

THE PROSODIC STRUCTURE OF CANADIAN RAISING

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This paper examines the phonological process of Canadian Raising, arguing that it is better understood as an allophonic difference of phonetic duration rather than vowel quality or height, as per most traditional accounts. A prosodic model is proposed in order to account for the aforementioned factors of duration and timing. The proposed model is innovative inasmuch as it relates allophonic differences in duration to post-vocalic consonantal sonority distinctions, manifested as voice quality.

1. Introduction

Canadian Raising (henceforth CR) as a phonological process has been described as far back as Joos (1942). As is probably well known by most linguists in the Canadian milieu, CR is a process of allophonic variation of the diphthongs /aj/ and /aw/ dependent on post-vocalic context. In tautosyllabic pre-voiceless context a “raised” allophone involving a higher initial tongue position occurs, while in other contexts the non-raised allophone is present. However, Onosson (2010) disputes this characterization of the pre-voiceless allophone (at least for the /aj/ diphthong) and proposes instead that length is the primary phonetic distinction between the two allophone, the pre-voiceless allophone being significantly shorter than the other allophone. This will be discussed in detail in §2. The evidence for phonological-prosodic analysis of CR are discussed in §3. There are three main elements: 1. phonological voice is construed as a measure of sonority; 2. sonority defines distinct prosodic structures; 3. distinct prosodic structures relate to durational differences. The optimality-theoretic description of English phonology in Hammond (1999) is used as a basis, with the addition of a new optimality-theoretic constraint which is compatible with Hammond’s model. In §4 a prosodic model of CR is proposed, and in §5 some outstanding issues are discussed.

2. Canadian Raising

2.1. Background

“Canadian Raising” (CR) is the accepted term for the occurrence of two different phonetic variants of each of the diphthongs /aj/ and /aw/ in Canadian English (Chambers 1973). CR has been fairly well documented in the linguistic literature, and most analyses agree broadly on its basic description, in terms of both the phonetic characteristics of the variants involved, as well as its defining phonological environment. It is often introduced in introductory courses on linguistics in Canada as a classic case of allophonic variation and complementary distribution. The following description is typical: “the diphthongs [ʌj] and /aj/ are in complementary distribution: [ʌj] occurs before the class of voiceless

consonants ([s, t, p], etc.) and /aj/ occurs elsewhere. A parallel relationship holds between the vowels /aw/ and [ʌw]” (Czaykowska-Higgins et al 2012:56). CR has been noted to occur in Canadian speech since the following description by Joos: “the diphthongs /aj/ and /aw/ (but not /oj/ in boy) each have two varieties. One, which I shall call the HIGH diphthong after its initial tongue-position, begins with a lower-mid vowel-sound; it is used before any fortis consonant with zero juncture: ... white, knife; shout, house. The other, the LOW diphthong, is used in all other contexts: ... high, find, knives; how, found, houses,” (Joos 1941:141). In a now classic account of CR, Chambers (1973:125-126) modified “fortis consonant with zero juncture” to “word-internal voiceless consonant”, but was otherwise consistent with Joos’ description. The author has not encountered any descriptions of CR which depart from the general view of CR as a case of allophonic variation, with voicing quality of the following coda being the determining factor for allophonic selection.

Hammond (1999) catalogues the various cooccurrence restrictions of consonants and vowels in Standard English (i.e. non-Canadian) syllables, identifying all known combinations or positions for /aj/ and /aw/ in a word-final syllable (Hammond 1999 §4.2 , pp. 108-119). The difference in distributional patterns which Hammond identifies between /aj/ and /aw/ in word-final syllables can be broadly summarized as a restriction on the occurrence of /aw/ with any noncoronal coda¹, and is formulated thus: “Heavy diphthong restriction: [aw,ɔy] do not occur before word-final noncoronals,” (Hammond 1999:135). Medially, the distributional facts are somewhat more equivocal, but the restriction against noncoronals following /aw/ in the same syllable seems to hold. Hammond proposes a mora-based analysis which assigns moras differently among the various diphthongs of English, as well as among the different natural classes of consonants (e.g. coronals vs. noncoronals); these facts will be discussed further in §3. There has been investigation of CR in some non-canonical environments, such as before nasal-voiceless codas e.g. -nt/ in *pint* (Dailey-O’Cain 1997), but Chambers suggests that such accounts mistakenly conflate CR and a distinct pattern found among some US speakers: “the fallacy lies in the assumption that northern U.S. /ai/-raising is Canadian Raising,” (Chambers 2006:110). This paper will strictly limit itself to discussion of CR as it occurs in its traditional context, before a voiceless coda, leaving aside questions of “non-Canadian Raising”.

Although CR involves both of the diphthongs /aj/ and /aw/, the discussion in this paper will focus largely on the former, the front diphthong /aj/. There are several reasons for this. First, the analysis will draw upon experimental data described in Onosson (2010) which only contained words with the /aj/ diphthong, but not /aw/. In addition to this technical limitation², Chambers (1989) suggests that CR may in fact be better analyzed as two distinct phenomena rather than as a single, unitary process of “Canadian Raising”.

¹ Hammond also argues that this restriction applies to the diphthong /ɔj/, but as that diphthong is not involved in CR it is not relevant to the present discussion.

² I am currently undertaking new data collection to address this limitation by gathering additional recordings of both diphthongs, which I plan to examine in the near future.

Vance (1987), Dailey-O’Cain (1997) and others have also identified a CR-like pattern in regions of the United States that involves /aj/ but not /aw/. The occurrence of American “CR-like” raising with only one of the CR diphthongs, lends support to Chambers’ suggestion that the two diphthongs may exhibit distinct (although similar) patterns of variation. As discussed above, Hammond (1999) has also noted that the two diphthongs exhibit distinct distributional patterns in English generally. Clearly, the relationship between what has been identified as CR in both /aj/ and /aw/ is more complex than was described by Joos (1942). This paper holds to the agnostic view that the two diphthongs may or may not be involved in the same phenomenon, as well as the practical approach that the primary data in Onosson (2010) do not inform an analysis of /aw/ in any case (but see footnote 2). Accordingly, the present analysis will most fully explore CR in /aj/ only, but will also provide suggestions for the analysis of /aw/ which would need to be confirmed pending further experimental data.

2.2. Vowel Duration

The primary data for this paper was originally published in Onosson (2010). That study involved a cohort of eight female speakers, between the ages of 24 and 34 at the time of recording, from southern Manitoba. A wordlist task was used to elicit tokens of the diphthong /aj/ within a variety of onset and coda consonants. The present analysis will be concerned only with the subset of tokens which were elicited for words containing a singleton coda consisting of either of the (obstruent) plosives /d/ or /t/, such as in *hide* and *height*. In total, there were 206 usable tokens of words with /d/ as a coda, and 210 with /t/ as a coda. As a voiceless consonant, coda /t/ is expected to co-occur with a raised allophone of any preceding /aj/, in contrast with voiced coda /d/, which would occur with a non-raised /aj/.

Onosson (2010) determined that the most significant difference between raised and unraised tokens of /aj/ among Manitoba speakers was not any aspect of vowel quality such as a raised initial articulation, but rather simply vowel duration. While vowel height was very slightly raised for the voiceless coda tokens in comparison to those with a voiced coda, duration differed greatly and statistically significantly between the two sets of tokens. The average duration of pre-/t/ (voiceless coda) and pre-/d/ (voiced coda) diphthongs is shown in (1) along with the ratio between the two sets:

- (1) *Diphthong duration and coda voice quality*
- | | |
|--|-------|
| /aj/ pre-/d/ duration: | 293ms |
| /aj/ pre-/t/ duration: | 159ms |
| Ratio of pre-/t/ duration to pre-/d/ duration: | .54 |

A least squares test of vocalic duration and coda voicing returned an R^2 value of +0.764, with a p value of <.0001, indicating a high degree of predictability from one factor to the other with a strong degree of confidence (Onosson 2010:55). These results indicate that there is a large and consistent proportional difference in phonetic vowel duration between

the two sets of tokens, which is strongly correlated to the voice quality of a following coda consonant.

Previous research on the relationship between vowel duration and coda consonant voicing in (non-Canadian) English indicates a similar pattern. A number of studies have touched on this topic over time: Peterson & Lehiste (1960), House (1961), Chen (1970), Umeda (1975) et al. To take one example, House (1961) conducted a study of American English speakers and found that “the average duration of vowels varies markedly as a function of the phonetic environment. The primary influence is contributed by the voicing characteristic of the consonant,” and also that “the voicing characteristic (or effort) associated with the consonant environment – more strictly, the following consonant as other research has demonstrated – changes the average duration of the vowels markedly” (pp. 1175-6). House’s study did not include diphthongs, but his findings were robust across all other vowels; vowel duration is significantly associated with the voice quality of the following consonant, longer vowel durations occurring before voiced consonants, shorter durations before voiceless consonants. The other studies mentioned reached similar conclusions: pre-voiceless vowels in English are almost universally shorter than in other contexts, this being the same environment which defines CR.

With respect to Canadian English, durational differences in CR diphthong variants have been discussed by Thomas (2000), who argues that “hyperarticulation” results from vowel shortening. However, most previous research has not taken duration to be a major factor involved in CR. A description of CR as primarily an effect of phonetic vowel duration does not appear to have been argued for previously in the literature. To the contrary, the earliest examination of CR by Joos explicitly denied any significant difference in vowel duration, describing CR as “a shift from a difference essentially of length to a difference essentially of quality, so that in /aj, aw/ the difference between pre-fortis and other articulation is not the same as it is for all other syllabics,” (Joos 1942:142). The general conception of CR in the literature has not shifted appreciably from this view in the intervening decades.

3. Prosodic Structure and Sonority

3.1. Voicing and Sonority

Previous discussion of CR in the phonological literature has generally viewed the voicing quality of the coda strictly as a binary matter, rather than seeing it as a function of degree of sonority more broadly. However, there are studies independent of CR research which propose a connection between voicing and sonority, and the availability of sonority distinctions related to voicing, among other such distinctions.

Parker (2011) offers the following definition of sonority: “Sonority can be defined as a unique type of relative, n-ary (non-binary) featurelike phonological element that potentially categorizes all speech sounds into a hierarchical scale.” Sonority contrasts with binary phonological features such as voice, in that a sonority scale offers a number

of potential points of discrimination between speech sounds of greater or lesser sonority, which languages may utilize in distinct ways. A broad and very general view of the cross-linguistic sonority hierarchy described in Parker (2011) marks sonority distinctions among major phonological classes: vowels are of highest sonority, with glides, liquids and nasals falling medially in that order, and finally obstruents being of least sonority. More finely delineated subdivisions of the hierarchy have also been proposed for a variety of languages. Parker (2008) discusses a number of independent phonological studies which argue for a variety of such subdivisions, including a split among obstruents based on voice quality: “Another split often made is to rank voiced obstruents over their voiceless counterparts,” (Parker 2008:58). Additional studies on the relative rankings of fricatives and affricates lead Parker to devise a sonority sub-hierarchy within the class of obstruents (Parker 2008, Table 2, p. 58). For the purposes of CR, the relevant ranking has voiced obstruents of all types higher in sonority than the voiceless obstruents, cross-linguistically. As a class, obstruents are the least sonorous of all the major classes; voiceless obstruents are thus the least sonorous of all speech sounds (see Parker 2008:60 for a complete hierarchy of all speech sounds).

Recall that occurrence of CR is tied to the presence of a voiceless (obstruent) coda, i.e. */aj/ and /aw/ are raised before voiceless consonants*. Parker’s hierarchy allows this distinction to be characterized in terms of sonority rather than voice: */aj/ and /aw/ are raised before low-sonority consonants*. This reformulation of the CR description is just as accurate, provided that “low-sonority” is defined as “less sonorous than a voiced obstruent” in the CR context. Parker’s study indicates that languages implement a number of subdivisions of the sonority hierarchy: “Some sonority scales ... make no distinctions between segment types within the major classes vowels, liquids, and obstruents. However, the weight of the overall evidence indicates that there is sufficient motivation for positing subdivisions within these three groupings,” (Parker 2008:57). A proposal for the interpretation of “low-sonority” as “less sonorous than a voiced obstruent” in the context of CR in Canadian English is paralleled by a minimal sonority restriction on onset consonant clusters in Koine Greek, which “permits the clusters /pn/ and /kn/ but proscribes */bn/ and */dn/,” (ibid., p. 58). Parker argues that this pattern “can be explained as a straightforward effect of minimum sonority distance between the two members of onset clusters if voiced stops are closer to nasals (in sonority) than voiceless stops are,” (ibid.).

3.2. Sonority and Prosodic Structure

Zec (1995) proposes an account of syllabic structure which has two key components: 1) a subsyllabic layer of *moraic structure*; and 2) *sonority constraints* which determine where and how specific segments are incorporated into the overall structure. Zec proposes a basic distinction between heavy and light syllables involving monomoraic and bimoraic syllables, wherein “the mora serves as a primitive subsyllabic constituent and as a measure of syllable weight ... all languages should possess a level with only bimoraic syllables, [and] some may also allow for a level with syllables containing more than two

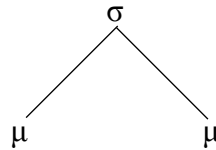
moras,” (Zec 1995:85-86). The distinction between light and heavy syllables as one of moraic quantity and structure is shown in (2)

(2) *Moraic structure and syllable weight* (Zec 1995:86)

a. Light



b. Heavy



Hammond (1999) applies an optimality-theoretic analysis to the English syllable, proposing a set of constraints on moraic quantity within the syllable as well as a schema for assigning moras. Two constraints relevant to analysis of CR (adapted from Hammond 1999) are: BIMORAICITY — All syllables must be bimoraic; and TRIMORAICMAXIMUM (3μ) — Syllables can contain no more than three moras. BIMORAICITY matches Zec’s bimoraicity generalization above, and is used to account for the restriction on lax vowel open syllables in English. 3μ prevents segmental combinations which would exceed three moras from occurring. Both of these constraints are highly ranked, and nonviolable. Moras are assigned in Hammond’s model via a “mora assignment schema”: $\{0,1,2,3\}\mu$ /segment, which conflates a set of related constraints that assign a certain quantity of moras to specific segments, or classes of sounds. Relevant to CR are the constraints for the diphthongs /aj/ and /aw/: 2μ /[aj]³ and 3μ /[aw]. As these constraint names indicate, they seek to assign 2 moras to /aj/ and 3 moras to /aw/. These constraints result in words such as *high* and *how* being assigned differing quantities of moras. For syllables containing /aj/ a following coda consonant of any type bearing its own mora does not violate 3μ ; 2 moras are assigned to the diphthong and a single mora to the coda consonant. However, because /aw/ has three intrinsic moras itself, coda consonants are more restricted. Hammond’s survey of existing and possible English syllables reveals that only coronal consonants may occur as codas in syllables containing /aw/. This is handled by a ranking the constraint 1μ /CORONALS lower than the nonviolable constraints mentioned above. 1μ /CORONALS assigns a mora to coronal codas, but as it is violable “coronal codas can be denied a mora to satisfy the three-mora maximum,” (Hammond 1999:138). The constraints for mora assignment of other coda segments are all nonviolable, and thus equally (highly) ranked. The tableaux in (3) illustrate the effects of the violation of violable constraints (e.g. 1μ /CORONALS) vs. nonviolable highly-ranked constraints (e.g. 1μ /NONCORONALS) under Hammond’s analysis, for the syllables *bout* and **boup*:

³ In Hammond (1999) the diphthongs are shown as /ay/ and /aw/ rather than /aj/ and /aw/. I have altered Hammond’s /ay/ to /aj/ throughout for consistency’s sake.

(3) *Mora assignment of codas following /aw/*
 a. *coronal coda*

Input: [bawt]	$3\mu/[aw]$	3μ	$1\mu/CORONALS$
			*
		*!	
	*!		

b. *noncoronal coda*

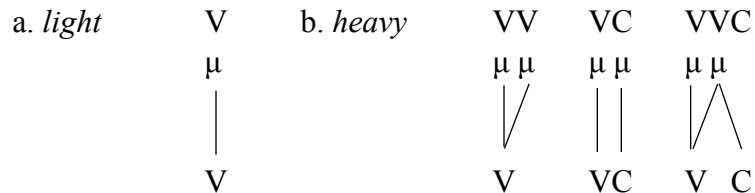
Input: [bawp]	$3\mu/[aw]$	3μ	$1\mu/NONCORONALS$
			*!
		*!	
	*!		

Because $1\mu/CORONALS$ is a violable, low-ranked constraint, coronal codas are permitted following /aw/ but are assumed to bear no mora in that context, as shown in the winning candidate in (3a). Noncoronals, however, must always be assigned a mora due to the higher rank of $1\mu/NONCORONALS$ which sits at the same rank as the other candidates in the second tableau. Hence the impossibility of *[bawp] in English; there is no winning candidate in (3b) because all of the relevant constraints in the tableau are nonviolable.

Turning now to the the issue of variations in prosodic structure, Broselow et al (1999) have proposed an analysis of moraic structure which allows coda consonants to be variously adjoined to either an independent mora, or else to a mora which is shared with a preceding vowel. Their analysis allows for such differing moraic structures for coda consonants both between different languages as well as within a single language, which is termed *variable coda weight*. For example, their analysis of Hindi syllable length shows that it assigns a distinct mora to all coda consonants. In contrast, Malayalam adjoins all coda consonants to the preceding vowel. Other configurations also exist, such as found in

Levantine (Jordanian) Arabic which utilizes both aforementioned structures. Levantine Arabic assigns codas their own mora in short-vowel syllables, but adjoins the coda to the preceding vowel's mora within a syllable containing a long vowel bearing two moras. Figure (4) (Broselow et al 1999:57, fig. 17) provides their analysis of the various rhyme structures of Levantine Arabic:

(4) *Levantine Arabic rhyme structures (Broselow et al 1999:57, fig. 17)*



Broselow et al relate these differing moraic structures to variable phonetic duration; moraic quantity and affiliation is directly related to duration, supported by experimental results: “The durational patterns of these languages are consistent with the posited structures: segments dominated by two moras are longer than those dominated by one, and segments exclusively occupying a mora are longer than those sharing a mora,” (Broselow et al 1999:61). Because the analysis in Onosson (2010) indicates that duration is the most significant distinction between each of the pairs of diphthong allophones occurring in CR, this suggests the applicability of Broselow et al’s moraic affiliation analysis to CR.

The final element to consider with respect to prosodic structure is the connection between sonority and the mora. Zec makes this connection explicit: “the segment projecting a mora is constrained with respect to minimal sonority, determined on a language-specific basis and expressed in terms of a sonority class,” (Zec 1995:91). Parker also comments on this connection: “the propensity for a coda consonant to project a mora is correlated with how sonorous it is,” (Parker 2011). As discussed in §3.1 there is evidence that voicing may be understood to constitute a distinction in sonority. Zec and Parker’s statements on sonority constraints on moraic assignment can be combined with the view of voicing-as-sonority, via a proposed constraint on mora projection. This constraint is further elaborated and revised in §4 and §5:

SONOROUSMORA — *a mora may be projected only by a segment which is minimally equal in sonority to that of a voiced obstruent*

4. The Prosodic Structure of Canadian Raising

In the preceding sections the following observations and arguments have been discussed:

- i. CR raised allophones occur before a tautosyllabic voiceless coda consonant (Joos 1942, Chambers 1973)

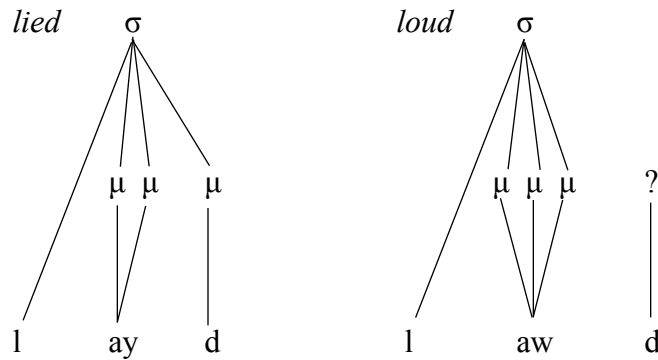
- ii. CR “raised” allophones are better characterized by the brevity of their duration rather than by articulatory height (Onosson 2010)
- iii. voicing is an available sonority distinction cross-linguistically (Parker 2011)
- iv. the prosodic structure of the syllable in English may be described by a series of moraic constraints related to specific segments and classes of sounds (Hammond 1999)
- v. rhymes may be assigned differing moraic structures in order to meet constraints on maximum allowable mora quantity; these are associated with variations in phonetic duration (Broselow et al 1999)
- vi. sonority distinctions are a determining factor in mora affiliation (Zec 1995)

The prosodic model of CR which will be proposed in this section derives from these points, and is couched within Hammond’s (1999) general model of the English syllable. As discussed, Hammond’s model assumes that English syllables are maximally trimoraic. With respect to CR diphthongs, Hammond’s mora assignment schema assigns two moras to /aj/ and three to /aw/. Finally, Hammond’s schema also differentiates coronals from noncoronals in terms of violable mora assignment, whereby coronals may be denied a mora in order to meet the trimoraic maximum, while noncoronals may not. These facts conspire together to produce expected differences in the distributional patterns of the two diphthongs with regards to possible coda combinations, in particular preventing the combination of /aw/ with a noncoronal coda, which would violate the TRIMORAICMAXIMUM constraint.

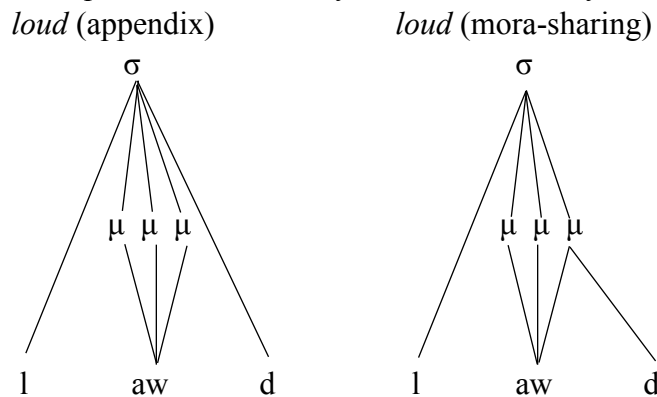
The model presented here departs from previous accounts such as Joos (1942) and Chambers (1973), by characterizing the canonical CR environment as a matter of sonority rather than strictly voice, following Parker’s (2011) sonority hierarchy. Doing so makes it possible to construe prosodic structure as a factor in CR. This is due to the observed durational differences between the “raised” and “non-raised” versions of the CR diphthongs; mora affiliation, as discussed by Broselow et al (1999), is directly reflected in phonetic duration. Consistent variation in phonetic duration is indicative of different moraic structure. And moraic structure, as discussed by Zec (1995), is related to the sonority of the various segments involved.

In the “non-raised” diphthongs, which occur in words with voiced codas such as *lied* and *loud*, the proposed model does not depart from Hammond’s analysis at all. Such words would have the following structures, with two moras for /aj/ and three for /aw/, and either one or zero moras for coronals⁴:

⁴ I leave aside here an analysis of noncoronal codas for two reasons: 1) they are not present in the data in Onosson (2010); 2) they are restricted following [aw]. But I do not expect a different treatment would be required than for coronals.

(5) *Prosodic structures of coronal codas of diphthongs, after Hammond (1999)*

While Hammond discusses mora assignment, he does not directly address the question of mora affiliation, hence the question mark over the [d] in *loud*. Hammond's violable constraint $1\mu/\text{CORONALS}$ permits [d] to be denied its own mora in order to satisfy the trimoraic maximum when three moras are already present in the structure, but there are several ways to achieve this structurally. Two possibilities, *appendix* and *mora-sharing* are compared in (6):

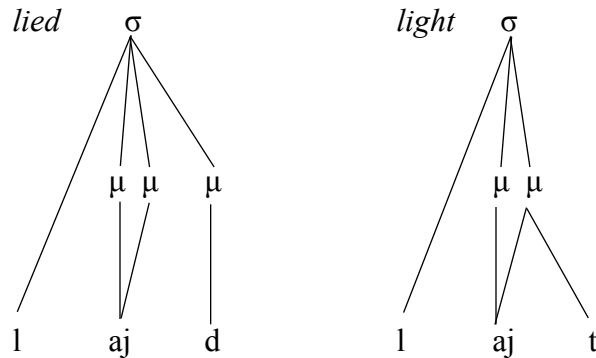
(6) *Alternate prosodic structures for coronal codas of /aw/*

The first structure shows the final [d] being attached directly as an appendix to the syllable, being denied a mora entirely. The second version adjoins the coda to the final mora of /aw/. There is no obvious argument for selecting one over the other on their own merits without further evidence; the question of coda mora affiliation following /aw/ will be addressed in the discussion in §5.

Recall from §2 that “raised” /aj/ has a duration which is proportionally about .54 of the duration of “non-raised” /aj/. Broselow et al’s (1999) analysis of mora-sharing in Arabic found that mora-sharing vowels were between about 0.90-0.80 of the duration of non-mora-sharing vowels (Broselow et al 1999:59). In comparison, the duration of raised /aj/ in Onosson (2010) is 0.54 of non-raised duration. However, mora-sharing in Arabic only occurs with long vowels, so all of the vowels involved are phonemically long. English does not have contrastive vowel length (although the tense vs. lax distinction does parallel it in some ways). Although there is much greater disparity in duration

among English /aj/ in CR contexts as compared to Arabic mora-sharing long vowels, I propose here that the underlying phonological source of such distinctions is the same: differing mora affiliation of the coda. Specifically, I propose that the difference in duration of /aj/ in the context of CR arises from whether the coda consonant either bears its own mora, or is adjoined to a mora belonging to the nuclear vowel (diphthong). That is, while *lied* is structured as indicated on the previous page (repeated below), *light* has a different moraic structure, resulting in the shorter phonetic duration of its vowel:

(7) *Prosodic structure of Canadian Raising in /aj/*



The evidence for the different moraic structures in (7) is found in the different phonetic durations of the two diphthongs, following Broselow et al's (1999) exploration of the correspondence between prosodic structure and phonetic duration. This raises the question: what is the phonological motivation for this difference in structure? I propose that, following the discussion in §3 based on Parker (2011), the motivation is a difference in the sonority of the coda: voiced /d/ is of higher sonority than voiceless /t/. This can be generalized as the constraint proposed at the end of §3, repeated here: SONOROUSMORA — *a mora may be projected only by a segment which is minimally equal in sonority to that of a voiced obstruent*. The model proposed here assumes this constraint to be present in Canadian English, along with the other constraints in Hammond (1999). Satisfaction of SONOROUSMORA does not necessitate violation of any of Hammond's mora assignment constraints, if we also assume that coda consonants are free to adjoin to the preceding vowel's mora in order to satisfy their mora requirements, as shown in (7) for *light*.

5. Discussion

At this point the prosodic analysis of CR cannot be considered complete. Several outstanding issues and questions remain, two of which will be discussed here:

1. The prosodic structure of /aw/ as distinct from /aj/
2. The best formulation of the constraint(s) needed for a prosodic analysis of CR

The first point concerning correct analysis of /aw/ as opposed to /aj/ in terms of mora affiliation lends itself to several possible solutions, including the following:

- i. a coda following /aw/ is adjoined as an appendix
- ii. a coda following /aw/ is adjoined to the final mora of /aw/
- iii. a coda following /aw/ projects its own mora

None of these alternatives are entirely satisfactory. Considering (i), if a post-/aw/ coda is adjoined as an appendix, several problems may be noted:

- a. codas following /aw/ and /aj/ are treated dissimilarly
- b. there is no justification for adjoining voiceless codas to a mora of /aw/
- c. there is no explanation for Hammond's restriction of /aw/ to coronal codas

Problem (a) poses the greatest possible challenge; if codas-as-appendices are possible for /aw/ there is no reason to suppose they are not possible for /aj/ as well, negating the entire proposed prosodic model. The other problems are also serious, making the "appendixization" of codas possibly the least satisfactory alternative of the three.

Solution (ii) proposes that a post-/aw/coda is adjoined to the final mora of /aw/. However, under this analysis it is no longer possible to propose differing structures for voiced and voiceless codas following /aw/ — both would have the same structure, and there would be no expectation for them to differ in terms of duration. Given the lack of empirical data on /aw/ duration, this should remain open to further experimental examination. Intuitively, however, it does seem likely that /aw/ duration relates strongly to coda voicing, as it does for /aj/.

The final alternative (iii) has a coda following /aw/ project its own mora. This is unsatisfactory primarily because it violates one of either Hammond's constraint on trimoraic maximums, or his mora assignment schema stipulating three moras for /aw/. Under this analysis, it is difficult to maintain Hammond's larger architecture for the English syllable. However, this analysis is not inconsistent with the model discussed in §4 outside of that; it would still be possible to distinguish voiced and voiceless codas via denial of a mora to the latter. More empirical evidence showing a durational difference correlated with coda voicing following /aw/ under CR conditions is needed, however, before proposing that this is the best analysis.

Turning now to the formulation of constraint(s) needed for a CR prosodic model, the constraint proposed in §3 is repeated once more: SONOROUSMORA — *a mora may be projected only by a segment which is minimally equal in sonority to that of a voiced obstruent*. There are two aspects to this constraint: a) the connection between mora projection and a minimum level of sonority; and b) the definition of a minimum level of sonority. It is reasonable to consider that these may be better treated as two constraints, although the analysis of a single phenomenon such as CR does not permit the determination of the ideal formulation of distinct constraints in a more precise way. Based on Parker's (2008) discussion of cross-linguistic sonority effects, the following two constraints suggest themselves:

SONOROUSMORA (revised) — *a mora may be projected only by a segment which is sufficiently “sonorous”, as defined by MINIMUMSONORITYX*

MINIMUMSONORITY:X — *a segment is considered sonorous if it is equal or greater in sonority to that of a segment of class X where X is some natural class (e.g. vowel, voiced obstruent, etc.)*

MINIMUMSONORITY:X would in fact define a class of constraints, which a given language may specify differently in various contexts. Within the context of CR, the specific version of this constraint may be: MINIMUMSONORITY:VOICEDOBSTRUENT — *a segment is considered sonorous if it is equal or greater in sonority to that of a voiced obstruent*. At this stage, such a family of constraints is merely speculative. Investigation of some phenomena in other languages where such constraints might be applicable would be needed before making such a proposal in more concrete terms.

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