonority scale given in (40).

(39) SYLLCONTACT — Where C_1 and C_2 are (output-)adjacent non-tautosyllabic consonants, C_1 and C_2 must be of the same sonority level.

(40) Sonority Scale (MOHAWK)
Obstruents
Sonorants
Vowels

The insertion of an epenthetic vowel interrupting an underlying consonant-sonorant sequence satisfies the SYLLCONTACT constraint by rendering the problematic consonants non-adjacent. This is the only response which allows both underlying consonants to surface without violating principles of syllabification (e.g. by syllabifying both consonants in the margin of a single syllable). This indicates that the constraint responsible for minimizing epenthesis, FILL, is ranked below SYLLCONTACT, PROPERSYLL, and PARSE-C, as in (41).[27]

[27] As stated in (39), the SYLLCONTACT constraint predicts symmetrical behavior; epenthetic *e* should break up *RC* clusters as readily as it breaks up *CR* clusters. Michelson (1988) in fact gives a few examples which seem to show this, given below in (i), where an epenthetic *e* breaks up underlying *nk* clusters. However, Michelson (1988:143) also indicates that epenthetic *e* is not inserted in morphologically internal *sn* clusters (thanks to Phil LeSourd (p.c.) for calling this to my attention), but I tentatively attribute this to the fact that *s* generally has special properties with respect to syllabification (cf. the statement of the PROPERSYLL constraint in (14)). That said, I should nevertheless point out that the issue of whether SYLLCONTACT is defined symmetrically is of very little significance to the overall proposal.

(i)	a.	ʌtk*e*wʌnín*e*kʌʔn*e*ʔ	/ʌ-t-k-wʌn-inkʌʔ-nʔ/	‘I speak up, out’
	b.	ʌ́n*e*koks	*unknown*	‘buckwheat’

(41) SYLLCONTACT, PROPERSYLL, PARSE-C >> FILL

The second context in which epenthetic *e* appears, namely between a consonant and a word-final glottal stop (6b), is discussed in the next section, so we temporarily put it aside.

The last context for epenthetic *e* is inside sequences of underlying consonants (6c), to allow proper syllabification of the input string without deletion of any underlying consonants. In this case, the driving force is straightforwardly PROPERSYLL and PARSE-C.[28]

To summarize, we have the motivated the following partial rankings for Mohawk.[29]

(42) SYLLCONTACT, PROPERSYLL, PARSE-C >> FILL, *WEAKPEAK
ALIGN-FT-R >> FTMAX, FTMIN >> PARSE-σ
*STRESSEDLIGHT >> FILL-μ
FTFORM(L) undominated

1.6 The glottal stop in Mohawk

There are several interesting issues which arise with respect to the glottal stop in Mohawk. One of the primary contexts (6b) in which we find the metrically invisible epenthetic *e* is between a consonant and a word-final glottal stop. Because we interpret metrical invisibility to indicate the lack of a syllable node, it must therefore be the case that a word-final glottal stop is incorporated into the prosodic structure in some way that does not involve a syllable node.

The suggestion I make is that the glottal stop in Mohawk is dependent on the neighboring vowel, which I will implement by proposing that the glottal stop in Mohawk must "share a mora" with vowels. An example of the structure I refer to is shown in (43).

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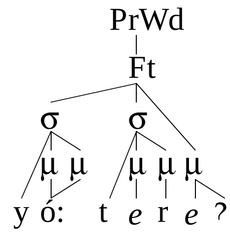
[28] It is perhaps interesting to note that the insertion of epenthetic *e* for syllabifiability is functionally similar to the insertion of prothetic *i* to satisfy the minimal word requirement. I leave unexplored the issue of choice of vowel quality for the epenthetic vowels. It may be possible to look at prothetic *i* as a variant of epenthetic *e*, although how this could be worked out in a testable way is not clear.

[29] One fairly minor issue remains unresolved for the Mohawk data discussed so far, which is how it is determined which *e* in a sequence of epenthetic *e*'s must be metrically visible. Recall that in such examples like (18a) *yó:tere̲ʔ*, the lengthening of the stressed vowel indicates that the stressed vowel is in an open syllable and that therefore it is the first epenthetic *e* in a sequence which is forced to be metrically visible. This can be accounted for in terms of an alignment constraint, such as ALIGN(σ, L; PrWd, L).

(43)



There are several reasons to suppose that such a representation is at least plausible. First considering language-internal evidence, the glottal stop in Mohawk has several properties which set it apart from other consonants. First, it appears generally invisible to syllabification processes, second, it conditions the appearance of a falling tone when following a stressed vowel, and third, it participates in a process of "vowel doubling." We discuss these properties in turn.

With respect to the invisibility of the glottal stop to syllabification, Piggott (1995) points to contrasts like that shown in (44).

(44)	a.	sasáhk*e*t	/sa-s-ahkt/	'go back!'
	b.	ón*e*raht*e*ʔ	/o-nraht-ʔ/	'leaf'

In both of these examples, an epenthetic *e* breaks up an underlying triconsonantal cluster. In (44a), the final consonant is not a glottal stop, and we see that the epenthetic *e* is metrically visible, implying that a syllable was introduced into the representation for the purpose of prosodifying the final consonant. Where the final consonant is a glottal stop, as in (44b), the behavior is different. In particular, the epenthetic *e* remains metrically invisible, indicating that the glottal stop could be prosodified without depending on a syllable node. Notice too that the metrical visibility of epenthetic *e* in (44a) indicates that we cannot account for the invisibility of word-final glottal stops by some *general* extrametricality of final consonants, since it is only glottal stops which have the appearance of "extrametricality."

Word-medial glottal stops behave in essentially the same way. Compare (45a) and (9a), each of which have an underlying triconsonantal cluster word-medially. However, only the epenthetic *e* which breaks up the cluster in (9a) is metrically visible. In (45a), despite the fact that the epenthetic *e* is followed by a consonant sequence, the *e* remains metrically invisible.

(45)	a.	rák*e*ʔni	/rak-ʔni/	'father (voc.)'
	b.	k*e*yáʔt*e*ʔkʌs	/k-yaʔt-ʔkʌs/	'I am fat'
cf.	(9a)	wak*é*nyaks	/wak-nyak-s/	'I get married'

If we understand the glottal stop to be dependent on the vowel or its mora and not on the syllable, we have a straightforward interpretation of these facts.

The second respect in which the glottal stop is differentiated from other consonants is by its role in conditioning a falling tone when following a stressed vowel.[30] Some examples of this process, called LARYNGEAL LENGTHENING by Michelson (1988) and TONE by Postal (1969), are given in (46).

(46)	a.	karù:tats	/k-aruʔtat-s/	‘I blow’
	b.	wakyà:ku	/wak-yaʔk-u/	‘I cut it off’

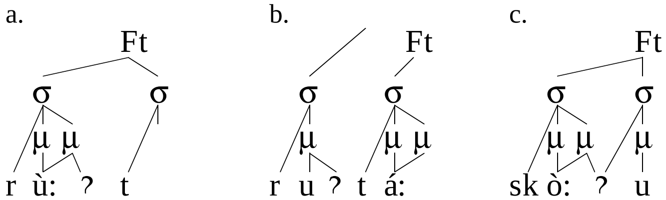
Notice that the falling tone only occurs on the stressed vowel. If a glottal stop follows an unstressed vowel, such as in the examples in (47), no tonal reflex is seen. Where the glottal stop triggering a falling tone is intervocalic, it also surfaces, as in (48).

(47)	a.	wakaruʔtá:tu	/wa-karuʔtat-u/	‘I have blown’
	b.	tékyaʔks	/te-k-yaʔk-s/	‘I break it in two’

(48)	a.	à:ʔareʔ	/w-aʔar-ʔ/	‘curtain, net, veil’
	b.	wak*e*ʔskò:ʔu	/wak-ʔskoʔ-u/	‘I have drowned’

This cluster of properties can be understood in terms of the representation of glottal stop which is dependent on the mora of the neighboring vowel, rather than on a canonical syllable margin. In (49a-c) are illustrated the relevant parts of the structures I assume for examples like (46), (47), and (48), respectively. I suggest that the falling tone is a phonetic reflex of having a bimoraic vowel whose second mora is shared by a glottal stop, as in (49a, c). In monomoraic cases, like (49b), I assume that this structure is phonetically interpreted as a “checked” vowel.[31]

(49) a. b. c.



The third respect in which glottal stop is differentiated from other consonants in Mohawk is seen by its participation in a “vowel doubling” process, discussed by Postal (1969). Postal states this as a rule (VOWEL TWIN) which breaks

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[30] This falling tone also appears on stressed vowels followed by an *h* and a resonant consonant, as in *yehà:reks* /ye-hra-hrek-s/ ‘he pushes’ (M88:59), cf. *yehohré:ku* /ye-hro-hrek-u/ ‘he has pushed’ (M88:59). I do not have a specific analysis to offer for this case.

[31] There are a few examples which seem to indicate that vowel lengthening with a falling tone can even occur in closed syllables under certain circumstances. I give two such examples below, although I have no analysis of them at the moment.

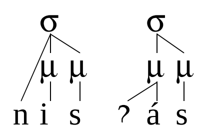
(i)	a.	è:n*e*kʌ	*unknown*	‘up’
	b.	otsì:n*e*kwar	/yo-tsiʔnkwar-Ø/	‘yellow’

up underlying consonant-glottal stop sequences by inserting a vowel between them which shares the quality of the vowel following the glottal stop (Postal 1969:293).

(50)	a.	ʌyotunis*u*ʔúhak*e*ʔ	/ʌ-wa-o-atunisʔa-u-hak-ʔ/	'it will have been ripening'
	b.	ʌwatunis*a*ʔásheke*ʔ*	/ʌ-wa-atunisʔa-s-hek-ʔ/	'it will be ripening repeatedly'
	c.	wak*e*nuhsis*u*ʔuhátye	/wak-nuhs-isʔa-u-hatye-Ø/	'I finish the house a little bit at a time'

These are cases where the glottal stop underlyingly precedes the vowel whose mora it shares. I assume that the phonetic interpretation of a structure like that shown in (51) yields the "doubled" vowel by simultaneous articulation of the vowel and the glottal constriction.[32]

(51)



Recall that the point of this section is to show that the glottal stop in Mohawk does not require prosodification as part of a syllable in order to surface. The suggestion which has been put forward is that the glottal stop shares the mora of the vowel next to it, and the surface effects are due to principles of phonetic interpretation. Up to this point, the evidence and discussion have had a language-internal focus, but I would also like to briefly note similar phenomena in other languages.

Walker (1994) discusses Buriat, a language whose syllable inventory in general excludes syllables with complex margins. The only exception to this generalization are syllables of the shape (C)Vŋg. Walker notes that although (C)Vŋg syllables pattern with light (monomoraic) syllables, no syllables of the form (C)VVŋg exist. Walker accounts for these facts by proposing that *ŋ* shares the strong mora of a syllable, where only strong moras can branch and coda consonants are not moraic. While this analysis bears neither on Mohawk nor on the glottal stop, it does lend support to the existence of such "mora sharing" structures.

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[32] When the vowel which follows the glottal stop is the last vowel in the word, the timing of articulation is altered so that the glottal stop closes the vowel, giving an impression of metathesis, as in (i).

(i)	a.	watunís*a*ʔs	/wa-atunisʔa-s/	'it ripens'
	b.	k*é*roʔks	/k-rʔok-s/	'I chop with an axe'
	c.	waʔkshuʔkar*á*r*o*ʔk*e*ʔ	/waʔ-k-shuʔkar-rʔok-ʔ/	'I chopped the board'

I do not offer an explanation for this here.

Shaw (1989) discusses the glottal stop in Dakota and concludes that it should be represented not as a segmental root node, but as a floating [+constricted glottis] feature which anchors to the vowel which precedes it. Shaw also notes that where the word-final declarative suffix, a glottal constriction, associates to a vowel, the vowel tends to be followed by an "echo vowel" which does not constitute an independent syllable (e.g., /kiyą̨[ʔ]/ [kiyą̨ʔᵃ̨] 'he is flying'). This phenomenon appears to be quite similar to the "vowel twin" phenomenon in Mohawk.[33]

Lastly, Meechan (1990) discusses two behaviors of the glottal stop in Villa Alta Zapotec. In one case, the glottal stop forms "checked vowels," interpreted as floating laryngeal features which associate to the strong mora of the nearest syllable. In the other case, the glottal stop forms "laryngealized vowels," which are articulated as a sequence of vowels with an intervening glottal stop, but which pattern with single vowels (i.e. light syllables). Both of these cases have parallels within Mohawk; the Zapotec checked vowels look like the analog to glottal stops after monomoraic vowels in Mohawk, and the laryngealized vowels in Zapotec seem to be the analog of Mohawk "vowel twin."

In short, there are several cases where glottal stop or other segments can be and have been analyzed as having a prosodic structure similar to that which I have suggested for the Mohawk glottal stop. It therefore does not seem implausible to maintain that in Mohawk, the glottal stop may be incorporated into the prosodic structure without need of a syllable node.

Having given some foundation to the structure I assume for the glottal stop, I complete the set demonstrating the cases of epenthetic *e* with the tableau in (52). It illustrates the remaining context (6b), where epenthetic *e* appears between a consonant and a word-final glottal stop. Tableau (52) parallels tableau (24).

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[33] Note that the difference between the view taken in this section that the glottal features share a mora with a vowel and Shaw's (1989) view that the glottal features dock below vocalic root node is not significant at all to the main point. In fact, by choosing to adopt the "shared mora" representation, I intend to abstract away from the issue of how exactly the dependence of the glottal stop on the neighboring vowel is implemented.

(52)

/ ʌ-k-arat-ʔ /	*BAD SEQ	PROPER SYLL	PARSE-C	*WEAK PEAK	DEP
a. PrWd, Ft: ʌ k á: r a tʔ	*!	√	√	√	√
b. PrWd, Ft: ʌ k a r á: t *e* ʔ	√	√	√	*!	*!
c. ☞ PrWd, Ft: ʌ k á: r a t *e* ʔ	√	√	√	√	*

1.7 The joiner vowel and weak edges

Mohawk has another epenthetic vowel, referred to as the JOINER VOWEL, which acts somewhat differently from epenthetic *e*. Like the epenthetic *e*, the joiner vowel is invisible for stress placement if all underlying consonants can be syllabified without it, but there is a difference with respect to tonic lengthening. This discussion of the joiner vowel does not directly add to our general understanding of weak vowels, but it is worth considering both for Mohawk-internal completeness and because it could be construed as a counterexample to parts of the preceding discussion.

The joiner vowel, whose vowel quality is invariably *a*, appears at certain morphological boundaries where consonants from different morphemes would otherwise be adjacent. In (53), I give some examples which show the joiner vowel appearing prior to the stressed syllable. In this position, there can be no interaction with stress placement, but where the joiner vowel is inserted near the end of the word, as in the cases in (54), it interacts with stress placement in the same way as epenthetic *e*.

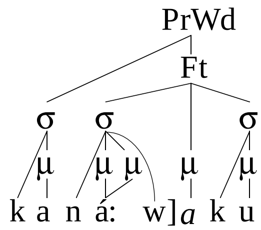
(53)	a.	wak*e*r*a*ʔnúhneʔ	/wak-r-ʔna-u-hneʔ/	‘I went and put it in’
	b.	karist*a*kʌ́:ra	/ka-rist-kʌra-ø/	‘tin’
	c.	yerist*a*karanyè:thaʔ	/ye-rist-karanye-ʔt-haʔ/	‘file’
	d.	ruhskw*a*h*é*hrhaʔ	/hru-ahskw-hr-haʔ/	‘steel-workers (they put the bridge up)’
(54)	a.	kaná:w*a*ku	/ka-naw-ku-Ø/	‘in the swamp’
	b.	tekaʔshá:r*a*riks	/te-k-aʔshar-rik-s/	‘I put the knives side by side’
	c.	wakiʔtuhkw*á*rhos	/wak-iʔtuhkw-rho-s/	‘I have a fever’
	d.	k*e*r*á*kwas	/k-r-kw-as/	‘I take it out of something’
	e.	tekahruw*á*nyu	/te-kahruw-nyu-Ø/	‘many objects put in your path’
cf.	(7b)	ték*e*riks	/te-k-rik-s/	‘I put them together’

Like epenthetic *e*, the joiner vowel is metrically invisible except when it breaks up a sequence of three or more consonants. Unlike epenthetic *e*, however, even when it is metrically invisible, the joiner vowel does not prevent tonic lengthening. Recall that in examples like (7b), a stressed vowel fails to lengthen before an epenthetic *e*. However, in (54a) and (54b), we see that a stressed vowel does lengthen before a metrically invisible joiner vowel. We explained cases like (7b) by saying that the stressed syllable is closed by the consonant preceding the metrically invisible vowel, due to the fact that the metrically invisible vowel does not head a syllable. Given this, the behavior of (54a) demands an explanation.

Assuming syllables are maximally bimoraic, it turns out that there is only one possible structure for such examples that is consistent with the discussion so far. This structure is shown in (55). Because the joiner vowel is not dominated by a syllable, the preceding consonant must be prosodified by the stressed syllable. The long vowel heading the stressed syllable accounts for both moras, so the consonant between the stressed vowel and the joiner vowel must be a non-moraic consonant appendix of the stressed syllable.[34]

[34] The existence of syllable appendices may be somewhat controversial. I take any consonant directly dominated by the syllable node at the end of the syllable to be an appendix (Sherer 1994:51). Under this view, an appendix is not a very exotic creature; any language with CVC syllables and no weight distinction has appendix consonants. The appendix consonants I use in the analysis of the Mohawk joiner vowel are of this sort. Perhaps a more unusual syllable type would be a CVCC syllable where the first coda consonant is moraic and the second is an appendix, and indeed such syllables must be ruled out in Mohawk if I am to correctly capture the contextual dependence of metrical invisibility (see fn. 37).

(55)



Let us suppose that the morphological boundary at which the joiner vowel appears is the boundary of the lexical root,[35,36] and let us further suppose that consonants at the right edge of a lexical root, like the *w* in (55), cannot be dominated by a mora. If this is true, the observed patterns follow; because the boundary consonant cannot be moraic, it can only be an appendix which does not contribute weight, so the vowel must still lengthen in order to make the stressed syllable heavy.

To capture this generalization, I adopt a slight variant of a constraint introduced by Spaelti (1994). The constraint, WEAKEDGE, minimizes structure along the right edge of a prosodic representation, such as the prosodic structure which dominates segments of the lexical root. I give the technical definitions in (56) and (57) below.

(56) WEAKEDGE (LexRoot): The right periphery of the lexical root should be empty.

(57) PRSTRUC(*x*) is the subset of the prosodic structure which dominate segments of the morphological domain *x*.

The RIGHT PERIPHERY of *x* is a set of nodes *n* from PrStruc(*x*) which satisfy one of the following conditions:
(*i*) *n* dominates all other nodes in PrStruc(*x*), *or*

---

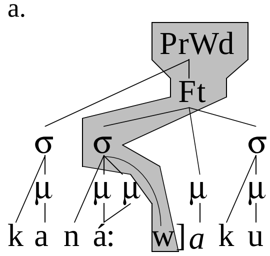
[35] Specifically, the contexts for joiner vowel insertion are (a) between an incorporated noun root and a following verb root, and (b) between a verb root and a following derivational suffix such as the causative, the "undoer" suffix, the "distributive" suffix, and the "dislocative" suffix (Michelson 1988:157-8). The assumption I am making here is that there is some characteristic boundary which these contexts share, and I have called it the boundary of the "lexical root." While this may not be the correct characterization of the shared property, the analysis does rely on there being *some* such characterization.

[36] Michelson (1988:164) points out that a significant number of words with a weightless penultimate *a* do not appear to be synchronically segmentable into smaller morphemes, although she indicates a probable historical analysis involving noun incorporation into the verb root -*r*- 'fill in.' If there is no synchronic morpheme boundary in these positions, we are left with two possibilities. First, the *a* found in these morphemes is "really" an epenthetic *e* (that is, not a joiner vowel) whose *a* quality is somehow determined exceptionally. The second, more likely possibility is that in these cases, the *a* is an *underlying* weak vowel, whose quality is determined in its underlying form. We will discuss underlying weak vowels at great length in the later sections of this paper.

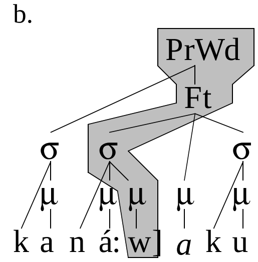
(*ii*) there is some *m* in the Right Periphery of *x* such that the following holds of PrStruc(*x*): *m* immediately dominates *n* and there is no *n′* which follows n (in linear order) such that *m* immediately dominates *n′*.

Rather than go through the technical definitions in detail, we will illustrate the idea with an example. Consider the two candidate prosodifications in (58). In the shaded box are the nodes contained in the "right periphery" of the lexical root. The function of WEAKEDGE is to choose the candidate with the minimal amount of structure in the shaded box. Because the box in (58b) contains a mora node as well as all of the elements found in the box in (58a), (58a) is better with respect to WEAKEDGE. The effect of WEAKEDGE, then, is to force root-final consonants in these environments to be nonmoraic.

(58) a.



b.



WEAKEDGE promotes the use of a bimoraic syllable with an nonmoraic appendix at the junctures where the joiner vowel appears. To prevent syllables from freely taking appendices, we will adopt the constraint *APPENDIX from Sherer 1994. Because appendix consonants occur before joiner vowels, we know that WEAKEDGE outranks *APPENDIX[37]

(59) *APPENDIX Appendix consonants are not allowed.

(60) WEAKEDGE >> *APPENDIX

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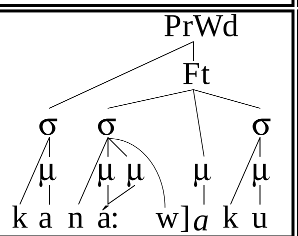
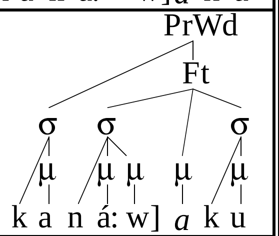
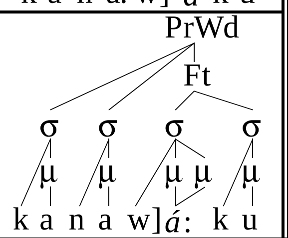
[37] There are a few slightly hidden implications made by this ranking, pointed out to me by Yoonjung Kang. We will see shortly that WEAKEDGE (as expected) is satisfied equally well by onset and appendix consonants, and so the fact that /kanaw-ku/ 'in the swamp' is realized as *kaná:waku* (joiner metrically invisible, *w* is an appendix) and not **kanawá:ku* (joiner metrically visible, *w* is an onset) indicates that *WEAKPEAK outranks *APPENDIX. In cases where epenthetic *e* breaks up an underlying triconsonantal cluster, this forces us to consider a syllabification like ...$V_{\mu}C_{\mu}C\ _{\sigma}]e_{\mu}[_{\sigma}CV_{\mu}$... where *WEAKPEAK is satisfied at the cost of having a consonant appendix on the preceding syllable, and all underlying consonants are prosodified. In the Mohawk cases I have come across so far, a syllabification of the kind we are considering would violate the Sonority Sequencing Principle (e.g., *wakényaks* 'I get married' but not **wákneyaks*), which might independently rule out the case we are concerned about. However, assuming that a constraint on Sonority Sequencing cannot rule out all possible instances of $CV_{\mu}C_{\mu}C$ syllables, this suggests that $CV_{\mu}C_{\mu}C$ syllables are more marked (perhaps discouraged by more constraints) than $CV_{\mu\mu}C$ syllables are. I will not pursue this further here, however, but instead I will subsume the impossibility of $CV_{\mu}C_{\mu}C$ syllables under the PROPERSYLL constraint.

To illustrate, some tableaux in which WEAKEDGE makes the crucial distinction are given below. Consider the following tableau for the word (54a), *kaná:waku* 'in the swamp,' where the major morpheme boundary is marked in the input form by a hyphen.

(61)

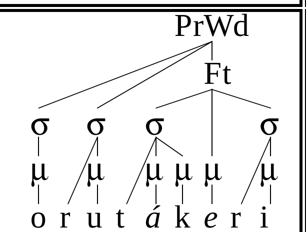
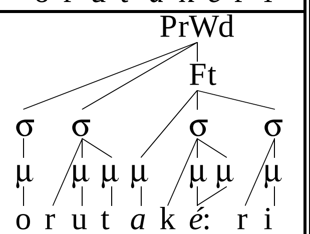
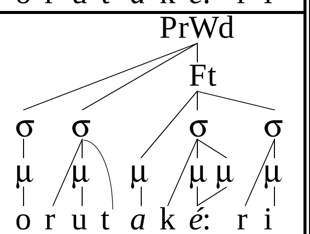
/kanaw-ku/	*WEAK PEAK	WEAK EDGE	*APPENDIX
a. ☞ 	√	*w*, σ, Ft, PrWd	*
b. 	√	*w*, μ, σ, Ft, PrWd!	√
c. 	*!	*w*, σ, Ft, PrWd	√

Recall that in a sequence of weak vowels, it is not possible for both to remain metrically invisible, since the intervening consonants must be prosodified into proper syllables. Where one of two weak vowels in sequence is a joiner vowel, as in the examples in (62), it turns out that whether *a* precedes *e* (62a-c) or follows *e* (62d-e), it is *a* which surfaces as metrically visible, heading a syllable.

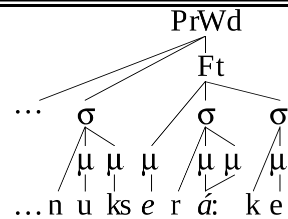
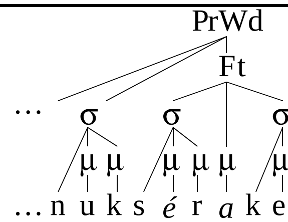
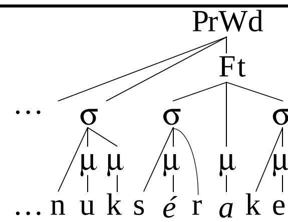
(62)	a.	orut*á*k*e*ri	/o-rut-kri-Ø/	'maple sap'
	b.	ohnek*á*k*e*ri	/yo-hnek-kri-Ø/	'broth'
	c.	wakhné:k*are*ʔ	/wak-hnek-r-ʔ/	'I have put water into it'
	d.	tekanuks*erá*:ke	/te-ka-nuksr-ke/	'two onions'
	e.	k*erá*kwas	/k-r-kw-as/	'I take it out'

This turns out to be a prediction of the WEAKEDGE analysis as proposed above, under the syllable structure we have adopted. To see why, consider the tableau in (63). Given that there is a sequence of weak vowels, any viable candidate will violate *WEAKPEAK, so it no has crucial role to play. WEAKEDGE then becomes crucial, requiring that the joiner be preceded by a nonmoraic element. Before, this meant that the joiner vowel must be preceded by a syllable appendix, but a new option is available in the present case, namely that the joiner vowel be preceded by a syllable onset. In fact, given the presence of *APPENDIX in the ranking and the neutralization of *WEAKPEAK, an onset is preferred. This is illustrated in (63) for the case where joiner *a* precedes epenthetic *e*, and in (64) for the case where epenthetic *e* precedes joiner *a*.

(63)

/ orut-kri /	*WEAK PEAK	WEAK EDGE	*APPENDIX
a. ☞ 	*	*t*, σ, Ft, PrWd	√
b. 	*	*t*, μ, σ, Ft, PrWd!	√
c. 	*	*t*, σ, Ft, PrWd	*!

(64)

/ tekanuksr-ke /	*WEAK PEAK	WEAK EDGE	*APPENDIX
a. ☞ 	*	*r*, σ, Ft, PrWd	√
b. 	*	*r*, μ, σ, Ft, PrWd!	√
c. 	*	*r*, σ, Ft, PrWd	*!

1.8 Summary of Mohawk analysis

To close the section on Mohawk, let us briefly review the most basic conclusions we should draw from the preceding discussion.

An epenthetic *e* and the epenthetic joiner vowel *a* in Mohawk are weak vowels, subject to the *WEAKPEAK constraint which prohibits it from being the nucleus of a syllable node in prosodic structure. Because the *WEAKPEAK constraint is outranked by syllabification constraints, which require all underlying consonants to surface (PARSE-C) and require all surfacing syllables to be proper syllables (PROPERSYLL), an epenthetic *e* is not always metrically invisible. The proposal is that where epenthetic *e* is metrically invisible, there is no syllable node dominating it in the prosodic structure.

Where a vowel is not dominated by a syllable in the prosodic structure, it will be invisible to syllable-sensitive phenomena, such as stress assignment and minimal word evaluation. This explains how antepenultimate stress arises in the examples in (7) and (8), and why a prothetic *i* is inserted to ensure two syllables in (10). Where all of the underlying consonants cannot be incorporated into the prosodic structure without the addition of a syllable node dominating a weak vowel, the weak vowel will be visible for syllable-sensitive effects. This is the reason that metrical invisibility is context sensitive.

2 Passamaquoddy

Passamaquoddy is an Eastern Algonquian language spoken in parts of Maine. What makes Passamaquoddy particularly interesting for our investigation of weak vowels and metrical invisibility is that it shows weak vowels which are not epenthetic, but underlying. This tells us that whatever "weakness" is, it cannot follow from properties of epenthesis. This fact undermines the several previous analyses of Mohawk mentioned earlier, all of which attempt to draw a principled connection between the metrical invisibility of the weak vowels and their epenthetic status.[38] The Passamaquoddy data and much of their interpretation are taken from Phil LeSourd's dissertation, published as LeSourd (1993).[39,40] To begin the discussion, we will look at the stress patterns, and then we will review the evidence that the weak vowels in Passamaquoddy are underlying.

2.1 The stress patterns of Passamaquoddy

The examples in (65) below illustrate the basic stress pattern of Passamaquoddy.[41] Initial syllables are stressed, as are even syllables counting from right to left.[42]

(65)	a.	wás-is	'child'
	b.	l-éwésto	'he speaks'
	c.	wík-ewésto	'he likes to talk'
	d.	séhtáy-ewésto	'he speaks while walking backwards'

[38] In fact, Michelson (1988, 1989) analyzes certain instances of weightless vowels as underlying in Mohawk, which may already have disqualified accounts which tie invisibility to epenthesis. See also section 4.1 and fn. 36.

[39] In the Passamaquoddy examples, I follow LeSourd's transcriptions, except that I transcribe /k^w/ as "q" rather than "kw" to avoid confusion concerning its single-segment status.

[40] An earlier and different analysis of Passamaquoddy stress is given by Stowell (1979), who in turn attributes the basic analysis to LeSourd. Although LeSourd (1993) convincingly argues against the analysis from Stowell 1979, the earlier analysis has been taken as the basis for several reinterpretations since then, e.g. in Prince 1983 and Hayes 1995.

[41] Main stress is not differentiated from secondary stress here. According to LeSourd (1993), main stress in Passamaquoddy falls on the last stressed syllable when a word is utterance-final, but shifts to the penultimate stressed syllable in cases where the word is not utterance-final.

[42] The right-to-left orientation of Passamaquoddy stress is interesting from a comparative perspective, given that many Algonquian languages have a left-to-right stress pattern. I do not know how the Passamaquoddy stress patterns compare to those of related languages, but the brief description of the "strong" and "weak" vowel distinction in the Unami dialect of Delaware, an Eastern Algonquian language discussed by Goddard (1979), looks as if it shares similar properties and is worth further exploration. In Unami Delaware (Goddard 1979:21), vowels are "automatically strong" if they are long, if they occur before consonant clusters, and when they occur in even-numbered positions (counting left-to-right) in a sequence of syllables headed by underlyingly short vowels followed by a single consonant. Stress appears on the penultimate strong vowel.

We will suppose that this stress pattern reflects binary trochaic feet constructed from the right edge leftward. A word-initial stress clash (65b, d) is taken to indicate the presence of a degenerate foot at the left edge of the word.

The regular stress pattern just described is disrupted in words containing ə,[43] as we see by looking at the examples in (66). In (66a), the word-medial ə is metrically invisible, causing the stress to surface on the antepenultimate vowel where it would normally have surfaced on the penultimate vowel. Compare this to (66b) which receives stress normally, indicating that the word-medial ə is metrically visible. The word in (66c) contains a large sequence of schwas, and it shows an alternating pattern of metrical visibility.

(66)	a.	sók-ə̲lan	'it pours (rain)'
		*sók-ə́lan	
	b.	písk-ə́lan	'it rains so hard that it is dark or hard to see'
	c.	ásəw-ə̲cək-ə́po	'it (an.) is flopped over to one side'

The explicit statement of the contexts in which ə counts for stress placement is complex,[44] but the intuition behind our analysis is the same as it was in Mohawk: A weak vowel will be metrically visible only if necessary given other considerations, e.g. proper syllabification.

If we suppose that the Passamaquoddy ə is a weak vowel subject to *WEAKPEAK, just like the Mohawk epenthetic *e*, the behavior of ə in (66a) and in (66b) follows just as before. While *sok* and *lan* are well-formed syllables, *pisk* is not. Thus, in (66a), ə need not head a syllable to ensure that all underlying consonants can be prosodified into well-formed syllables, as shown in (67a). In (66b), however, the fact that *pisk* is not a well-formed syllable forces ə to head a syllable, as in (67b). That is, *WEAKPEAK must be violated in order to prosodify the *k* preceding ə, and so the ə is metrically visible.

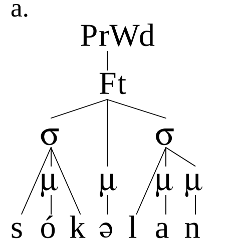
---

[43] The overwhelming majority of the vowels which have this stress-disrupting property are ə. As will be discussed shortly, ə also alternates with zero depending on its context, and LeSourd (1993) indicates that in certain cases *i*, *a*, and *o* also show the same alternation, deleting when it would have been metrically invisible if it had surfaced. We take this to mean that it is not only ə which can be "weak" in Passamaquoddy, although it seems to be only ə which surfaces when metrically invisible. Whether this is a historical accident or the result of something more principled remains an open question. See LeSourd 1993, chapter 6 for further discussion.

[44] Specifically, the (pretheoretic) conditions given by LeSourd (1993) for when ə is "stressable" (metrically visible) are if it is either underlyingly marked as stressable, or:

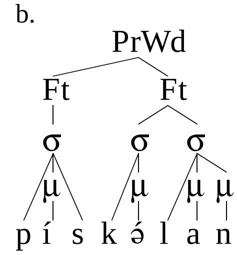
a) last vowel of a word
b) follows a cluster of nonsyllabics other than *hC*
c) follows *hl*
d) stands between *s* and *hs*
e) is the first ə in word-initial /(C) ə [+sonorant] ə/ where second ə is unstressable
f) in even position, counting from left to right, in a series of /C_0 ə/ sequences in which no ə falls under conditions *a* - *e* or is inherently stressable.

(67) a.



√: *WEAKPEAK
√: PROPERSYLL

b.



*: *WEAKPEAK
√: PROPERSYLL

This implies, as it did in Mohawk, that the syllabification constraints, in (68) and (69),[45] outrank *WEAKPEAK (70).

(68) PARSE-C — An underlying consonant must be parsed in the output.

(69) PROPERSYLL — No clusters are allowed in syllable margins—except in cases where *s* is the external member of a cluster (*s*CVC or CVC*s*) and cases where *h* is the internal member of a cluster (CV*h*C or C*h*VC). (PASSAMAQUODDY)

(70) PARSE-C, PROPERSYLL >> *WEAKPEAK

There are also cases where ə precedes a cluster. Since clusters are not well-formed onsets, we expect that the ə must head a syllable in order to properly syllabify part of the cluster into its coda. Sure enough, "schwa is always stressable [metrically visible] in forms like *ə́ptan* '(a woman's) coat' where it precedes an underlying cluster other than /sC/ or a geminate" (LeSourd 1993:97). However, it turns out that visibility *alternation* in precluster position is extremely rare. Alternation would arise if a morpheme ending in *əC* could be followed by either a consonant-initial or a vowel-initial morpheme. Facts of Passamaquoddy morphology, including allomorphic variation and the insertion of connecting vowels, generally prevent this situation from arising; however, Phil LeSourd (p.c.) provided me with one possible case of this sort. In general, a connective vowel is inserted between consonants at morpheme boundaries, but /-pe-/ 'liquid' appears to be exceptional in this regard, attaching to consonant-final roots directly, as in (71) (LeSourd 1993:156).

(71) át-pe 'the water level changes'

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[45] As was true for Mohawk, an adequate discussion of the issues involved in deriving PROPERSYLL from more basic constraints would take us far afield and would be irrelevant to the basic points here. For Passamaquoddy, these issues are discussed in greater detail in Hagstrom (1995).

This will allow us to set up the alternation context, where a cluster over a morphological boundary follows a weak ə. The second ə in the morpheme /cələk-/ 'squeeze' is a weak vowel, which we can deduce from the fact that in (72), the weak vowel in /-ən/ 'by hand' is stressed.

(72) h-cə́lək-ə́n-a-l 'he squeezes the other (something soft)'

Bringing the two morphemes together, in (73), we see that this weak vowel is syllabified before a cluster.

(73) cələ́k-pe 'it is oozing, leaking'

The lack of alternation in the general case led LeSourd to propose that instances of ə which precede a cluster are all marked as metrically visible in the lexicon, leaving the regularity unexplained. However, under the present analysis, their metrical visibility is predicted.[46]

The exact analysis of how the stress pattern comes about is not crucial here, so we will go through it with very little discussion. I take the stress pattern to be a reflection of syllabic trochees aligned with the left edge, where a monosyllabic foot is allowed if needed in words with an odd number of syllables. This pattern can be derived using the constraints in (74) taken from commonly cited literature in the Optimality Theory framework (Prince & Smolensky 1993, McCarthy & Prince 1993, Everett 1996), ranked as in (75). The tableau in (76) illustrates how these constraints interact.

(74) PARSE-SYLL Syllables must be parsed into feet.
FTMAX Feet can contain no more than two syllables.[47]
FTMIN Feet can contain no fewer than two syllables.
FTFORM(L) Feet are left-headed.
ALIGN-FT-L ALIGN (Foot, L; PrWd, L).

(75) PARSE-SYLL, FTMAX >> FTMIN, ALIGN-FT-L

[46] As will be discussed in greater detail in section 3, nonalternating vowels will be represented as full vowels, given certain assumptions about the process of acquisition. Thus, even in my analysis, these instances of ə before a cluster will be lexically "full vowels," but notice that under my analysis ə before a cluster *could not* be metrically invisible, at least explaining the generalization.

[47] FTMAX and FTMIN split FTBIN into two constraints in order to distinguish degenerate feet from ternary feet, following Everett (1996). Thus is functionally equivalent to the FTBIN and LAPSE constraints proposed by Green & Kenstowicz (1995).

(76)

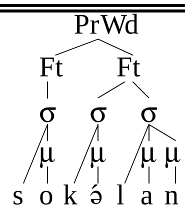
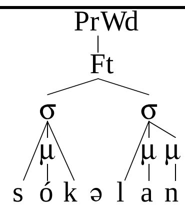
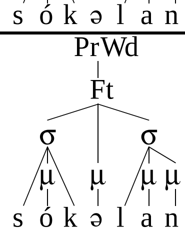
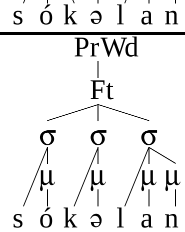
/ CVCVCVCVCV /	PARSE-SYLL	FTMAX	FTMIN	ALIGN-FT-L
a. ☞ (σ́)(σ́σ)(σ́σ)	√	√	*	σ;σσσ
b. (σ́σσ)(σ́σ)	√	*!	√	σσσ
c. σ(σ́σ)(σ́σ)	*!	√	√	σ;σσσ
d. (σ́σ)(σ́σ)(σ́)	√	√	*	σσ;σσσσ!

Because vowels can delete in Passamaquoddy (as will be discussed in section 2.2), PARSE-C must be distinguished from PARSE-V, which we define in (77). It will turn out to be ranked quite low in the hierarchy of constraints.

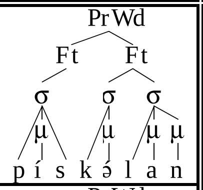
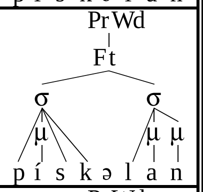
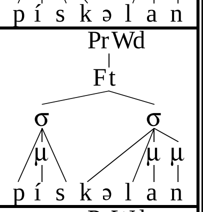
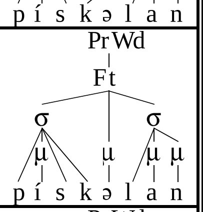
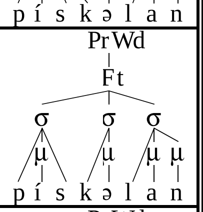
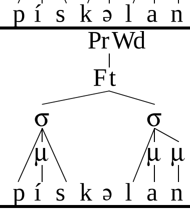
(77) PARSE-V An underlying vowel must be parsed in the output.

Tableaux which demonstrate the various components of the analysis described above are given in (78) and (79).

(78)

/ sokəlan /	PROPER SYLL	PARSE -C	*WEAK PEAK	PARSE -V	FTMAX	FTMIN
a. 	√	√	*!	√	√	*
b. 	√	√	√	*!	√	√
c. ☞ 	√	√	√	√	√	√
d. 	√	√	*!	√	*	√

(79)

/ piskəlan /	PROPER SYLL	PARSE -C	*WEAK PEAK	PARSE -V	FTMAX	FTMIN
a. ☞ 	√	√	*	√	√	*
b. 	*!	√	√	*	√	√
c. 	*!	√	√	*	√	√
d. 	*!	√	√	√	√	√
e. 	√	√	*	√	*!	√
f. 	√	*!	√	*	√	√

We leave the discussion of the analysis of the Passamaquoddy stress system at this point, and turn to the evidence that the weak vowels in Passamaquoddy can be underlyingly represented.[48]

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[48] As was true in Mohawk (see fn. 29), there are some cases in Passamaquoddy where, due to a sequence of weak vowels, two possible syllabifications are available, each satisfying *WEAKPEAK equally well. Some examples of such cases are listed in (i). The gen-

2.1 Weak vowels can be underlying in Passamaquoddy

It is worth reiterating that if it is true that weak vowels can be underlying, this tells us something important and interesting about the nature of weak vowels, namely that their metrical invisibility cannot and should not be derived from some property of epenthesis. Keeping this in mind, we will review some arguments for the underlying status of *ə* in Passamaquoddy.[49,50]

The first argument is a simple one. Consider the examples in (80), each of which contains the putatively *ə*-initial morpheme -*əpɨ*-.[51] However, if we consider the clusters *lp*, *kp*, *tp*, which are broken up by *ə* in (80), we see that these clusters occur elsewhere without any vowel intervening. Examples are given in (81). If *ə* is epenthetic in (80), why is it not inserted in (81)?

(80)	a.	wə́l-əpo	'he sits nicely, comfortably; he is well off'
	b.	nís-ek-əpí-si-t	'ghost'
	c.	tót-əpo	'he sits a long way off, he is far along'

(81)	a.	ktə́kəməlpə̀n	'we (exc.) hit you (sg. or pl.)'
	b.	tə́lpáyo	'he is scared'
	c.	ktəmakpekət	'it is a weak liquid'
	d.	kpə́cále	'he is hoarse'
	e.	wìkp	'black ash'
	f.	piskitpohkət	'it is a dark night'
	g.	tpəlokemo	'he gossips'

eralization seems to be that the leftmost weak vowel which can be left undominated by a syllable node, satisfying *WEAKPEAK, is. As before, we can suppose that the crucial decision between candidates is made by a constraint like ALIGN(σ, R; PrWd, R).

(i)	a.	kínəw-ə́so	'he is a certain one'
	b.	ásəw-əcək-ə́po	'it (an.) is flopped over to one side'
	c.	ht-ə́təl-ət-əm-ə́n-əl	'he is eating them (in.)'
	d.	h-péhk-ən-ə́m-ən	'he takes it all'
	e.	ə́təl-ə́lohk-é-c-ik	'they (du.) who are working'
	f.	íhtəl-ə́kehkí-m-ot	'where he goes to school'
	g.	h-pásk-əcək-ə́n-a	'you (sg.) break him, it (an., squishy) with your hand'

[49] The first two arguments are based on discussions of LeSourd's (1993), arguing for the same point.

[50] It is important to note that not *all* weak vowels in Passamaquoddy are underlying. Epenthetic *ə*, which is a weak vowel, can be inserted at certain morpheme boundaries (see LeSourd 1993, ch. 7). There are also cases of weak *i* derived from underlying (full vowel) *e* before *y* across a morpheme boundary (see LeSourd 1993, ch. 8), a situation which poses interesting questions for the present account, as LeSourd (p.c.) points out to me. I must leave a full exploration of this for future research.

[51] The final vowel of -*əpi*- surfaces as *o* due to an assimilation process involving a word-final deleted *w* in /-əpi-w/. See LeSourd 1993 for discussion.

The second argument is more complicated, revolving around the conditions for insertion the “connective *i*” between consonants at certain morpheme junctures.

The first step is to look at a consonant-final morpheme which conditions the insertion of a connective *i*. One such morpheme is *kis-* in (82). Notice that connective *i* is inserted only when it is followed by a consonant-initial root.

(82) a. kís-ewésto ‘he talked’
b. kís*í*-ko ‘he is full grown’

Now, consider example (83), where the connective-inserting morpheme is followed by a putatively *ə*-initial root. Notice that no connective *i* is inserted. This means that the stem in (83) patterns with the vowel-initial stems, not with consonant-initial stems. This already suggests that the metrically invisible *ə* in (83) is in fact part of the underlying representation.

(83) kís-əpo ‘it (an.) is finished’

The dependence of the insertion of connective *i* on the underlying forms is further supported by the examples in (84) and (85). It is an independent fact of Passamaquoddy that certain instances of *a* delete in certain contexts. One morpheme which contains a syncopating *a* is the morpheme *-ahte-* meaning ‘be located.’ This *a* surfaces in (84), and is deleted in (85).

(84) a. sákh-áhte ‘it protrudes into view’
b. íhtəl-áhte ‘it is always there’

(85) a. émék-te ‘it is down below’ < / emehk-ahte-w /
b. nís-ék-te ‘it has two layers’ < / nis-ek-ahte-w /

Interestingly, combining a connective-inserting root with this morpheme in a syncope context yields the form in (86), where the connective *i* is *not* inserted, even though it results in a consonant cluster on the surface. This indicates that the connective *i* is conditioned not by the surface form, but by some aspect of the underlying form. That is, no *i* is inserted in (86) because the second morpheme is *underlyingly* vowel initial even though the underlying vowel does not surface. What this means is that the fact that no connective *i* is inserted in (83) should be taken as evidence for the underlying presence of *ə*.[52]

(86) kís-te ‘it is finished’ < / kis-ahte-w /

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[52] By the reasoning of this section, the underlying form of the morpheme surfacing as *-pe* ‘liquid’ in (71) might also be vowel-initial; this was in fact the assumption made by LeSourd (1993:156). However, as LeSourd notes, if there is an initial vowel there, it must undergo syncope in all environments, since it never surfaces. In this respect, /əpi/ ‘sit’ is crucially different, since its initial *ə* surfaces frequently.

The third argument is a historical one.[53] LeSourd (1993:364) gives an outline of the historical development from Proto-Algonquian to Proto-Eastern Algonquian to Passamaquoddy. The vowel systems he lists, taken from Goddard (1980), are given below.

(87)	Proto-Algonquian	i	o	i·	o·
		e	a	e·	a·
(88)	Proto-Eastern Algonquian			ī	ō
		ə	a	ē	ā

According to Goddard's analysis, the PA **e* became PEA **ə*. Moving to Passamaquoddy, LeSourd indicates that **ə* was lost in weak positions before obstruents, but **a* was generally retained in such contexts. These two vowels later merged to *ə*, but even in contemporary Passamaquoddy, the distinction between *ə* which deletes before obstruents and *ə* which persists before obstruents remains (this distinction will be discussed in more detail in the next two sections).

For our purposes, what is important here is that the weak vowel *ə* in Passamaquoddy has a historical correspondent (in fact, it has two). For comparison, I list forms of 'he sits' in (89) from four Algonquian languages (taken from Kenstowicz 1994b:119, who in turn took Cowan's (1972) normalized transcriptions of words analyzed by Bloomfield). In (90), I list some Passamaquoddy examples involving the same morpheme.[54]

(89)	'he sits'	Fox	Cree	Menomini	Ojibwa
		-nāhapiwa	nahapi	-nāhapɛw	nahapi

(90)	a.	wə́l-əpo	'he sits nicely, comfortably; he is well off'
	b.	pét-ék-əpo	'it (an.) comes to be located here.'
	c.	tót-əpo	'he sits a long way off, he is far along'
	d.	tékk-ə́pi-t	'as far away as he sits'
	e.	nís-ek-əpí-si-t	'ghost'

To complete this argument, it should be shown that in PA and PEA, the vowels in these positions did not arise via epenthesis. Although I cannot show this here, I will assume that it is true, and conclude that given its underlying status in closely related languages, it is unlikely to be epenthetic in Passamaquoddy.[55]

[53] Thanks to David Pentland for pointing me in this direction.
[54] Unfortunately, I'm not certain about the morphology in the examples in (89), and I lack an exactly matched example from Passamaquoddy. Nevertheless, the point should be clear.
[55] The evidence provided by the historical argument is murky at best, since it would also be important to establish that historical vowels weren't reanalyzed as epenthetic. Moreover, there are cases of epenthetic *ə* in the inflectional system at least historically in Passamaquoddy, according to LeSourd (p.c.).

Taken together, these three arguments give us good reason to believe that ə in Passamaquoddy is not epenthetic.

2.2 Syncope of weak vowels as an alternative to nonsyllabicity

Underlying weak vowels have an important property which epenthetic weak vowels lack. Both types of weak vowel are subject to *WEAKPEAK, but underlying vowels have two distinct ways to satisfy this constraint, listed in (91). One way is familiar, namely being prosodified without a syllable node. However, underlying weak vowels can also satisfy *WEAKPEAK by being deleted. It turns out that the Passamaquoddy ə takes full advantage of both options.

(91) A language may avoid violations of *WEAKPEAK by
 a. Parsing the weak vowel, but not into a syllable.
 b. Not parsing the weak vowel at all.

In Passamaquoddy, metrically invisible weak vowels are often deleted when they would have preceded an obstruent, although they always surface before sonorants. The examples in (92) show such a ə where it is in a metrically visible position, following a cluster. Where the preceding cluster is removed, as in (93) the ə does not surface. This type of syncope occurs only before obstruents—a (non-initial) ə before a sonorant invariably surfaces (recall (66a)).

(92) a. áps-əkíhqən ‘it is small’
 b. n-kə́pəcàl ‘I am hoarse’

(93) a. kín-kíhqən ‘it is big’ < / ...-ə̲kihqən /
 b. kpə́cále ‘he is hoarse’ < / kə̲pəcale /

cf. (66a) sók-ə̲lan ‘it pours (rain)’

The examples in (93) appear to be cases where *WEAKPEAK is satisfied by deleting the weak vowel altogether, option (91b). Following a suggestion by Phil LeSourd (p.c.), let us interpret these facts as follows. Suppose that deletion of a metrically invisible weak vowel is the default option in Passamaquoddy, but that a constraint on syllable contact rules out structures in which a sonorant onset follows a coda consonant. Thus, where syncope of ə would cause a sonorant onset to be adjacent to a coda consonant, syncope is blocked in order to avoid violating the syllable contact constraint. This approach to ə syncope both explains the fact that Passamaquoddy basically lacks sonorant-final consonant clusters (Sherwood 1986:72),[56] and the fact that word-initial ə will delete whether it precedes an obstruent or a sonorant, as in (94-95).

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[56] The only sonorant-final clusters allowed word-internally are geminates and *h*-initial clusters. *h* has various special properties that make this an unsurprising gap, and in *hl* clusters, it may well be the case that *l* is in coda position. Geminates blur the boundary between syllables, and are often claimed to be exempt from various processes as a result. Word-initially, *km, kn,* and *nm* clusters are possible, but I take this to be due to the special

(94) a. ht-ə́lamí-ptin ‘the palm of his hand’
b. lámí-ptin ‘palm of the hand’

(95) a. ht-ə́təlí-na-n ‘he is dying (subordinative)’
b. tə́lí-ne ‘he is dying’

To explain why syncope of *ə* (91b) is the default option, we suppose that there is a cost incurred by allowing a metrically invisible *ə* to surface. As mentioned earlier, to allow deletion of underlying vowels while retaining the high ranking prohibition on deletion of underlying consonants, we must distinguish PARSE-V, which requires vowels to be parsed, from PARSE-C, which requires consonants to be parsed. The definition of PARSE-V is repeated in (77) below. The ranking in (96) allows satisfaction of *WEAKPEAK to motivate syncope.

(77) PARSE-V An underlying vowel must be parsed in the output.

(96) PARSE-C, PROPERSYLL >> *WEAKPEAK >> PARSE-V

If weak vowels enter the computation without a mora (discussed in the next section), then a mora must be added to the representation if the weak vowel is to surface. The FILL-μ constraint (defined earlier in (35)) discourages the addition of moras to the structure. So, if FILL-μ outranks the constraint against vowel syncope (PARSE-V), then syncope will be the default option.

(97) FILL-μ, *WEAKPEAK >> PARSE-V

There is an additional advantage to interpreting the syncope facts in this way. Passamaquoddy has a significant class of exceptional morphemes in which a *ə* before an obstruent nevertheless “resists syncope,” even when metrically invisible. For example, the *ə* in the stem *-əpi-* surfaces, despite being metrically invisible before an obstruent, as we see in (98).

(98) a. pét-ék-ə̲po ‘it (an.) comes to be located here.’
b. wə́l-ə̲po ‘he sits nicely, comfortably; he is well off’
c. nís-ek-ə̲pí-si-t ‘ghost’
d. tót-ə̲po ‘he sits a long way off, he is far along’
e. ə̲pì-n ‘sit (sg.)!’

The proposal I make is that “syncope-resistant” *ə* like the one in *-əpi-* is underlyingly associated with a mora, unlike “syncope-prone” weak vowels, since syncope is taken to occur when no mora is available underlyingly to allow the weak vowel to surface. Thus, there are two types of weak vowels in Passamaquoddy, those which enter the computation with a mora—the “syncope-

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treatment of the word-initial consonant (some interpretation of extrametricality) that allows word-initial clusters at all in a language where CVC is generally the maximal syllable.

resistant" weak vowels—and those which do not—the "syncope-prone" weak vowels.[57] We will use this distinction in the next section to try to determine the representational nature of weak vowels.

3 The nature of weak vowels and *WEAKPEAK

An issue which has not been directly addressed so far is what differentiates "weak vowels" from "full vowels," and how the distinction relates to the nature of the *WEAKPEAK constraint. Put another way, it seems that although positing a lexical feature "[+Weak]" on certain vowels and a constraint like *WEAKPEAK to govern the behavior of vowels marked in this way can give us a way to interpret the data we have been faced with, it remains mysterious what such a "[+Weak]" diacritic would represent and why a language would make use of such a mechanism.

To start the discussion, let me first point out why we do need something *like* a diacritic to distinguish between strong and weak vowels. In Passamaquoddy, ə can act in one of three ways. As discussed in the preceding sections, ə may be a weak vowel, being counted for stress only in certain environments. In this case, there are two distinct behaviors; either it is deleted by pre-obstruent syncope ("syncope-prone") or it resists such syncope ("syncope-resistant"). The ə in Passamaquoddy can also behave as a normal full vowel (LeSourd 1993:95-97), metrically visible in all contexts just as any other underlying vowel would be. The three behaviors of the Passamaquoddy ə are summarized in (99).

(99) Three behaviors of the Passamaquoddy ə
  a. Full vowel
  b. Weak vowel which resists syncope
  c. Weak vowel which can delete before obstruents

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[57] This division of ə into just two categories is an oversimplification, according to LeSourd (p.c.), who notes that there are some instances of ə (e.g. the initial ə of /-əkehki(m)-/ 'teach' (LeSourd 1993:317)) which are syncope-resistant word-internally, yet delete word-initially before an obstruent. Notably, the exceptionality appears to go only in this direction; that is, there are no instances of ə which are syncope-resistant word-initially yet delete word-internally. LeSourd suggests an analysis that includes two distinct deletion rules, one deleting word-initial ə and one deleting ə before obstruents. Because two rules would delete a word-initial ə before an obstruent, only a ə marked as an exception to *both* rules can avoid deletion in this context. This derives the directionality of the asymmetry; no ə can be syncope-resistant word-initially without also being syncope-resistant word-internally as well. In the analysis I have been proposing, there is only one "rule exception feature" available, namely the underlying association to a mora. Thus, for the cases where a ə behaves differently in initial and internal positions, I would have to say that the *input* for the ə in the two positions differs. LeSourd (p.c.) notes that "initials and finals related to them aren't *always* identical," and accounting for these exceptions under the view I have been taking seems to require this to be true. It does, however, leave the directionality of the asymmetry without explanation.

The proposal made at the end of the previous section was that syncope-resistant ə (99b) is distinguished from syncope-prone ə (99c) by being underlyingly endowed with a mora. This leaves the question of how to distinguish full vowels (99a) from weak vowels (99b-c).

First, it is clear the distinction between full and weak vowels is not simply derivable from vowel quality, since ə in Passamaquoddy can behave in any of the three ways listed in (99). The same is true of Mohawk *e*; some vowels which phonetically surface as *e* count for stress in every environment (the underlying *e*), while others only count for stress in certain contexts (the epenthetic *e*). Moreover, in each of these languages, there are at least two different surface vowels which exhibit behavior associated with weak vowels; in Mohawk, the joiner *a* and the epenthetic *e* can each be metrically invisible, and in Passamaquoddy, certain instances of *i*, *a*, and *o* undergo syncope just like ə when in a metrically invisible context. Given these conditions, we seem to be forced to posit some kind of indication in the lexical representation of vowels to determine whether they are weak or full.

We can understand this situation in a way which is more principled than simply adopting a diacritic feature on underlying vowels. Suppose instead that the distinctions in (99) arise from three different levels of underlying prosodic specification on vowels. Each type of vowel is underlyingly associated with a certain kind of prosodic structure. Full vowels are underlyingly associated with a syllable, while syncope-resistant weak vowels are underlyingly associated with a mora. Syncope-prone weak vowels will not be associated with any underlying prosodic structure.

(100) Underlying representations of Passamaquoddy ə

a.	V—μ—σ	Full vowel
b.	V—μ	Weak vowel which resists syncope
c.	V	Weak vowel which can delete before obstruents

Given such structures, consider the effect of a general faithfulness constraint against adding things to the prosodic representation, *STRUC (Prince & Smolensky 1993:25, Zoll 1993). The result of such a constraint would be to ensure that a vowel which enters the computation without a syllable will leave the computation undominated by a syllable, up to satisfaction of higher ranked constraints. This is, of course, exactly the function of *WEAKPEAK; it prohibits weak vowels (now interpreted as being vowels which underlyingly have no associated syllable) from heading a syllable (which would be something added to the structure). Thus, *WEAKPEAK is actually subsumed by the much more general *STRUC. Of course, given the stipulative nature of *WEAKPEAK to begin with, this is a welcome result. The question which must be faced now is whether by admitting the possibility of such underlying prosodifications, we have lost more than we have gained.

It is clear that this view is not compatible with a view which holds that nothing predictable is stored in the lexicon. Inkelas (1994) takes up this issue and shows that within the phonological framework of ranked constraints we have adopted, the most natural representation for the learner to adopt does include nonalternating structure. Below, I briefly summarize her argument.[58]

We begin by considering a language learner who is attempting to infer the underlying form of a phonetic output, given a set of ranked constraints. It is generally true that several different underlying forms could generate the correct output, so it is an issue how the learner decides upon the correct underlying form from among the possible candidates. A natural way to imagine such a decision being made is to suppose that the underlying form chosen will be the one which causes the least significant violations to the ranked constraints in the grammar. That is, if we suppose that two potential underlying forms U_1 and U_2 can generate a single surface form T, but U_1 violates a high-ranked constraint that U_2 satisfies, U_2 will be assumed to be the correct underlying form. This is the intuition expressed as Lexicon Optimization by Prince & Smolensky (1993: 192). Inkelas (1994) generalizes this principle slightly in order to allow information from surface alternations to be used in the decision of which is the correct underlying form. Her statement of the Lexicon Optimization principle is given in (101).

(101) LEXICON OPTIMIZATION (Inkelas 1994)
Given a grammar G and a set $S = \{S_1, S_2, ..., S_i\}$ of surface phonetic forms for a morpheme M, suppose that there is a set of inputs $I = \{I_1, I_2, ..., I_j\}$, each of whose members has a set of surface realizations equivalent to S. There is some $I_i \in I$ such that the mapping between I_i and the members of S is the most harmonic with respect to G, i.e. incurs the fewest marks for the highest ranked constraints. The learner should choose I_i as the underlying representation for M.

In more intuitive terms, what Lexicon Optimization guarantees is that, given the alternations a morpheme exhibits, the underlying representation that a learner will posit for that morpheme will be the one which causes the fewest violations of high-ranked constraints throughout the forms it appears in.

The concept of faithfulness between the underlying form and the output form, fundamental to Optimality Theory, supposes that differences between the input and output forms is minimized to the greatest extent possible without incurring violations of higher ranked constraints. This intuitive faithfulness is instantiated by PARSE and FILL constraints (Prince & Smolensky 1993), which penalize omission from and addition to the structure, respectively.

As Inkelas notices, the juxtaposition of faithfulness constraints and Lexicon Optimization predicts a certain nonminimality in underlying forms. That is, underlying forms (i.e. the members of the set I in (101)), will be compared with one another on the basis of how well they satisfy all of the constraints, including the faithfulness constraints. If a morpheme surfaces in all environments with a certain structure, the Lexicon Optimization principle will result in the represen-

[58] See also Yip (1996) for a similar discussion reaching a similar conclusion.

tation of that entire structure in the lexicon. However, where there are alternations, structural underspecification will be forced.

Applied to the question at hand, this means that since a full vowel always surfaces as the nucleus of a syllable, the preferred underlying representation will include the syllable node.[59] On the other hand, a weak vowel, which does not always surface attached to a syllable node, will not be underlyingly represented with a syllable node.

The conclusion so far, then, is that given this at least reasonable view of the task of learning underlying forms in a constraint-based framework, we are in fact *forced* to represent full vowels as underlyingly associated with a syllable.[60]

4 Comparison to other approaches

Now that my proposal has been sufficiently outlined, we will turn to consideration of other analyses of the same phenomena. Many of these analyses share the common problem of attempting to make a principled link between the metrical invisibility phenomenon and fundamental properties of epenthesis. We have seen, however, that it is also possible for underlying vowels to be contextually invisible to syllable-sensitive processes, a fact which an adequate account must be able to accommodate.

4.1 The timing slot approach (Michelson 1989, LeSourd 1993)

The approach taken by Michelson (1989) to the Mohawk facts and by LeSourd (1993) to the Passamaquoddy facts assumes that epenthesis, syllabification, and tonic lengthening are rules which can be ordered with respect to one another.

Michelson (1989) proposes the ordered set of rules for Mohawk given in (102), assuming the framework of Clements & Keyser (1983), in which segmental material is taken to be on a separate tier from CV timing slots.

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[59] LeSourd (p.c.) points out to me that this is not entirely accurate; in a certain context (see fn. 50), an underlyingly full vowel *e* becomes a weak *i* by some mechanism. Without an analysis of this phenomenon in the current framework, it is difficult to know what implications this has. However, we will need to ensure that the learner does not take this as evidence that the *e* was a weak vowel. I leave this for future exploration.

[60] Supposing that Lexicon Optimization forces underlying representation of syllables does not necessarily entail a view in which a language where stress is invariant, represents the *entire* prosodic structure underlyingly. For example, one can imagine that the underlying cause for the Hierarchical Locality constraint (section 1.4) might prohibit lexical storage of underlying forms which span prosodic levels from a foot to a segment. There is also a question of subsegmental nonalternation as well; we presumably do not want the initial aspiration of English *pin* stored in the lexicon, for example. I acknowledge that adopting Lexicon Optimization in this form opens up a vast territory of issues and implications, but these must be left to future research.

(102)	Joiner Insertion	(insert *a* onto melody tier in C]_[C)
	e-Epenthesis	(insert *e* onto melody tier in C_R, C_?#)
	V-Insertion I	(link unlinked vowel to V slot in C_CC)
	Mohawk Stress Rule	(build *sw* foot at right edge—i.e. stress penult)
	V-Insertion II	(link unlinked *a* [joiner] to V slot)
	Vowel Lengthening	(lengthen stressed vowel in _CV)
	Prothesis	(insert *i* in #_C_0VC_0#)
	V-Insertion III	(link unlinked *e* to V slot)

In many ways, this original analysis is quite close to the current proposal, properly translated into the theoretical perspective we adopt. Under Michelson's analysis, metrical visibility of an epenthetic vowel is due not to a property of epenthesis, but to various repair strategies which make unlinked (invisible) vowels visible in certain contexts. Although this is expressed as a conspiracy of rules, the clear goal is to ensure proper syllabifiability of the underlying form.

Another point Michelson (1989:57) makes explicitly, and which wasn't brought up during the discussion of Mohawk previously, is that "weightless vowels" can occur morpheme-internally, and in these cases should not be attributed to synchronic epenthesis, but instead should be underlyingly represented. As she points out, both weightless *e* and weightless *a* appear in contexts which appear to be synchronically morpheme-internal, although some instances of *a* may be at historical morpheme junctures (see also fn. 35). Michelson proposes underlying representations which have, in such positions, a segment alone on the segmental tier, undominated by any nodes on the CV tier. An example of the underlying representation she proposes for the word *wákeras* 'it smells' is given in (103).

(103)

```
  σ       σ
  |       |
C V C   C V C
| | |   | | |
w a k e r a k
```

Notice that this is in fact a very close relative of the underlying forms proposed in our discussion of underlying weak vowels in Passamaquoddy; full vowels are underlyingly associated to a syllable, weak vowels are underlyingly unassociated to prosodic structure.

LeSourd (1993) takes essentially the same approach to weak vowels in Passamaquoddy, suggesting that underlyingly they are unassociated to the CV tier, and various "epenthesis" rules operate to associate such segments to V-slots.

The analyses of Michelson (1988, 1989) and LeSourd (1993) deal with a much broader range of facts than I have attempted to discuss here; both have the property that, while being quite complicated and intricate, they manage to predict the correct forms over a very large database, and involving many interacting forces.

The main problem with this CV-style approach is that it doesn't provide (at least in any direct way) any principled motivations for the rules required for a particular language. Although from the viewpoint of the theory constructor, the use of specific rules is clearly syllabification-driven in many cases, this is not expressed in any direct way in the analysis but instead becomes a conspiratorial consequence of several distinct (and often quite stipulative-looking) rules. By contrast, in the proposal I advanced in the earlier sections of this paper, syllabification is the driving force not just in theory construction, but within the system as well. As mentioned initially, though, many of the basic insights captured in the analyses of Michelson and LeSourd can be translated into a framework without these problems.

4.2 The weightless syllable (Piggott 1995, Erwin 1996, Kager 1990)

Another approach to the Mohawk phenomena is the "weightless syllable" approach, proposed in the greatest detail by Piggott (1995), but also advocated by Kager (1990) (for Dutch) and Erwin (1996) (for Malagasy). This approach supposes that the inventory of possible syllables should be expanded to include not just light (monomoraic) and heavy (bimoraic) syllables, but also "weightless" (moraless) syllables. We will begin by reviewing Piggott's (1995) analysis.

The idea behind this approach is that, under normal circumstances, epenthetic vowels will project to weightless syllables. In a quantity-sensitive language where moras are counted for the purposes of stress assignment, such syllables should be metrically invisible. Piggott also proposes that in a language where coda consonants are moraic (that is, where CVC syllables are heavy), a closed syllable headed by an epenthetic vowel will become visible again by virtue of the weight associated to the coda consonant. What this means is that by virtue of both being monomoraic, open syllables and closed syllables headed by an epenthetic vowel are equivalent in terms of stress assignment. Notice that this implies that only a quantity-sensitive language should exhibit contextual metrical invisibility, since it is the nonmoraicity of epenthetic vowels which is taken to be the cause of this behavior.

To explain the varying metrical visibility of the epenthetic vowels to stress and lengthening effects in Mohawk, Piggott makes crucial use of three derivational levels at which epenthetic vowels can be inserted. In the first two levels, labeled "lexical" in (104), an inserted vowel necessarily projects a mora into the representation. The third ("postlexical") level is distinguished from the lexical levels by the fact that a vowels inserted postlexically need not project a mora. Between the first and second lexical levels, syllabification and foot structure is established, determining stress placement, whereas vowel lengthening occurs at the third level.

(104)		
(104)	Lexical level 1	(insertion of metrically visible epenthetic *e*)
	|	
	|	(Syllabification, foot structure assignment)
	|	
	Lexical level 2	(insertion of joiner vowel *a*)
	|	
	Postlexical level	(insertion of metrically invisible epenthetic *e*) (tonic lengthening)

An epenthetic vowel inserted postlexically will not have a mora and will not count for stress, thereby failing to satisfy the environment for tonic lengthening; these are the metrically invisible epenthetic *e*'s. A vowel inserted lexically but after syllabification will not count for stress, but will have a mora by the time tonic lengthening applies, allowing tonic lengthening; these are the metrically invisible joiner *a*'s. A vowel inserted lexically and before stress assignment acts just like an underlying vowel with respect to stress and tonic lengthening; these are the metrically visible epenthetic vowels.

This analysis is fundamentally a rule-ordering account, but with some attempt to derive the order of rule application from independent principles. A principle called "Procrastinate" dictates that an epenthetic vowel will be inserted in the latest level possible,[61] up to other requirements. Constraints which force epenthetic vowels to be inserted early include a requirement that morphologically governed epenthesis (i.e. of joiner *a*) take place at one of the lexical levels, a requirement that two epenthetic nuclei may not be adjacent at the point of syllabification ("Proper Government"), and a requirement that a word must be minimally bisyllabic at or before the last lexical level (the Minimal Word requirement). While there are some deep differences between the weightless syllable approach and the one which I have argued for, the invocation of the Procrastinate constraint instantiates an intuition which is shared by both analyses, namely that an epenthetic syllable will be metrically visible (i.e. be "inserted early") only when forced to be by other overriding constraints.

One point of divergence between the weightless syllable and the weak vowel analyses of the Mohawk facts is in the answer to the question of what prosodic unit stress is sensitive to. While I have claimed that stress in Mohawk is sensitive only to syllables, the weightless syllable analysis must suppose that

[61] Clearly, Procrastinate is intended to be interpreted as an instantiation of the principle proposed by Chomsky (1995) as a constraint on syntactic derivations, which Piggott characterizes as requiring all processes in grammar to occur as late as possible. The proposal Chomsky makes in syntax is very theory-internal, however, and it is not at all clear how such a principle would carry over to phonology. In syntax, Procrastinate avoids operations that have overt reflexes. In phonology, no similar overt/covert distinction exists. As far as I can see, the only coherent way to interpret the Procrastinate principle Piggott proposes is not as an extension of an independently justified principle, but as a new principle specific to phonology. Perhaps Piggott's analysis, to the extent it is successful, could be considered a partial argument for attempting to unify the two notions of Procrastinate in syntax and in phonology, but no independent argument to this effect has been given.

Mohawk stress is sensitive to moras. That is, one must suppose that a trochaic foot which contains at least two moras is constructed at the right edge of the word, stress falling on the syllable which contains the penultimate mora. Nothing else being said, we should expect to find that closed word-final syllables are stressed, since we know from the tonic lengthening facts that coda consonants are moraic in Mohawk. Of course, this expectation is counter to the facts, as we have seen in cases like (9a) *wakényaks*.

The moraic trochee analysis also makes a prediction for words that end in a closed syllable followed by an epenthetic *e*. In such words, given that closed syllables are bimoraic, the closed syllable should bear the stress, since it contains the penultimate mora. Again, though, as we have seen in cases like (8e) *óne̲raht<u>e</u>ʔ*, this prediction is not borne out.

Lastly, with respect to a minimal word requirement, if we assume that its purpose is to ensure that word contains a well-formed foot, the moraic trochee analysis predicts that a single closed syllable should not require a prothetic *i*, which is contradicted by forms like (5b) *í:keks*.

To accommodate these cases, Piggott proposes an overriding, inviolable NONFINALITY constraint, which rules out stress on the final syllable. This handles cases like *wakényaks*, where word-final closed syllables are not stressed, and cases like *í:keks*, where prothetic *i* is inserted to keep stress from being final, but in order to correctly predict the stress in *óne̲raht<u>e</u>ʔ*, Nonfinality must actually be interpreted as preventing the last syllable *which has weight* in a word from being stressed, ignoring word-final weightless syllables altogether.

An entirely different analysis is required to explain the invisibility of joiner vowels for stress assignment, since they must project a mora into the representation by virtue of their being "lexical." Relying on the fact that syllabification and foot formation occurs before the insertion of the joiner vowel, Piggott proposes that where joiner insertion creates a trimoraic foot, the foot structure is readjusted by a repair rule that retracts the right edge of the foot, leaving the head in place.

The main problem with Piggott's analysis of Mohawk in terms of weightless syllables is that nearly every fact is accounted for by a distinct principle or rule. The differences between weightless vowels and full vowels comes from timing of insertion with respect to syllabification and footing, where this timing is mainly governed by Procrastinate and restrictions on morphologically-driven epenthesis. To explain stress retraction in the cases discussed above, a Nonfinality constraint is required. To explain the inability of adjacent epenthetic vowels to be weightless, a "Proper Government" constraint—which in essence simply prohibits two adjacent epenthetic vowels—is invoked. To explain the apparent weightlessness of joiner *a* in contexts where epenthetic *e* would be weightless, a foot readjustment rule is called upon. To explain tonic lengthening, a mora transfer process called "Trochaic Enhancement" is called upon, and a locality restriction is added to it in order to explain why an intervening epenthetic *e* blocks lengthening. In short, the prosodic patterns of

Mohawk under the weightless syllable view do not result from any coherent driving forces, but rather from a hodgepodge of independently operating rules and principles, each of which has very little evidence for it outside of the domain it accounts for.

A weightless syllable approach has also been proposed by Erwin (1996) for Malagasy and Kager (1990) for Dutch. The Dutch case will be examined in section 6.1. In Malagasy, syllables have a strict CV shape,[62] and stress normally surfaces on the penultimate syllable. However, where the final syllable contains a diphthong, stress falls on the final syllable. Erwin takes this to suggest that stress falls on the syllable containing the penultimate mora, essentially a moraic system. Where a word is underlyingly consonant-final, an epenthetic vowel is inserted to satisfy the strict CV template, but the epenthetic vowel does not count for stress purposes. Erwin quite sensibly interprets this to indicate a word-final nonmoraic syllable.[63]

Although the arguments presented against Piggott's (1995) analysis of Mohawk do not carry over to Erwin's (1996) analysis, there is a conceptual reason to disprefer an analysis which allows nonmoraic syllables. Specifically, such structures should be ruled out by the Proper Headedness constraint (Itô & Mester 1992), discussed earlier in section 1.4. We have some reason to believe that Proper Headedness holds at other prosodic levels; for example, the minimal word requirement suggests that a foot is required as the head of a prosodic word for it to be well formed. By removing this constraint on structure, we not only allow the representation of a moraless syllable, but also a large class of unattested prosodic structures.

The other main problem with the nonmoraic syllable approach in general is that it does not translate well to languages like Passamaquoddy, which shows a contextual metrical invisibility effect very similar to that found in Mohawk. First, Passamaquoddy stress is very clearly based on the syllabic trochee; vowel length distinctions are not phonemic, and the location of stress does not depend on the distinction between open and closed syllables. Given this, the number of moras in a syllable—whether it is two, or one, or zero—would not be expected to have any effect on stress patterns. Thus, there is no obvious way to represent metrically weak vowels in Passamaquoddy under this view.

Even setting that aside, recall also that in Passamaquoddy, a consonant cluster *preceding* an underlying ə causes the ə to be metrically visible where it otherwise would not be; compare *sókəlan* (66a) to *pískə́lan* (66b). Piggott's account of Mohawk, however, made crucial use of the moraic status of coda consonants in the explanation of the visibility of closed syllables headed by an

[62] Here, I assume with Erwin (1996) that apparent NC clusters are actually prenasalized consonants which have the phonological status of a single segment.
[63] I do not provide a full reanalysis of the Malagasy data here. It is clear that a reanalysis under the present assumptions would require a relaxation of the strict CV syllable structure under pressure from *WEAKPEAK in some form, but the specific details of a suitable analysis of Malagasy stress must await future investigation.

epenthetic vowel, but no such mechanism is available to explain how an onset triggers visibility given that onsets are universally nonmoraic. Under the weightless syllable view, there is no clear way to account for how the presence of an onset could make a weightless syllable become visible, yet this appears to be what happens in Passamaquoddy.

4.3 The prosodic head-dependence approach (Alderete 1995b)

Another view takes as a starting point the intuition that epenthetic vowels make bad prosodic heads. We will look most closely at the "head-dependence" analysis presented by Alderete (1995b) because it deals directly with the Mohawk facts, although other analyses of stress/epenthesis interactions have been proposed in the same vein, e.g., by Shinohara (1997) for epenthesis in Japanese loanwords.

Under Alderete's analysis, the metrical invisibility of epenthetic vowels in Mohawk follows from the HEAD(Pcat)-DEP constraint in (105).[64]

(105) HEAD(PCat)-DEP Every segment contained in a prosodic head PCat in S_2 has a correspondent in S_1. If PCat is a prosodic head in S_2, and PCat contains β, then $\beta \in$ Range($\Re$).

What HEAD-DEP essentially says is that no epenthetic vowels can be contained in a prosodic head. The effect of this is that where an epenthetic vowel heads a syllable that would have been stressed, that structure is ruled out in favor of a structure which has stress placed elsewhere. Notice that this approach takes very seriously the connection between epenthesis and metrical invisibility, a connection whose existence we have seen reason to doubt, both in Passamaquoddy and in Mohawk.

Alderete (1995b) proposes a specific analysis of a subset of the Mohawk facts, which we will review here. He does not address either the joiner vowel or tonic lengthening, however, nor does his approach lead to a clear analysis of these aspects of the Mohawk data.

The basic stress pattern in Alderete's analysis comes from constraints requiring a syllabic trochee to be aligned with the right edge of the prosodic word.[65] Where a metrically invisible epenthetic *e* interrupts an underlying word-final consonant-glottal stop sequence (106a), the final syllable is left unparsed, under pressure from HEAD(Ft)-DEP to avoid having any epenthetic material in the main stress foot. Where an epenthetic *e* appears between the stressed vowel and the last vowel in the word (106b), a different constraint must be called upon, HEAD(σ)-DEP, which prevents an epenthetic vowel from bearing main stress.

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[64] In this definition, $\Re$ is a correspondence relation between S_1, taken to be the input string, and S_2, taken to be the output string.

[65] Alderete also ranks PARSE-SYLL above ALIGN(Ft, R, PrWd, R) which causes a right-to-left iterative foot parsing pattern. However, given the absence of secondary stress in Mohawk, it would seem that the default assumption should be that there is no such iterating foot pattern.

(106) a. /ʌ-k-arat-ʔ/ ʌ.(ká:.ra).t*e*ʔ 'I lay myself down'
b. /te-k-rik-s/ (té.k*e*).riks 'I put them together'

Yet a third explanation is needed for cases like (107) where two epenthetic *e*'s appear between the main stress and the end of the word. Here, the suggestion is that in order to satisfy HEAD(Ft)-DEP, a discontinuous foot can be constructed, skipping the syllable with epenthetic material.

(107) /o-nraht-ʔ/ (ó.{n*e*}.rah).t*e*ʔ 'leaf'

This analysis seems less than optimal to explain the Mohawk facts, relying on three different constraints and footing structures to capture the three different behaviors of the epenthetic *e*. Moreover, it allows for discontinuous constituents in the prosodic structure, which is clearly a power we should endow our theory with only if we are uncontroversially forced to do so. For example, one question that immediately arises with respect to the analysis in (107) is how the skipped syllable is attached to the prosodic structure, assuming that this is a precondition for elements to surface phonetically. This issue will come up again when we consider Cohn & McCarthy's (1994) analysis of Indonesian as well, in section 6.2. Further, the head-dependence analysis of Mohawk does not provide any clear way of explaining why tonic lengthening should be blocked before an epenthetic *e*, not to mention why it should fail to be blocked before joiner *a*. Looking at the structures in (106b) and (107), there is no clear way to even state the environment in which tonic lengthening should be blocked. What we are left with is an impression that an analysis has been forced upon the Mohawk facts which is not well suited to them.[66]

4.4 Other analyses of Mohawk (Potter 1994, Ikawa 1995, Pizer 1996)

To close this section, I will comment briefly on three other recent analyses of the Mohawk data.

Potter (1994), outlining an Optimality theoretic account of Mohawk, proposes that where epenthetic *e* is metrically invisible, it is an excrescent vowel, using the terminology of Levin (1987). Such vowels are taken to be low-level phonetic reflexes, and not participating in the phonology in any way. If we suppose that the invisible *e* is actually outside of the phonology altogether, we have an automatic explanation for why it blocks tonic lengthening and why it does not count for stress placement. What we lose is any connection between the metrically visible epenthetic *e* inserted for syllabification and the metrically invisible epenthetic *e*. Potter takes the joiner vowel facts to indicate that even in an Optimality theoretic analysis, a second level of candidate evaluation is necessary, where stress assignment and tonic lengthening occur in the first level and

[66] I do not, however, wish to deny the existence of a dispreference for epenthetic prosodic heads; although I believe that Alderete's (1995b) analysis of Mohawk is incorrect, other cases he discusses are more convincing and do not lend themselves in any obvious way to a reanalysis in terms of "weak vowels."

the joiner *a*, when invisible, is only inserted after the first level. However, I take the entire discussion of Mohawk here to refute his claim that a two-level evaluation and recourse to excrescent vowels is required to provide a satisfactory account of the Mohawk facts.

Another recent analysis was proposed by Ikawa (1995), who accounts for the Mohawk data by suggesting that a constraint against double-epenthesis within a syllable, FILL-σ, and the constraint against epenthesis and tonic lengthening, FILL, are both active in the constraint set. The driving force of his analysis is an avoidance of lengthened epenthetic vowels; epenthetic vowels in open syllables are the ones which do not count for stress, and Ikawa notices that this is also the context in which an epenthetic vowel would be subject to tonic lengthening. In such a case, stress is shifted off the epenthetic vowel so that, if tonic lengthening is to occur, it will be an underlying vowel that is lengthened. To handle stress shift in cases where the epenthetic vowel is the last vowel in the word, such as in the contexts where the epenthetic vowel is inserted before a word-final glottal stop, Ikawa suggests that two distinct Nonfinality constraints are at play—one which requires stress to be nonfinal in the prosodic word (NONFINALITY-P) and one which prevents stress from falling on the last *underlying* vowel (NONFINALITY-M). Where the last vowel of a surfacing word is epenthetic, the only place that stress can fall and satisfy both Nonfinality constraints is on the antepenult. The main problem with this account is that there is no obvious way to incorporate the fact that tonic lengthening fails to occur before an metrically invisible *e*, something which Ikawa does not mention. Under his system, a word like *tékeriks* would be footed as (té).ke.riks, meaning that the syllable which is responsible for conditioning tonic lengthening is on the other side of a foot boundary from the syllable which would be lengthened. I believe that the facts concerning tonic lengthening are quite significant, and I take the inability to account for them to be a serious flaw in Ikawa's account.

Finally, another sketch of an analysis of these facts is proposed by Pizer (1997). She confronts the interaction of epenthetic *e* and tonic lengthening, deriving the behavior from a structure fairly similar to the one proposed here. Epenthesis is driven by an avoidance of tautosyllabic clusters containing resonants, and syllabification of epenthetic vowels is driven by the need to incorporate underlying consonants into syllables. She seeks to discredit the view that prosodic incorporation is a precondition for phonetic interpretation (i.e. "stray erasure"), analyzing weightless epenthetic *e* as completely unprosodified, yet surfacing. However, she does not provide any arguments against the view taken here, that such vowels are unsyllabified yet prosodified through domination by a mora. Moreover, it would seem to be desirable to retain the assumption that unprosodified material is not phonetically interpreted in light of its ability to allow a uniform account of the syncope and metrical invisibility of the Passamaquoddy ə (from section 2.2). Another problem with the analysis presented by Pizer is that she does not address the joiner vowel facts. Her analysis as presented cannot account for them, since the failure of lengthening before invisible *e* is derived from a very high-ranked ban on syllables with a long vowel and a coda consonant; yet, in her analysis as in mine, such a syllable structure is basically forced by the facts where a stressed vowel precedes a weightless joiner vowel.

5 Implications and conceptual issues

Having discussed the implications and conceptual difficulties with some competing approaches to the "contextual metrical invisibility" phenomenon, I wish to briefly address some of the implications of the approach I am taking here that have not yet come up in the preceding discussion.

One question which often arises in discussions of this material is what the implications are of allowing a structure such as the one I have proposed, where a mora can be directly dominated by a foot in prosodic structure. In particular, the concern is whether allowing such structures will "overgenerate" and predict a larger range of languages than we actually find. Assuming (following the arguments of Itô & Mester 1992) that Selkirk's (1984) "Strict Layer Hypothesis" is too strict, the "footed mora" is a very natural structure in a theory which already allows for onsets directly dominated by a syllable, or syllables directly dominated by a Prosodic Word. It does entail, however, that we treat the mora as a true prosodic entity, on a par with the with foot and the syllable. Under this view, a mora cannot simply be a feature of a syllable, given that it can stand alone, without a syllable present. Others have argued for such a view; Bagemihl (1991) argues that nonsyllabified moras are responsible for the prosodic licensing of the large consonant sequences in Bella Coola, Zec (1994) and Ní Chiosáin (1991) propose accounts which rely on the ability of moras to be "projected" into the prosodic representation by one segment but linked to another. In short, it seems to be independently necessary both to allow for weak layering of prosodic structure and to represent moras as full members of the prosodic representation.

Another question concerns the concept of surface syllabification. Many of the forms I have discussed above (and will discuss in the next section) contain sequences like CVC.*v*, where *v* is a metrically invisible vowel. Yet, phonetically, these appear to sound like CV.C*v* sequences; LeSourd (1993:118) writes that "at least in deliberate speech, the *k* of *sókəlan* forms the onset of a syllable of which the following *ə* is the nucleus," yet I have argued for the representation $[[\text{sok}_\sigma][\text{ə}_\mu][\text{lan}_\sigma]_{\text{Ft}}]$. The question is: what relation do the phonological forms I have proposed here have to the phonetic forms one hears in the surface representation? Several answers are available; one is to assume that the phonetic realization should precisely reflect phonological structure, and to take the surface realization as counterevidence to the whole approach I've taken here. This is not the answer I wish to adopt. I believe that we have seen some fairly good *phonological* evidence for the existence of a structure like $[[\text{sok}_\sigma][\text{ə}_\mu][\text{lan}_\sigma]_{\text{Ft}}]$ somewhere in the phonology. What this means is that this phonological structure and its phonetic realization must be dissociated in some way. Phil LeSourd (p.c.) has pointed out striking differences between the "word level" and "phrase level" phonology in Passamaquoddy, and such a distinction is commonly required for a complete account of the phonology of any language. In Passamaquoddy, which of the stressed syllables in a word receives *main* stress is conditioned by its position in the utterance (see fn. 41). Nonhomorganic clusters of obstruents within a word which arise from the deletion of a weak ə are pronounced as clusters, but such clusters formed at word boundaries have a brief ə inserted between them. Metrically invisible ə invariably deletes word-internally between identical consonants (e.g., *tə́l-lan* </tel-əlan/ 'it is pouring (rain)' (LeSourd 1993:277), *mét-témo* </met-ətemi-w/ 'he stops crying' (LeSourd 1993:283)), yet where a word-initial ə does not undergo syncope and appears between identical consonants at the phrase level, the ə will not delete (e.g., *nə̀t ətóhk* 'that deer' **nə̀t tóhk* (LeSourd (p.c.)). The natural suggestion to make is that the structure $[[\text{sok}_\sigma][\text{ə}_\mu][\text{lan}_\sigma]_{Ft}]$ is in fact a word-level phonological representation, obscured by either the phrase-level phonology or the principles of phonetic interpretation themselves.[67] Clearly this is an area which requires more exploration, but my goal here was just to make clear the need for some dissociation between the phonological structure I have argued for and its phonetic interpretation. Obvious issues remain, including the question of whether some of what has been attributed to word-level phonology should in fact belong to phrase-level phonology. I assume not, but it should be shown.

Because epenthetic vowels commonly exhibit the properties of weak vowels crosslinguistically, we will close this section by taking a moment to look at a prediction that this approach to metrical invisibility makes for epenthetic weak vowels. Broselow (1982), investigating the relationship between epenthesis and metrical visibility, identified the three distinct types of epenthesis listed in (108).

(108) Types of epenthesis (Broselow 1982)
- a. Metrically-conditioned epenthesis
- b. Syllabically-conditioned epenthesis
- c. Segmentally-conditioned epenthesis

Mohawk provides examples of each of the three types. An example of metrically-conditioned epenthesis is the insertion of the prothetic *i*, which ensures that a word is minimally a well-formed foot. Syllabically-conditioned epenthesis occurs in order to rescue strings which would be otherwise unsyllabifiable. When such environments arise in Mohawk, a metrically visible epenthetic *e* is inserted. Notice that because the first two types of epenthesis are defined in terms of syllable structure, a syllable node is also motivated in these cases. This means both metrically-conditioned and syllabically-conditioned epenthetic vowels will *necessarily* be metrically visible.

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[67] In this connection, it is interesting to note that LeSourd (1993:157) writes that "it would probably be more accurate to say that the *k* of *sókəlan* becomes ambisyllabic [...]. In sufficiently rapid speech for the ə of this word to be deleted altogether, this *k* presumably remains part of the syllable *sok*." Unless we suppose that the phonological representations differ in fast and slow speech, we might take this as support for the view that phonetic interpretation itself is responsible for conferring a surface "CV.C*v*" structure to phonological structure with CVC.*v* constituency.

The third type of epenthesis, segmentally-conditioned epenthesis, is motivated not by syllable structure, but by language-particular phonotactic constraints against certain sequences of segments. The epenthetic *e* serves this function as well, since it is inserted to break up consonant-sonorant and consonant-glottal stop sequences. Importantly, because syllabic structure is not part of the motivation for segmentally-conditioned epenthesis, these are the epenthetic vowels which may surface as metrically invisible.

Thus, this approach makes the following prediction: only epenthetic vowels which are segmentally-conditioned can be metrically invisible. Note, however, that it is clearly not entailed that *any* disruption of the normal stress pattern of a language caused by epenthesis is necessarily segmentally-conditioned. This is because, aside from disruption of the sort we have discussed so far, there may also be effects from other sources, such as avoidance of prosodic heads containing epenthetic material (as proposed by Alderete (1995b) and Kenstowicz (1994c)). In this latter case, we might expect a "foot-reversal" (e.g., a trochaic foot in a normally iambic system) or "foot-shifting" (i.e. moving the boundaries of the foot in such a way as to avoid an epenthetic head syllable). The cases which do require segmentally-conditioned epenthesis are the cases like Mohawk, where neither foot reversal nor foot shifting can explain the facts.

6 Potential extensions

The "weak vowel" approach to Mohawk and Passamaquoddy outlined above also has some promise for explaining similar phenomena in other languages as well. In the next few subsections, I will sketch very brief outlines of analyses of certain phenomena in Dutch, Indonesian, and Winnebago which look as if they can be fruitfully analyzed in terms of an avoidance of syllabified weak vowels.[68]

6.1 Dutch

First, we will consider Dutch, based on the data and presentation of Kager (1990). In Dutch, the vowel *ə* never receives stress. Kager presents several arguments, which I briefly summarize here, in favor of considering *ə* to be a "defective syllable head" in Dutch.

Dutch distinguishes short vowels (*a*, *ε*, *ɔ*, *œ*, *ɪ*) from both long vowels (*a*, *e*, *o*, *ø*, *i*, *y*, *u*) and diphthongs (*au*, *εi*, *œy*) in open syllables. Short vowels cannot occur in open syllables (109), and to account for this fact, Kager proposes the BIMORAIC CONSTRAINT in (110).

(109) a. *tɑksi
b. *slε
c. taksi 'taxi'
d. sle 'sledge'

[68] I also suspect that "ghost segments" such as those discussed by Zoll (1993) will receive a natural analysis in these terms, very much in the spirit of the discussion of Passamaquoddy syncope.

e. bʌy 'rain shower'
f. χalɛi 'galley'

(110) BIMORAIC CONSTRAINT Syllables dominate at least two moras.

Although ə is realized phonetically as a short vowel, it is exempt from the bimoriacity requirement as we can see from (111).

(111) a. *mikɑ
b. *hɪndɪ
c. mika 'mica'
d. hɪndi 'Hindi'
e. mikə (name)
f. hɪndə 'hind'

Kager takes this to indicate that ə does not head a syllable at the point where the Bimoraic Constraint takes effect, and we will follow his intuition.

Kager also gives numerous arguments, which are summarized in (112), for believing that a consonant which precedes ə is syllabified in the coda of the preceding syllable rather than as an onset to a syllable headed by ə.

(112) a. /h/, /ŋχ/, and diphthong + /r/ do not occur either before ə or syllable-finally. They may occur before full vowels.
b. /ŋ/ may occur before ə and may occur syllable-finally. It does not occur before full vowels.
c. Obstruent + liquid consonant clusters do not occur before ə.
d. Syllable final consonant clusters and consonant clusters before ə undergo optional epenthesis of a very short ə-like vowel.
e. In Dutch dialects where /sp/ is metathesized at the end of a syllable, it is also metathesized before ə, but not before full vowels.

These properties make sense if we interpret ə as a weak vowel subject to a high-ranked *WEAKPEAK. Moreover, the fact that *WEAKPEAK in Dutch appears to be "surface true," since ə never surfaces as the head of a syllable, instantiates a possible ranking that the Optimality Theory framework leads us to expect. We saw that in Mohawk and Passamaquoddy, *WEAKPEAK was ranked below constraints on syllable structure and was therefore often violated. If languages can differ with respect to the relative rankings of constraints, we expect to find a language where *WEAKPEAK is ranked high enough to be unviolated in the surface forms. Dutch seems to be just such a language, as does Indonesian (discussed in the next section).

Further evidence for the weak vowel analysis of Dutch ə comes from the stress patterns. Although stress in Dutch is descriptively quite complex, we will consider the somewhat simplified "penultimate/antepenultimate" pattern as it is characterized by Kager (1990) in (113a-b), along with the property (113c) that superheavy syllables (either a closed syllable with a long vowel, or a syllable closed by two or more consonants) attract stress (Kager 1989).[69]

(113) *Dutch primary stress*
- a. If the penultimate syllable is closed, it is stressed.
- b. If the penultimate syllable is open, stress either the penultimate or antepenultimate syllable.
- c. Final superheavy syllables are generally stressed.

In words where the last vowel is ə and preceded by consonants, main stress falls on the preceding syllable (114).

(114) *Dutch final ə*
Stress is always prefinal in words whose last vowel is ə, preceded by a consonant.

Under a weak vowel analysis, (114) is explained by the fact that the consonants preceding the ə are forced into the coda of the preceding syllable, thereby closing it. Because this syllable with therefore be a heavy syllable, it will attract stress.

As one last note, there are plenty of words in Dutch which end in a final *əC* sequence, such as those listed in (115). Under a weak vowel analysis which supposes that the ə is a weak vowel unassociated to a syllable node, we are left with the somewhat familiar question of what becomes of the word-final consonant. Clearly, the word-final consonant must be extrametrical in some way, able to be licensed without a syllable node. How exactly this extrametricality should be implemented is too complex of an issue to enter into here, but Hung (1993) and Spaelti (1994) each provide discussion of extrametricality within the framework we are assuming.

(115)	a.	kalender	[ka.lɛn.dər]	‘calendar’
	b.	catalogus	[ka.ta.lo.χəs]	‘catalogue’
	c.	notulen	[no.ty.lən]	‘minutes’
	d.	pantoffel	[pan.tɔ.fəl]	‘slipper’

Notice that if we suppose that the word-final consonant is extrametrical, this also allows for a great simplification of the statement of the Dutch stress generalizations, as follows:

(116) *Dutch primary stress (revised)*
Stress is on the antepenultimate vowel unless followed by a heavy syllable, in which case the heavy syllable is stressed.

Although a more detailed analysis of the stress system of Dutch is beyond the scope of this section, approaching Dutch ə as a weak vowel governed by a high-ranked *WEAKPEAK constraint appears to be promising. By adopting this

[69] A much more in-depth study of the stress system of Dutch is set out in Kager (1989).

view, we gain an simpler generalization of the stress patterns as well as an explanation of the behavior of consonants which precede ə.

6.2 Indonesian

Indonesian, like Dutch, has a weak vowel (ə) which never counts for stress. Cohn & McCarthy (1994) and Kenstowicz (1994a) analyze Indonesian within an Optimality Theory framework, but both are mainly concerned with the effects of morphological structure and neither discuss the treatment of ə at any length. Since our goals here are just the opposite, we will only consider monomorphemic words and ignore the behavior of prosody at morpheme boundaries.

Basic stress in monomorphemic words is assigned to even numbered syllables counting from the end, as well as to the initial syllable in words longer than three syllables. Stress clash is resolved in favor of the initial syllable.

(117)	a.	cát	'print'
	b.	cári	'search for'
	c.	bicára	'speak'
	d.	bìjaksána	'wise
	e.	kòntinuási	'continuation'
	f.	èrodìnamíka	'aerodynamics'
	g.	àmerikànisási	'Americanization'

We can analyze this pattern as strictly binary trochaic stress feet aligned to the right edge, with the left edge of the word preferentially aligned with a foot as well. An unfooted syllable is allowed in words with an odd number of syllables. The constraints involved in deriving this are discussed in Cohn & McCarthy (1994), Kenstowicz (1994a) and will not be reviewed here.

A ə can never receive stress, and is always skipped over for the purposes of stress assignment. This can be seen in the examples in (118).

(118)	a.	bərí	'give'
	b.	gáməlan	'Indonesian orchestra'
	c.	sətəláh	'after'
	d.	apártəmen	'apartment'
	e.	cərítəra	'story'
	f.	pərəmpúan	'woman'
	g.	kopərási	'cooperation'
	h.	dìfərensiási	'differentiation'

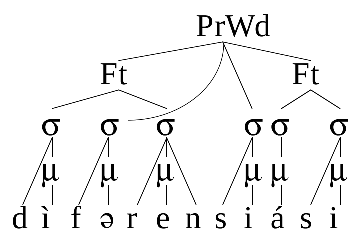
Cohn & McCarthy (1994) analyze the metrical invisibility of ə by means of the NON-FOOT(ə) and NON-HEAD(ə) constraints given in (119).[70] They ex-

[70] In Cohn and McCarthy's system, Non-Foot(ə) provides pressure to not include a ə in a foot at all. However, if it ends up being unavoidable, a second constraint NON-HEAD(ə) is necessary to ensure that ə doesn't wind up being the head of a foot. This could, for example, yield an iambic foot in a language which is otherwise strictly trochaic.

plicitly devote no further attention to formalization of these constraints, yet as they are stated they seem to predict structures which are somewhat suspect under normal assumptions about the prosodic representation, such as that shown in (120) (pointed out by Morris Halle, class lectures 1995). The difficulty lies in the fact that the analysis leaves undetermined how a syllable headed by a ə, not allowed to be dominated by a foot, can nevertheless be part of the prosodic representation at the point of phonetic interpretation.

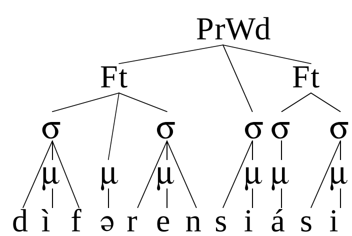
(119) NON-FOOT(ə) Schwa-headed syllables have no metrical projection.
NON-HEAD(ə) Stressed ə is prohibited.

(120)



If we instead adopt a weak vowel analysis of Indonesian ə, this representational difficulty does not arise. Supposing that ə is a weak vowel, we would predict a structure more in line with current assumptions, such as that given in (121).

(121)



Like Dutch, Indonesian shows evidence that *WEAKPEAK is very highly ranked. In Indonesian, examples like *apártəmen* (118d) indicate that *WEAKPEAK even outranks constraints against complex codas, since in this word *part* must form a syllable. Given that, this analysis of Indonesian ə makes testable predictions about syllable structure which remain to be explored; in particular, pre-ə consonants in Indonesian, like in Dutch, should behave not like onsets but like codas. Investigation of these predictions is left for future research.

6.3 Winnebago

The stress pattern of Winnebago provides a (fairly well-discussed) case in which epenthetic vowels have a sometimes-visible, sometimes-invisible behavior (see

Miner 1979, 1992, Hale & White Eagle 1980, Alderete 1995a, Halle & Vergnaud 1987).

In simple (nonepenthetic) cases, main stress can be described as falling on the third mora of a word, or the second mora of a bimoraic word. Secondary stress then shows an alternating pattern rightward from the main stress. The examples in (122) show cases where the first syllable is heavy, and the examples in (123) show cases where the first syllable is light.

(122)	a.	zíi	'yellow, orange'
	b.	čiinák	'town'
	c.	xǰaanánе	'yesterday'
	d.	čiinák-šąną̀	'only towns'
	e.	haakítuǰìk-gaǰą̀	'after I pull taut'

(123)	a.	waǰé	'dress' (n)
	b.	waniğík	'bird'
	c.	waniğíg-ra	'the bird'
	d.	hakirúǰik-gàǰą	'after 3p pull taut'

Alderete (1995a) argues for an analysis of the stress patterns above as involving moraic trochees with the initial foot extrametrical.[71] The head of the second foot bears the main stress. Cases like *waniğík* (123b) indicate that parsing all syllables into feet takes priority over avoiding degenerate feet. I will suppose (contrary to Alderete 1995a) that cases like *waǰé* (123a) actually have two degenerate feet, and in cases like *zíi* (122a) no feet can be made extrametrical.

In Alderete's analysis, noninitial heavy syllables invariably receive stress by virtue of a WEIGHT-TO-STRESS-PRINCIPLE (WSP) constraint, and a high-ranking constraint against stress clash (*CLASH) forces the syllable after a stressed heavy syllable to be left unfooted. We can see the effect of this in examples (124); in (124a, b), the heavy syllables receive stress, but the final vowels do not receive stress, despite the fact that they would otherwise be able to form a degenerate foot. In (124c), we see that the heavy syllable receives primary stress under pressure from WSP, despite the fact that this forces the initial extrametrical foot to be degenerate, like in *wăǰé* (123a) discussed above. (124d) shows that where a heavy syllable is followed by light syllables, the heavy syllable receives stress and is followed by a longer lapse than is normally expected, due to the high-ranking *CLASH constraint.

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[71] Alderete (1995a) proposes that the initial foot extrametricality stems from a general NONINITIALITY constraint, but I believe a more straightforward analysis brings this configuration about by a high ranking alignment constraint with mismatched edge parameters: ALIGN(PrWd, L, Foot, R). If we interpret an extrametrical foot as being adjoined to the PrWd (following Hung 1994), the alignment constraint would force one foot to be adjoined off to the left of the PrWd whenever possible, given some assumptions about the evaluation of ALIGN constraints in the context of adjoined constituents.

(124)	a.	hit’et’éire	‘they speak’
	b.	mąąčáire	‘they cut a piece off’
	c.	kiríiną	‘he returned’
	d.	hižąkíicąšguną́nągá	‘nine and’
	e.	wağįğį́ğišgap’ų́įžeré	‘baseball player’

Winnebago has a well-known epenthesis process (“Dorsey’s Law”) that breaks up obstruent-sonorant clusters by inserting a vowel between the consonants, the quality of which is determined by the following underlying vowel. A statement of Dorsey’s Law as a rule is given in (125) below. We will follow Alderete in interpreting this as a response to a SyllContact constraint (126) making reference to the language-particular sonority scale in (127).

(125) Dorsey’s Law $\text{Ø} \rightarrow V_i$ / [voiceless obstruent] —[sonorant] V_i

(126) SyllContact Where C_1 and C_2 are (output-)adjacent non-tautosyllabic consonants, $C_1 < C_2$ by no more than one sonority interval.

(127) Winnebago sonority scale:
Voiceless obstruents
Voiced stops
Voiced fricatives, Sonorants
Vowels

The epenthethic vowel inserted by Dorsey’s Law is metrically visible in some contexts (128), but not in others (129). In (129), we see that the primary accent falls on the fourth surface vowel of the word, skipping over the epenthetic vowel. In (130), we see a word which contains both metrically visible and metrically invisible epenthetic vowels within the same word.[72]

(128)	a.	k*e*ré	‘leave returning’
	b.	š*a*wažók	‘you mash’
	c.	š*a*wažókǰį	‘you mash hard’
	d.	hip*e*rés	‘know’
	e.	hojiš*ą́*ną	‘recently’
	f.	boop*é*res	‘sober up’
	g.	p*o*rop*ó*ro	‘spherical’
	h.	hirak*ó*rohò	‘you prepare’

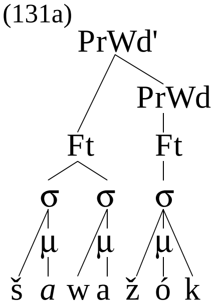
(129)	a.	hoš*a*wažá	‘you are ill’
	b.	hik*o*rohó	‘prepare’

[72] Benjamin Bruening (p.c.) pointed out to me that we cannot say for certain that the DL-vowel in (128a, b, d) is metrically visible, given that bimoraic words like *waǰé* show final stress as well. This noted, I will continue to assume that it is visible in such cases, although this should be kept in mind in future consideration of the generalizations.

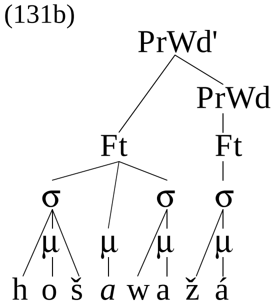
(130) a. wak*i*rip*á*ras ‘flat bug’
b. wak*i*rip*ó*rop*ò*ro ‘spherical bug’

We can analyze the DL-vowel as a weak vowel which avoids heading a syllable wherever possible. The representations in (131) depict the proposed structures for (128b) and (129a).

(131a)



(131b)



In terms of these structures, the generalization is that a DL-vowel can successfully avoid metrical visibility if it falls internal to the word-initial foot (131b).

This differs from the analysis of DL-vowels proposed by Alderete (1995a). His proposal is that “DL-sequences” (C*v*RV) are structurally a heavy syllable whose nucleus is interrupted by the resonant. The best evidence he provides for this view is, first, a reduplication process which seems to reduplicate a syllable or an entire DL-sequence, and second, phonotactic constraints against homorganic consonants occurring within a DL-sequence, common crosslinguistically as a syllable-internal constraint. In this brief analytical sketch, I have no counterexplanation for these two arguments, but they deserve serious consideration before finally adopting the weak vowel proposal.

That said, however, I should also point out that the most basic prediction of Alderete’s approach is that DL-sequences should behave just like heavy syllables, yet they do not appear to do so. I will briefly go through how this prediction is not met, concluding that despite the arguments mentioned above for DL-sequences as heavy vowels, it is not an entirely adequate account.

The two ways in which DL-sequences differ from heavy syllables are (*i*) in their behavior under stress clash and (*ii*) in their interaction with initial light syllables. Starting with the clash facts, recall (124), where we saw that heavy syllables attract stress and that a following syllable will be unfooted under pressure from *CLASH. If a DL-sequence is simply a heavy syllable, we would expect that stress cannot follow a DL-sequence either, but this is not true: stress can surface after a DL-sequence either on a light syllable *hò*, as in *hirakórohò* (128h), or on another DL-sequence *pòro,* as in *wakiripóropòro* (130b). Alderete proposes to account for this by interpreting *CLASH as sensitive to moras rather than to syllables. However, by revising *CLASH in this way, we lose the explanation for clash avoidance in examples like *hit'et'éire* (124a), where the mora dominating the penultimate vowel *i* should intervene between the stressed mora of the diphthong and the mora of the following syllable nucleus, predicting that stress should be allowed on the word-final vowel. Thus, this restatement of *CLASH does not seem to solve the problem, and we are left with the basic conclusion that with respect to clash resolution, DL-sequences just do not act like heavy syllables.

The second difference between DL-sequences and heavy syllables is in their interaction with an initial light syllable. Recall that in examples like (124c), *kiríina*, a heavy syllable following a light syllable was taken to cause the light syllable to form a word-initial degenerate foot. If DL-sequences are heavy syllables, then we predict (incorrectly) that (129b) should be **hikórohò*. The actual form, *hikorohó*, indicates that all but the last vowel are contained in the word-initial extrametrical foot. Although Alderete questions the transcription of the data in these cases, the suspicion does not seem to be warranted. His argument revolves around the fact that Miner (1979) transcribed such forms with a grave accent on the DL-vowel *hikòrohó* (Miner 1979:30), yet Miner (1990:9) and Hale & White Eagle (1980:128) write it as *hikorohó*. Hale & White Eagle (1980:117) mention this in a footnote, indicating their uncertainty as to what Miner (1979) was indicating by the grave accent in these positions, and pointing out that the special quality of the vowels Miner marked with a grave accent is not secondary accent but extra brevity. A survey of Miner (1979) in fact reveals that the grave accent appears on every DL-vowel which does not itself receive primary stress, and is used nowhere else. For example, he writes (128a) as *kèré* (128d) as *hipèrés* (Miner 1979:26), and where a word has enough syllables to carry secondary stress, it is marked with a second acute accent, as in *hokiwároké* 'swing (n.)' (Miner 1979:28). Further, in the published interchanges between Miner and Hale and White Eagle on the topic of Winnebago metrics (Hale & White Eagle 1980, Miner 1981, Hale 1985, Miner 1990), this transcription issue has never arisen outside of the footnote in Hale & White Eagle (1980). Given this, I see no reason to believe that the transcriptions used since Miner (1979) are in doubt, and conclude that we indeed have a second instance of DL-sequences which do not act like heavy syllables.

Given the failure of DL-sequences to pattern as complex heavy syllables, the alternative analysis based on weak vowels holds some promise. However, the many issues remaining must be left open for future research.

7 Concluding remarks

To recap, we have seen that the proposal that weak vowels are avoided as syllable heads in prosodic structure allows us to explain their invisibility to syllable-sensitive phenomena, and also gives us an explanation for why they sometimes are rendered visible in certain contexts. It has also been suggested that the nature of weak vowels derives from their underlying lack of prosodic associations, while nonalternating "full" vowels are generally stored lexically with an associated syllable node. A constraint against addition of structure (particularly syllable nodes) to the prosodic representation keeps weak vowels from being dominated by a syllable node. A secondary claim, crucial to the results, is that moras can exist outside of syllables in a weakly layered prosodic structure.

Of course, several questions still remain unanswered. One such question is why it is that weak vowels tend to be the epenthetic vowels and vowels which have a neutral (ə) quality. This tendency cannot be derived in principle from the analysis presented here, although it has also been shown that the properties of weak vowels in specific languages should not be derived either from vowel quality or from the nature of epenthesis in general. Accepting this, the tendency for epenthetic and neutral vowels to be the weak vowels in a language is nevertheless clear but not captured by the proposals I have outlined.[73]

Lastly, I wish to point out that the analysis I have developed suggests a strong hypothesis, namely that in any language where a vowel acts invisible to syllable-sensitive processes, this vowel is not dominated by a syllable node in the prosodic structure. This means, among other things, that surrounding consonants must always be taken to be associated to neighboring constituents in such situations. The strength of the hypothesis is a good aspect of the approach, making it empirically testable. How successful the approach will be when extended remains to be seen, but the initial results are encouraging.

Appendix. Data sources

Key:			
Key:	C	=	Cohn 1989
	HWE	=	Hale & White Eagle 1980
	K	=	Kager 1990
	L	=	LeSourd 1993
	M88	=	Michelson 1988
	M89	=	Michelson 1989
	M79	=	Miner 1979
	M90	=	Miner 1990
	P69	=	Postal 1969
	P94	=	Potter 1994
	P95	=	Piggott 1995
	S43	=	Susman 1943
	S86	=	Sherwood 1986

(1) L:22
(3) M88:53, M88:55, M89:44, M88:53, M89:44, M88:63, M88:59
(4) M89:44, M89:44, M88:53, M88:53

[73] However, Kenstowicz (1994c) shows that there are languages for which vowel quality, in terms of sonority, is the driving force in stress placement. If it is in general true that more sonorous vowels are better suited for stress, this may interact with the present proposals in a way that predicts the tendency for languages to choose ə as their weak vowel if they have weak vowels. Similarly, John McCarthy (p.c.) points out that if epenthesis is understood as inserting the minimal amount of structure, this might explain the tendency for epenthetic vowels to be weak vowels as well. Further development of this point awaits future research.

(5) M89:45, M89:45, P94:350, M88:163
(7) M89:41, M88:133, M88:142, M89:46, M88:140
(8) P95:292, M89:43, M88:140, M89:41, P95:292, M88:137
(9) M89:42, M89:42, P95:292 (cf. M88:142 *tekahsutéhrhaʔ*, which I take to be an error), M88:135, P95:307
(10) M88:137, P95:294, M88:140
(11) M88:133, M88:142, M89:46, M88:140, M89:41, P95:292
(18) M89:65, M88:143
n.27(i)M88:143, M88:143
n.31(i)M88:143, M88:143
(44) P95:307, P95:307
(45) P95:308, P95:308
(46) M88:59, M88:59
(47) M88:59, M88:59
(48) M88:63, M88:64
(50) P69:293, P69:293, M88:57
n.32(i)P69:292, M88:58, M88:58
(53) M88:62, M88:33, M88:48, M88:37
(54) M89:48, M89:39, M89:39, M89:48, M89:48
(62) M89:64, M88:161, M89:65, M89:65, M88:158
(65) L:75, L:75, L:75, L:75
(66) L:22, L:22, L:92
(71) L:156
(72) L:156
(73) L:156
n.48(i)L:90, L:92, L:52, L:90, L:91, L:91, L:92
(80) L:87, L:90, L:286
(81) L:389 (typographical error corrected by LeSourd (p.c.)), L:59, S86:75, L:168, L:59, S86:74, S86:73
(82) L:369, L:370
(83) L:370
(84) L:340, L:340
(85) L:341, L:341
(86) L:370
(90) L:87, L:81, L:286, L:82, L:90
(92) L:169, L:169
(93) L:168, L:168
(98) L:81, L:87, L:90, L:286, L:317
(109) K:242, K:242, K:242, K:242, K:242, K:242
(111) K:242, K:242, K:242, K:242, K:242, K:242
(115) K:246, K:246, K:246, K:246
(117) C:170, C:170, C:170, C:170, C:170, C:170, C:170
(118) C:174, C:174, C:174, C:174, C:174, C:174, C:174, C:174
(122) M90:3, M90:3, M90:4, M90:5, M90:5
(123) M90:3, M90:4, M90:5, M90:5
(124) M79:29, M79:29, S43:14, M79:25, M79:25
(128) M90:6, M90:7, M90:7, M90:7, M90:8, M90:8, M90:8, HWE:128
(129) M90:9, M90:9
(130) M90:9, M90:9

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