Pitch accent drives stress placement in Passamaquoddy-Maliseet

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1 Introduction

Passamaquoddy-Maliseet is known among linguists for having a stress system that is insensitive to reduced vowels – the system treats these vowels as if they do not exist (LeSourd, 1988, 1993). The vowel that most commonly exhibits this invisible behaviour is schwa, although all other vowels are capable of being skipped over by the stress system, with varying degrees of regularity (LeSourd, 1993). Previous analyses of these invisible vowels have noted that their behaviour cannot be explained by positing that they are epenthetic (Hagstrom, 1995), and instead have proposed that they are structurally "deficient", either in their lexical representation (LeSourd, 1988, 1993) or in the associated prosodic structure (Hagstrom, 1995). I propose that these vowels are not "deficient" or "invisible" to the stress system, but instead are simply too short to be able to host the pitch accent associated with stress or the transitions between these pitch accents. In order to better establish the above claims, some basic facts about Passamaquoddy-Maliseet will be reviewed, such as the default stress pattern and the behaviour of reduced vowels.

Passamaquoddy-Maliseet is an Eastern Algonquian language spoken in Maine, United States (Passamaquoddy) and New Brunswick, Canada (Maliseet). Although around 5,500 people identify themselves as Passamaquoddy or Maliseet (Lewey, personal communication), only about 500 are native speakers (Lewis et al., 2015). As a result, this language is classified as "shifting [into disuse]" by Ethnologue (Lewis et al., 2015).

The default stress pattern of Passamaquoddy-Maliseet is defined in (1), with examples provided in (2). No distinction is made between primary and secondary stress when transcribing stress in this language – all are written with an acute accent (´).

(1) **Default stress pattern of Passamaquoddy-Maliseet** (LeSourd, 1988, 1993):
  a. Stress is assigned to the **first syllable** of every word.
  b. Stress is assigned to **every other syllable**, starting on the **penult** and proceeding from **right to left**.
  c. Primary stress is generally held to be **rightmost**.

(2) **Examples of the default stress pattern** (LeSourd, 1993, 75):[1]

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[1]A list of abbreviations that are used in this paper, in alphabetical order: 1: first person; 2: second person; 3: third person; AI: animate intransitive; AN: animate; DIM: diminutive; DU: dual; EXCL: exclusive; II: inanimate intransitive; IMP: imperative; INAN: inanimate; INCL: inclusive; INTRANS: intransitive; OBJ: object; OBV: obviative; PL: plural; SG: singular; SUB: subordinative; TA: transtive animate; TI: transitive inanimate; TRANS: transitive.

a. *σ́σ* .wá.sis. ‘child’
b. *σ́σ́σ* .lé.wés.tu. ‘3.SG.AN speaks’
c. *σ́σσ́σ* .wí.ke.wés.tu. ‘3.SG.AN likes to talk’
d. *σ́σ́σσ́σ* .séh.tá.je.wés.tu. ‘3.SG.AN speaks while walking backwards’

Non-standard stress patterns are derived by addition of final stress to a word, which shifts all preceding stresses one syllable to the left, illustrated in in (3), where stressed syllables are underlined. Word-final stress is transcribed with a grave accent (̀).

(3) **Example of words that differ in final stress assignment** (LeSourd, 1988, 125):
a. .<u>ná</u>.tə.<u>kéh</u>.kim.<u>kèn</u>. ‘go (SG.IMP) to school’
b. .<u>ná</u>.tə.keh.<u>kím</u>.ken. ‘I go (SUB) to school’

Whether a word has final stress appears to be governed by the lexicon – for instance, certain morphemes always appear with final stress – such as *skítàp*, ‘man’ – or introduce final stress – such as -*`w*, ‘3.SG.AN.INTRANS’. These morphemes will not be considered for the remainder of the paper, which is concerned with the manner in which default stress assignment interacts with reduced vowels.

Words which contain reduced vowels are capable of disrupting the expected stress pattern, usually by introducing a lapse in stress that includes the reduced vowel. Some examples are provided in (4). LeSourd (1988, 1993) refers to these vowels as “unstressable”.

(4) **Examples of reduced vowels disrupting the default stress pattern** (LeSourd, 1993)[2]:
a. *σσ́* **σ́σ* .pə.nápsk^w. ‘rock’ (p.61)
b. *σ́σσ* **σ́σ́σ* .sú.kə.lan ‘3.SG.INAN pours (rain)’ (p.81)
c. *σ́σ́σσ* **σ́σσ́σ* .pé.té.kə.pu ‘3.SG.AN comes to be located here’ (p.81)
d. *σ́σσσ́σ* **σ́σ́σσ́σ* .ní.se.kə.pí.sit ‘ghost (antiquated)’ (p.90)

Although reduced vowels are capable of being skipped over, there are certain environments in which they behave like regular vowels. In LeSourd’s terminology, these vowels are “stressable”, although I will refer to them as behaving like full vowels for the remainder of the paper. A complete list is given in (5), following the environments listed in LeSourd (1988); Hagstrom (1995). The reader may note that the consonant *h* is excluded from the environments that reference consonant clusters, *[¬h]C__* and *__[¬h]C* – this is a result of the way that this consonant manifests phonetically. Any *hC* cluster is not realized as such, but instead causes lengthening of the preceeding vowel and devoicing of the collowing consonant, without any frication associated with *h*. The exception is *hl*, which does behave as a proper consonant cluster.

(5) **Examples of environments where reduced vowels are not skipped**:
a. $\_\_C_0\#$.á.má.<u>kən</u>. ‘fishing tackle’ (PMDP 2016)
b. [¬h]C__ .pí<u>s.kə́</u>.lan. ‘it rains so hard that it is dark’ (LeSourd, 1993, 81)
c. __[¬h]C .á.l<u>ə́n.t͡ʃ</u>is. ‘orange’ (PMDP 2016)
d. hl__ .á.t͡ʃe<u>h.lə́</u>.su. ‘3.SG.AN changes self’ (LeSourd, 1993, 82)
e. s__ss .skə́.ni.<u>sə́s.s</u>is. ‘bone (DIM)’ (LeSourd, 1988, 260)
f. $\#C_0__$Rə .<u>ht͡ʃə́</u>.lə.kíp.tun. ‘3.SG.AN squeezes it once, quickly’ (PMDP 2016)
g. $C_0əC_0\_\_$ .ná.<u>tə.mə́</u>.kil. ‘3.SG.AN is fairly tall, big’ (PMDP 2016)

At first glance, it may appear as if the difference in stressability is due to the vowel being either epenthetic, in the case of reduced vowels; or underlying, in the case of full vowels. Other languages are known to treat epenthetic vowels as if they are invisible to stress, such as epenthetic *i* in Arabic (Gouskova and Hall, 2009, and references therein), or epenthetic *i, e,* or *a* in Mohawk (Michelson, 1989). However, as noted by Hagstrom (1995), this analysis is not viable for Passamaquoddy-Maliseet. Hagstrom provides the example of the stem -*əpu*-, ‘sit’, which contains a vowel which behaves as if it is reduced, introducing lapses in all cases in (6).

[2]The gloss for this word is just given as ‘ghost’ by LeSourd (1988, 1993), but speaker Newell Lewey has informed me that this word is no longer used.

(6) **Schwa in -*əpu*- is a reduced vowel** (Hagstrom, 1995, 11):

a. wé**l-əp**u-∅
good-sit-3.SG.AN
'3.SG.AN sits nicely, comfortably; 3.SG.AN is well off'

b. pét-é**k-əp**u-∅
arrive-sheetlike-sit-3.SG.AN
'3.SG.AN (*e.g.*, cloth) comes to be located here'

c. nís-e**k-əpí**-si-t
two-sheetlike-sit-AI-3.SG.AN
'ghost (antiquated)'

If this reduced vowel were indeed epenthetic, then it would be inserted in order to repair an illegal consonant cluster, indicated by bolding in the examples above. However, these clusters do appear without epenthesis in Passamaquoddy-Maliseet, both across morpheme boundaries and within single morphemes, as in (7).

(7) **Consonant clusters are legal** (Hagstrom, 1995, 11):

a. k-tə́k-əm-ə́**l-p**ən
2-hit-TA-2.OBJ-1.PL.EXCL
'we (EXCL) hit you'

b. **kp**ə́tʃále-∅
hoarse-3.SG.AN
'3.SG.AN is hoarse'

Since these clusters are legal and do not require an epenthetic vowel to "fix" them, the schwa in (6) must be present in the underlying morpheme. Further evidence of its underlying nature is provided by the fact that it can receive stress when located in an environment where reduced vowels must count towards the stress system, as in (8).

(8) **Schwa in -*əpu*- can behave as if unreduced** (Hagstrom, 1995, 11):

té**kk-ə́**pi-t
as.far-sit-3.SG.AN
'as far away as 3.SG.AN sits'

Given that the schwa in -*əpu*- is not introduced in order to break up illegal consonant clusters and that it behaves like a full vowel in certain environments, its invisible behaviour in (6) cannot be attributed to epenthesis.

Similarly, it is not possible that the behaviour of reduced vowels in Passamaquoddy-Maliseet is due solely to a constraint banning them from hosting stress. In a framework like Optimality Theory (Prince and Smolensky, 1993), such a constraint could be formalized simply as a Markedness constraint which assigns a violation for each schwa or other reduced vowel that receives some degree of stress, *[ə́]. This constraint is not claimed to be inviolable – schwa has been shown to be able to bear stress in the environments in (5). However, if this constraint is ranked highly enough in the grammar it could adequately predict forms such as *pənápsk*^{w} 'rock', as in (9), or *súkəlan* '3.SG.AN pours (rain)', as in (10). Nevertheless, it would fail on forms such as *nísekəpísit* 'ghost (antiquated)', as in (11).

(9) **Stress can shift rightwards**:

/pənapsk^w/	*[ə́]	L-MOST	NONFIN
a. .pə́.napsk^w.	*!		
☞ b. .pə.nápsk^w.		*	*

(10) **Stress can be deleted in favour of a lapse**:

/sukəlan/	*[ə́]	NonFin	*Lapse
a. .sú.kə́.lan.	*!		
☞ b. .sú.kə.lan.			*
c. .sú.kə.lán.		*!	

(11) **Stress cannot shift to create a lapse**:

/nisekəpisit/	*[ə́]	L-most	*Lapse
☞ a. .ní.sé.kə.pí.sit.			
b. .ni.sé.kə.pí.sit.		*!	
✘ c. .ní.se.kə.pí.sit.			*!

The stress repelling constraint *[ə́] is capable of shifting stress only when the reduced vowel appears in a location where it would receive stress under default stress assignment. In (9), the reduced vowel is word-initial, and should receive stress under the stress assignment criteria in (1). Similarly, in (10), the reduced vowel is penultimate, another location where stress would be predicted to fall. However, since *[ə́] is ranked above any constraints responsible for assigning default stress, the candidates expected under default stress assignment are ruled out, and stress must either shift or be deleted.

The reduced vowel in (11) does not, however, fall within a syllable that should receive stress under default stress assignment. Since it cannot receive stress, *[ə́] will never be active for this input, and no stress shift is predicted to occur. This is contrary to what is observed, where a lapse containing the reduced vowel is introduced. It thus appears that reduced vowels are not only inadequate for hosting stress, but are also inadequate for acting as an interval between stresses.

Since neither epenthesis nor simple stress-repellance proves to be an adequate explanation for the invisibility of reduced vowels, previous analyses of these data have posited that these reduced vowels receive a "deficient" structural representation. For example, LeSourd (1988, 1993) posits that reduced vowels are stored in the lexicon differently than their full vowel counterparts. While full vowels are stored pre-linked to a timing tier slot in the tradition of autosegmental phonology (Goldsmith, 1976), reduced vowels are not linked to their timing tier until after stress assignment. Since stress rules are only able to apply to vowels linked to the timing tier, reduced vowels will be skipped over when stress is assigned. Similarly, Hagstrom (1995), working from within early Optimality Theory (Prince and Smolensky, 1993) and making use of the Prosodic Hierarchy (Selkirk, 1980), posits that reduced vowels are banned from being the heads of their own syllables by a constraint *Peak/ə. Since stress applies to feet and feet can only consist of syllables, any non-syllabified reduced vowels will appear to be "skipped over" by the stress system. Schwa can occasionally be forced to be the head of a syllable, under which circumstances it will behave as a full vowel and be counted when assigning stress.

In contrast to the analyses posited above, I claim that reduced vowels are not invisible to the stress system, and are therefore not structurally "deficient". The stress system treats them as it does any other vowel. Rather, it is the primary cue to stress, which is pitch accent (LeSourd, 1988, 1993), that is incapable of being realized on a durationally reduced vowel. Similarly, the transitions between one pitch accent and another are incapable of being realized on this short vowel. The interaction between stress assignment constraints. pitch accent alignment constraints, and constraints on the typical durations of vowels is what is responsible for the apparent invisible behaviour of reduced vowels.

This claim will be outlined in more detail within Optimality Theory (hereafter OT) in section 3, immediately after a more thorough review of the existing literature in section 2. Phonetic data from the Language Keepers and Passamaquoddy-Maliseet Dictionary Project (2016) will then be examined in sections 4, 5, and 6 in order to back up the analysis presented in section 3. Discussion and conclusion follows in sections 7 and 8, respectively.

2 Background

2.1 LeSourd (1988, 1993)

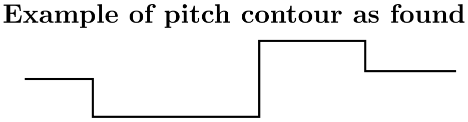
The most extensive resource on the stress system of Passamaquoddy-Maliseet comes from LeSourd (1988, 1993). The focus of the work is on the interaction of the stress system with schwa and other reduced vowels, but it also serves as a careful and thorough guide of the phonology of the language in general. As such, LeSourd includes instructive comments on how stress is cued, primarily focusing on alternations in pitch.

If the primary cue to stress is pitch, the question of whether Passamaquoddy-Maliseet is a pitch accent language or a stress language is raised. LeSourd (1988) does not make reference to any cues other than pitch, and for the most part assumes that the two are co-extensive. Although there may be other cues to stress that may or may not co-occur with pitch – such as increased duration and intensity, and more peripheral vowel quality (Fry, 1958, *a.o.*) – I will follow LeSourd in assuming that pitch is the primary cue to stress, and that pitch and stress do not occur on separate syllables. As such, it is difficult to tell whether this language should be properly classified as a stress language or a pitch accent language. Passamaquoddy-Maliseet is not unique in this respect – other languages, such as Creek (Haas, 1977; Martin and Johnson, 2002) and Ho Chunk (Hall, 2006) have been claimed to have pitch accent systems that behave incredibly similarly to stress, and I will consider Passamaquoddy-Maliseet to be one of these languages. Hereafter, the terms stress and pitch accent will be used interchangeably.

According to LeSourd (1988), stressed syllables are "relatively high-pitched" (p.119), and word-medial unstressed syllables "are relatively low-pitched" (p.126). As such, alternating stress should be correlated with alternating high and low pitch. LeSourd gives the example of *wít͡ʃuhkétahámal* '3.SG.AN thinks of helping 3.SG.AN.OBV', stating that the word-medial syllables are "alternatively relatively high and relatively low" (p. 126). LeSourd also observes that unstressed initial and final syllables are "pronounced on a fairly high pitch" (p. 126). I will take this to mean that the beginnings and ends of utterances are accompanied by a high boundary tone, under the assumption that the words transcribed by LeSourd were uttered in isolation. This assumption will later be largely borne out by the phonetic data collected, to be discussed further in section 4.

To make his claims more concrete, LeSourd provides some hand-drawn pitch contours for select words. One such example has been roughly copied in (12). While this is a very rough approximation of what the F_0 contour could be, based on the data from section 4 I believe the statements about pitch that LeSourd makes are fairly accurate, although the alignment of pitches to stresses does not match what is observed from the phonetic data.

(12) **Example of pitch contour as found in LeSourd (1988, 125)**:



.n á . t ə . k e h . k í m . k e n.
'I go to school (SUB)'

LeSourd uses pitch primarily as a diagnostic to determine where stress appears within a word. Once stress has been diagnosed, he notes that reduced vowels have the unusual behaviour of being "invisible" to the stress system, illustrated in in (4), and provides an analysis within autosegmental phonology (Goldsmith, 1976) to explain this invisibility.

Within LeSourd's analysis, reduced (unstressable or invisible) vowels are stored in the lexicon without a link to the timing tier, in contrast to full (stressable) vowels, which are stored pre-linked to their timing tier slot. Once accessed from the lexicon, a series of rules applies in the contexts listed in (5),[3] linking reduced vowels in these contexts to the timing tier. Stress rules then apply, counting only the timing slots linked to vowels. Vowels not linked to the timing tier – *i.e.*, the reduced vowels – are skipped by the stress rules, leading to their invisibility. Before pronunciation, a rule linking any stray vowels to the timing tier applies to

[3]With the exception of (5c), which is a context that only appears in Hagstrom (1995).

prevent them from being deleted. This process is schematized in (13) using the word *htә́tәlәtәmә́nәl* '3.SG.AN is eating 3.PL.INAN'. For the sake of clarity, only timing tiers for vowels will be shown, although it should be assumed that all consonants are stored in the lexicon pre-linked to a timing slot.

(13) **Schematic example of LeSourd's analysis of reduced vowels**:

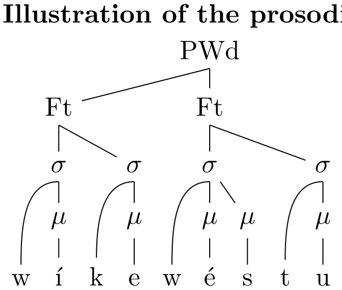
Underlying form	x x x x x x h t ә t ә l ә t ә m ә n ә l
Linking rules apply	x x x x x x h t ә t ә l ә t ә m ә n ә l
Stress rules apply	**x** x x x **x** x h t **ә́** t ә l ә t ә m **ә́** n ә l
Linking of stray vowels	**x** x x x **x** x h t **ә́** t ә l ә t ә m **ә́** n ә l
Surface form	h t ә́ t ә l ә t ә m ә́ n ә l

The derivation begins with only the first vowel in the word *htә́tәlәtәmә́nәl* underlyingly linked to a slot in the timing tier, a location in which LeSourd says it is common for underlyingly visible reduced vowels to appear (LeSourd, 1988, p.177). The remaining schwas are linked to their timing slot when located in one of the contexts in (5), condensed in the diagram above into the step entitled "Linking rules apply". The final schwa is linked to the timing tier in this step since it is the final vowel in the word. The other two schwas are linked to the timing tier since they are the second in a sequence of unlinked schwas. No other schwas are capable of being linked, so the derivation moves to the next step, where stress applies according to the stress assignment rules in (1). There are four vowels linked to timing slots, so the first and third linked vowels receive stress. Once stress is assigned, the remaining schwas are linked to the timing tier and the word is pronounced with two stresses. It is due to this interleaving of linking rules and stress rules that there is a sequence of three word-medial schwas which lack stress.

2.2 Hagstrom (1995)

Hagstrom's main contribution to the analysis of stress in Passamaquoddy-Maliseet is his Optimality-Theoretic reanalysis of the data presented in LeSourd (1993). At the time his analysis was developed, segments in OT were required to be parsed into the Prosodic Hierarchy (Selkirk, 1980) in order to be pronounced. Since much of his analysis centres on how the different segments of Passamaquoddy-Maliseet are parsed into the Prosodic Hierarchy, I will focus on this aspect of the work, rather than re-iterating his OT analysis. The Prosodic Hierarchy that Hagstrom makes use of is sketched in (14) for the word *wíkewéstu* '3.SG.AN likes to talk' (LeSourd, 1993, p.75).

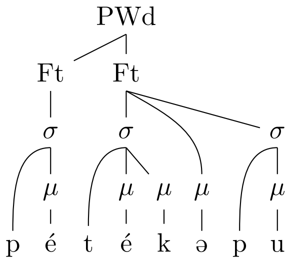
(14) **Illustration of the prosodic hierarchy**:



In the example above, each level above the level of the mora (μ) obeys the property of strict layering, wherein each level can only consist of members of the level immediately below it. For example, Feet only consist of syllables (σ), and the Prosodic Word only consists of Feet. Syllables do not obey strict layering, since they can consist of both moras and segments. Hagstrom extends the ability to subvert strict layering from syllables to Feet, so that Feet can consist both of syllables and a moras. He does this so that vowels that are banned from being linked to a syllable can nevertheless be parsed into prosodic structure and subsequently pronounced.

Under Hagstrom's reanalysis of the Passamaquoddy-Maliseet data, reduced vowels are subject to a constraint *PEAK/ə, banning reduced vowels from being the peak of a syllable. This is interpreted as banning the moras linked to these vowels from being parsed into syllables. Thus, when ranked above a constraint ensuring strict layering, this constraint will have the effect of allowing moras that domiante reduced vowels to be parsed directly into Feet, skipping the syllable layer. An illustration is given in (15).

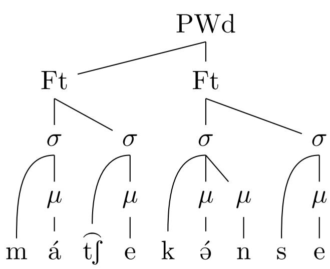
(15) **Reduced vowels are not parsed into syllables** (Hagstrom, 1995, 14):



It should be noted that since the reduced schwa in the above example cannot be parsed as the head of a syllable, the adjacent consonants must be parsed into the surrounding syllables. This is unsurprising for *p*, since it would normally be expected to be parsed into a syllable with the following *u* by the principle of onset maximization. However, *k* cannot be parsed into a syllable with ə since it has been banned from being parsed into a syllable by *PEAK/ə, so it must be parsed as the coda to the syllable *tek*.

The main insight that Hagstrom makes in his analysis is that the constraints on syllable structure of Passamaquoddy-Maliseet outrank the constraint *PEAK/ə, so that when it is impossible to parse a consonant into any other syllable, reduced vowels will be parsed into a syllable in order to host that consonant. Passamaquoddy-Maliseet is a language that disallows onset or coda clusters word-medially, so if a consonant cluster appears next to a reduced vowel, that reduced vowel will have to be parsed into a syllable in order to host an onset or coda for the adjacent consonant. Once parsed into a syllable, the reduced vowel will then be parsed into a Foot as a syllable head, and will count for stress placement. This is illustrated for *mát͡ʃekə́nse* '3.SG.AN begins to gather driftwood, moves away gathering driftwood' (PMDP 2016), below.

(16) **Reduced vowels can be forced to be parsed into syllables**:



Since any consonant cluster adjacent to a reduced vowel can force that vowel to be parsed into a syllable, both the environments [¬h]C__ and __[¬h]C will cause an adjacent reduced vowel to be counted as visible to the stress system, in contrast to the previous claim made by LeSourd that it is only the prior environment that forces a reduced vowel to be counted for stress. Similarly, a sequence of two reduced vowels, as in (5g), C_0əC_0__, will force one of the schwas to be parsed into a syllable in order to allow all of the consonants to be parsed into the larger prosodic structure, although this is not guaranteed to be the second schwa in all cases. The remaining environments where reduced vowels are counted for stress are also subsumed under the umbrella of forcing the reduced vowel to be parsed into a syllable. In the first case, Hagstrom claims that sonorants are inherently linked to a syllable, but cannot head that syllable (to account for hl__ and #C_0__Rə). In the second case, he claims that words must obligatorily end in a syllable (to account for __C_0#). Thus, reduced vowels, which are by default considered to be invisible, can be made visible to the stress system in environments where their adjacent material must be parsed appropriately into the prosodic hierarchy.

2.3 Commonalities

While both of the analyses discussed above are defined in terms of different phonological theories and make use of different phonological architectures, they both posit that reduced vowels are somehow structurally "deficient", when compared with their full vowel counterparts. Reduced vowels are either lexically deficient in that they do not come stored with their timing slot, according to LeSourd (1988, 1993), or the grammar considers them to be deficient in that they ideally cannot be the head of a syllable, according to Hagstrom (1995). The cues to stress outlined in LeSourd (1988, 1993) are merely diagnostic tools to tell where stress is located – they have no bearing on how stress is aligned with the segments of the word.

However, given the fact that Passamaquoddy-Maliseet appears to be a language where stress and pitch accent are indistinguishable or co-extensive, and given the fact that cross-linguistically, reduced vowels characteristically have a very short duration, I believe both the above accounts are missing an important generalization. Given that stress is cued by alternating high and low pitch – a transition that is known to take some time – and that reduced vowels are shorter than full vowels, it is possible that a full pitch transition cannot be realized within the span of a single reduced vowel. This idea will be explored in more detail in the following section, and an analysis within OT will be provided.

3 OT Analysis & predictions

As outlined in the previous section, there are some suggestive observations about how pitch might drive reduced vowels to behave as if they are invisible to the stress system of Passamaquoddy-Maliseet. As LeSourd (1988) observes, stress is cued by alternating low and high pitch. From the existing literature on the alignment of pitch accents with stress, pitch accents tend to be anchored near one edge of a stressed syllable or another (Arvaniti et al., 1998, *a.o.*), with an independent constraint on whether the pitch target is sufficiently separated from any adjacent pitches (Cho, 2011). Given that schwa – a commonly reduced vowel – is known to be shorter than most other vowels, there is a possibility that it is too short for the pitch accents to be adequately separated. This will be the case when schwa appears in a position where it should be stressed, accounting for its stress-repelling behaviour. It will also occur when schwa appears between two vowels that would receive stress under the default analysis, accounting for why it repels stress on its immediate neighbours.

In the following subsections, this intuition will be formalized within OT, making use of pitch accent alignment constraints adapted from Cho (2011). These constraints will be discussed, and then the basic stress pattern will be accounted for in a foot-free OT analysis. A foot-free analysis is assumed in order to avoid the question of whether Passamaquoddy-Maliseet is a trochaic language, as claimed by LeSourd (1988, 1993) and Hagstrom (1995), or an iambic language, as claimed by Hayes (1995). The claims about how pitch accent and stress are realized in Passamaquoddy-Maliseet will also be revised at this point, previewing the findings of the first phonetic study in section 4. Once these two pieces are in place, an illustration of how durationally reduced vowels force the introduction of a stress lapse will be provided. In addition, some hypotheses about how the environments in (5) can prevent the introduction of this lapse will be discussed. While it will be shown in section 6 that these environments are largely environments that cause lengthening of reduced vowels, it will not always be clear why these environments have this effect, and further investigation will have to be left to future research.

3.1 Constraints on the alignment of pitch accents

As outlined in her analysis of Seoul Korean, Cho (2011) identifies two main families of pitch accent alignment constraints: constraints that govern the anchor point of particular tonal targets, and constraints that govern the optimal distance between tones. The constraints used by Cho (2011) for the alignment of tones in Seoul Korean are presented in (17), where $T()$ indicates the time at which the given tone occurs, A indicates the ideal timing anchor for that tone, and D indicates the ideal duration between tones.

(17) **Constraints governing pitch accent alignment used by Cho (2011, 310)**:

	Constraint	*Cost of violation*
ALIGN(L)	$T(L) = A_L$	$w_L(T(L) - A_L)^2$
ALIGN(H)	$T(H) = A_H$	$w_H(T(H) - A_H)^2$
DURATION	$T(H) - T(L) = D$	$w_D(T(H) - T(L) - D)^2$

It should be noted that Cho's analysis is framed within Harmonic Grammar, where the violations assigned are equivalent to the weight of the constraint multiplied by the particular value that it assigns. Thus, the larger the value between, for instance, the actual alignment of a high pitch and its idealized anchor point, the more violations are assigned by the constraint ALIGN(H). These kinds of gradient constraints are disfavoured in traditional OT, since they have been shown to be capable of creating pathological grammars (McCarthy, 2002). As such, rather than using these constraints as they appear above, I will translate them into entire families of constraints that are strictly ranked within OT. The formulations of the non-gradient versions of Cho's constraints are provided below. Distances are generally stated in proportions of segments, syllables, or words, to account for differences in speech rate.

(18) **Constraint families within OT governing pitch accent**:

a. T-ANCHOR(m): The tone T is located within m% of a typical syllable of its ideal anchor point.

b. T-DISTANCE(n): Two tones are separated by a minimum of n% of a typical syllable.

Within each family, a constraint with a smaller m or n value is strictly ranked above a constraint with a larger m or n value, so that a constraint like T-DISTANCE(10), "two tones are separated by a minimum of 10% of a typical syllable", is ranked above a constraint like T-DISTANCE(15), "two tones are separated by a minimum of 15% of a typical syllable". This will ensure that tones that are closer together will be penalized by higher-ranked constraints.

It should be noted that I am following Cho (2011) in only making reference to constraints governing the anchoring point of a particular tone or the distance between tones. It is also possible that there are constraints that govern the degree to which a tonal target is met. I will assume for the remainder of the paper that these constraints are not violated or violated minimally in Passamaquoddy-Maliseet, although more research should be done to ensure that this is true.

The intuition behind using the above constraints is that the duration of a reduced vowel will fall within the range specified by the grammar as the minimum distance between tones. Given a fairly rigid interpretation of the T-ANCHOR constraints associated with stress or the lack of stress, a syllable with a reduced vowel will be unable to maintain an appropriate separation between the two, incurring a violation of the appropriate T-DISTANCE constraint. This constraint will cause the default stress pattern to shift, the details of which will be outlined in the following sections.

3.2 Analysis of the default stress pattern

In order to establish how reduced vowels can interact with the default stress pattern, the constraints governing this stress pattern will be outlined. Default stress was defined in (1), repeated as (19), below.

(19) **Default stress pattern of Passamaquoddy-Maliseet** (LeSourd, 1988, 1993):

a. Stress is assigned to the **first syllable** of every word.

b. Stress is assigned to **every other syllable**, starting on the **penult** and proceeding from **right to left**.

c. Primary stress is generally held to be **rightmost**.

It should be noted that this set of rules for assigning default stress will create a clash at the left edge of any odd-numbered, multisyllabic word consisting only of full vowels. Thus, words like *léwéstu* '3.SG.AN speaks' and *séhtájewéstu* '3.SG.AN speaks while walking backwards' are claimed to contain two initial syllables which are both stressed. However, when examining recordings from Language Keepers and Passamaquoddy-Maliseet Dictionary Project (2016), a modern online dictionary of Passamaquoddy-Maliseet, initial stress in these words is rarely present. Since the data presented in the remainder of this paper come from this dictionary, I will assume that the stress assignment rule in (1a) and (19a) is not in effect for this group of speakers, and will construct my OT analysis around this idea. Why there is this discrepancy between LeSourd's work and the modern dictionary is not known at this time – it could be that the speakers LeSourd interviewed lived in a different area than the speakers who recorded the dictionary, or it could be that the speakers belonged to different generations. Regardless, I will assume that only rules (19b) and (19c) are the default rules for stress assignment.

These rules of stress assignment will create a strictly alternating stress pattern anchored on the penultimate syllable, counting from right to left. This stress pattern is quantity insensitive, so that both open and closed syllables behave identically with respect to stress. Some examples illustrating both the updated analysis of stress placement and its quantity-insensitive nature are provided in (20).

(20) **Examples of the default stress pattern** (PMDP 2016):

a.	*σ́σ*	.wá.sis.	'child'
		.áp.t͡ʃa.	'again'
b.	*σσ́σ*	.ki.nák^{w}.su.	'3.SG.AN is big in diameter'
		.meh.k^{w}í.min.	'bunchberry'
c.	*σ́σσ́σ*	.sáp.tu.hú.su.	'3.SG.AN stabs self'
		.t͡ʃí.pih.ták^{w}.su.	'3.SG.AN sounds creepy or scary'
d.	*σσ́σσ́σ*	.ka.káw.ta.há.su.	'3.SG.AN is beaten'
		.mal.túh.sis.há.su.	'3.SG.INAN is malleable'

Since this is a strictly alternating pattern, it is easily accounted for under both a foot-based analysis that assumes trochees (LeSourd, 1988, 1993; Hagstrom, 1995) and an analysis that assumes iambs (Hayes, 1995). In order to avoid claiming that one of the above analyses is preferable, I will instead use a foot-free constraint system, following Gordon (2002). The constraints used are listed in (21). This system will also make it possible to avoid making claims about how adjacent unstressed syllables are parsed into feet.

(21) **Constraints governing stress assignment**:

a. ALIGN-L: Assign one violation mark for each stressed syllable that is not at the left edge of a word (non-gradient version of Gordon's (2002) ALIGN(X_1, L), following McCarthy (2002).)

b. ALIGN-R: Assign one violation mark for each stressed syllable that is not at the right edge of a word (non-gradient version of Gordon's (2002) ALIGN(X_1, R), following McCarthy (2002).)

c. *CLASH: Assign one violation mark for each pair of adjacent stressed syllables.

d. *LAPSE: Assign one violation mark for each pair of adjacent unstressed syllables.

e. L-MOST: Assign one violation mark if the leftmost syllable is not stressed (a decomposition of Gordon's (2002) ALIGNEDGES).

f. NONFIN: Assign one violation mark if the rightmost syllable is stressed.

g. R-MOST: Assign one violation mark if the rightmost syllable is not stressed (a decomposition of Gordon's (2002) ALIGNEDGES).

In order to arrive at the correct assignment of default stress, only three of the above constraints need to be ranked above all others, in addition to the standard Correspondence constraints Max and Dep (McCarthy and Prince, 1995). The crucial rankings are presented in (22 – 26).

(22) Max **is undominated**:

/σσσσσ/	Max	Align-L	Align-R	L-most
☞ a. σσ́σσ́σ		∗∗	∗∗	∗
b. σ́σ	∗!∗∗		∗	

(23) Dep **is undominated**:

/σσσσσ/	Dep	L-most
☞ a. σσ́σσ́σ		∗
b. σ́σ́σ́	∗!	

(24) NonFin **is undominated**:

/σσσσσ/	NonFin	L-most	R-most
☞ a. σσ́σσ́σ		∗	∗
b. σ́σσ́σσ́	∗!		

(25) *Clash **is undominated**:

/σσσσσ/	*Clash	L-most
☞ a. σσ́σσ́σ		∗
b. σ́σ́σσ́σ	∗!	

(26) *Lapse **is undominated**:

/σσσσσ/	*Lapse	Align-L	L-most
☞ a. σσ́σσ́σ		∗∗	∗
b. σ́σσ́σσ	∗!	∗	

Having established these rankings, only the constraints NonFin, *Clash, and *Lapse will commonly appear in any remaining tableaux, as they have the most direct bearing on stress assignment.

In order to account for how pitch accent is used to cue stress, as claimed by LeSourd (1988, 1993), an additional set of constraints will be invoked. However, before doing so, it should be noted that there are a few discrepancies between the pitch pattern observed by LeSourd (1988) and the pitch tracks actually observed in the Passamaquoddy-Maliseet online dictionary. While LeSourd claims that high tone is associated with stressed syllables, the pitch tracks from Language Keepers and Passamaquoddy-Maliseet Dictionary Project (2016) instead show that stressed syllables are associated with a rise in pitch, beginning with a low pitch and ending on a high pitch. Similarly unstressed syllables are not simply low in pitch, but are generally associated with a fall in pitch. Thus it appears as if the alternating pattern is offset about one syllable from what LeSourd originally claimed – stressed syllables must begin with a low tone, and stressless syllables must begin with a high tone. I have chosen to interpret these facts as realization of a complex pitch accent, beginning with a low tone and ending with a hight one (L+H). I have arbitrarily chosen to posit that the low tone is the proper pitch accent, since it appears at the left edge of the stressed syllable, although the reverse could easily be claimed. Thus the pitch accent associated with stress will appear as L*+H for the remainder of this paper. Phonetic motivations for this claim will be presented in section 4.

Given the above observations about how the pitch accent is realized in Passamaquoddy-Maliseet, the constraints on pitch accent/tone alignment to be used for the remainder of this paper are listed in (27). The exact formulation of these constraints will be updated as the phonetic studies are introduced.

(27) **Constraints governing tonal alignment**:

a. H-Anchor: The tone H is located at its ideal anchor point, arbitrarily chosen to be 25% of the way through the syllable following the stressed syllable.

b. L-Anchor: The tone L* is located at its ideal anchor point, arbitrarily chosen to be 25% of the way through the stressed syllable.

c. PA-Form: The form of the pitch accent is L*+H.

d. Stress-to-Accent: Stressed syllables are aligned with a pitch accent.

e. T-Distance(0.5): Two tones are separated by a minimum of 50% the duration of a typical syllable.

The constraints H-Anchor, L-Anchor, and T-Distance(0.5) are present in the grammar to govern how particular tones align with particular segmental anchors within the word. The constraint PA-Form is introduced to establish what form the pitch accent will take. This cannot be specified in the lexicon, since pitch accent is associated with predictable default stress, and predictable information is not considered to be part of the lexicon. Finally, Stress-to-Accent is introduced to ensure that all stressed syllables are associated with a pitch accent. All of these constraints are unranked with respect to one another, shown in the tableau in (28). For ease of exposition, boundary tones are omitted from the following tableaux and all syllables are assumed to be equivalent in length, with the exception of the final syllable, which is increased to 125% of the default syllable duration.

(28) **Tonal alignment constraints are unranked**:

/σσσσσ/	PA	StoA	L-Anchor	H-Anchor	T-Dist
☞ a. L* H L* H σ σ́ σ σ́ σ					
b. L* L* H σ σ́ σ σ́ σ	*!				
c. L* H σ σ́ σ σ́ σ		*!			
d. L*H L* H σ σ́ σ σ́ σ			*!		
e. L* HL* H σ σ́ σ σ́ σ				*!	
f. L*H L* H σ σ́ σ σ́ σ				*	*!

In a word that consists only of full vowels, the relative ranking of the top-ranking stress assignment constraints and the pitch alignment constraints is indeterminate, since the optimal candidate satisfies all of them. A ranking between them can only be established when the word under consideration contains at least one reduced vowel.

3.3 Tone alignment and reduced vowels

The main intuition behind the behaviour of reduced vowels in Passamaquoddy-Maliseet is that their duration is less than the minimum distance between tones required by the grammar. If this is true, then the reduced vowel will be too short to properly host the rise associated with stress, encoded as the pitch accent L*+H, as adequate distance between the L* and H tones cannot be maintained. This will also ensure that the reduced vowel will be too short to host the fall from one stress to another, since there will not be adequate distance between the H and L* portions of two adjacent pitch accents. The repair chosen by Passamaquoddy-Maliseet speakers is to introduce a lapse into the word that includes the schwa, indicating that the constraint *Lapse is ranked below all other constraints assigning stress and tone alignment. Its ranking with respect to the alignment constraints is illustrated in the tableau in (29) for the word *kísəlukému* '3.sg.an talked (about something)' (PMDP 2016). An additional constraint banning the lengthening of reduced vowels, *[əː], is also introduced to eliminate the potential repair of lengthening the reduced vowel to host pitch accent. For the time being, it will be assumed that syllables with reduced vowels are 30% of the duration of a normal vowel. More concrete evidence for this state of affairs will be presented in Section 5.

(29) *Lapse **is ranked below all tone alignment constraints**:

/kisəlukemu/	*[əː]	PA	StoA	L-⚓	H-⚓	T-Dist	*Lapse
a. L*H L* H ki sə́ lu ké mu						*!	
b. L* H L* H ki sə́ lu ké mu	*!						
c. L* L* H ki sə́ lu ké mu		*!					
d. L* H ki sə́ lu ké mu			*!				
e. L* H L* H ki sə́ lu ké mu				*!			
f. L* H L* H ki sə́ lu ké mu					*!		
☞ g. L* H L* H kí sə lu ké mu							*

Under the analysis above, placing stress on the reduced vowel and placing the pitch accent at the anchors set by the T-Anchor constraints will cause a violation of T-Distance(0.5), as in (29a). Lengthening the schwa will incur a violation of *[əː](29b). Removing one of the offending tones (29c) results in a violation of the constraint that governs the shape of the pitch accent, PA-Form, and removing one of the pitch accents entirely (29d) results in a violation of Stress-to-Accent. Altering the anchoring of either the L* or the H tone (29e,f) causes a violation of L-Anchor and H-Anchor, respectively. The only possible recourse is to shift stress (29g).

It remains to be shown why it is only this one stress which shifts leftwards. If the stress were to shift rightwards, it would incur a violation of *Clash, in addition to *Lapse and H-Anchor. If both stresses were to shift leftwards, placing the lapse at the end of the word, it would still violate T-Distance(0.5), since the H of the first pitch accent would be too close to the L* of the second pitch accent. This would also be the case if final stress were introduced to eliminate the lapse. Thus, introducing a lapse that includes the reduced vowel will always be the most optimal candidate.

(30) **Stress constraints ranked below tone alignment constraints**:

/kisəlukemu/	H-Anchor	T-Dist	*Clash	NonFin	*Lapse
☞ a. L* H L* H kí sə lu ké mu					*
b. L* H L* H ki sə lú ké mu	*!		*		*
c. L* H L* H kí sə lú ke mu		*!			*
d. L* H L* H L* H kí sə lú ke mú	*	*!		*	*

In this way, the high-ranked pitch accent alignment constraints can force stress to shift one syllable to the left, off of a syllable that contains a reduced vowel. This ranking accounts for the reduced vowel's stress-repelling behaviour, but it has the added advantage that the same ranking can be used to explain why stress is repelled from neighbouring syllables. This makes for a more explanatorily adequate analysis than an account making use of the constraint *[ə́], briefly discussed in section 1. An illustration of a reduced vowel shifting stress from its neighbour is given in (31) for *nísekəpísit* 'ghost (antiquated)'.

(31) **Ranking *Lapse below tone alignment, cont.**:

/nisekəpisit/	*[əː]	PA	StoA	L-⚓	H-⚓	T-Dist	*Lapse
a. L* H L* H ni sé kə pí sit						*!	
b. L* H L* H ni sé kə pí sit	*!						
c. L* L* H ni sé kə pí sit		*!					
d. L* H ni sé kə pí sit			*!				
e. L* H L* H ni sé kə pí sit				*!			
f. L* H L* H ni sé kə pí sit					*!		
☞ g. L* H L* H ní se kə pí sit							*

As with *kísəlukému* '3.sg.an talked (about something)', assigning default stress with the proper alignment of tones to segmental anchors will cause the H portion of the first pitch accent to be too close to the L* portion of the second pitch accent incurring a violation of T-Distance(0.5). Altering the length of the reduced vowel incurs a violation of *[əː]. Altering the form of the pitch accent or deleting it altogether is ruled out by PA= $L^* + H$ and Stress-to-Accent, respectively. Similarly, altering the anchoring of the tonal components of the pitch accent is ruled out by both L-ANCHOR and H-ANCHOR. The only possible solution is to shift stress onto the syllable *ni*, introducing a lapse.

The constraints on the realization and alignment of pitch, when ranked above the stress assigning constraints, force stress to shift off of reduced vowels. This gives the impression that these schwas do not count towards the assignment of stress, since they are always associated with a lapse and lapses are not attested elsewhere in the stress system. Under this analysis, schwas are visible to the stress assignment system, as encoded by the stress assignment constraints and their ranking – they are just durationally insufficient to host the cue to stress. No recourse to an independent structural deficiency is needed to account for their behaviour.

This re-analysis of reduced vowels also allows a re-analysis of the environments in Passamaquoddy-Maliseet where reduced vowels do not behave in this way. A discussion of these environments and their behaviour is provided below.

3.4 Reduced vowels in lengthening contexts

There are a variety of contexts where reduced vowels do not introduce lapses into the stress system, and instead behave as if they are full vowels. The full list introduced in (5) is repeated below as (32), with the stresses altered to reflect the lack of clashes in the words of the Passamaquoddy-Maliseet Dictionary.

(32) **Examples of environments where reduced vowels cannot appear**:

a.	$\_\_C_0\#$	.a.má.kən.	'fishing tackle' (PMDP 2016)
b.	[¬h]C__	.pis.kə́.lan.	'it rains so hard that it is dark' (LeSourd, 1993, 81)
c.	__[¬h]C	.a.lə́n.t͡ʃis.	'orange' (PMDP 2016)
d.	hl__	.á.t͡ʃeh.lə́.su.	'3.SG.AN changes self' (LeSourd, 1993, 82)
e.	s__ss	.skə́.ni.sə́s.sis.	'bone (DIM)' (LeSourd, 1988, 260)
f.	#C_0__Rə	.ht͡ʃə́.lə.kíp.tun.	'3.SG.AN squeezes it once, quickly' (PMDP 2016)
g.	C_0əC_0__	.ná.tə.mə́.kil.	'3.SG.AN is fairly tall, big' (PMDP 2016)

A selection of these environments, such as (32a,c,e), are environments where segments are known to be lengthened phonetically. Environment (32a) is that of the final vowel in the word, an environment that is known for being longer than other environments within the word. Environment (32c) is that of being located before a consonant cluster. In such an environment, a vowel may be lengthened in order to better realize phonetic cues of the following consonant, which may not be able to realize some of its other cues on the final consonant of the cluster. For example, if both consonants in the cluster are obstruents, the first obstruent may not be able to realize a proper burst or full set of formant transitions if followed by a second obstruent, meaning that only the transitions between the preceding vowel will be present. In order to better realize these transitions, the vowel may lengthen. Environment (32e), located immediately prior to a geminate obstruent, is one that has been attested to be a lengthening environment for vowels.

Since these are environments where all vowels can lengthen, it would be unsurprising if reduced vowels also lengthened in these contexts. In order for this to be possible, the constraints *V̆C_0#, *V̆CC, and *V̆Cː – the markedness constraints that ban short vowels in the contexts mentioned above – must outrank the constraint *[əː], introduced in the previous section. The tableaux in (33–35) illustrate these rankings. Reduced vowel durations will be increased to be twice as long as their default duration (a claim that will be substantiated more in Section 5), but will still not be as long as full vowels. It should be noted that the initial vowel in (35) always appears as long – this will be discussed further below.

(33) **Reduced vowels must be lengthened word-finally**:

/amakən/	*V̆C_0#	*[əː]
a. a mákən	*!	
☞ b. a má kən		*

(34) **Reduced vowels must be lengthened before consonant clusters**:

/alənt͡ʃis/	*V̆CC	*[əː]
a. a lə́n t͡ʃis	*!	
☞ b. a lə́n t͡ʃis		*

(35) **Reduced vowels must be lengthened before geminates**:

/skənisəssis/	*V̆Cː	*[əː]
a. skə́ ni sə́s sis	*!	
☞ b. skə́ ni sə́s sis		*

If the reduced vowels are lengthened sufficiently, then they should be able to properly host a pitch transition and avoid being "skipped" by the stress system. This idea is illustrated for the pre-consonant cluster reduced vowel in *mat͡ʃə́skehpúte* '3.SG.INAN begins to vibrate'. Lengthening of the *Vh* cluster is not shown, and constraints governing length of the reduced vowel are omitted.

(36) **Lengthened reduced vowels behave as full vowels**:

/mat͡ʃəskehpute/	PA	StoA	L-⚓	H-⚓	T-Dist	*Lapse
☞ a. L* H L* H ma t͡ʃə́s keh pú te						
b. L* L* H ma t͡ʃə́s keh pú te	*!					
c. L* H ma t͡ʃə́s keh pú te		*!				
d. L* H L* H ma t͡ʃə́s keh pú te			*!			
e. L* H L* H ma t͡ʃə́s keh pú te				*!		
f. L*H L* H ma t͡ʃə́s keh pú te				*	*!	
g. L* H L* H má t͡ʃəs keh pú te						*!

In section 6, it will be shown that almost all environments listed in (32) behave as lengthening contexts in Passamaquoddy-Maliseet. One of these, *hl__* (32d) is perhaps the most surprising. While it has been reported to be a context where reduced vowels are visible (LeSourd, 1988, 1993; Hagstrom, 1995), it is not clear why it should cause lengthening of the adjacent vowel. Perhaps *h*, in addition to causing devoicing on following obstruents, also causes devoicing on following sonorants, thus forcing the following vowel to lengthen in order to better cue the sonorant. If this is the case, it is unknown why the same behaviour does not extend to *hm* and *hn* sequences. I will unfortunately be unable to answer this question here, although it is an interesting venue for future research. For the present time, it will be assumed that there is a constraint *[hlV̆] that must be ranked above *[əː].

(37) **Reduced vowels must be lengthened after *hl***:

/at͡ʃehləsu/	*[hlV̆]	*[əː]
a. á t͡ʃeh lə́ su	*!	
☞ b. á t͡ʃeh lə́ su		*

Another lengthening context that is surprising from a phonetic point of view is an extension of $\#C_0$__Rə (32f) into strict word-initial position $\#C_0$__. Initial position appears to be a context where only reduced vowels are lengthened, to be shown in sections 5 and 6. According to LeSourd (1988), this is due to a restriction on the lexicon of the language, such that initial schwa is almost always linked to a timing slot in the underlying form. This suggests that there may be in fact two schwa-like phonemes – one that is reduced and one that is not. This, however, does not ultimately explain why the lengthened/unreduced schwa appears in initial position almost to the exclusion of the other, while other environments appear to favour reduced schwa. As with the case of the *hl*__ context above, this will be noted as a lengthening environment and encoded as a constraint $*\#\mathrm{C}_0\breve{\mathrm{V}}$, but the reason that it acts as such will be left for future research.

(38) **Reduced vowels must be lengthened in initial syllables**:

/ht͡ʃələkiptun/	$*\#\mathrm{C}_0\breve{\mathrm{V}}$	*[əː]
a. ht͡ʃə́lə kíp tun	*!	
☞ b. ht͡ʃə́lə kíp tun		*

Finally, it will be noted that C_0əC_0__ (32g) is also an environment where reduced vowels can be lengthened. Unlike word-initial position, this is not unique to reduced vowels – it will be shown in section 6 that all vowels, full or reduced, lengthen when they are the second member of a sequence of two identical voweled syllables. This could be due to an OCP effect, whereby two adjacent syllables headed by identical vowels must be different in some way and so one must lengthen (Walter, 2007). Following this line of reasoning, the constraint that bans two adjacent vowels from being the same length and quality will be $*\breve{\mathrm{V}}_i\mathrm{C}_0\breve{\mathrm{V}}_i$. However, why it is the second vowel that lengthens rather than the first is unknown at this time, and again, will be left for future research.

(39) **Reduced vowels must be lengthened if they are second in a sequence of identical vowels**:

/natəməkil/	$*\breve{\mathrm{V}}_i\mathrm{C}_0\breve{\mathrm{V}}_i$	*[əː]
a. ná tə mə́ kil	*!	
☞ b. ná tə mə́ kil		*

The only context where reduced vowels do not lengthen is after a consonant cluster, *[¬h]C*__ (32b). Nevertheless, these schwas are reliably visible to the stress system. Under these circumstances, it may be possible that the additional consonant adds enough length between the preceding vowel and the reduced vowel to push the whole vowel-and-consonant sequence over the T-Distance threshold. This also means that part of the transition between tones must be able to be realized on at least one of the two consonants. Vowel duration has been used as a proxy for syllable duration in this study, although future work will examine total syllable duration and segmental makeup to examine how it interacts with the T-Distance threshold and pitch transition cueing.

With the exception of this context, it appears as if all other contexts where reduced vowels behave as full vowels are those contexts where it must lengthen. This lengthening can in most cases be attributed to some independent phonetic requirement, such as domain-final lengthening, lengthening to cue a following consonant, pre-geminate lengthening, or avoidance of purely identical adjacent vowels. This lends credence to the hypothesis that reduced vowels are visible to the stress system, but are simply too short outside of these contexts to host tonal transitions – once they are long enough to host tonal transitions, they behave as full vowels and no longer introduce lapses in stress.

Three phonetic studies are presented to provide evidence for the analysis proposed above. Section 4 shows that a rise in pitch is associated with stress, as claimed in section 3.2. Section 5 shows that pitch rises shift one syllable to the left of their default posiiton if one of the syllables of a word contains a reduced vowel, and that these reduced vowels are substantially shorter than other vowels, as claimed in section 3.3. Finally, section 6 shows that most of the contexts where reduced vowels behave as full vowels are contexts where they are lengthened, and that rises in pitch return to where they would otherwise be expected under the default pattern, as claimed in section 3.4.

4 Study I: Default stress and pitch

In order to show that pitch accent is a reliable cue to stress in Passamaquoddy-Maliseet, recordings from the Passamaquoddy-Maliseet Dictionary (Language Keepers and Passamaquoddy-Maliseet Dictionary Project, 2016) were examined. Given what was claimed in LeSourd (1988, 1993), it was expected that stress in Passamauqoddy-Maliseet would co-occur with alternating high and low pitch, with high pitch occurring on stressed syllables and low pitch occurring on unstressed syllables. As previewed in section 3, this was not strictly what was found – instead, a pitch rise was found to co-occur with stressed syllables, and a pitch fall was found to co-occur with unstressed syllables. Furthermore, the analysis of these recordings did not provide any evidence that initial syllables in odd-parity words bore stress, contrary to the default stress assignment rules poisted in LeSourd (1988, 1993); Hagstrom (1995). The study outlined in this section will show the phonetic evidence for both of these claims.

4.1 Methodology

All recordings used in this paper were taken from the Passamaquoddy-Maliseet recorded dictionary, located at `http://www/pmportal/org/` (Language Keepers and Passamaquoddy-Maliseet Dictionary Project, 2016) and hereafter abbreviated as PMDP. Recordings are organized by dictionary entry, each of which contains between one and four `.mp3` recordings of the entry spoken in isolation by a native speaker of Passamaquoddy from Motahkomikuk (Indian Township) or Sipayik (Pleasant Point), Maine. Most entries consist only of one word, although a few consist of up to four variants of the same lexical item. If multiple variants were included on an entry, they were included in the same recording, but each variant was separated from the others by a substantial pause. All recordings of the word spoken in isolation for any given entry were included in the study.

No direct information is given on the website for how the recordings were made, although some information can be inferred from the recordings themselves. Based on the file names downloaded from the website, it appears that the recordings were first made in `.wav` format, since this suffix appears within the file name, and then compressed to `.mp3`. Most sound recordings have audible final mouse clicks or keyboard button presses at the end, indicating that each recording was done in isolation and likely saved as a separate file. Recording was not often done in a sound-proof or sound-attenuated room, as there could sometimes be a slight echo in the recording. Occasionally, some recordings were done in a noisy environment, since low chatter or mechanical hum can be detected. All entries were included regardless of background noise or echo, since these issues did not often affect the acoustic measurements being made.

Since this study was meant to investigate the realization of default stress and pitch accent, only entries that did not contain any reduced vowels were considered. In addition to schwa, written as *o* in the native orthography, the vowels *i* when located before *y* (in IPA, [j]) or *u* before *w* were also considered to be reduced vowels for the purposes of this study. LeSourd (1988, 1993) claims that these sequences are underlyingly /əj/

and /əw/, lending credence to this exclusion criterion. All words had to be between one and five syllables in length, and were semi-randomly selected by the author from a list of words matching the above criteria, generated by searching the raw dictionary text in Python. An attempt was made to have an equal number of words beginning with vowels, obstruents, and sonorants, and to have a balance between syllables that were open and those that were closed. This was not always possible, and notable absences or imbalances will be indicated throughout the paper. For the present study, a total of 183 recordings were selected, with an average of 36.6 words per desired syllable length.

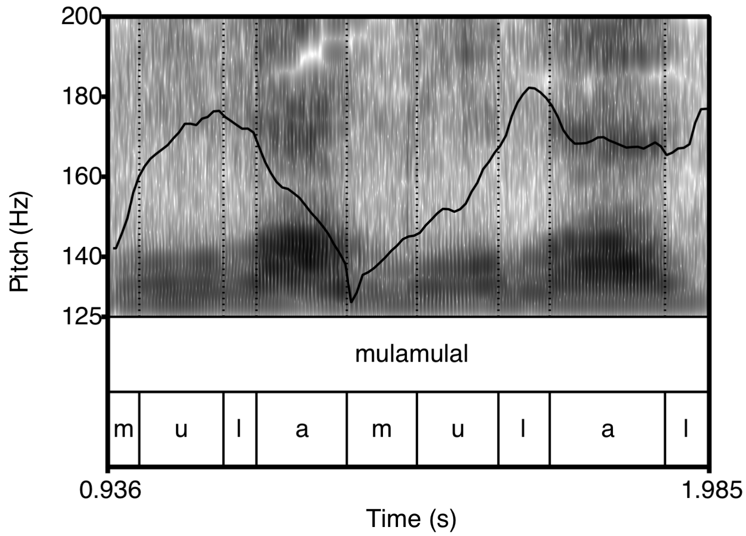


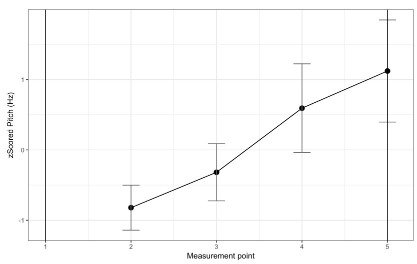
Figure 1: Sample segmentation for *mulamulal*, '3.SG.AN puts 3.SG.AN.OBV in deep'

Segmentation was done by hand by the author in Praat (Boersma and Weenink, 2016). Segmentations were stored in `.TextGrid` files with two tiers – one tier for the entire word, and one tier for segments. Each segment was labeled according to the Passamaquoddy-Maliseet orthography, so that [ə] is labeled with *o* and [j] with *y*. All other phonemes are as they appear in this paper. Boundaries between segments were selected according to the criteria listed in (40). An example of a segmented word with associated pitch track is given in Figure 1.

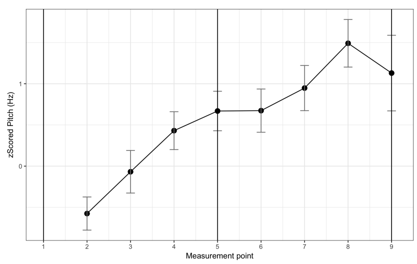
(40) **Criteria for segmentation of phonemes**:

a. Obstruent-Obstruent (TT) sequences were segmented after the burst of a stop or at the offset of turbulent noise of a fricative.
b. Obstruent-Sonorant (TR) sequences were segmented at the onset of voicing of the sonorant.
c. Sonorant-Obstruent (RT) sequences were segmented at the offset of clear formant structure of the sonorant.
d. Sonorant-Sonorant (RR) sequences were segmented at the onset or offset of whichever sonorant had higher amplitude.
e. If amplitude was even in RR sequences, the onset of steady state in F_1 was used as the boundary, as well as a steady state in F_2 and F_3 where possible.
f. If none of the above criteria could be applied, as in *ij* and *uw* sequences, no boundary was posited.
g. No boundary was ever posited for the *Vh* sequence in *VhC* environments.

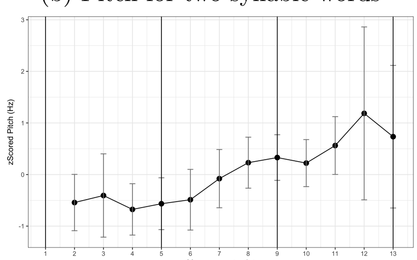
After segmentation was performed, F_0 measurements were taken for each word. Each word was broken up into vowel-to-vowel intervals, and pitch was measured at five equidistant points within each interval to time-normalize the data. Intervals had to be used over syllables due to the occasional presence of ijV and uwV sequences. If syllables were to be used as the basis for time normalization, it would require these sequences to be segmented as $i.jV$ and $u.wV$, respectively. However, since no segment boundary was posited between ij and uw during the segmentation process, this syllable division was impossible. Consonants at the beginning of the word were included in the first interval. Pitches measured at these five points within the interval fell within the Praat default of 75.0 Hz to 500.0 Hz, and all pitches were then z-scored by speaker in R (R Core Team, 2018).



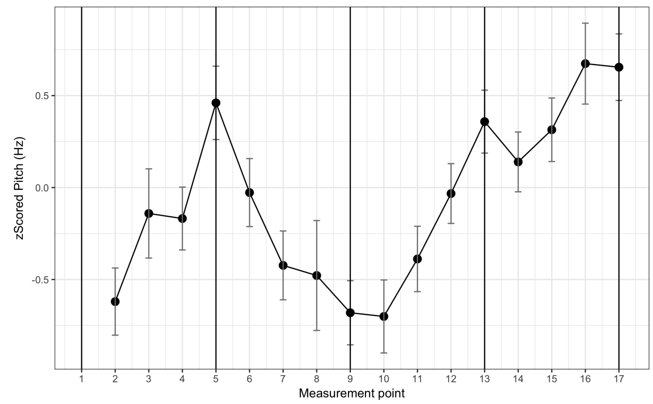
(a) Pitch for one-syllable words



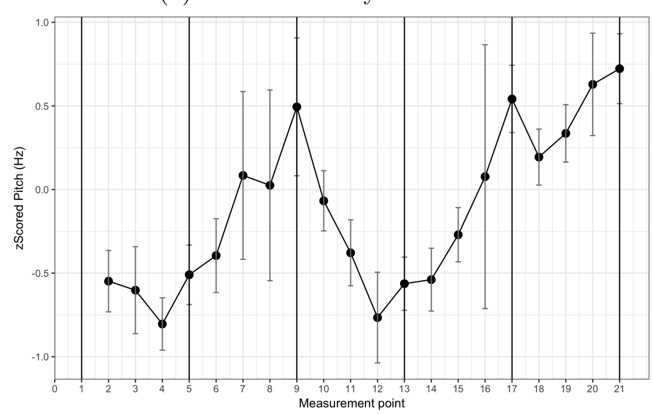
(b) Pitch for two-syllable words



(c) Pitch for three-syllable words



(d) Pitch for four-syllable words



(e) Pitch for five-syllable words

Figure 2: Averaged pitch tracks for all lengths of word examined in Study I

4.2 Results

All results for the pitch tracks are presented in Figure 2. Ninety percent confidence intervals are shown for each measurement point. Initial measurement points were excluded due to pitch estimation errors – more often than not the confidence interval for this point was substantially larger than all other confidence intervals, covering the whole range of z-scored pitches.

No direct measurements of the anchor points of the low and high pitches were attempted, since the proportion of words in the study that consisted only of sonorant segments was low, and the microprosody associated with obstruents would throw off the desired measurements. Moreover, certain word lengths (five-syllable words) had no words that consisted only of sonorants, meaning that the tonal anchor points could not be determined with certainty for these words. An examination of the graphs provided above suggests that the anchor point for the low tone L* is either the beginning of the stressed vowel (Figure 2d) or the measurement point before it (Figure 2c,e). This prior measurement point likely falls within the onset of the stressed syllable, since vowels in hiatus are a banned configuration in Passamaquoddy-Maliseet. In a similar manner, the anchor point for the high tone H is likely the beginning of the vowel following the stressed syllable, most clearly seen in words with multiple pitch accents (Figure 2d,e).

4.3 Discussion

As can be seen in the Figure 2, there is a strictly alternating pitch pattern, as observed by LeSourd (1988, 1993). However, contrary to what was claimed by LeSourd, it does not appear to be the case that stressed syllables are high-pitched and unstressed syllables are low-pitched – rather, it appears that stressed syllables must be associated with a rise in pitch, encoded as some sort of L+H pitch accent. Since the low portion of the pitch accent is the portion located within the stressed syllable, I have taken it to be the head of the L*+H pitch accent, although there is no reason not to believe that the pitch accent could equally be L+H*.

Another claim made by LeSourd is also partly borne out by these data, which is that there is an utterance-final high boundary tone, H%. This is seen by the continuing rise of pitch to the end of the utterance in the final syllable of all graphs in Figure 2. However, there is no evidence to suggest that there is a matching utterance-initial boundary tone H% – all utterances begin on a low tone, regardless of whether the initial syllable is stressed. This lends additional support to the accuracy of LeSourd's overall impressions about pitch accent, although it has little bearing on the analysis presented in section 3.

These data diverge more dramatically from LeSourd's claims about basic stress assignment in that there is no evidence for obligatory initial stress. If this were so, the graphs in Figure 2 c,e would have an additional pitch peak on the first syllable. However, the initial syllable in these words only has a low tone, without any attempt at realizing a rise. Why there is such a discrepancy is not known for certain at this time. It could be that these syllables bear other cues to stress but are ignored by the pitch accent system, or it could be that there is a difference among the speakers interviewed by LeSourd and the speakers interviewed for the dictionary recordings. Perhaps the speakers interviewed by LeSourd belonged to a different speech community from the speakers interviewed for the dictionary, or it could be that there is a generational difference in the speaker groups. Regardless, since the available evidence does not indicate that there is a stress on the initial syllable of these words, I will assume that there is no obligatory initial stress in this language.

Since absolute tone anchoring data were not able to be obtained through this study, the exact values of the anchor points for the constraints H-Anchor and L-Anchor are unable to be determined. However, it is clear from the data obtained that the low tone may have some slight freedom in where it is able to appear, while the high tone appears to have a more strictly enforced anchor point at the beginning of the following vowel. Regardless, any refinement of these constraints should not significantly change the analysis presented in section 3, since they will ensure that the tones of the rising pitch accent appear at or very close to the edges of the stressed interval.

5 Study II: Pitch and reduced schwa

In Study I, it was determined that stress must co-occur with a rise in pitch, encoded as the pitch accent L*+H and anchored to the left edges of the stressed vowel and the following vowel. This study will examine the behaviour of stress in words that contain a reduced vowel. If LeSourd's claims are correct, introduction of a reduced vowel into a word will cause the pitch rise associated with stress to shift one syllable to the left of where expected under default stress assignment, regardless of whether this rise would fall on the reduced vowel or its leftmost neighbour. If the claim made in section 3 is correct, reduced vowels will also be significantly shorter than other vowels.

5.1 Methodology

The methods for this study were largely the same as in Study I, with the exception of the selection criteria. In order to be included in this study, all words had to be between two and five syllables in length. Monosyllables were excluded since they are predicted to host stress, and will not show the desired shift in stress. Each word contained exactly one reduced vowel, always chosen to be schwa so as to avoid segmentation issues in *ij* and *uw* sequences. Schwa was never located in the final syllable, since this context is one where reduced vowels are predicted to behave as full vowels. Schwas were, however, allowed to be in the word-initial syllable, as this was not identified as a environment where full vowel behaviour is expected at the time of word selection. Finally, an attempt was made to ensure that the schwa was located in all possible obstruent-sonorant contexts, listed in (41). Schwas were always selected to be in double-sided open syllables, since a consonant cluster on either side of the reduced vowel has been claimed to be an environment where the reduced vowel will count towards stress assignment (LeSourd, 1988, 1993; Hagstrom, 1995).

(41) **Environments for reduced vowels**:

a.	Obstruent-obstruent	VT__TV
b.	Obstruent-sonorant	VT__RV
c.	Sonorant-obstruent	VR__TV
d.	Sonorant-sonorant	VR__RV
e.	Word initial-obstruent (when applicable)	#__TV
f.	Word initial-sonorant (when applicable)	#__RV

The ideal number of entries per obstruent-sonorant context and word type was arbitrarily chosen to be five. However, this was not always possible. For example, environments where the first member is a sonorant (41c,d) are environments where reduced vowel deletion is common. These words were not included in the present study. Environments where schwa was word-initial (41e,f) were also rare. All words found that matched these criteria were included, although they make up a somewhat smaller portion of the data than environments (41a,b). In total, 249 recordings were selected for inclusion, with an average of 24.9 words of each combination of schwa location and syllable length.

In addition to time-normalized and z-scored pitch measurements, taken in the same way as described in Study I, duration measurements for each vowel were also collected for this study.

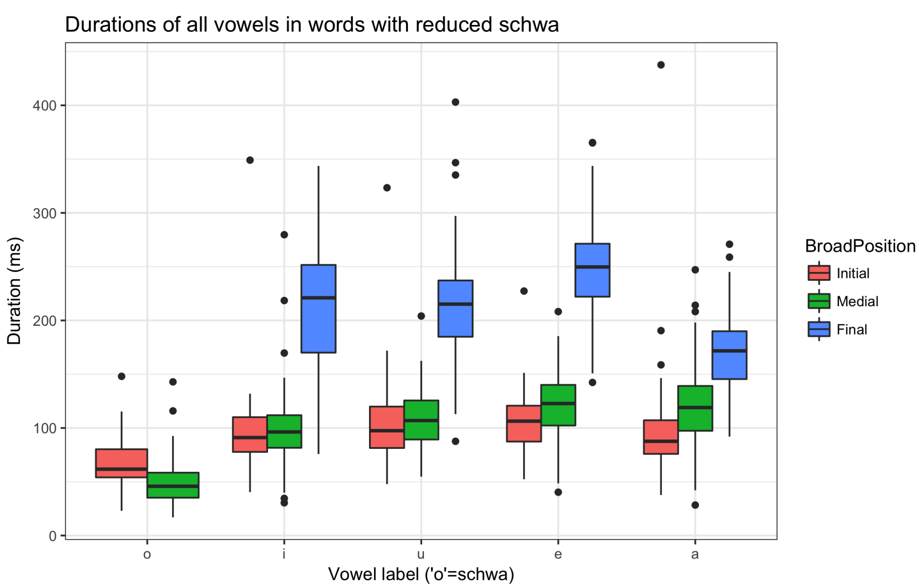


Figure 3: Average durations in ms for all non-lengthened vowels in Study II

	Estimate	*Std. Error*	*t value*
(Intercept)	54.649	4.448	12.29
Reduced vs. Full	55.432	3.644	15.21
Initial vs. Medial	1.586	3.444	0.46
Initial vs. Final	110.813	8.700	12.74

Table 1: Results of mixed effects model
`Duration ~ Quality + Position + (Quality + Position|Speaker)`

5.2 Results

Results for duration are given in Figure 3 (previous page). Durations are grouped by vowel examined (*o, i, u, e, a*) and position within the word (*initial, medial, final*). A linear mixed effects model was run on the duration data using the `lmer` package in R (Bates et al., 2015), with fixed effects for Position (Initial vs. Medial vs. Final) and Vowel Quality (Reduced vs. Full). Random slopes and intercepts were included for each speaker. The results of running the mixed effects model, as well as the formula used to specify the model, are included in Table 1. It was found that Full vowels were significantly longer than Reduced vowels ($t = 15.21$), and that Final vowels were significantly longer than Initial vowels ($t = 12.74$). There was no significant difference between Initial and Medial vowels ($t = 0.46$). It should be noted that it was impossible to run a full model with interactions between Vowel Quality and Position, since no word-final schwas were included in the study. A fully specified model was run on a subset of the data without final vowels, but the model did not converge.

Results for pitch tracks are given in Figure 4 (next page). If a particular interval contains a schwa, it is presented with a grey background.

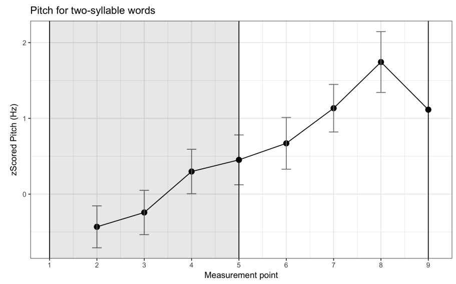
5.3 Discussion

With regard to pitch, the predictions about shift of the pitch rise associated with stress are largely borne out. When a schwa is located medially within a word, the pitch rise appears one syllable to the left of where it is expected, regardless of whether it would fall on a reduced or a full vowel. For example, in Figure 4h, the second syllable contains a reduced vowel, as indicated by the grey shading. This vowel would, under default stress assignment, be expected to host a pitch rise, but this is not what is observed. Instead, the pitch rise appears one syllable to the left, on the first syllable. The same is true of Figure 4i, with a reduced vowel in third position – although default stress rules would assign stress and pitch accent to the second syllable of the word, the initial syllable instead bears the rise in pitch. This word also contains a reduced vowel located medially within the word, immediately to the right of the syllable that would be expected to bear stress. Thus, it appears that reduced vowels shift stress off of their leftmost neighbours, just as predicted by all accounts of the interaction between stress and reduced vowels mentioned thus far.

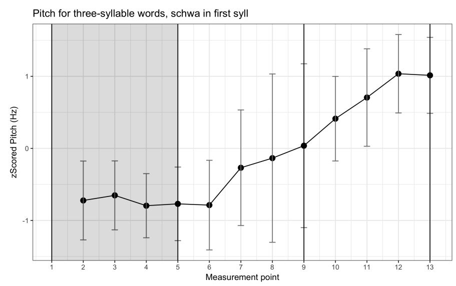
While these results can easily be seen for all three- and five-syllable words, the four-syllable words in Figures 4d,e do not fall easily within this pattern. When the reduced vowel falls within the second syllable as in Figure 4e, it appears as if there is a mid-to-high pitch plateau or slight rise on the first syllable. If the accounts outlined thus far are correct, then this higher pitch is unexpected – if this syllable is indeed unstressed, it should remain on a low pitch. Why this is so is unknown at the present time.

What is more surprising is how this figure compares with Figure 4d, which has a reduced vowel in the initial syllable. Instead of finding a purely low-pitched interval over the first two syllables or a slightly higher plateau over the first or second syllable as in Figure 4e, this word displays two full pitch rises, one on the first syllable and one on the third. This matches the default stress pattern for four-syllable words found in Study I. However, if the durations of the initial two vowels in Figures 4d,e are roughly equivalent across positions, then why this difference in pitch realization exists is a mystery.

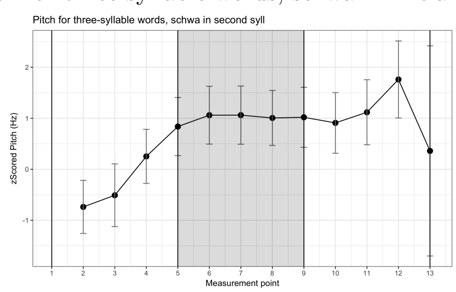
While the statistical tests run found no difference between Initial and Medial syllables, the graph in Figure 3 indicates that there may be a difference for schwa – schwa in Initial syllables appears to be longer



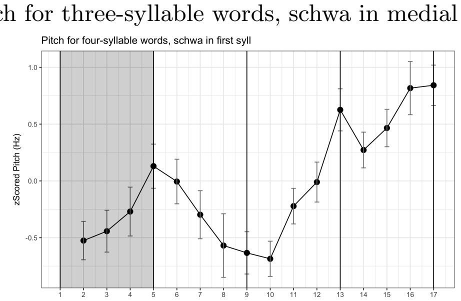
(a) Pitch for two-syllable words, schwa in initial syllable



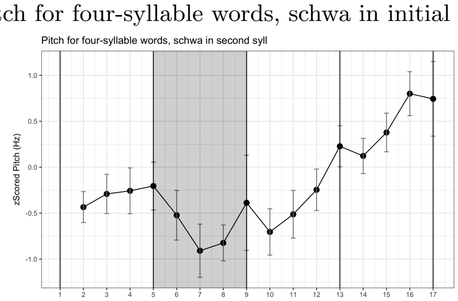
(b) Pitch for three-syllable words, schwa in initial syllable



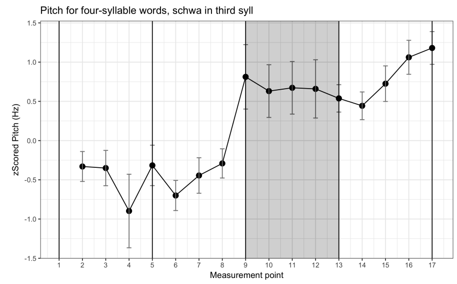
(c) Pitch for three-syllable words, schwa in medial syllable



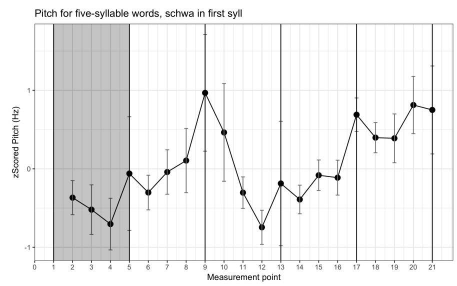
(d) Pitch for four-syllable words, schwa in initial syllable



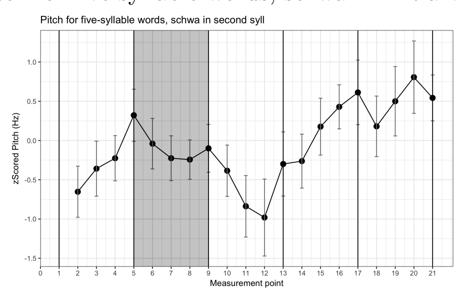
(e) Pitch for four-syllable words, schwa in second syllable



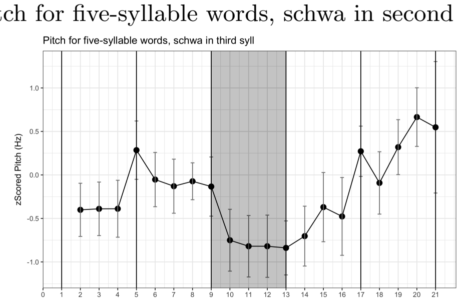
(f) Pitch for four-syllable words, schwa in third syllable



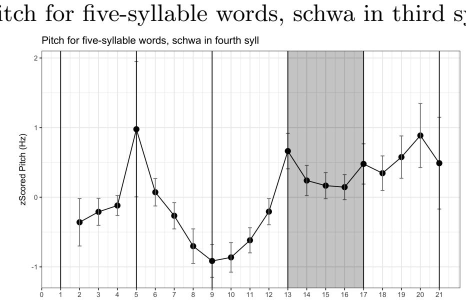
(g) Pitch for five-syllable words, schwa in initial syllable



(h) Pitch for five-syllable words, schwa in second syllable



(i) Pitch for five-syllable words, schwa in third syllable



(j) Pitch for five-syllable words, schwa in fourth syllable

Figure 4: Averaged pitch tracks for all types of word examined in Study II

than schwa in Medial syllables. This appears to be a pattern that is unique to schwa, since all other vowels appear to exhibit the opposite preference, where vowels in Initial syllables tend to be shorter than vowels in Medial syllables. LeSourd (1988) claims that this is due to the different underlying forms of these two kinds of words – schwa in Initial syllables is more likely to be linked to a timing slot, while schwa in Medial syllables is not. However, as discussed in section 3.4, this merely a notational difference, and does not get at the root of the difference in distribution of longer vs. shorter schwa in these environments. I take this to indicate that initial syllables are a lengthening environment for schwa. If this environment is capable of lengthening schwa sufficiently over the T-DISTANCE threshold, then this schwa should be able to host the full pitch rise. This will then adequately explain the difference between Figures 4d and e, where initial schwa in Figure 4d is capable of hosting a pitch rise, but the medial schwa in Figure 4e is incapable of hosting an equally-timed pitch fall. This will be examined in more detail in Study III.

Figure 4 also provides some additional evidence about how specific tones are aligned within the word. Possible pitch plateaus on the reduced vowel in Figure 4c,f,j indicate that the high pitch associated with the end of the pitch accent must be strictly aligned with the onset of the vowel following stress – in this case, the reduced vowel itself. Since pitch does not continue to rise throughout this vowel, it appears as if the high pitch must be achieved beforehand. However, these data should be taken with a grain of salt, since if reduced vowels are substantially shorter than full vowels, more pitch measurements will have been taken over a shorter span of time for these intervals. This may skew the results in such a way so as to exaggerate potential pitch plateaus over these syllables and de-emphasize potential plateaus in their full vowel neighbours. However, the data presented are nevertheless suggestive of a strict anchoring point for the high tone of the pitch accent. These data also provide support for the hypothesis that the anchoring point for the low tone is slightly more fluid than for the high tone, since the lowest tone of a word may appear within the syllable before the main rise, as in Figure 4e,i.

The hypothesis about schwa duration is borne out by the duration data in Figure 3 and Table 1. Schwas are significantly shorter than all other vowels. When taken together with the pitch shifting behaviour, this suggests that they are too short to adequately separate the tones that make up the pitch accent. In order to adequately host this pitch accent, stress must shift away from the reduced vowel, as modelled in the OT analysis in section 3.

6 Study III: Pitch and unreduced schwa

The third and final study is meant to examine how full-vowel schwas behave with respect to stress in Passamaquoddy-Maliseet, and is broken up into two separate sub-experiments. Study IIIA examines the behaviour of schwass in the environments listed in (42), repeated from (32). These are largely the environments which are defined solely in terms of adjacent segments or word edges, although the word-initial syllable environment is left out of this study since it was already determined to be a potential lengthening environment in Study II.

(42) **Environments examined in Study IIIA**:

a.	__C_0#	.a.má.kən.	'fishing tackle' (PMDP 2016)
b.	[¬h]C__	.pis.kə.lan.	'it rains so hard that it is dark' (LeSourd, 1993, 81)
c.	__[¬h]C	.a.lə́n.t͡ʃis.	'orange' (PMDP 2016)
d.	hl__	.á.t͡ʃeh.lə́.su.	'3.SG.AN changes self' (LeSourd, 1993, 82)
e.	__ss	.skə́.ni.sə́s.sis.	'bone (DIM)' (LeSourd, 1988, 260)

It should be noted that (42e) was expanded from the attested *s__ss* to simply *__ss* since it is the presence of the geminate that is expected to be the trigger for any potential lengthening, as discussed in section 3.4. The final environment, where a reduced vowel is second in a sequence of reduced vowels, was examined separately in Study IIIB.

6.1 Study IIIA: Single unreduced schwa

As discussed above, all words examined in this sub-experiment were those that meet the criteria in (42), which are all environments that do not require there to be an additional reduced vowel within the word. This allowed for a more thorough comparison between Study II and the present study, since word position and number of potentially reduced vowels was controlled for across experiments.

It was expected that in the environments examined for this study, schwa would be lengthened with respect to the schwas in Study II. As outlined in section 3.4, the environments __C_0# and __*ss* are already attested as potential lengthening environments, and it is not unexpected that __[¬h]C could also be one such lengthening environment. The other two environments are not known for causing vowel lengthening, but since their behaviour is consistent with other lengthening environments, it would be unsurprising if they did. Since these vowels are expected to be lengthened, it is also expected that they will be capable of bearing pitch accent or of being the lone vowel separating two pitch accents – in other words, they should be long enough to cross the threshold set by the T-Distance constraint. As such, all pitch rises should return to the positions where they would be expected under default stress assignment.

6.1.1 Methodology

Methods used for this study were largely the same as in Studies I and II, although the selection criteria were changed to accommodate the desired environmental conditions listed in (42). Words had to be between one and five syllables in length. As in Study II, each word contained exactly one reduced vowel, always chosen to be schwa, which appeared in all potential positions within a given word length. If the schwa was not word-final, it had to be located within one of the other environments listed in (42). Again, an attempt was also made to ensure that a potentially reduced vowel appeared at least five times in all possible obstruent-sonorant contexts, to make it as similar as possible to Study II.

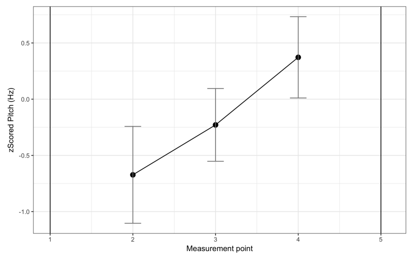
For cases where the schwa was not in the final syllable, an attempt was made to find at least one example of each potential lengthening environment for each word category, although this was rarely possible. The majority of the words contained a potential lengthening environment of the form [¬*h*]C__, with the remainder of environments being largely of the form __[¬*h*]C, and __*ss* and *hl*__ being the rarest examples. In addition, some combinations of word length, position, and segmental context mostly yielded results for one particular lengthening environment, especially when the word was four or five syllables long. For example, in five-syllable words with initial schwa, almost all words where schwa is surrounded by obstruents are those where the following segment is *ss*, such as *kossápiténsu* '3.sg.an brushes (own) teeth', *kossíkaténsu* '3.sg.an washes (own) feet', *hpossíkinéhtun* '3.sg.an splits 3.sg.inan in two (by tearing)', *etc.* (PMDP 2016). These limitations should be kept in mind when examining the results, presented below.

6.1.2 Results

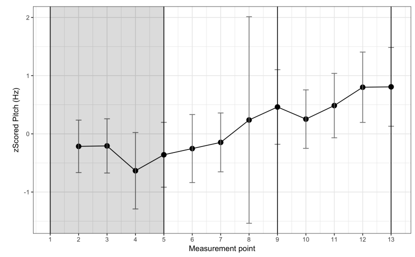
Pitch tracks for each word length and schwa position are presented in Figures 5 – 7. As in Study II, intervals which contain schwa are displayed with a grey background, with the exception of monosyllabic words. The data of one of the speakers was excluded from analysis, since she tended to produce pitch contours which ended on a low pitch rather than a high pitch, indicating that the word-final syllables in these words may not have been truly utterance-final.

The results for the measurement of duration for each vowel are presented in Figure 8. As in Study II, durations are grouped by vowel examined and by position within the word. In addition, the vowels were separated also by whether they were stressed or unstressed – this was not performed for Study II, since it was predicted that all reduced vowels would be unstressed and would not offer a full set of comparisons with the full vowels.

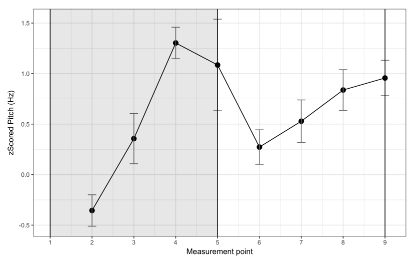
A linear mixed effects model was run on the duration data with fixed effects for Position (Initial vs. Medial vs. Final), Vowel Quality (Reduced vs. Full), and Stress (Stressed vs. Unstressed), with random slopes and intercepts for each fixed effect included for each speaker. Results and model formulation are presented in Table 2. There was found to be a significant difference in duration between schwa and all other vowels ($t = 6.659$), such that schwa is still the shortest of all vowels. There was a significant difference



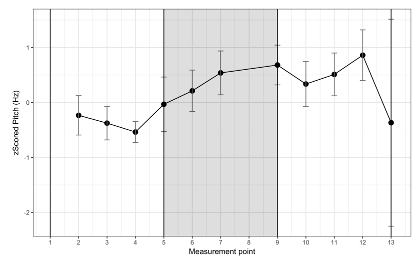
(a) Pitch for one-syllable words with schwa



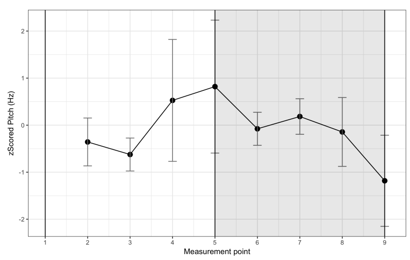
(d) Pitch for three-syllable words, schwa in initial syllable



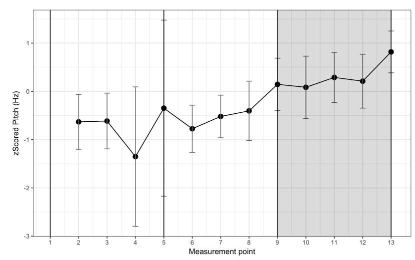
(b) Pitch for two-syllable words, schwa in initial syllable



(e) Pitch for three-syllable words, schwa in medial syllable

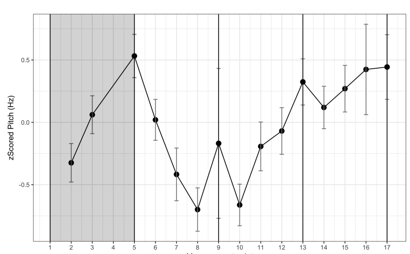


(c) Pitch for two-syllable words, schwa in final syllable

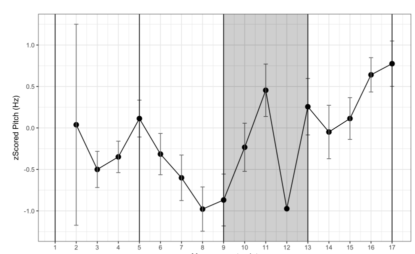


(f) Pitch for three-syllable words, schwa in final syllable

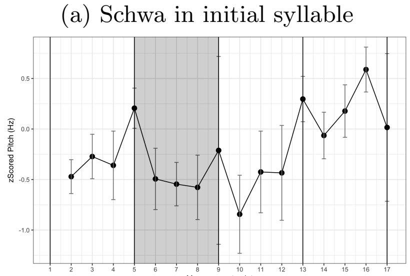
Figure 5: Averaged pitch tracks for words of up to three intervals, Study IIIA



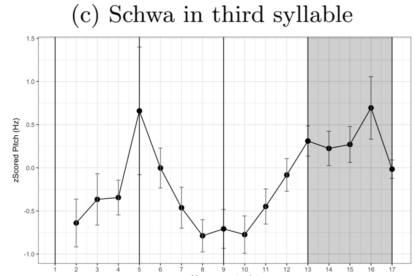
(a) Schwa in initial syllable



(c) Schwa in third syllable

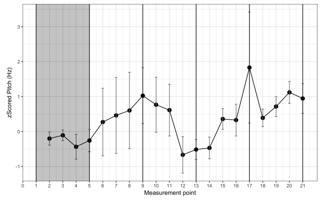


(b) Schwa in second syllable

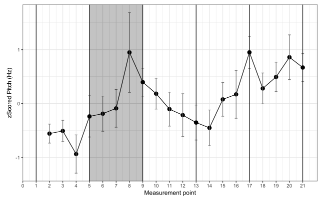


(d) Schwa in final syllable

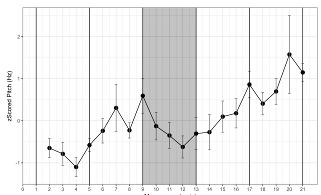
Figure 6: Averaged pitch tracks for words of four intervals, Study IIIA



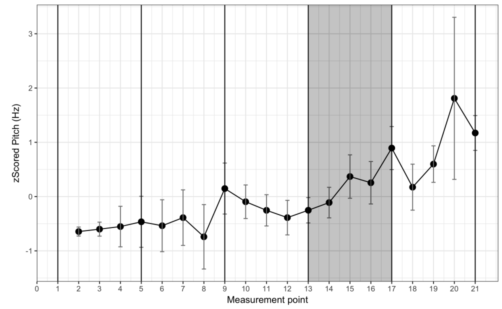
(a) Schwa in initial syllable



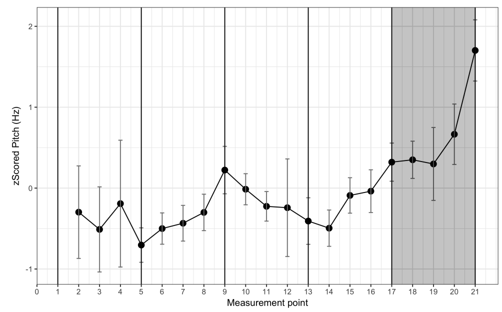
(b) Schwa in second syllable



(c) Schwa in third syllable



(d) Schwa in fourth syllable



(e) Schwa in final syllable

Figure 7: Averaged pitch tracks for words of five intervals, Study IIIA

between Initial and Final position (t = 9.401) such that Final vowels are longer overall than Initial ones, although there is not a significant difference between vowels in Initial and Medial position (t = 1.307). Finally, there was a difference in duration between Stressed and Unstressed vowels ($t = -3.703$).

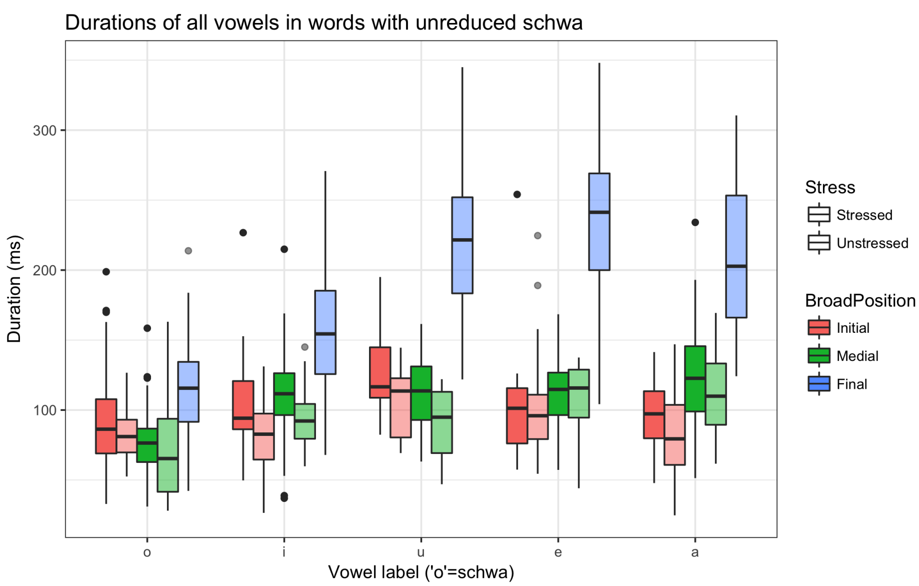


Figure 8: Average durations in ms for all vowels in Study IIIA

	Estimate	*Std. Error*	*t value*
(Intercept)	61.935	10.321	6.001
Reduced vs. Full	52.806	7.930	6.659
Initial vs. Medial	8.072	6.174	1.307
Initial vs. Final	110.954	11.802	9.401
Stressed vs. Unstressed	-11.868	3.205	-3.703

Table 2: Results of mixed effects model
`Duration ~ Quality + Position + Stress + (Quality + Position + Stress | Speaker)`

While the data above are instructive in showing how assignment of stress can influence vowel durations, they do not help answer the question of whether schwas are lengthened with respect to the schwas in Study II. The result of this comparison is illustrated in Figure 9, where all non-initial schwas in Study II are classified as "Invisible". All other schwas are classified according to the segmental context in which they appear.

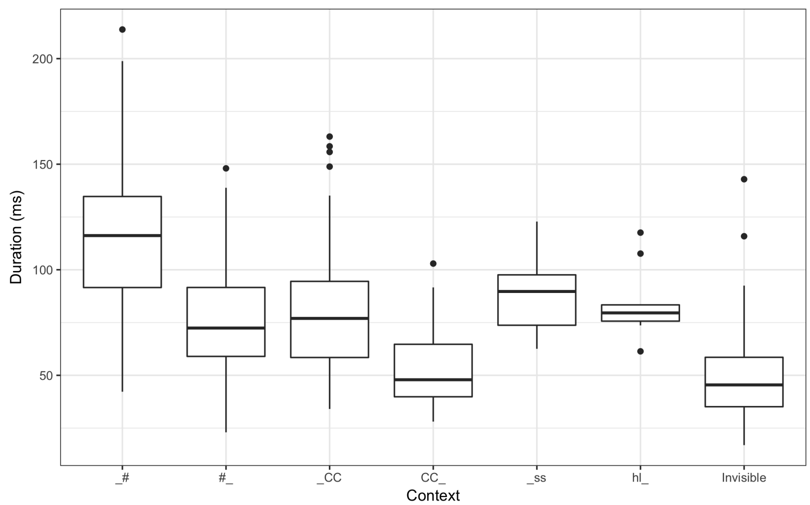


Figure 9: Average durations in ms for schwas in Studies II & IIIA, separated by context

In order to determine whether any of the differences in Figure 9 were significant, a linear mixed effects model was run on the duration data with Context as a fixed effect, with random slopes and intercepts included for each speaker. Context was dummy-coded so that the non-initial vowels from Study II were used as a baseline. Results are shown in Table 3. When compared to the non-initial schwas in Study II, all contexts except post-consonant cluster (CC__) showed a significant increase in vowel duration.

	Estimate	*Std. Error*	*t value*
(Intercept)	50.149	3.562	14.078
Word-final (__#)	71.403	6.797	10.505
Word-initial (#__)	26.219	4.348	6.030
Pre-consonant cluster (__CC)	33.278	9.267	3.591
Post-consonant cluster (CC__)	7.257	5.552	1.307
Pre-geminate *s* (__ss)	42.158	7.328	5.753
Post-*hl* (hl__)	35.626	9.292	3.834

Table 3: Results of mixed effects model comparing durations of schwa in different segmental contexts
`Duration ~ Context + (Context | Speaker)`

6.1.3 Discussion

For this study, it was predicted that pitch rises should appear in the positions dictated by default stress assignment, regardless of whether the syllable contains a schwa or not. For the four-syllable words in Figure 6, the pitch rises always appear in the first and third intervals, regardless of which syllable contains the schwa, as expected. A similar phenomenon is observed for the five-syllable words in Figure 7, where the pitch rises always appear on the second and fourth syllables. Thus, even though these words contain schwa, they do not display the same stress-repelling behaviours observed in Study II. Although it is less pronounced, the same can be said for the three-syllable words in Figure 5 – the syllable which bears the majority of the rise always appears to be the second syllable. Monosyllabic words as in Figure 5a are not expected to show anything but a rise, and the initial syllable of the two-syllable words does bear an expected rise as well. However, the results for the second syllable in the two-syllable words examined does not match any predictions up to this point.

In the case of Figure 5b, it appears as if there is not only a rise on the first syllable, but on the second syllable as well, rather than a smooth rise all the way to an utterance-final high boundary tone H%. After examination of the raw pitch tracks for the words in question, it appears as if this is an artefact of a "dip" in the final syllable of the word. A pitch track displaying this pitch "dip" is shown in Figure 10. Many of the two-syllable words included in the study displayed this dip in pitch, which may account for the dip in pitch in the second syllable of Figure 5b. In the case of Figure 5c, the odd behaviour of the second syllable may simply be due to the incredible scarcity of data for this word type – only eleven recordings were found that matched the criteria desired.

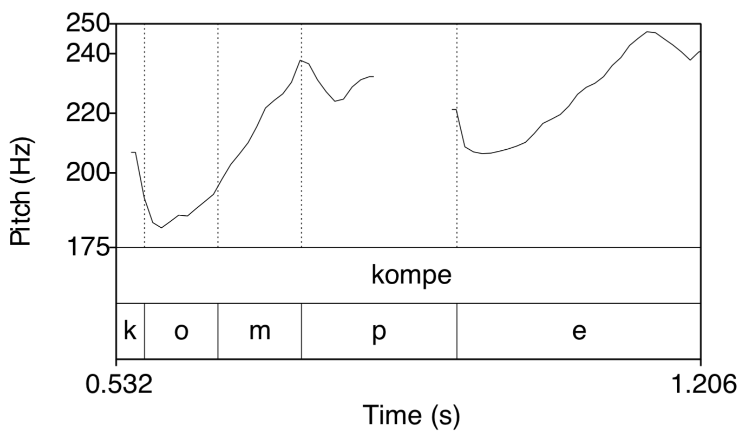


Figure 10: Illustration of a final syllable dip in pitch for *kə́mpe*, '3.SG.INAN (*i.e.,* land) floods

Taking this information into account, it appears as if the hypothesis about pitch is met across most word types included in the study – even though these words contain schwas, which are expected to be reduced, they do not behave as such with respect to pitch accent and stress assignment.

Although it was found that schwas remained significantly shorter than vowels of all other qualities, it was nevertheless shown that for the majority of contexts in (42), schwas were significantly longer than their reduced counterparts in Study II. If it is assumed that the minimum tone distance set by the T-DISTANCE constraint lies between the average length of non-initial schwas in Study II and the average length of schwas in these environments, then it will explain why lengthened schwas are capable of hosting pitch transitions, while truly reduced schwas are not.

The one exception to this finding is that there is no significant difference between the non-initial schwas in Study II and post-consonant cluster (CC__) schwas. As discussed in section 3.4, this discrepancy may potentially be due to how one of the consonants in the cluster behaves – if it is capable of hosting pitch transitions, then it may be that the simple presence of this consonant may allow the entire vowel-to-vowel interval to satisfy the T-Distance constraint, rather than forcing the vowel to bear the entirety of the pitch transition. As the behaviour of consonants was not examined for this study, this is a topic that will have to be left for future research. Nevertheless, the fact that schwa lengthens in the majority of environments in (42), and that many of these are known to cause vowel lengthening for independent reasons, lends credence to the theory that it is the raw duration of the vowel and its interaction with the pitch accent system that causes reduced vowels to be skipped over for stress.

6.2 Study IIIB: Adjacent reduced vowels

According to LeSourd's (1988, 1993) observations, sequences of two reduced vowels are an environment where one of the reduced vowels must be visible to the stress system. Passamaquoddy-Maliseet apparently chooses to make the second such reduced vowel visible to the stress system, since it is the only member of such a sequence that is capable of bearing stress and pitch accent. As shown by the previous studies in this paper, the duration of the vowels in question is the primary criterion by which reduced and unreduced vowels are distinguished, since the longer, unreduced vowels are capable of maintaining adequate separation between low and high tones while reduced vowels are not. However, while the environments examined in Study IIIA were largely shown to be environments where vowels lengthen for independent phonetic reasons, there is no *a priori* reason to believe that the second vowel of a sequence of identical vowels is such a lengthening environment. The purpose of this study is to examine if this is the case – if so, then this environment behaves as all others examined in Study III and can receive the same theoretical analysis within OT.

6.2.1 Methodology

As above, segmentation and measurement methods were performed as described in the previous studies. Selection criteria were again changed to accommodate the desired environmental conditions listed in (43).

(43) **Selection criteria for inclusion in Study IIIB**:

a. Words had to have a sequence of exactly two syllables containing schwa.

b. The first and last members of the schwa sequence could not be located in any environment where they would be independently lengthened, such as initial or final position, or adjacent to a consonant cluster. This had the consequence that only words of four or five syllables could be examined.

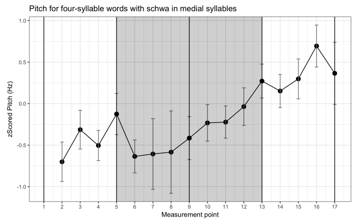
c. All other possible schwa sequence locations were included.

Due to the scarcity of data, no attempt was made to control for obstruent and sonorant contexts, as in Study II and Study IIIA. This meant that a majority of the schwas examined were located between obstruents (T__T). The remainder of the data was mostly taken up by schwas located between an obstruent and a sonorant (T__R, R__T), with very few located between two sonorants (R__R). Twenty-five recordings were chosen for each combination of word length and initial schwa position.

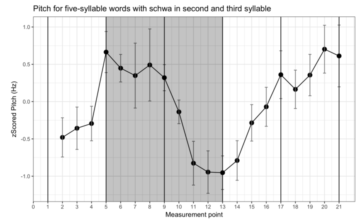
6.2.2 Results

The pitch tracks obtained through analysis of the data are presented in Figure 11. Syllables which were headed by a schwa are displayed in grey.

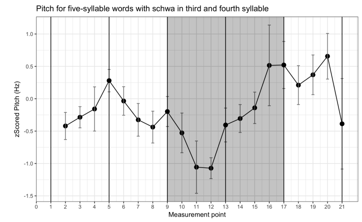
Figure 12 shows the durations of all schwas examined in Study IIIB, grouped first by the word category they belong to, of the format [word length].[position of initial schwa], and then divided by whether the schwa was first (left) or second (right) in the sequence. It is apparent that regardless of word length or absolute position within the word, the second schwa in the sequence is longer than the initial schwa. This was tested by running a linear mixed effects model on Duration with Position and Word Class as fixed effects, in addition to their interaction, and random slopes and intercepts for Position and Word Class for each Speaker. The results of the mixed effects model are shown in Table 4.



(a) Four-syllable words, schwa in medial syllables



(b) Five-syllable words, schwa in second and third syllables



(c) Five-syllable words, schwa in third and fourth syllables

Figure 11: Averaged pitch tracks for words included in Study IIIB

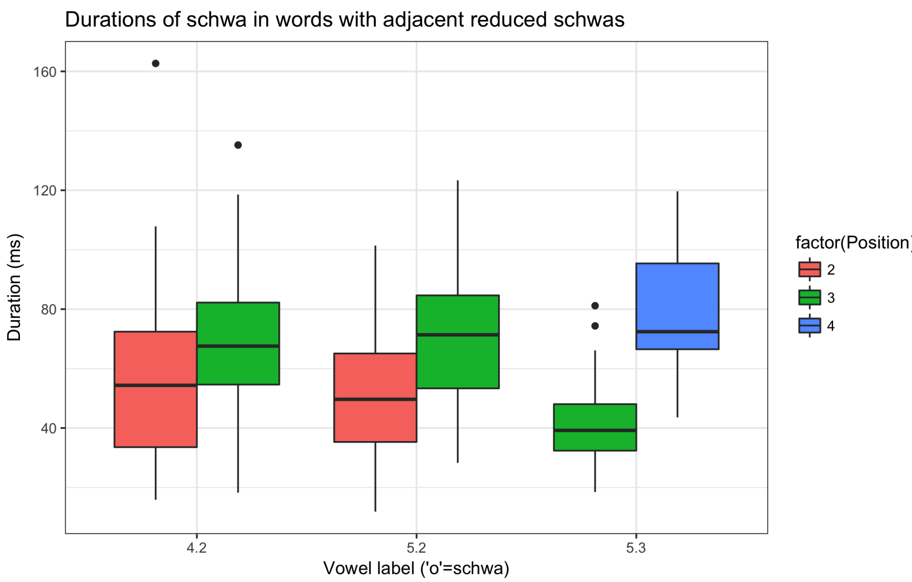


Figure 12: Average durations in ms for all schwas in Study IIIB

	Estimate	*Std. Error*	*t value*
(Intercept)	32.1256	11.757	2.732
Position	13.250	4.646	2.852
4.2 vs. 5.2	-20.305	17.548	-1.157
4.2 vs. 5.3	-102.759	23.330	-4.405
Position:4.2 vs. 5.2	7.602	6.884	1.104
Position:4.2 vs. 5.3	24.826	7.274	3.413

Table 4: Results of mixed effects model comparing durations of initial vs. final schwa in sequences
`Duration ∼ Position * Word.Class + (Position + Word.Class | Speaker)`

The results of the linear mixed effects models reveal that there is a significant effect of Position, such that the second vowel in a sequence is longer ($t = 2.852$). They also show a significant effect of Word Class, such that initial members of a sequence of schwas are shorter when strictly medial in five-syllable words than they are in all other sequences examined in the study ($t = -4.405$). There is also an interaction between Position and Word Class, such that final members of a sequence of schwas are longer when penultimate in five-syllable words ($t = 3.413$). No other interactions or fixed effects are significant.

When compared to the durations of the schwas examined in Studies II and IIIA, it is apparent that most of the first schwas are comparable to those that cannot host stress in Study II, while the durations of the second schwas are closer to those that can host stress in Study IIIA. This lends support to the idea that the second reduced vowel in a sequence of such vowels is a lengthening environment, and can receive the same interpretation in OT as the reduced vowels included in Study IIIA.

6.2.3 Discussion

With respect to the pitch tracks for five-syllable words examined in this study, it appears as if the predictions made by the current account and by LeSourd's account are mostly borne out – the pitch rises appear on the first and fourth syllables, with the second and third syllables bearing the drop in tone. This is true even if the fourth syllable is the second schwa in a sequence of two schwas, lending support to the generalization that it is always the second reduced vowel which is counted when assigning stress. However, when examining the data from the four-syllable words, the same generalization cannot be clearly made – it appears that for the four-syllable words, the pitch rise is shared between both reduced syllables, although the majority of the rise appears within the second syllable. This may be the correct generalization, or it may be that the combination of the short duration of the vowel in question and the flexibility of the L* anchor point are conspiring to make it appear as if the rise is shared. If the L* anchor point can be moved within the preceding syllable, and if that syllable is particularly short, it may be the case that it appears much closer to the beginning of the preceding syllable than expected. This may account for the way pitch appears to behave in Figure 11a. I will for the time being adopt the latter interpretation, since it is consistent with Figure 11c.

However, being the second schwa in a sequence of schwas is not a known lengthening environment for vowels of any quality. To ensure that this was not a behaviour unique to reduced vowels, a *post-hoc* analysis of all words examined in all three studies was performed. All words which had a sequence of exactly two syllables headed by identical vowels were included in the *post-hoc* analysis. No member of the sequence could be word-final. The results of examining the durations of these vowels are presented in Figure 13. The results of performing a linear mixed effects model with fixed effects for Order and Vowel Quality, with random slopes and intercepts for each Speaker, are presented in Table 5. The data set was not robust enough to test for an interaction between Order and Vowel Quality.

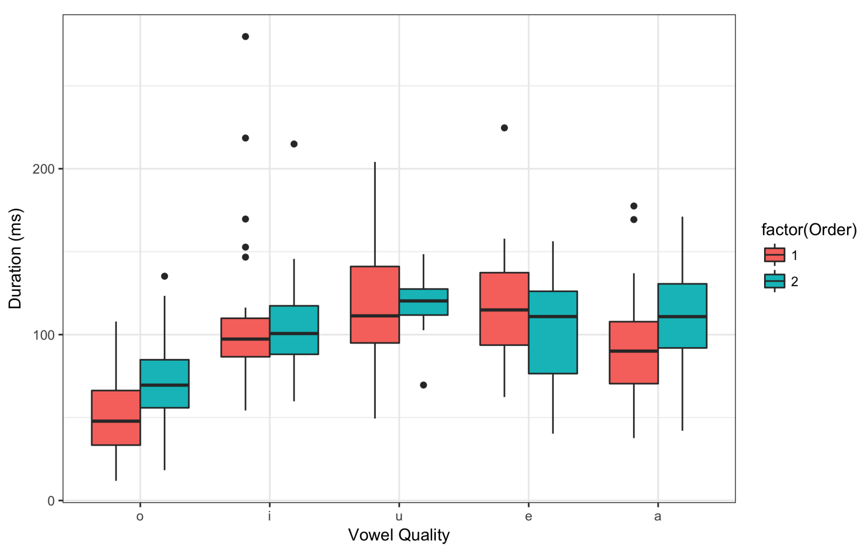


Figure 13: Average durations in ms for all sequences of identical vowels

	Estimate	*Std. Error*	*t value*
(Intercept)	58.103	4.680	12.415
First vs. Second	11.043	3.267	3.380
Schwa vs. i	42.544	5.721	7.437
Schwa vs. u	46.131	11.193	4.122
Schwa vs. e	44.631	10.226	4.365
Schwa vs. a	38.238	5.435	7.035

Table 5: Results of mixed effects model comparing durations of initial vs. final vowel in sequences `Duration` $\sim$ `Order + Vowel + (Order + Vowel | Speaker)`

Examining Figure 13 reveals that, with the exception of the vowel *e*, the second vowel in a sequence is always longer than the first vowel in that sequence. The results of the linear mixed effects model bear this out, since the difference between the two positions comes out significant ($t = 3.380$). Thus, it cannot be said that this is not a lengthening environment that is unique to reduced vowels – rather, it appears to be a lengthening environment universal to all sequences of identical vowels. This is, perhaps, a strategy employed to ensure that vowels in adjacent syllables are not strictly identical, in order to avoid repetition (Walter, 2007). Why it is the second vowel that is longer, rather than the first, remains unexplained. Nevertheless, this is concrete evidence that the second reduced vowel in a sequence of reduced vowels should be grouped with reduced vowels in other lengthening environments. This has the result that it is capable of hosting transitions between the tones of a pitch accent, and will not be skipped over during stress and pitch assignment.

7 Discussion

This study began by examining the claims made by LeSourd (1988) about the realization of stress and pitch accent in Passamaquoddy-Maliseet. As shown by Study I, the main cue to the presence of stress is the presence of a pitch rise on the stressed syllable. The pitch rise is assumed to consist of a low pitch accent L*, followed by a high tone, H. The low pitch accent ideally appears at the beginning of the stressed syllable, although it can appear slightly before the stressed syllable as well, as enforced by the constraint L-Anchor; while the high pitch accent must appear at the beginning of the vowel following the stressed syllable, apparently without exception, as enforced by the constraint H-Anchor. Since the anchoring constraints on the high tone are much stricter than those of the low tone, it is also possible to say that the pitch accent is the high portion of the pitch rise, making the entire rise L+H*. However, if this is the case, then the pitch accent, H*, will not appear within the stressed syllable, leading to a violation of Stress-to-Accent. While it is possible to re-formulate this constraint to be consistent with the alternate analysis of the pitch accent, it will not change the main claim about the anchoring points of each tone. It is the strictness of maintaining these anchoring points that will cause reduced vowels to be inadequate for hosting the full pitch rise associated with stress. This claim is a refinement of the claim made by LeSourd (1988), where stress is cued by alternating high pitches on stressed syllables with low pitches on unstressed syllables.

While the data examined in Study I are suggestive of the anchoring points established by L-Anchorand H-Anchor, they are not exact measurements. The exact anchoring points of these two tones should be established by further studies into pitch accent alignment within Passamaquoddy-Maliseet, with a special focus on sonorant-only words, so that the microposody associated with obstruents does not obscure anchoring points. The words that consist only of sonorants in the Passamaquoddy-Maliseet dictionary are largely concentrated in words of three or four syllables – there are no words of five or more syllables to examine, so a complete picture of how pitch is aligned word-medially is not available at the present time. Additional data should be collected, perhaps via acoustic experiments, to determine the exact locations of these anchor points.

Study II showed that single reduced vowels, exemplified by schwa, cause any pitch rises expected to be located on that reduced vowel or any preceding vowel to shift one syllable to the left, as predicted by LeSourd (1988, 1993); Hagstrom (1995), and the current account. It also showed that reduced vowels are significantly shorter than their full vowel counterparts. It was hypothesized in section 3 that the duration of the reduced vowels falls below the minimum tone separation threshold established by the constraint T-DISTANCE(0.5), but that the duration of the unreduced vowels would exceed this threshold. Furthermore, it was established in that section that the tonal anchoring constraints L-ANCHORand H-ANCHOR are ranked together with T-DISTANCE(0.5) above the stress assignment constraints, such as *LAPSE. Since durationally reduced vowels are not capable of simultaneously satisfying all three tonal alignment constraints, the pitch rise – and with it, stress – must shift. This will be true regardless of whether the reduced vowel would be expected to bear the pitch rise and stress, or whether it acts as the sole vowel between two pitch rises.

Study III showed that reduced vowels are lengthened when located within most contexts where they had been established by LeSourd (1988, 1993); Hagstrom (1995) to be visible to the stress system. This was true for all contexts mentioned, with the exception of when a reduced vowel was located after a consonant cluster, CC__. As discussed in section 6.1.3, since only vowel length was examined in this study, it is unknown whether the lengths or qualities of the intervening consonants played a role in maintaining adequate separation between the tones associated with the pitch accent. However, with respect to the other environments, it is clear that they lengthen the reduced vowel significantly. It was hypothesized in section 3 that these lengthened reduced vowels allow the minimum pitch distance set by T-DISTANCE(0.5) to be exceeded – thus, they are capable of hosting transitions between the tones associated with the pitch accent, and do not need to be skipped over when stress and pitch accent are assigned.

A large question raised by the above analysis and unanswered by Studies II and III is what the proper minimum distance set by T-DISTANCE(0.5) should be. In the current set of studies, it is hypothesized that it must lie between the average duration of a typical reduced vowel and the average duration of such a vowel when located in a lengthening context – this will account for the difference in behaviour between these two kinds of reduced vowels with respect to stress. However, there is no other direct evidence for this threshold, and due to the nature of the data examined, there is no way to examine the effects of the T-DISTANCE(0.5) constraint separately from reduced vowels. In order to provide more direct evidence for this constraint, an experimental study should be performed. For instance, as in Cho (2011), an experiment could be performed where speech rate is varied systematically, to see when the T-DISTANCE(0.5) constraint could cause deviations in pitch alignment – especially in the alignment of the low pitch accent L*, since this pitch has been shown to vary in position in this study.

An additional question raised by the T-DISTANCE(0.5) constraint is whether it necessarily applies equally to both pitch rises and pitch falls. The current analysis is based on the assumption that both will require the same minimum distance in order to be realized, although it is conceptually possible that there could be a separate minimum distance for rises and for falls. Whether this is strictly true for Passamaquoddy-Maliseet is again not a claim that can be directly substantiated by the evidence collected in Studies II and III. While it is known that both should lie within the range established by the durations of single reduced vowels and those located within lengthening contexts, whether they are the same or different cannot be known without performing additional studies.

One shortcoming that this analysis has with respect to the analyses presented by LeSourd (1988, 1993) and Hagstrom (1995) is that it currently cannot straightforwardly account for the stress pattern of a word with more than three reduced vowels in a row, such as *htə́tələtəmə́nəl* '3.SG.AN is eating 3.PL.INAN', introduced in section 2. As it currently stands, the sequence *ələtə* will violate a constraint *EXTLAPSE under the proposed account, regardless of whether any of the reduced vowels are lengthened. There is not sufficient data in the current corpus to investigate how sequences of three or more reduced vowels behave with respect to stress and pitch accent, and this question will have to be left to additional experimental research.

Another question raised by all accounts is how to represent reduced vowels that always behave as full vowels, like initial reduced vowels in LeSourd's analyses. The accounts that make use of structurally deficient reduced vowels have a simple way of accounting for this by simply positing that these vowels are lexically stored as full vowels – either pre-linked to a timing tier (LeSourd, 1988, 1993) or to a syllable (Hagstrom, 1995). This account must instead make the claim that there are potentially two different reduced vowel phonemes – a short schwa [ə] and a long schwa [əː]. Previous researchers, such as **?**, have made similar claims about reduced vowels in Passamaquoddy-Maliseet, although these claims were not pursued in much detail by LeSourd or Hagstrom. The current study likewise did not take such a division into account, but making such a division could be instructive for future research.

In addition to the exact nature of the pitch alignment constraints used in the analysis in section 3, it was hypothesized that for Passamaquoddy-Maliseet, all pitch alignment constraints outrank all stress assignment constraints. While this is an analysis that is consistent with the data, the only direct evidence for this ranking comes from the domination of *Lapse by the pitch alignment constraints – constraints such as H-Anchor and T-Distance(0.5) are capable of ruling out the same candidates as *Clash and NonFin, as shown in (30), repeated below as (44).

(44) **Stress constraints ranked below tone alignment constraints**:

/kisəlukemu/	H-Anchor	T-Dist	*Clash	NonFin	*Lapse
☞ a. L* H L* H kí sə lu ké mu					*
b. L* H L* H ki sə lú ké mu	*!		*		*
c. L* H L* H kí sə lú ke mu		*!			*
d. L* H L* H L* H kí sə lú ke mú	*	*!		*	*

Two questions are raised by this ranking: first, is it possible to eliminate *Clash and NonFin in favour of an analysis in terms of tonal alignment and tonal crowding? Second, is this ranking between stress assignment and pitch alignment constraints fixed, or do other languages rank these constraints differently?

With respect to the second question, there is currently no concrete reason to suppose that the ranking between pitch alignment constraints and stress assignment constraints is fixed. Passamaquoddy-Maliseet is an unusual language in that it assigns multiple pitch accents per word (one per stress), and even more unusual in that it bans reduced vowels from not only hosting pitch accents and stress but the transitions between them, as well. If the ranking were fixed, it would be expected that languages like this should be more common. Furthermore, it is known from the literature on pitch accent alignment that alternate strategies can be employed to satisfy the pitch alignment constraints mentioned in this paper – for instance, tonal targets like L* and H may be undershot, violating constraints like Flemming's (2001) Ident constraints. This would imply that the constraints ensuring that tonal targets are met are ranked below the stress constraints – a clear contradiction of the starting assumption that the ranking between the two is fixed.

With respect to the first question, just such an analysis has been proposed for NonFin, whereby a ban on utterance-final tonal crowding is responsible for shifting stress off of the final syllable of a word (Gordon, 2000; Karvonen, 2008). I am currently unaware of a similar analysis for *Clash. The current analysis of Passamaquoddy-Maliseet stress would fit in nicely with the above two accounts of the tonal basis for a non-finality constraint, and would suggest that the pitch accents associated with stress have a more significant role to play in stress assignment than previously supposed.

The current analysis and the analyses of the tonal basis of NonFin proposed by Gordon (2000) and Karvonen (2008) raise an additional question, which is whether other potential cues to stress can behave in a similar manner, or whether the stress constraints posited here could have a phonetic basis in areas other than pitch accent. For example, raw duration could be one such phonetic property that could be used to provide a basis for constraints like *Clash and *Lapse. Some evidence for this idea comes from an analysis of Italian *raddoppiamento sintattico*, where word-initial segments are significantly lengthened only when they are both preceded and followed by a stressed vowel (Esposito and Truckenbrodt, 1998). This lengthening is proposed to be a repair to a stress clash, and lends support to the idea that *Clash is sensitive to raw duration, since there is only ever one segment that separates the two stressed vowels, yet the duration of this segment is what distinguishes a *Clash-violating candidate from a non-*Clash-violating one. A more recent analysis of stress on the suffix *-ative* in English also provides evidence for the idea of an interpretation of *Lapse that is sensitive to raw duration as well (Stanton, 2018). Stress on the initial syllable of *-ative* is more likely if it is preceded by a consonant cluster or obstruent consonant than if it is preceded by other single consonants, indicating that having a longer consonant or group of consonants would lead to a more severe violation of *Lapse than a shorter consonant. Thus in order to repair this *Lapse violation, a stress is introduced onto the suffix. If stress assignment constraints are sensitive to raw duration, it would indicate that a similar analysis is possible for Passamaquoddy-Maliseet, where reduced vowels are both incapable of hosting stress, and incapable of meeting the duration requirements set by a duration-sensitive *Clash constraint, unless it is present in a lengthening environment or accompanied by consonants or consonant clusters of sufficient duration.

At the current time, I known of no additional evidence to determine which of the two proposals is correct – the current proposal, where the duration of the reduced vowel is only indirectly related to stress assignment via constraints on pitch accent; or the proposal where the duration of the reduced vowel is directly related to stress assignment via the durationally-sensitive nature of *Clash and *Lapse constraints. Some evidence that could distinguish between the two proposals would be if similar behaviour of reduced vowels were to be exhibited for a language that did not make use of pitch accent the same way that Passamaquoddy-Maliseet does. For instance, such a language would have the same stress patterns and apparent invisibility of reduced vowels, but would nevertheless would assign only one pitch accent to to any word – this would provide evidence that it was not the realization of pitch accent that was driving the invisibility, but rather simply the duration of the reduced vowels themselves. However, if the behaviour of such invisible vowels is restricted to languages which have similar pitch accent patterns, then it would provide evidence that the account put forth in this paper is correct. It would have the added advantage of explaining the apparent rarity of these languages as well, since this behaviour would be tied to the rare cases where multiple pitch accents per word are attested.

Regardless of which analysis is strictly correct, both make interesting new predictions about how stress and vowel length might interact, especially with respect to reduced vowels of other qualities and with respect to other potential vowel lengthening environments. For example, LeSourd (1988) observes that reduced vowels in the context *s__ss* behave as if they are unreduced. The current account postulates that this is because these vowels are in pre-geminate position, which is a lengthening environment. However, this was not examined in detail for all geminates, only those consisting of [s]. It would be expected that this behaviour is not unique to [s], but is true for all geminates. LeSourd (1988) also makes the claim that it is not only schwa that behaves as a reduced vowel, but that all vowels are capable of behaving as if they are reduced. The most common are the vowels *i* and *u*, especially when these two vowels are located next to their glide counterparts, but all are claimed to have examples of the vowel being skipped over during stress assignment. One such environment where this would be expected is in cases of vowel copying across *h*, which LeSourd hismelf has noted to be an environment where both vowels are significantly shorter than in other phonetic contexts. I have not examined the Passamquoddy-Maliseet data to see if reduced, non-schwa vowels occur more frequently in this context, but it is an intriguing area for further research, and it would be interesting to see if languages with vowel copying across glottal consonants display similar behaviour with respect to these durationally reduced vowels and stress.

8 Conclusion

This study has provided a new explanation for why reduced vowels such as schwa are capable of being skipped over by the stress system of Passamaquoddy-Maliseet. The explanation relies on the fact that stress must be accompanied by a rise in pitch accent, and that reduced vowels are too short to adequately host either this pitch rise or the transition between the pitch rises. This can be modelled in OT by positing that constraints on the anchoring points of pitch accent, L-Anchor and H-Anchor, and a constraint on the minimum required distance between tones, T-Distance(0.5), are strictly ranked above the constraint *Lapse, and any other stress-assigning constraints. This analysis is in contrast to previous analyses of the interaction between reduced vowels and stress, which posit that these vowels are somehow structurally "deficient" which leads to their invisibility to the stress system (LeSourd, 1988, 1993; Hagstrom, 1995). Instead, all vowels are visible to the stress system, as encoded by the constraints responsible for stress assignment, eliminating the need to make special claims about the representations of these vowels. Instead, the burden of explanation lies on constraints that are already necessary for pitch accent alignment, thus reducing the complexity of the analysis.

References

Arvaniti, Amalia, D. Robert Ladd, and Ineke Mennen. 1998. Stability of tonal alignment: the case of greek prenuclear accents. *Journal of Phonetics* 26:3–25.

Bates, Douglas, Martin Mächler, Ben Bolker, and Steve Walker. 2015. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software* 67:1–48.

Boersma, Paul, and David Weenink. 2016. Praat: Doing phonetics by computer. Computer program, version 6.0.10, retrieved 14 January 2016.

Cho, Hyesun. 2011. The timing of phrase-initial tones in seoul korean: a weighted-constraint model. *Phonology* 28:293–330.

Esposito, Anna, and Hubert Truckenbrodt. 1998. A note on raddoppiamento sintattico and the phonological phrase in italian. Ms.

Flemming, Edward. 2001. Scalar and categorical phenomena in a unified model of phonetics and phonology. *Phonology* 18:7–44.

Fry, D. B. 1958. Experiments in the perception of stress. *Language and Speech* 1:126–152.

Goldsmith, John A. 1976. Autosegmental phonology. Doctoral Dissertation, Massachusetts Institute of Technology.

Gordon, Matthew. 2000. The tonal basis of final weight criteria. In *Chicago Linguistics Society (CLS) 36 (Main Session)*, 141–156.

Gordon, Matthew. 2002. A factorial typology of quantity-insensitive stress. *Natural Language & Linguistic Theory* 20:491–552.

Gouskova, Maria, and Nancy Hall. 2009. Acousitcs of epenthetic vowels in lebanese arabic. In *Phonological argumentation: Essays on evidence and motivation*, ed. Stephen George Parker, 203–225. Equinox.

Haas, Mary R. 1977. Tonal accent in creek. In *Studies in stress and accent*, ed. Larry M. Hyman, volume 4 of *Southern California Occasional Papers in Linguistics*. Los Angeles, CA: University of Southern California.

Hagstrom, Paul. 1995. When a passamaquoddy unstressable /ə/, that's a mora. Ms., July 1995.

Hall, Nancy. 2006. Cross-linguistic patterns of vowel intrusion. *Phonology* 23:387–429.

Hayes, Bruce. 1995. *Metrical stress theory: Principles and case studies*. Chicago, IL: University of Chicago Press.

Karvonen, Daniel. 2008. Explaining nonfinality: Evidence from finnish. In *Proceedings of the 26th West Coast Conference on Formal Linguistics*, ed. Charles B. Chang and Hannah J. Haynie, 306–314. Somerville, MA: Cascadilla Proceedings Project.

Language Keepers, and Passamaquoddy-Maliseet Dictionary Project. 2016. Passamaquoddy-maliseet language portal. URL `http://www.pmportal.org/`, February 2016.

LeSourd, Philip S. 1988. Accent and syllable structure in passamaquoddy. Doctoral Dissertation, Massachusetts Institute of Technology, Cambridge, MA.

LeSourd, Philip S. 1993. *Accent and syllable structure in passamaquoddy*. Taylor & Francis.

Lewis, M. Paul, Gary F. Simons, and Charles D. Fennig, ed. 2015. *Ethnologue: Languages of the world*. Dallas, TX: SIL International, 18th edition.

Martin, Jack B., and Keith Johnson. 2002. An acoustic study of "tonal accent" in creek. *International Journal of American Linguistics* 68:28–50.

McCarthy, John J. 2002. Against gradience. Ms., ROA-510.

McCarthy, John J., and Alan Prince. 1995. Faithfulness and reduplicative identity. Ms.

Michelson, Karin. 1989. Invisibility: Vowels without a timing slot in mohawk. In *Theoretical perspectives on native american languages*, ed. Donna B. Gerdts and Karin Michelson, 38–69. Buffalo, NY: State University of New York Press.

Prince, Alan S., and Paul Smolensky. 1993. Optimality theory: Constraint interaction in generative grammar. Technical Report 2, Rutgers University Center for Cognitive Science.

R Core Team. 2018. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria.

Selkirk, Elisabeth. 1980. The role of prosodic categories in english word stress. *Linguistic Inquiry* 11:563–605.

Stanton, Juliet. 2018. Phonetic lapse in american english *-ative*. Ms. `lingbuzz/004074`.

Walter, Mary Ann. 2007. Repetition avoidance in human language. Doctoral Dissertation, Massachusetts Institute of Technology, Cambridge, MA.