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Weight sensitivity and prominence in Laurentian French

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Main prominence is conventionally described as being assigned to the final syllable of phrases in French, but previous quantitative and qualitative work has shown that this is not always the case. Using corpus data from Laurentian French (Saguenay, Quebec), we test the hypothesis that prominence is preferentially assigned to heavy syllables. Our results demonstrate that this is indeed the case, with both codas and heavy vowels attracting prominence away from final syllables, particularly when the final syllable is open. We infer two distinct types of prominence: lexical and phrasal. Lexical prominence, which is marked using duration and amplitude, variably attracts phrasal prominence, which is marked using pitch. We interpret these findings as indicating that the location of phrasal prominence is sensitive to syllable weight and that this prominence is best formally expressed as a pitch accent due to its attraction to lexically prominent syllables.

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1 Introduction

Final syllables are conventionally characterised as obligatorily bearing main prominence in French (e.g. Grammont 1914; Delattre 1939; Pasdeloup 1990; Jun & Fougeron 1995). This prominence is defined via longer durations and higher pitch peaks relative to non-prominent syllables (e.g. Jun & Fougeron 1995; 2000). For example, the final syllable in /patʁɔn/ *patronne* 'boss-FEM' is the longest and has the highest pitch of the two syllables, which we indicate with the diacritic for stress: [paˈtʁɔn]. In contrast to languages like English with lexical stress, prominence in French is not a word-level phenomenon, but is instead computed at the phrasal level (e.g. Jun & Fougeron 1995). Thus, while in English, both the adjective and noun are prominent within a noun phrase: [ðə ˌfjuːʧəˑ ˈbɑs] *the future boss,* in the corresponding phrase in French, only the phrase-final syllable is obligatorily prominent: [la fytyʁ paˈtʁɔn] *la future patronne* 'the future boss-FEM'. French additionally includes an optional phrase-initial pitch peak, often realised on the first syllable of the leftmost lexical word (for variation in initial pitch peak alignment, see e.g. Jun & Fougeron 2002; Welby 2006; Torres, Fletcher & Wigglesworth 2020). If no more than one pitch peak can be realised, as in shorter phrases, it is the final one that is preserved (Jun & Fougeron 2002). In the current study, we investigate this obligatory final prominence, thereby excluding all other types of prominence, including focus (see e.g. Féry & Feldhausen 2020).[1]

The observation that the domains of prominence assignment in French and English are different suggests that prominence serves different functions in the two languages. In French, prominence allows interlocutors to reliably recover the right edge of phrases and therefore reduce the risk of ambiguity (e.g. Mertens 2006; Vaissière 2010), for example, distinguishing between adjectival modifiers and reduced relative clauses in the one-phrase parse of *la patronne responsable*, [la patʁɔn ʁɛspɔ̃ˈsab(l)], in which the boss is a responsible person, and the two-phrase parse, [la paˈtʁɔn ʁɛspɔ̃ˈsab(l)], in which the boss is responsible for something specific. However, one challenge for the view that prominence serves to mark phrasal domains in French is that the cues to prominence do not strictly fall on the final syllable; they often fall on the penult even when the final syllable does not contain a schwa (invisible to prominence assignment; e.g. Garde 1968; Pasdeloup 1990; Prieto et al. 2005). For example, in *le marquis* 'the marquis', the penult can be realised with longer duration and higher pitch than the final syllable: [lə ˈmaʁki]. This *shift* in prominence has been observed across varieties of French: Parisian and other northern varieties (Carton et al. 1983; Goldman & Simon 2007; Simon 2011), Midi (Coquillon 2005; Sichel-Bazin et al. 2011; Sichel-Bazin 2016), Laurentian (Thibault & Ouellet 1996), Swiss (Goldman & Simon 2007; Avanzi et al. 2011a; Avanzi et al. 2011b), and Belgian (Francard 2001; Simon 2004; 2011; Goldman & Simon 2007; Bardiaux 2013; Bardiaux & Mertens 2014); it has also been observed

[1] Notably, focus is realised with a pitch contour distinct from the one associated with final prominence in the variety under examination (Thibault & Ouellet 1996; see Section 5.2).

in data from over a century ago (Martin 2011). This suggests that the location of prominence in French is sensitive to considerations other than just phrase edges. The goal of this paper is to investigate the factors that condition such prominence shifts.

The literature on French predominantly focuses on extragrammatical motivations for prominence shift. Dialectal substrates (Carton et al. 1983) and broader language contact (e.g. Sichel-Bazin et al. 2011; 2012; Kaminskaïa & Poiré 2012; Mamode 2015; Kennard 2021) are particularly common explanations. Martin (2004), however, proposes that prominence shift is due to archaic tendencies and therefore that it is conservative, rather than innovated or induced by contact. The current study seeks to explain why – in the absence of contact-induced motivations – shift occurs, positing that the grammar generates pitch contours exhibiting prominence shift.

A plausible motivation for prominence shift is that speakers are enhancing word-level properties in addition to phrase edges. Heavy syllables commonly attract prominence across languages (Prince 1990) and could therefore be a relevant word-level property for French. If weight plays a role in predicting the location of prominence in French, then the penult in *marquis* would be more likely to be prominent than the penult in *patronne* because [maʁ] is closed (and therefore potentially heavy) while [pa] is not. Thus far, the evidence suggesting that weight is responsible for prominence shift is limited to native listener judgments (Paradis & Deshaies 1990; Bardiaux & Boula de Mareuïl 2012), effects of long vowels on pitch contours (Thibault & Ouellet 1996), and segmental alternations (Scullen 1997; Armstrong 1999; but cf. Bullock 1994).

In this paper, we test the hypothesis that prominence assignment is sensitive to relative weight, which is consistent with how weight interacts with prominence cross-linguistically. We use mixed effects linear regression to test the effects of prosodic domains, vowel weight and coda weight on the realisation of prominence in read speech collected from the Saguenay (Quebec) survey (Côté 2014) of the *Phonologie du français contemporain* corpus (Durand et al. 2002; 2009; http://www.projet-pfc.net/). We examine Laurentian French as it presents more heavy syllables than many other varieties due to having preserved a large number of vowel contrasts (e.g. Walker 1984; Côté 2012). Furthermore, vowel length is regularly enhanced through processes like diphthongisation (e.g. Dumas 1974; Paradis 1985; Côté 2012), facilitating detection of weight contrasts. Previous work suggests that pitch contours in Laurentian French match those of European counterparts albeit with differences in speaker pitch ranges (e.g. Boudreault 1968; Poiré & Kaminskaïa 2004).

In sum, this dialect is an ideal test case to systematically examine the relationship between weight and prominence shift in French. We will show that heavy syllables attract prominence, thereby affecting the same acoustic cues as those conventionally interpreted to mark phrase edges. Based on these results, we argue for a revised interpretation of prominence in (Laurentian) French: word-level prominence, which is marked using duration and amplitude, variably attracts phrase-level prominence, which is marked using pitch.

2 Theoretical context

2.1 Weight

Typological work shows that weight and prominence often interact; in languages with lexical stress, for example, heavy syllables typically attract stress (e.g. Prince 1990; Gordon 2014). Example words from the literature on non-Laurentian varieties of French (e.g. Boula de Mareüil et al. 2008; Bullock 2009) illustrating prominence shift typically suggest a pattern of weight-sensitivity: prominence is word final unless the penult is heavy or the final syllable is light. Additionally, previous work demonstrates that native Laurentian French speakers tend to perceive closed syllables as prominent (Paradis & Deshaies 1990) and that there exists a relationship between vowel quality and pitch contours (Thibault & Ouellet 1996). We draw on these three indications from the literature – typology of weight effects, literature on other varieties of French, and prosodic evidence from Laurentian French – to propose the hypothesis in (1). This hypothesis will inform specific predictions for the current study, as presented in Section 3.4.

(1) Hypothesis:
Final prominence assignment in French is sensitive to weight.

Languages vary in which types of rhymes count as heavy: codas may or may not be weight-bearing, while long vowels are consistently heavy (Hayes 1995). We begin by discussing the status of codas, a term which we use to cover both word-medial codas and word-final consonants. French has consonants in both positions, as we can see in [maʁ.ki] *marquis* 'marquis' and [ka.nal] *canal* 'canal', so one question concerns whether medial and final codas both pattern as heavy.

Some authors have analysed word-final codas in French as onsets of empty-headed syllables (e.g. Charette 1991; Dell 1995); consistent with this, consonants in this position have an onset profile and clusters with rising sonority are observed word-finally, as in [mɛtʁ] *mettre* 'to put', paralleling what are indisputably branching onsets in non-final position in the language. Since onsets do not typically contribute weight and empty nuclei are by definition weightless, final codas are not expected to attract prominence under this analysis, independent of the status of medial codas.[2] In contrast to the view that final consonants are onsets of empty-headed syllables, we analyse final consonants as true codas (i.e. as rhymal dependents) because vowels in final syllables are affected by following consonants in ways that are expected if these consonants are in coda: for example, final consonants in Laurentian French trigger productive laxing of high vowels (Walker 1984; Côté 2012). We consequently assume that final consonants pattern as codas in (Laurentian) French and that syllables containing codas will attract prominence.

[2] Note that we contrast *expectations* (which stem from properties of French) with *predictions* (specific quantitative results anticipated in the current analysis). Predictions drawing on the expectations described throughout Section 2 will be discussed in Section 3.4.

Turning to vowels, French has a relatively large inventory, which is generally described as including both light (short) and heavy (long) vowels even though these contrasts are predominantly realised through quality differences in contemporary French (e.g. Grammont 1914; Delattre 1959; Walker 1984; Tranel 1987; Martin 2002; Rizzolo 2002).[3] For example, /o/ is heavy, as seen in closed final syllables where it is realised as long ([koːt] *côte* 'hill'); in Laurentian French, this length can be reinforced by diphthongisation ([ko͡ʊt]) (e.g. Dumas 1974; Côté 2012). This pattern for /o/ contrasts with that for the light vowel /ɔ/ ([kɔt] *cote* 'code'), which is neither long nor diphthongised.

We exemplify the weight contrast in **Table 1**, where we describe vowel length in three phonologically distinct contexts (see e.g. Walker 1984; Paradis 1985; Martin 2002): open final syllables, closed final syllables, and open non-final syllables. We follow convention for French in transcribing the long phonemes using only quality distinctions and not the length diacritic. Light vowels are those whose variants in non-final and closed final syllables more closely correspond to their open-syllable variants, whereas heavy vowels are those whose variants in closed final syllables reflect their lengthened form (i.e. they are long and may frequently diphthongise). This diagnostic distinguishes a series of heavy vowels /ɑ e ø o ɛː ɑ̃ ɛ̃ œ̃ ɔ̃/ and a series of light vowels /a ɛ œ ɔ i y u/, with vowels of both weight categories surfacing as short (and therefore light) in open final syllables (e.g. Grammont 1914; Walker 1984; Montreuil 1995; Martin 2002; Côté 2012).[4]

Because we adopt the position that vowel quality differences reflect weight differences in French, we expect that prominence will shift inwards more often in /kote/ *côté* 'side' than in /kɔte/ *coté* 'coded (as)' because the heavy penult attracts prominence in *côté*, while the light penult in *coté* does not. This suggests that different behaviours are expected for vowel weight compared to coda weight in that codas always render a syllable heavy, while underlyingly heavy vowels do not. We therefore expect that final syllables will be sensitive to the *source* of weight (only codas contribute to syllable weight), whereas penults will be sensitive simply to the *presence* of a heavy syllable (vowels and codas both contribute to syllable weight).

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[3] We use *light* and *heavy* to refer to the classification of vowels rather than *short* and *long* because we distinguish phonological weight from phonetic duration.

[4] The patterns provided in Table 1 are not exhaustive. Final syllables closed by a lengthening consonant (/v z ʒ ʁ vʁ/) are not illustrated. In this context, most vowels are long and eligible for diphthongisation in Laurentian French (e.g. Walker 1984). Second, schwa has been excluded; it may pattern differently from the class of light vowels because, as mentioned in the text, it cannot be assigned prominence (Garde 1968; Pasdeloup 1990; Prieto et al. 2005), consistent with it having no mora (e.g. Tranel 1984; Hyman 1985; but cf. Eychenne 2006). Schwa does not surface in our data and we therefore cannot test how it patterns. We further point out that nasal vowels may form a special subclass of heavy vowels because they can variably be diphthongised in open final syllables (aside from /ɑ̃/), suggesting that they may maintain their weight (as heavy) in this position. Nonetheless, both oral and nasal heavy vowels exhibit the pattern of being long and diphthongised in closed final syllables.

Phoneme	Underlying weight	Open final syllable	Closed final syllable	Open non-final syllable
/a/	light	short	short	short
/ɛ/	light	short	short	short
/œ/	light	absent	short	short
/ɔ/	light	absent	short	short
/i/	light	short	short	short
/y/	light	short	short	short
/u/	light	short	short	short
/ɑ/	heavy	short	long	long
/e/	heavy	short	absent	long
/ø/	heavy	short	long	long
/o/	heavy	short	long	long
/ɛː/	heavy	absent	long	long
/ɑ̃/	heavy	short	long	long
/ɛ̃/	heavy	long	long	long
/œ̃/	heavy	long	long	long
/ɔ̃/	heavy	long	long	long

Table 1: Phonological length of phonemes according to syllable profile in Laurentian French.

Tables 2 and **3** illustrate the expected sources of weight in French with example words and the prominence pattern we expect will be favoured for words of each profile. While **Table 2** only includes example words with a single weight profile in the penult (i.e. varying the final syllable's weight profile) and **Table 3** only includes words with a single weight profile in the final syllable (i.e. varying the penult's weight profile), all weight profiles were included in the current study. The set of profiles illustrated is abridged to more directly compare our expectations for prominence assignment. As noted above, we expect that final syllables are always available for prominence assignment and therefore that final syllables can be prominent regardless of penult profile.

		Underlying vowel weight	
		Heavy	**Light**
Coda weight	Closed	Final prominence favoured *entente* [ɑ̃.ˈtɑ̃t] ‘agreement’	Final prominence favoured *antenne* [ɑ̃.ˈtɛn] ‘antenna’
	Open	Shift to penult favoured *hanté* [ˈɑ̃.te] ‘haunt (PTCP.M.SG)’	Shift to penult favoured *hantais* [ˈɑ̃.tɛ] ‘haunt (PST.2SG)’

Table 2: Expected prominence location based on final-syllable weight.

		Underlying vowel weight	
		Heavy	**Light**
Coda weight	Closed	Shift to penult favoured *conster* [ˈkɔ̃s.te] ‘to establish’	Shift to penult favoured *copter* [ˈkɔp.te] ‘to chime’
	Open	Shift to penult favoured *conter* [ˈkɔ̃.te] ‘to recount’	Final prominence favoured *coter* [kɔ.ˈte] ‘to code’

Table 3: Expected prominence location based on penult weight.

2.2 Cues

The acoustic profiles of syllables at the right edge of prosodic domains in French have been the subject of some debate, with pitch, duration and amplitude all having been discussed as possible cues. Authors typically agree upon the role played by pitch, with high and low tones marking phrase boundaries (e.g. Mertens 1987; 1993; Di Cristo & Hirst 1993; 1996; Post 1993; Jun & Fougeron 1995).[5] The presence of pitch peaks in phrase-final position results in the frequent characterisation of pitch being a cue for prominent syllables across varieties. Previous work on Laurentian French additionally suggests that pitch targets are sensitive to vowel weight, with high tones observed on the penult more often when the penult vowel is heavy (Thibault & Ouellet 1996). In addition, maximum pitch has been the main correlate examined in work describing prominence shift, so we expect that pitch will be affected by both prosodic domains and weight, such that heavy syllables will be realised with higher pitch maxima.

[5] As we discuss both pitch as an acoustic cue (a phonetic measurement, here measured in semitones) and pitch targets (a phonological category), we use the term *pitch* for acoustic measurements and the term *tone* for phonological targets.

Prominent syllables are typically longer than non-prominent ones, which has led to debate about whether length is a primary (Delattre 1968; Walker 1984; Schwab & Llisterri 2012) or secondary cue (Vaissière 1991; Jun & Fougeron 1995; 2000; 2002; Di Cristo 1998; Santiago 2011). We therefore expect that duration will pattern similarly to pitch in participating in prominence shift and, given previous work showing that Laurentian French has longer penults compared to Parisian French (Ouellet & Tardif 1996), we expect that duration will be a robust cue in our study. Durational differences on the final syllable, however, may be compressed; final syllables are subject to lengthening in French (e.g. Boudreault 1968; Walker 1984; Jun & Fougeron 2002), which could reduce the effect size in the final syllable while retaining the durational effect in the penult.

We point out that duration is confounded with weight: phonologically long segments (heavy vowels) and additional segments (codas) are, of course, expected to affect rhyme durations because there is more content to pronounce independent of weight. We expect a trade-off between syllables, however, with the prominent syllable being lengthened and the non-prominent syllable compressed. The effect of weight on duration should therefore be particularly robust; we would not conclude that there is sufficient evidence to support our hypothesis that prominence assignment is sensitive to weight if a small change in duration is the only effect of increased weight.

Unlike pitch and duration, amplitude is not typically reported in acoustic studies on French prominence. Indeed, some authors propose that amplitude is not a possible cue to prominence in French because it is associated only with word-level prominence (Féry 2013): languages with lexical stress use amplitude to signal word-level prominence, but not to mark phrase-level prominence. However, French speakers use increased amplitude as a cue to stress in Spanish in experimental settings (Féry et al. 2010) and amplitude is manipulated to signal prominence in Swiss French (Schwab & Llisterri 2012). In light of most previous literature, we do not expect amplitude to be associated with marking prosodic domains. However, if prominence shift serves to highlight word-level properties, we expect that amplitude will pattern with pitch and duration in enhancing weight.

We finally consider the possibility that prominence cues may not pattern together. For example, the pitch peak may remain on a light final syllable while the heavy penult increases in duration, in which case we would have evidence that both word-level and phrase-level prominences are signalled simultaneously but on different syllables.

2.3 Prosodic domains

In order to illuminate the phonological contribution of word-level properties to prominence in Laurentian French, we must assess the effect of the word's phrasal context. This is because, as

previously noted, the smallest domain of prominence in French is not the word; only phrasal domains assign pitch targets. The model we adopt is that of Jun & Fougeron (1995; 2000; 2002) as their model offers several benefits for the current study: (a) it elucidates the phonological aspects of the assignment of tones that will be central to our analysis (i.e. tone targets, applicable domains); (b) their description maps most directly onto the acoustic operationalisation that we implement (pitch as the realisation of low and high tone targets); and (c) our goal is to investigate the phonological effects of weight in limited prosodic contexts rather than characterising a wide variety of intonational contours.[6]

Many terms have been used to describe the domains under examination, but the smallest domain consistently groups together lexical words and their preceding syntactic dependents (e.g. Hirst & Di Cristo 1984; Di Cristo & Hirst 1993; 1996; Jun & Fougeron 1995; 2000; Delais-Roussarie 1996). We follow Jun & Fougeron in calling this domain the *accentual phrase* (AP). APs are typically characterised by rising intonation (LH* tone target) at the right edge, with high tone targets normally being associated with final syllables (e.g. Jun & Fougeron 1995; see Kaminskaïa 2009; 2015 for a variety of Laurentian French). APs are organised under larger units, *intonational phrases* (IPs), which typically correspond to sentences (Jun & Fougeron 1995). For brevity, we refer to any word at the right edge of an IP as IP-final without indicating that it is also AP-final, and we therefore refer to any word that is at the end of an AP but *not* at the end of an IP as AP-final. In this paper, we focus only on assertive IPs, given the content of the text from which the data are drawn, and we control for prosodic domain type when examining weight effects. More specifically, we compare APs and IPs to each other in order to verify which cues mark prosodic domains in Laurentian French.

The right edges of assertive IPs are typically marked with a low boundary tone (L%), which replaces the high (H*) of the AP's rise and makes the contour level or slightly falling (LL%).[7] Here, the percent sign indicates that the tone is a boundary tone (and is therefore associated to a phrase edge). We expect that AP-final syllables are marked with a high tone – and therefore high pitch – with the associated rise predominantly occurring on the final syllable. IP-final syllables have low pitch due to the IP-final low tone.

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[6] Delais-Roussarie et al. (2015) expanded Jun & Fougeron's model, establishing a ToBI-based notation system for French that provides more fine-grained distinctions. Their study and other recent work (e.g. Sichel-Bazin 2015; Persson 2020) largely focus on meaningful differences between surface contours (often with tonal contributions from intermediate phrases or specific conversational intentions on behalf of speakers) while highlighting discourse and prosodic contexts where variation is found in the surface contour (e.g. when L% and H% may vary) or its phonetic implementation (e.g. where downstep occurs).

[7] We abstract away from IP variability here, but note that prior studies find some variation in the realisation or selection of pitch contours in these contexts (e.g. Post 2000; Simon 2004). For example, both Parisian French (Post et al. 2006) and Swiss French (Delais-Roussarie et al. 2015) variably use a high boundary tone (H%) to mark IPs.

Although pitch differences between APs and IPs have been studied extensively and it is known that AP-final syllables exhibit lengthening relative to AP-internal syllables, it remains unclear whether duration and amplitude are also manipulated to distinguish between these two prosodic domains.[8] Concerning duration, some previous work finds that AP-final syllables are longer when they are also IP-final (e.g. Fletcher 1991; Jun & Fougeron 2000 and references therein; Michelas & D'Imperio 2010; 2011); other work finds that they are longer when not IP-final (e.g. Féry et al. 2010); and some authors comment that lengthening differences between these domains are optional or inconsistent (e.g. Vaissière & Michaud 2006). These mixed results suggest that, if there exists a significant difference in the degree of final lengthening based on type of domain, it is small and therefore small-scale studies are likely to find seemingly contradictory results simply by chance. The literature does not suggest an expected difference in penult durations for prosodic domains of different sizes, though it is worth noting that, in languages with lexical stress like English, final lengthening can target the last syllable with primary stress rather than the final syllable (Shattuck-Hufnagel & Turk 1998). We expect that final syllables at the right edge of IPs are longer than those at the right edge of APs, but for this difference to be small based on mixed results in previous work.

Finally, the use of amplitude to mark different types of prosodic domains in Laurentian French, if manipulated at all, is not yet known. Based on the cross-linguistic observation that amplitude is available as a cue to mark lexical prominence but not phrasal prominence (e.g. Féry 2013; see Section 2.2), we expect that amplitude will not be manipulated to distinguish APs from IPs.

2.4 Expectations for French prominence assignment

Based on previous literature, we expect that French, and particularly Laurentian French, will predominantly use pitch and duration to mark prosodic domains. We additionally expect the language to exhibit weight sensitivity, with both long vowels and closed syllables being heavy and therefore attracting prominence. These heavy syllables are expected to be marked with increased rhyme durations and greater amplitudes. Furthermore, we expect the tone target (H* in the AP's LH*) to shift inwards towards heavy penults and away from open final syllables, leading to higher pitch maxima for penults compared to final syllables. **Figure 1** illustrates expected pitch profiles using idealised pitch contours at the right edge of the accentual phrase for unshifted (top) and shifted (bottom) cases of APs (left) and IPs (right). In APs that are not IP-final, we expect a rising contour with H* aligned with the final syllable if prominence shift does not occur, but with the penult if shift does occur. In IP-final contexts, however, we expect to get no high tone

[8] Previous work does, however, demonstrate that duration differs between AP-final tokens at the right edge of intermediate phrases and AP-final tokens that are not at the right edge of intermediate phrases (Michelas & D'Imperio 2012; D'Imperio & Michelas 2014).

if shift does not occur, since H* in the final syllable gets replaced by the IP's L% boundary tone, assuming an assertive sentence. When prominence shift does occur, the AP's H* tone would be expected to move inwards to the penult and therefore the phrase would end in a rise-fall because the IP's L% tone would be aligned with the boundary and would not replace the AP's H* assigned to the previous syllable. In short, we expect that prominence assignment depends not only on the prosodic context, but also on the weight profile at the right edge of the phrase.

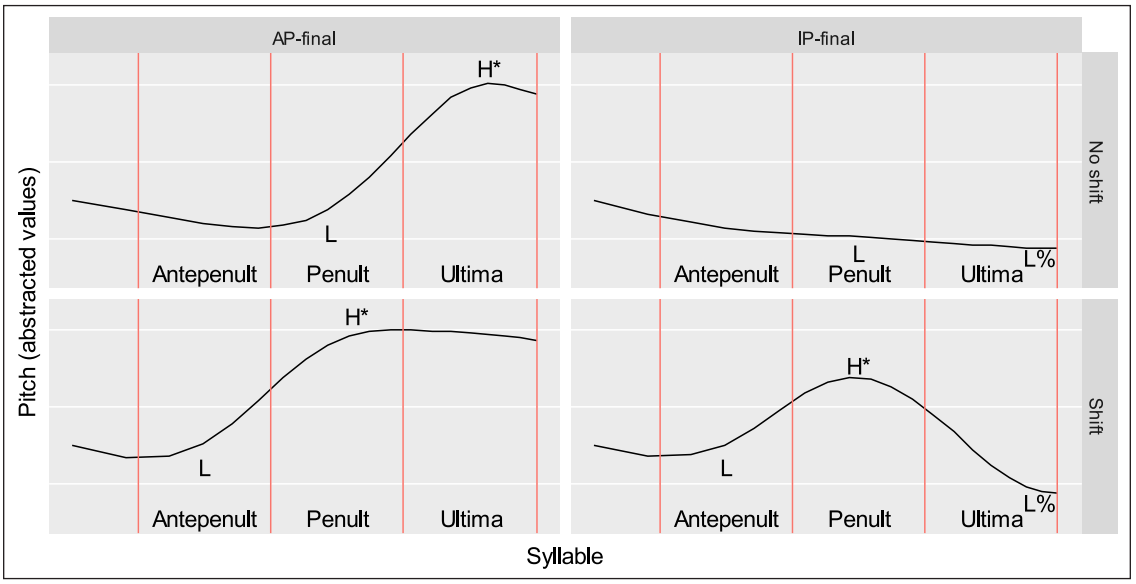

Figure 1: Expected pitch contours at end of APs depending on whether AP-final word is also IP-final (right) or not (left), and whether word undergoes prominence shift (bottom) or not (top).

3 Methods

The goal of this study is to quantitatively test whether phonologically heavy syllables attract final prominence in Laurentian French.

3.1 Corpus and speakers

As mentioned, we draw our data from the Laurentian sub-corpus (Côté 2014) of the *Phonologie du français contemporain* corpus (PFC; Durand et al. 2002; 2009), the recordings and orthographic transcriptions from which are freely available on the PFC website (http://www.projet-pfc.net/). Speakers in this corpus take part in four tasks, one of which involves reading a short passage (included as Supplementary Material 1). We focus on this task as it increases the likelihood that the tokens within and across speakers are more comparable for two reasons: one, phrasing is relatively fixed, since the speakers generally formed prosodic domains based on the punctuation provided; two, speech rate effects are likely minimal, which is important because speech rate has

been proposed to impact accentual phrase size (see Jun & Fougeron 2002 and references therein) and to underlie prominence shift (Avanzi et al. 2011a; Avanzi et al. 2011b).

As previously noted, we examine Laurentian French because it conserves a large number of vowel length contrasts, providing more opportunities for weight effects to be observed. Furthermore, diphthongisation enhances the salience of weight contrasts. This variety is consequently an optimal starting point for probing prosodic effects of syllable weight in French.

We specifically examine speakers from Chicoutimi, Quebec, located 200km north of Quebec City. This area was selected as it has limited contact with other languages and dialects. In the Saguenay area, which includes Chicoutimi, 98.3% of inhabitants report speaking French as a native language, and 98.9% speak only French at home; further, the rate of bilingualism, including French-English bilingualism, is relatively low: inhabitants aged 20–44 are the most likely to be bilingual (31.8%; nearly double the next highest group's rate) (Statistics Canada 2012). The Saguenay area additionally sees relatively little immigration, from both inside and outside of Quebec or Canada, reducing the potential for language contact to affect the results.

The data in this study come from 11 native French speakers who were born and raised in Chicoutimi, with speakers spanning three generations (age 22–74) and being relatively well-balanced for sex (5 men, 6 women). All speakers were fluent readers. **Table 4** provides more detailed demographic data for each speaker using the age cohort divisions that guided speaker selection during the collection of the PFC corpus.

	Sex	
Age Group	**Male**	**Female**
Young adult	fv1 (1984, 22) pl1 (1983, 23)	cl1 (1982, 24) jv1 (1979, 27) mb1 (1985, 21)
Middle-aged	db1 (1954, 52) pt1 (1965, 41)	gm1 (1958, 48) ma1 (1953, 53)
Older	rt1 (1934, 72)	gt1 (1932, 74)

Table 4: Speakers in the Chicoutimi survey and their demographic factors (year of birth, age during data collection).

3.2 Procedure

3.2.1 Alignment and syllabification

The recordings were segmented using the SPLalign forced aligner created by Milne (2014). The forced aligner was trained on Laurentian French and uses speaker-adapted word-internal

triphone models to maximise accuracy in word and phoneme segmentation. A Praat (Boersma & Weenink 2015) script then performed syllabification using an onset-maximisation algorithm. The syllabifications used in the analysis are based on realised forms, as segmented by the forced aligner; reduced clusters and omitted schwas are not reconstructed, so that a word like /mɛtʁ/ *mettre* 'to put' was considered as having one syllable if the possible final schwa was not realised (e.g. [mɛt], [mɛtʁ]), but two if it was (e.g. [mɛtʁə]).

3.2.2 Identifying prosodic domains

As we examine prominence shift to the penult, only words with at least two realised syllables were extracted. We only examine the last two syllables of each target word, regardless of how many syllables are in the word. We additionally restricted the words analysed to those that are at the end of an AP, given that this is the smallest prosodic domain described as assigning pitch targets in French (e.g. Jun & Fougeron 1995; 2000; 2002). This was done based solely on the text to ensure that the coding was not biased by the presence or absence of cues that we would normally associate with the right edge of a domain. No manual corrections were made based on the acoustic profiles observed.

The contexts included are shown in (2)–(4), where we see examples of tokens that are taken directly from the text analysed.[9] All tokens are deemed to be at the end of accentual phrases and may additionally be at the end of larger prosodic domains. Right-edge boundaries, which are indicated using pipes ("|") in the examples, correspond to syntactic junctures (Jun and Fougeron 1995) and are further supported by work that examines the prosodic domains relevant to phonological processes in French, like liaison (Hannahs 1995). We considered the following to be AP-final: nouns not followed by adjuncts within their syntactic phrase (2a), non-auxiliary verbs not followed by adjuncts within their syntactic phrase (2b), post-nominal adjectives (2c) and post-verbal adverbs (2d). We code as APs only phrases where variable phrasing is least expected; notably, nouns and verbs that are followed by adjuncts (e.g. a prepositional phrase, an adjective or an adverb) are not included in the analysis because they can be realised in the same or separate APs (Post 2000), as mentioned in Section 1. AP-final words followed by punctuation are coded separately (see below).

(2) Contexts coded as AP-final without punctuation:

a. … *le gouvernement* | *prend contact* …
… the government | makes contact …

b. … *le gouvernement … et s'assure* | *que* …
… the government … and ensures | that …

[9] The translations correspond to the senses of the words as they appear in the text, taking into account portions of the text not included in the abridged examples. Where example passages also include prosodic boundaries of types other than the one being illustrated, only the boundaries targeted for the example have been marked.

c. *La côte escarpée* | …
The steep hill | …

d. … *qui tournaient toujours* | …
… that always pivoted | …

When punctuation was present, as in (3) and (4), we treated the prosodic context as being distinct from when there was no punctuation present (2) because the token is final within a domain larger than the AP, leaving us with three groups that were included in the statistical models: AP-final tokens not followed by punctuation, AP-final tokens followed by a comma, and assertive IP-final tokens (AP-final tokens followed by a period). Only two of these groups are under focus in the current study: AP-final tokens without punctuation (2), which, as mentioned earlier, we refer to as AP-final; and AP-final tokens followed by a period (4), which we refer to as IP-final.[10] In total, 1368 tokens were included, meaning that there were 2736 syllables measured (final and penultimate syllables).

(3) Contexts coded as AP-final with punctuation:
Le hasard, | *tout bêtement,* | *car le Premier Ministre,* | …
Happenstance, | quite frankly, | since the Prime Minister, | …

(4) Contexts coded as IP-final:
… *depuis les élections.* | …
… since the elections. | …

3.2.3 Acoustic measurements

For each syllable included in the analysis, a Praat script extracted the rhyme duration,[11] as well as the syllable's maximum pitch and maximum amplitude, based on the cues discussed by Gordon (2014) in his typological work and those examined for French by Jun & Fougeron (1995; 2000; 2002).[12] We focus our analysis on maximum pitch (see further §3.4.1) because it locates phrase-

[10] AP-final tokens followed by a comma were excluded from the analysis for reasons of space and were coded as a separate prosodic level using Helmert contrast coding for statistical analysis (see further Section 3.3). In previous work (Lamontagne et al. 2017), we discuss the results for this domain and their implications for the projection of intermediate phrases (e.g. Post 2000; Michelas 2011; Michelas & D'Imperio 2012; Delais-Roussarie et al. 2015; Torres, Fletcher & Wigglesworth 2020).

[11] Preliminary data analysis considered vowel duration; we do not report these results because the patterns under focus for the rhyme and vowel are the same.

[12] Earlier analyses, such as those in Lamontagne et al. (2018), included results for pitch range, which is not included in the current study for two reasons. First, results closely mirror the ones found for maximum pitch. Second, pitch ranges less directly reflect the high-tone target of the AP than pitch maxima do. We note that results for maximum pitch are compressed because values are always obtained from maxima: a rise beginning in an earlier syllable will show a smaller difference between syllables than a rise that takes place entirely within a single syllable, and the lowest point of a fall is not captured by the measure.

final high tones (the acoustic target for AP prominence; e.g. Jun & Fougeron 1995). **Figures 2** and **3** illustrate unshifted and shifted prominence in non-final APs, respectively. We see that the pitch maximum is highest in the final and penult syllables, respectively.

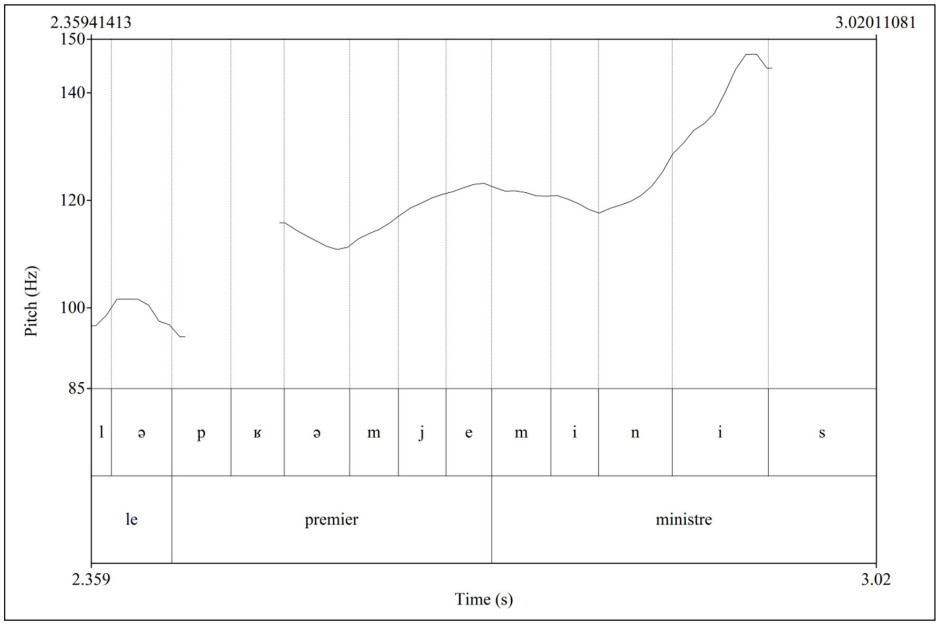

Figure 2: *Le premier ministre* 'the prime minister' without prominence shift in an AP-final context (speaker cl1).

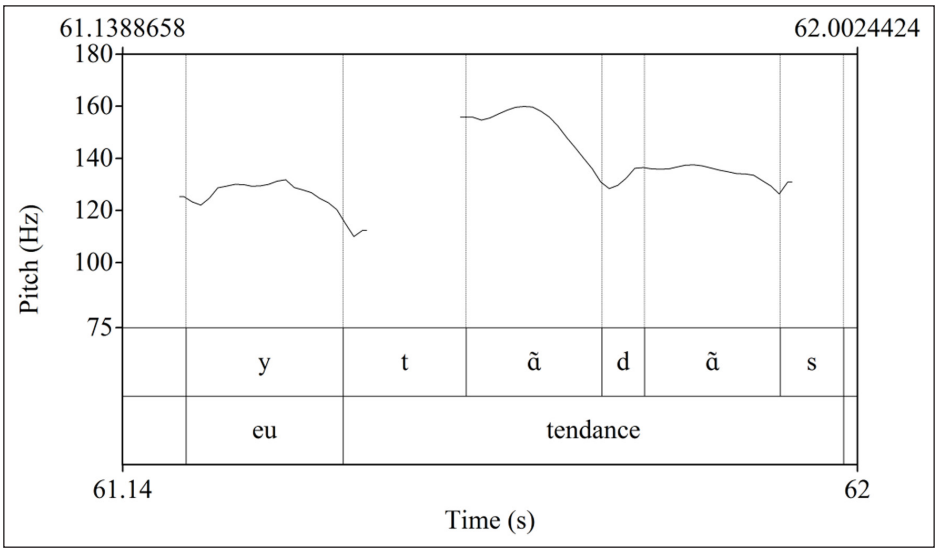

Figure 3: *(Ont) eu tendance* '(had) a tendency' with prominence shift in an AP-final context (speaker fv1).

Maximum amplitude was preferred over mean amplitude because the mean is more affected by the segments present in a given syllable and because a shorter vowel would be expected to be at its maximum for a shorter period of time, thereby reducing the mean value without necessarily reflecting a lower amplitude target. Using maximum amplitude also meant that we could reliably measure through the rhyme instead of limiting ourselves to the vowel, which could have resulted in not including the point with the greatest amplitude if, for example, there was a sonorant consonant in the coda that was higher in amplitude than the immediately preceding vowel.

3.3 Models

Acoustic cue realisations of the 2736 targeted syllables were analysed using the lme4 package (Bates et al. 2015) in R (R Development Core Team 2015) to compute mixed-effects linear regressions with speaker and word as random intercepts.[13] We discuss the results of three models, one for each acoustic cue (maximum pitch, rhyme duration, maximum rhyme amplitude). The distribution of the residuals was approximately normal and correlation matrices confirmed that the assumption of multicollinearity was not violated.[14]

The models take as their dependent variables not the raw acoustic measurements, but instead, the difference between the last two syllables' values, which yields a relative value (RV) to provide some adjustment for context (e.g. speech rate), with the use of random intercepts simulating normalisation procedures to remove inter-speaker differences (Drager & Hay 2012). The formula for the RV, presented for each cue in (5), involves subtracting the final syllable's value from the penultimate syllable's value. This provides an interpretable value: an RV greater than 0 indicates that the penult has a higher cue measurement; an RV below 0 indicates that the final syllable has a higher value. The further from 0 the RV is, the larger the difference between the two syllables.

We use subtraction when calculating the RV for two reasons. First, cues are already log-scaled (manually for duration; by virtue of being in decibels for amplitude and in semitones for pitch). Second, this allows for a more intuitive interpretation of RVs: not only does the RV's sign indicate which syllable has a greater cue measurement, but the RV can be interpreted as the change in measurement value. Because our models predict RVs, the model considered 1368 data points (one per word). Four tokens were excluded from the maximum pitch and maximum amplitude models due to excessive devoicing of high vowels.

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[13] Our study does not have a sufficient number of speakers to confidently test inter-speaker variability, but the consistency within our sample suggests that weight effects are comparable across speakers. We leave examination of individual differences for future work.

[14] While the factors are not too confounded for testing, there are distributional asymmetries in French which mean that the data are skewed towards having certain phonemic content in some contexts only (see Table 1). For instance, while /e/ is common word-finally, it does not occur in closed final syllables. Similarly, /ɔ/ is absent in word-final open syllables.

(5) Formula for calculating RVs:

$$RV_{cue} = measurement_{penult,cue} - measurement_{final,cue}$$

Figure 4 illustrates how RVs relate to cue measurements using 2000 hypothetical words generated through the *rnorm* function in R.[15,16] In the left panel, we provide an example of hypothetical results for penult weight; penults have a higher value when heavy than when light. In the right panel, we see RVs based on hypothetical measurements: positive RVs when the penult vowel is heavy; negative RVs when the penult vowel is light. For maximum pitch, the RV will often be near 0 in the case of tone targets retracted to the penult because the final syllable will not have a separate tone target, as shown in **Figure 1**, and therefore the final syllable's pitch will be similar to the penult's pitch. In our statistical analysis, model coefficients reflect the penult attracting prominence through increased RVs in the heavy-vowel context compared to the light-vowel context.

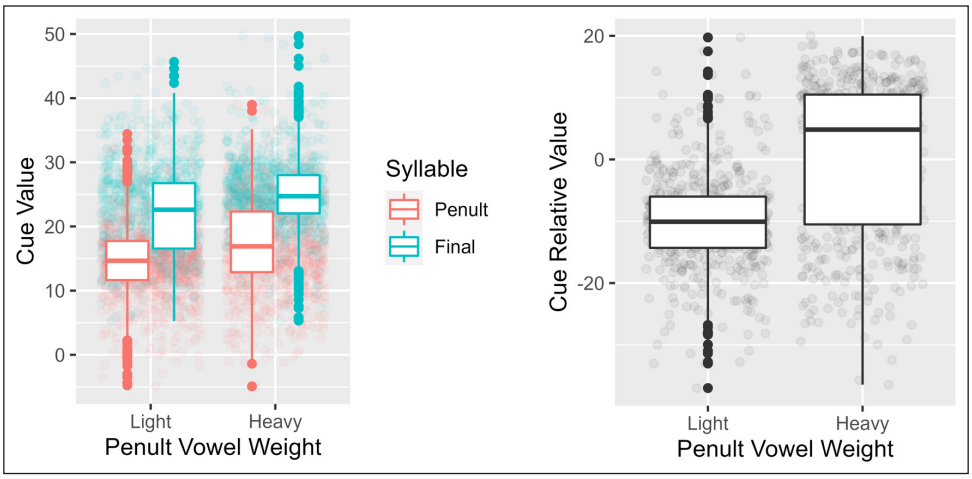

Figure 4: Syllable weight values and their associated RVs using hypothetical data.

[15] 500 tokens were generated for each combination of the penult and final syllables being light or heavy. Prominent syllables were given a mean of 25, and non-prominent syllables, a mean of 15. If a final syllable was heavy (expected to preserve prominence) or the penult was light (not expected to attract prominence), the final syllable was prominent. To reflect the hypothesis that heavy penults will optionally attract prominence from light final vowels, the penult was treated as prominent (mean value of 25) in half of the cases where the penult syllable was heavy, with the final syllable thus not being prominent (mean value of 15). If the two syllables had equal weight and therefore more variation in prominence was expected to occur, the standard deviation for both syllables was set to 7, while it was set to 3 if the syllables differed in weight.

[16] Note that the blue dots for final-syllable datapoints were added after the red dots for penult datapoints, meaning that the distribution of points visually underrepresents the number of penult datapoints in higher cue value ranges. Additionally, recall that cue RVs are not based on individual datapoints independently, but instead on the difference between a penult value and its associated final-syllable value. The consequence of this is that RVs better illustrate the shift in prominence because plotting syllables separately masks the fundamental relationship between the values in each of these simulated words.

Returning to the statistical analysis, all models include identical fixed and random effect structures to ensure comparability. With the exception of prosodic domain, all factors are binary and were both rescaled by two standard deviations and centred for better comparability with potential non-binary factor effects. The prosodic domain is a ternary factor (AP with no punctuation vs. AP with comma vs. IP) and was Helmert-coded so that the first prosodic domain factor in the model provides the difference between APs with no punctuation and IPs, the domain comparison we focus on in the analysis. In all cases, the following directions of effect are interpreted as an increase in prominence: increased pitch, amplitude and duration. The coefficients in the model can be interpreted as the size of the change in acoustic cue measurements.

We included one additional factor in the model that does not directly relate to the predictions under focus: morphological structure. A larger and more diverse dataset would be required to test the effects of morphological structure in detail since many properties of individual morphemes could play a role (e.g. consonant-initial vs. vowel-initial, derivation vs. inflection). However, preliminary data exploration revealed that we would need to control for morphological structure in our models, so we included a manually coded factor that identified whether the penult was base-final. We will point out where this factor was crucial in our description of results, but not treat it as a focus given that our dataset provides only a limited sample of distinct suffix types (inflectional, derivation) and suffix shapes (closed or open syllable; with or without onset).

3.4 Predictions

In this section, we discuss predictions for the quantitative analysis that we undertake. These predictions stem from our hypothesis that final prominence in French is sensitive to weight. We begin with prosodic domains.

3.4.1 Prosodic domains

As evident from **Figure 1**, we must establish how speakers mark prosodic domains in order to investigate prominence shift in Laurentian French. The literature across varieties of French (see Section 2.3) shows that AP-final syllables are typically marked with LH*. We expect that the speakers under study will pattern like those from other regions in marking APs with a final pitch rise, which means that penults will have lower maximum pitch than final syllables, yielding a negative RV for maximum pitch. We also expect IP-final syllables to be marked with an LL% (LH* for the AP with the IP's L% replacing the H* on the same syllable) or H*L% contour (shifted LH* with the L% being assigned to the toneless final syllable), which means that RVs will be near or above 0 since the final syllable will bear a low tone and therefore the penult will have higher maximum pitch than the final syllable. These expectations lead to the prediction that maximum pitch RVs will be significantly higher in IPs (L% and therefore lower pitch on the final syllable) compared to in APs (no L% and therefore higher pitch on the final syllable, barring prominence shift).

Given the literature on final lengthening, we expect that duration RVs will be higher in APs than in IPs because the final syllable of IPs will be subject to greater phrase-final lengthening. However, this difference is likely to be small based on mixed results in the literature, and this study lacks the statistical power required to confidently conclude that no small effect exists. These expectations lead to the prediction that we will not find any significant effect of prosodic domain in duration.

Finally, we do not expect there to be a significant difference between APs and IPs with respect to amplitude RV because amplitude is not expected to be used as a cue to phrasal prominence, though again we will cautiously not conclude that no small effect exists if no statistically significant effect is found. We therefore do not predict any difference in amplitude resulting from the type of prosodic domain. We summarise our expectations in Prediction 1:

(6) **Prediction 1:** We predict that IPs will have significantly lower-pitched final-syllable rhymes than APs will; we do not predict that there will be a significant difference in duration or amplitude between APs and IPs.

3.4.2 Coda weight

One source of weight we consider is codas, where closed syllables are heavy and open syllables (with short vowels) are light. Words exemplifying prominence shift from multiple varieties of French as well as previous findings that Laurentian French speakers associate closed syllables with increased prominence in perception (see Section 2.1) lead us to expect that syllables with codas will be more prominent than those without. As a result, our expectations for coda weight are straightforward: closed penults will attract prominence; closed final syllables will preserve prominence. These expectations lead to Prediction 2:

(7) **Prediction 2:** We predict that closed syllables will have significantly higher values compared to open syllables for all acoustic cues signalling prominence (maximum pitch, duration, amplitude).

3.4.3 Vowel weight

Recall that we model vowel weight as binary as determined by vowel behaviour in closed final syllables: heavy vowels surface as long in closed final syllables, while light vowels are short in this context. We expect that heavy vowels will attract prominence and therefore that final high tones will be attracted to heavy vowels; that heavy vowels will have significantly longer duration; and that heavy vowels will be marked with greater amplitude. Combining our expectations that final syllables must be closed to count as heavy and that vowel weight contributes to weight in closed final syllables, we expect that open final syllables will pattern as light even if they contain an underlyingly heavy vowel. These expectations lead to Prediction 3:

(8) **Prediction 3:** We predict that syllables containing a heavy vowel will have significantly higher values for all acoustic cues (maximum pitch, duration, maximum amplitude) compared to syllables containing a light vowel, except in the case of open final syllables where we do not predict that a significant effect will be found.

3.4.4 Differences between syllables

Thus far, we have treated the two syllables under focus as equally capable of hosting prominence. This, though, is not consistent with the literature where final syllables are standardly considered to be the default position for prominence in French. In view of this, we must modulate our predictions to ensure that the prominence-retaining properties of final syllables will have a greater effect than the prominence-attracting properties of penult syllables. This may manifest not only in the relative sizes of the predicted coefficients (larger for factors relating to final syllables than for those relating to penults), but also in the distributions. RVs may be visually compressed when plotting the data: values tend to be negative or near zero even where penult prominence is predicted because the cue values across the whole dataset remain biased in favour of the final syllable having higher values.

4 Results

In this section, we discuss the results of our statistical models (included as Supplementary Materials 2–4). We present findings thematically, to directly compare each factor's effect on acoustic cues. All figures will follow the same layout: panel A shows maximum pitch, panel B shows rhyme duration, and panel C shows maximum amplitude. Contra Lamontagne (2020), we present plots of cue RVs, which visually adjust for individual tokens' contexts and best reflect our statistical analysis (see Section 3.3), but we nonetheless highlight aspects of individual syllables' cue use where relevant.

4.1 Prosodic domains

Prediction 1 stated that IPs would have higher pitch maximum RVs than APs because IP-final syllables receive a low boundary tone. We find that IPs have considerably higher values ($\beta = 1.1817$, $p < 0.0001$), which is consistent with IPs having a low tone rather than a high tone in the final syllable. Panel A of **Figure 5** shows that this difference is mainly a result of the final syllable's pitch changing, consistent with these phrase types having different final-syllable pitch targets.

Regarding duration RVs, we predicted lower values in IPs than in APs due to greater IP-final lengthening. Consistent with this and as shown in panel B of **Figure 5**, we find a small but significant difference whereby IP-final syllables are proportionally longer than AP-final ones ($\beta = –0.1068$, $p = 0.0480$). However, this result should be tested in future work, as the effect is

small and only barely reaches the threshold for significance. Additionally, we note that the effect is too small to counteract the intercept ($\beta = -0.6097$, $p < 0.0001$), meaning that overall, final syllables are longer than penults, unless other factors (such as weight, discussed below) lengthen the penult or shorten the final syllable.

As for amplitude, we predicted that we would find no significant difference between APs and IPs because amplitude is not expected to be manipulated to signal boundaries. Contrary to this, we find that IPs have significantly higher RVs for maximum amplitude ($\beta = 1.9705$, $p = 0.0011$), which indicates that IP-final syllables have much lower amplitude than AP-final ones. Panel C of **Figure 5** illustrates this interpretation, where we see that both the penult and final syllables have lower amplitude in IPs than in APs, with final syllables showing the largest decrease.

Overall, these results are consistent with APs being marked with a rising pitch contour and IPs being marked with low final pitch. We additionally find evidence that IP-final syllables are longer than AP-final ones and that IPs have lower final amplitude. These results suggest that Laurentian French patterns like other varieties of French in the tone targets used to mark phrasal domains. With the tone for APs established, we turn to the results for weight.

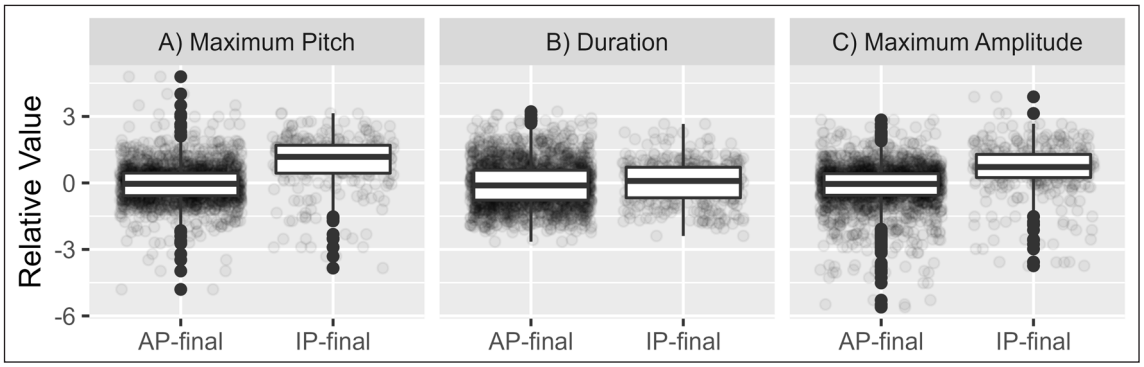

Figure 5: Results for domain type.

4.2 Coda weight

Prediction 2 stated that the RV for all acoustic cues would be higher in closed syllables, following from our hypothesis that closed syllables attract prominence.

4.2.1 Penult coda weight

We predicted that closed penults would have higher pitch maxima (i.e. a significantly higher pitch RV) because heavy penults attract H* from the final syllable. Our models support this prediction ($\beta = 1.1533$, $p < 0.0001$), but an examination of panel A in **Figure 6** suggests only

a trend in the expected direction. Based on model comparisons, the prediction of greater penult pitch maxima is borne out so long as we control for morphological structure (morphologically complex words in our data often have open penults due to resyllabification) and for whether the final syllable is closed (closed final syllables block prominence shift; see Section 4.2.2). This result appears to be consistent whether the penult is base-final or not, but skewed data proportions mask this result in the figure, particularly because morphological structure has additional effects on pitch contours.

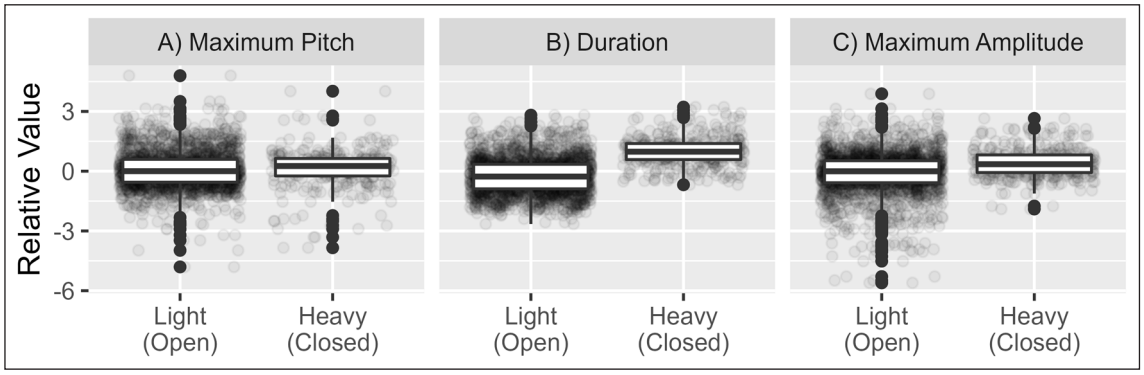

Figure 6: Results for penult coda weight.

We predicted that closed penults would have significantly longer rhymes (i.e. higher RVs) because penults of this shape optimally attract prominence. Closed penults have significantly longer rhymes ($\beta = 0.6992$, $p < 0.0001$), and panel B of **Figure 6** shows the expected trade-off between syllables, such that penults being heavy not only increases penult rhyme durations, but also decreases final syllable rhyme durations. This relationship between the two syllables allows us to infer that the increase in relative duration does not simply result from the addition of segments in the penult independent of prominence assignment. Finally, as shown in panel C of **Figure 6**, we also find that closed penults have higher amplitude RVs ($\beta = 2.0582$, $p < 0.0084$).

In short, these results show that words with closed penults (e.g. /mɛʁsi/ *merci* 'mercy') more often have higher pitch, greater amplitude and longer duration in the penult than words with open penults (e.g. /mɛsi/ *messie* 'saviour'), consistent with Prediction 2.[17] Based on our hypothesis that French prominence exhibits weight sensitivity, we expect that closed final syllables will similarly have higher values for these acoustic cues. We discuss this next.

[17] The examples we provide to illustrate results are (near-)minimal pairs rather than words drawn from the text (see Supplementary Material 1) because they most clearly demonstrate the contrasts under discussion.

4.2.2 Final syllable coda weight

Turning to coda weight in final syllables, we predicted that the final syllable being closed would be associated with that syllable likely preserving prominence and thereby being realised with a high tone (i.e. lower RVs). We see from panel A of **Figure 7** that this does have an effect ($\beta = -0.1440$, $p = 0.0139$), though the effect appears smaller in **Figure 7** than in our model due to effects of other factors (e.g. the presence of a heavy penult, morphological complexity).

Also in line with our prediction that closed syllables are heavy, closed final syllables have significantly longer relative rhyme durations (i.e. lower RVs). While the increase in relative duration for the penult is large, we find an even larger effect for final syllables ($\beta = -0.9202$, $p < 0.0001$), as shown in panel B of **Figure 7**, suggesting that this effect is not solely the result of adding segments.

Finally, we find much lower RVs for amplitude when the final syllable is heavy ($\beta = -3.1101$, $p < 0.0001$), as illustrated in panel C of **Figure 7**. This is consistent with our prediction that a heavy final syllable would have increased amplitude because weight is a word-level property and therefore amplitude is available as a cue.

In summation, we find that closed final syllables (e.g. /navɛt/ *navette* 'shuttle') typically have higher pitch, amplitude and duration than open final syllables (e.g. /navɛ/ *navet* 'turnip'), consistent with Prediction 2. We next examine the results for vowel weight.

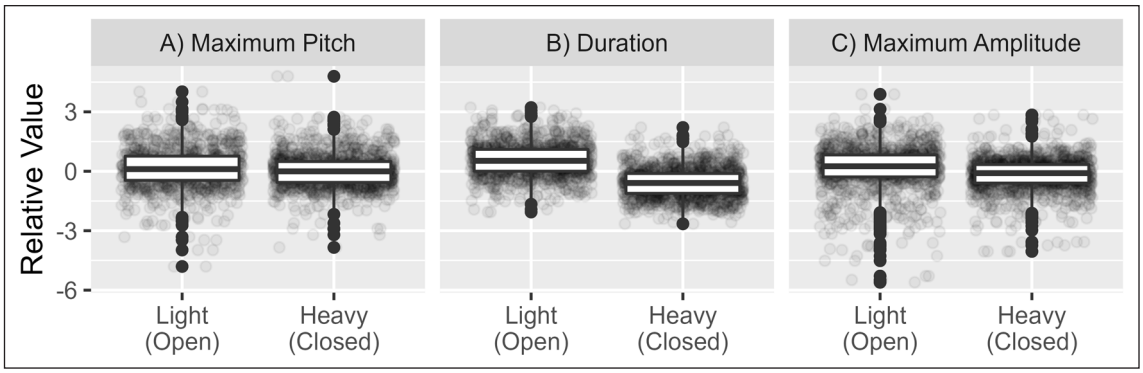

Figure 7: Results for final coda weight.

4.3 Vowel weight

Prediction 3 stated that heavy vowels should attract prominence in penults, but that open final syllables should pattern as light and therefore vowel weight should not have a significant effect in this position because the underlying weight contrast that was used to code vowels is typically neutralised. We predicted that RVs would be higher for heavy penults, but unaffected

by underlyingly heavy final-syllable vowels unless the final syllable is also closed, in which case the syllable would be more likely to attract prominence. We again begin by presenting the results for penults.

4.3.1 Penult vowel weight

We predicted that heavy penults would be associated with higher RVs for pitch maxima consistent with increased prominence shift to the penult, but the results are marginal ($\beta = 0.2493$, $p = 0.0720$), as illustrated in panel A of **Figure 8**. Once again, asymmetries in morphological and phonological profiles in the data visually reduce the magnitude of certain statistical trends.

We find the predicted increase in duration RVs when the penult vowel is heavy ($\beta = 0.1881$, $p = 0.0024$), shown in panel B of **Figure 8**, but find no significant effect of penult vowel weight on amplitude RVs. As shown in panel C of **Figure 8**, the amplitude differences are small with a possible trade-off between syllables and therefore this statistical trend should be explored further in future work. In other words, a penultimate heavy vowel (e.g. /gɑto/ *gâteau* 'cake') is likely to have longer duration and higher pitch maximum than a penultimate light vowel (e.g. /bato/ *bateau* 'boat'), but may not have greater amplitude, overall in line with Prediction 3.

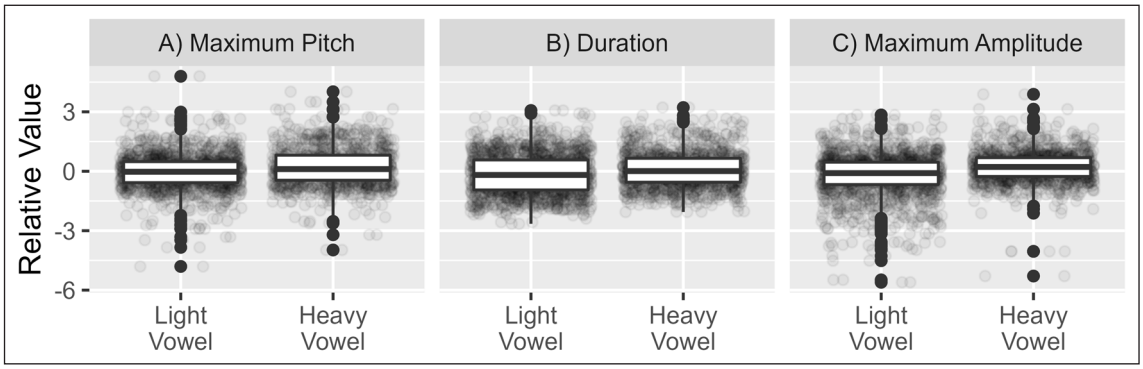

Figure 8: Results for penult vowel weight.

4.3.2 Final syllable vowel weight

For final syllable vowel weight, we predicted no main effects with the possible exception of a small increase in final rhyme duration (i.e. lower duration RVs). The plot in this case is somewhat misleading: we appear to get higher RVs associated with heavy final vowels, which should indicate that the penult – rather than the final syllable – increases in prominence when the final syllable has greater (vowel) weight. This is a visual artefact of distributional trends in the data that does not confound the models due to the number of tokens for different word shapes; light vowels in final syllables are more likely to be followed by a coda, which, as shown previously, has a considerable effect on prominence. We return to the question of the interaction between coda and vowel weight in final syllables in Section 4.4.

Pitch maxima (panel A of **Figure 9**) and amplitude (panel C) show no noteworthy effects not resulting from other factors; our models reveal no significant effects for these factors (though for the maximum pitch and amplitude, there may be a small effect). For duration, however, we find that RVs are significantly lower when the final syllable is heavy ($\beta = -0.2662$, $p = 0.0184$), consistent with the small predicted effect that is seemingly driven by final nasal vowels (see footnote 4). Overall, this means that the final oral syllables in words like /ami/ *ami* 'friend' (light final vowel) and /ane/ *année* 'year' (underlyingly heavy final vowel) likely show no difference in pitch, duration or amplitude, consistent with Prediction 3.

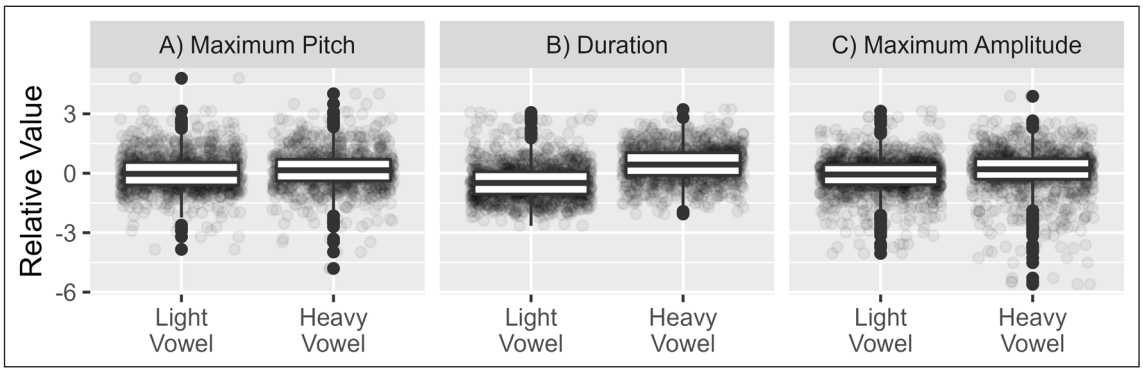

Figure 9: Results for final vowel weight.

4.4 Closed final syllables with heavy vowels

Prediction 3 stated that the effects of a final syllable's underlying vowel weight would primarily be observed in syllables that contain both a coda and a heavy vowel because vowel length is retained only in closed final syllables in French. We find no significant interaction for maximum pitch (see panel A of **Figure 10**). However, the figure suggests that future analyses should revisit this comparison, since closed final syllables with light vowels (leftmost in panel A) seem to show much smaller differences in cue values compared to those found in other panels.

Turning to duration (panel B), we find a significant interaction between the presence of a coda and vowel weight in the final syllable ($\beta = 0.4866$, $p = 0.0006$). However, while it seems that closed syllables are longer when they contain a heavy vowel, data inspection reveals that the interaction predominantly reflects that the final syllable's weight is instead affecting duration in the penult.[18]

As for amplitude RVs, we find a large and significant interaction ($\beta = 4.8909$, $p = 0.0007$), revealing that light syllables pattern differently from heavy syllables. Panel C of **Figure 10** shows that the final syllable has lower amplitude than the penult when the final syllable has neither a

[18] Figure 10 underreflects this finding as a result of a morphological interaction whereby base-final syllables appear to gain prominence. We leave further exploration of this issue for future work due to data limitations.

coda nor a heavy vowel. In open final syllables that have a heavy vowel, the last two syllables of the word have roughly equal amplitude, while closed final syllables have greater amplitude than the penult that precedes them.

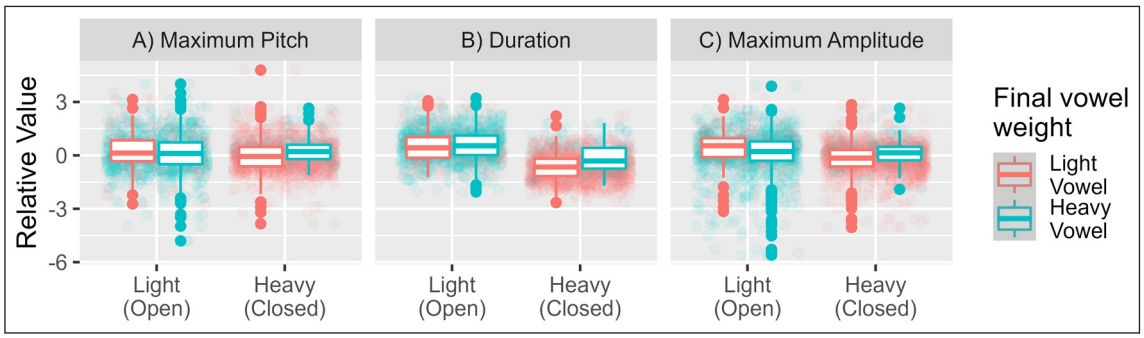

Figure 10: Results for the interaction between coda weight (x-axis) and vowel weight (colours).

4.5 Summary of results

All acoustic cues are affected by weight and prosodic context. Our results suggest that the basic patterns for marking prosodic domains in Laurentian French match the patterns for other dialects. Crucially, our predictions hold for weight: heavy syllables are associated with greater prominence than light syllables. We discuss the implications of these results next.

5 Discussion and conclusion

The results of this study confirm that prominence shift does occur in Laurentian French, where the acoustic cues associated with prominence are realised on the penult. In the analysis that follows, we show that, although this phenomenon is probabilistic such that the location of prominence cannot consistently be predicted for any given token, it is not arbitrary once we examine the broader patterns.

5.1 Marking prosodic domains

As discussed in Section 2, it was necessary to consider how speakers mark prosodic domains in order to test our hypothesis that weight conditions the location of prominence assignment and that the same acoustic cues are modulated for lexical and phrasal properties. In Section 5.1.1, we detail how pitch is used to mark APs and assertive IPs. In Section 5.1.2, we discuss our results in relation to the mixed results found for duration in the literature. Finally, in Section 5.1.3, we contribute to the relatively limited information in the literature on the manipulation of amplitude to mark phrases in French.

5.1.1 Pitch

We found that IP-final syllables have significantly lower maximum pitch than the AP's final syllable does. This is consistent with Laurentian French speakers marking APs with a rising (LH*) bitonal unit and with IPs being assigned an additional low boundary tone (L%) that replaces any tone assigned to the AP-final syllable. This result suggests that, at least with respect to general pitch contours, Laurentian French follows the same system as other dialects. These results are also consistent with Prediction 1 that prosodic domains are distinguished at least in part by the pitch contours at their right edge.

5.1.2 Duration

We found only a very small rhyme duration difference between APs and IPs, with IPs tending to have longer final syllables compared to APs. That we did not find a robust result is consistent with the mixed results found in the literature for other dialects (see Section 2.3); the durational difference between APs and IPs may be very small, highly variable or non-existent, which leads to certain studies finding that final syllables in IPs get compressed, others finding that final syllables are further lengthened, and some studies not being able to conclude either way. Given that the results across studies are so mixed, and based on our relatively marginal result, our expectation that higher domains would show greater degrees of lengthening cannot be confidently confirmed (consistent with Prediction 1).

We conjecture, however, that the presence of mixed results across studies may be a consequence of the type of data analysed. In the present study (on read speech), speakers were not required to plan the content of upcoming phrases; they only had to retrieve lexical entries, potentially reducing the need to slow down at the end of an IP to facilitate planning the next prosodic domain. Future work should test the possibility that speech planning and discourse constraints are responsible for differences in the degree of phrase-final lengthening. If greater lengthening in IP-final tokens reflects planning limitations (with lengthening providing more time to plan upcoming words) or conversational cues (for example, signalling that the speaker is not ceding the floor), then perhaps IP-final lengthening is sensitive to speech context.

5.1.3 Amplitude

Lastly, we found that IPs have lower relative amplitude than APs do, seemingly contrary to Prediction 1 that amplitude would not be used as a cue to phrasal prominence. While this may suggest that amplitude could be directly manipulated by speakers as a cue because a gradual decrease in amplitude could signal that the right edge of the current IP has not yet been reached, cross-linguistic evidence leads us to believe that amplitude is not intentionally used by speakers to mark the right edge of prosodic domains.

Based on findings from German (Poschmann & Wagner 2016) and Vietnamese (Brunelle 2016), we suggest that the results obtained reflect aerodynamic and physiological effects. In particular, the articulatory force will be lowest IP-finally, leading to a decrease in amplitude unless the speaker intentionally counters these effects (e.g. to hold the floor). If the syllable that is assigned default prominence (signalled through higher pitch and longer duration) has lower amplitude and this results from a gradual decrease throughout the phrase, then it seems unlikely that amplitude is being intentionally manipulated to signal phrasal prominence. This reduction is instead aerodynamic in nature.

However, even if amplitude is not consciously manipulated by speakers, it could still be used as a perceptual cue by listeners. This proposal is not only consistent with the cross-linguistic acoustic work just mentioned, but we believe it is also supported by the results of a previous perceptual study on French speakers. Schwab & Llisterri (2012) found that French speakers learning Spanish readily attended to amplitude to identify stressed syllables in Spanish although Féry (2013) contends that amplitude is not a possible cue to prominence in French and amplitude is typically not tested in perception studies of French prominence. Future work could test whether speakers of French use amplitude for parsing phrases and whether it is therefore a candidate for transfer: French speakers could repurpose this cue that marks IP boundaries in their native language in order to identify stress in a second language.

5.2 Signalling weight

Our results provide support for the hypothesis in (1) that prominence assignment in French is sensitive to weight. Only three studies to our knowledge have quantitatively examined the relationship between weight and prominence in French. The first (Paradis & Deshaies 1990) is a perceptual study on Laurentian French that found that listeners were more likely to categorise closed syllables as prominent. The second (Bardiaux & Boula de Mareuïl 2012) demonstrates that Belgian French speakers perceive syllables with phonemically heavy long vowels as prominent. The final study (Thibault & Ouellet 1996) demonstrates that pitch contours from prominence shifting to the penult (using heavy vowels to elicit tokens) are distinct from those that arise under focus in Laurentian French, and therefore that penultimate prominence cannot be explained by focus. The current study, we believe, is the first to examine both vowel and coda weight when probing prominence assignment, as well as the first to consider all prominence cues when testing weight effects. The results align with earlier work motivating the existence of weight contrasts based on segmental processes in French (e.g. Scullen 1997; Armstrong 1999) and suggest that final prominence is assigned rather than being lexically specified (as in Di Cristo 2000; Astésano & Bertrand 2016).

Beginning with coda weight, which was expected to significantly attract prominence based on Prediction 2, we observe that a final coda increases the relative prominence of the final syllable, affecting pitch, amplitude, and duration. Similarly, closed penults show an increase in RV for

these same cues. Our results suggest not only that these cues signal weight, but additionally, that only one syllable is targeted by these effects, and the other may even show *decreased* values for the cues. These results are consistent with a phonological representation of weight, like the mora (Hyman 1985; Hayes 1989); relative durations are computed by comparing the weights of the final two syllables. In Section 2.1, we noted that there is some debate about whether word-final consonants in French are truly codas or whether they are instead onsets of empty-headed syllables. Given that both word-medial and word-final consonants in the data examined attract prominence, we conjecture that, at least in Laurentian French, they are best analysed as weight-bearing codas because analysing word-final consonants as onsets of empty-headed syllables suggests that word-final consonants and word-medial consonants should pattern differently. We leave further testing of alternatives – such as the possibility that only a subset of word-final consonants pattern as onsets, which could motivate the rare instances of antepenultimate prominence observed by Jun & Fougeron (2002) – for future work.

Our results suggest that heavy penult vowels attract prominence, consistent with heavy vowels contributing to syllable weight in Laurentian French, as we observe for codas. However, final syllables pattern differently from penults in this respect; a heavy vowel in the final syllable is not sufficient to retain prominence on that syllable. Instead, vowel weight only has a slight effect in enhancing final syllables that are heavy by virtue of being closed, either making that syllable more prominent or further decreasing the likelihood that prominence shifts to the penult. This suggests that closed syllables containing a heavy vowel may be phonologically heavier than closed syllables containing a light vowel and, thus, that the label superheavy may be an appropriate characterisation of the phonological behaviour of these syllables. This result is particularly noteworthy because it confirms that underlyingly heavy (oral) vowels in open final syllables pattern as short for prominence assignment, which accords with the unavailability of diphthongisation in that position (see Section 2.1).

In summation, we have found evidence of weight effects for vowels as well as codas for all three acoustic cues, consistent with our predictions, but we observe that these effects are not identical. Heavy vowels only pattern as heavy (i.e. attract prominence) when they are not in open final syllables, while codas show the same prominence-attracting property in both penultimate and final syllables. As such, while prominence assignment is probabilistic, the conditions under which prominence shift is most likely to occur are not arbitrary. Based on examples from other varieties of French (see Section 2.1), we expect that these conditions are not confined to Laurentian French; instead, weight sensitivity should contribute to prominence shift across varieties. A dialect's propensity for prominence shift should, however, depend on its phoneme inventory. As proposed by Lamontagne (2020), the loss of vowel contrasts associated with weight may form a feedback loop with reduced propensity for prominence shift because weight contrasts become less salient while the motivation for prominence shift is also lost.

Indeed, Fónagy's (1980) claim that the prosodic system of French is in flux could relate directly to changes in phonological inventories across dialects. For example, the rate of prominence shift in Parisian French is likely to be decreasing because contrasts between the two mid-vowel series (e.g. heavy /e/ and light /ɛ/) have been or are being lost (e.g. Berit Hansen 2012). This is further supported by penult durations having decreased relative to final syllables since the turn of the 20th century in France but not in Laurentian regions (Léon & Jackson 1971; Boula de Mareuïl et al. 2008; Martin 2011), giving merit to Martin's (2004) characterisation of prominence shift as an archaic tendency. Given the potential for prominence patterns to diverge across varieties due to phonological considerations, future work should test for weight sensitivity in other dialects, compare dialects' vowel inventories with their prominence shift patterns, and verify whether (word-final) codas contribute to weight.

5.3 Implications for the prosodic system of (Laurentian) French

Although Laurentian French may exhibit more frequent prominence shift because of its conservative phonemic inventory, our results demonstrate that the marking of prosodic domains in this dialect is consistent with what has been found for other dialects. The cues used to mark prosodic domains also signal weight, which means that these factors interact to produce the prominence patterns we observe. Heavy syllables attracting prominence therefore has important repercussions for our understanding of the prosodic system itself.

At the least, prominence, including the assignment of the AP's H* tone, appears to play a different role in the grammar of French than conventionally proposed; *word*-level factors (i.e. weight) influence the prosody of a *phrase*, while previously it was typically assumed that only phrase-level information was relevant (barring the inability to assign prominence to a phrase-final schwa). This may account for speakers' judgments in perceptual studies being variable and difficult to interpret (e.g. Paradis & Deshaies 1990; Schwab & Llisterri 2012) and may have led to the characterisation of French speakers as "stress deaf" (e.g. Dupoux et al. 1997; Peperkamp & Dupoux 2002). If only the location of phrasal domain edges is presumed to be relevant for prominence assignment and stimuli are resynthesised without taking word-level factors into account, then we might expect speakers to provide inconsistent responses in experimental settings when faced with conflicting acoustic information and uncertainty as to which aspect of prominence they are asked to identify (see e.g. Frost 2011; Li et al. 2017). For instance, Li et al. (2017) observe that Hexagonal French speakers perceive penults as "stronger" unless the final syllable is sufficiently enhanced through amplitude, pitch or duration. Given earlier literature on French, this result is surprising, but our results suggest an explanation. We have shown that acoustic cues other than pitch contribute to prominence. Further, the final syllable was light in their experiment, increasing the availability of prominence shift.

Signalling word-level factors (weight) using the same cues as those used to mark prosodic domains has implications beyond explaining otherwise surprising results in perceptual studies. In particular, it helps shed light on the type of prominence system that French employs. In Section 2.3, we mentioned that APs are marked with an LH* tone, described as a pitch accent, but we did not elaborate on how French prominence is best categorised. Authors differ in whether they label final prominence as stress (e.g. Cutler 2005; Schwab & Llisterri 2012), as a pitch accent (e.g. Jun & Fougeron 1995; Welby 2006; cf. also Rossi 1980), or whether they do not formally categorise it (e.g. Vaissière & Michaud 2006). In the literature, those who refer to prominence as a pitch accent rarely discuss their motivation for doing so: prominence is assigned to the last non-schwa vowel in the AP like a boundary tone would be. It may therefore be that the pitch accent notation is used because the tone is assigned by a domain that cross-linguistically assigns pitch accents (as per Gordon 2014). In other words, the pitch accent notation in French would reflect the *domain* of assignment but it may not be intended to indicate that the tone is *formally* a pitch accent: pitch is used to signal lexically prominent syllables, with the phonological assignment occurring in the phrasal domain.

As we have just noted, the formal description of obligatory final prominence in French is debated. On one hand, since many studies refer to the prominence in French as stress, it should be assigned at the level of the word and therefore its location should be sensitive to word-level properties, notably weight. On the other hand, since French prominence is often described as phrasal or post-lexical, it should not be sensitive to word-level properties (e.g. Jun & Fougeron 1995; Féry 2013). In this paper, we have shown that the H* tone patterns like a pitch accent in that H* is attracted to the rightmost heavy syllable, which leads to the pitch peak being on heavy penults when the final syllable is light. This is consistent with what we observe in pitch accent systems cross-linguistically in that phrasal tones or tone contours are assigned to lexically prominent syllables (Hyman 2006; van der Hulst 2011; Gordon 2014). We therefore conclude that (Laurentian) French is best categorised as a pitch accent language in which weight is a factor in determining prominence in the lexical domain.

Supplementary materials

Supplementary material 1

Text of the read passage used in the *Phonologie du français contemporain* corpus in the original French.

Le village de Beaulieu est en grand émoi. Le Premier Ministre a en effet décidé de faire étape dans cette commune au cours de sa tournée de la région en fin d'année. Jusqu'ici les seuls titres de gloire de Beaulieu étaient son vin blanc sec, ses chemises en soie, un champion local de course à pied (Louis Garret), quatrième aux jeux olympiques de Berlin en 1936, et plus récemment, son usine de pâtes italiennes. Qu'est-ce qui a donc valu à Beaulieu ce grand honneur? Le hasard, tout bêtement, car le Premier Ministre, lassé des circuits habituels qui tournaient toujours autour des mêmes villes, veut découvrir ce qu'il appelle « la campagne profonde ».

Le maire de Beaulieu – Marc Blanc – est en revanche très inquiet. La cote du Premier Ministre ne cesse de baisser depuis les élections. Comment, en plus, éviter les manifestations qui ont eu tendance à se multiplier lors des visites officielles ? La côte escarpée du Mont Saint-Pierre qui mène au village connaît des barrages chaque fois que les opposants de tous les bords manifestent leur colère. D'un autre côté, à chaque voyage du Premier Ministre, le gouvernement prend contact avec la préfecture la plus proche et s'assure que tout est fait pour le protéger. Or, un gros détachement de police, comme on en a vu à Jonquière, et des vérifications d'identité risquent de provoquer une explosion. Un jeune membre de l'opposition aurait déclaré: « Dans le coin, on est jaloux de notre liberté. S'il faut montrer patte blanche pour circuler, nous ne répondons pas de la réaction des gens du pays. Nous avons le soutien du village entier. » De plus, quelques articles parus dans La Dépêche du Centre, L'Express, Ouest Liberté et Le Nouvel Observateur indiqueraient que des activistes des communes voisines préparent une journée chaude au Premier Ministre. Quelques fanatiques auraient même entamé un jeûne prolongé dans l'église de Saint Martinville.

Le sympathique maire de Beaulieu ne sait plus à quel saint se vouer. Il a le sentiment de se trouver dans une impasse stupide. Il s'est, en désespoir de cause, décidé à écrire au Premier Ministre pour vérifier si son village était vraiment une étape nécessaire dans la tournée prévue. Beaulieu préfère être inconnue et tranquille plutôt que de se trouver au centre d'une bataille politique dont, par la télévision, seraient témoins des millions d'électeurs.

Supplementary material 2

Model outputs for maximum pitch relative values (maximum pitch in the final rhyme subtracted from maximum pitch in the penult rhyme). P-values calculated using Satterthwaite approximation.

	Estimate	Std. Error	df	t-value	p-value	
(Intercept)	–1.1343	0.2724	111.4	–4.164	0.0001	***
AP vs. IP	1.1817	0.2105	99.7	5.612	<0.0001	***
AP&IP vs. Comma	–0.8607	0.1746	93.0	–4.929	<0.0001	***
Base-final penult	0.3047	0.1677	109.4	2.04	0.0464	*
Closed final syllable	–0.1440	0.3668	196.6	–2.631	0.0139	*
Closed penult	1.1533	0.1812	137.3	7.215	<0.0001	***
Heavy final vowel	–0.1859	0.3606	200.8	–0.515	0.6070	
Heavy penult vowel	0.2493	0.2749	91.5	1.817	0.0720	.
Superheavy final syllable	–0.1119	0.6721	209.6	–0.366	0.7146	

Supplementary material 3

Model outputs for maximum amplitude relative values (maximum amplitude in the final rhyme subtracted from maximum amplitude in the penult rhyme). P-values calculated using Satterthwaite approximation.

	Estimate	Std. Error	df	t-value	p-value	
(Intercept)	1.3877	0.6574	111.4	2.111	0.0370	*
AP vs. IP	1.9705	0.5863	99.7	3.361	0.0011	**
AP&IP vs. Comma	–0.3995	0.4927	93.0	–0.811	0.4196	
Base-final penult	0.4822	0.4533	109.4	1.064	0.2900	
Closed final syllable	–3.1101	0.4576	196.6	–7.31	<0.0001	***
Closed penult	2.0582	0.7670	137.3	2.683	0.0084	**
Heavy final vowel	–0.3573	0.8689	200.8	–0.411	0.6813	
Heavy penult vowel	0.9189	0.6288	91.5	1.461	0.1483	
Superheavy final syllable	4.8909	1.4404	209.6	3.396	0.0007	***

Supplementary material 4

Model outputs for rhyme duration relative values (final rhyme duration subtracted from penult rhyme duration). P-values calculated using Satterthwaite approximation.

	Estimate	Std. Error	df	t-value	p-value	
(Intercept)	–0.6097	0.0696	111.8	–8.763	< 0.0001	***
AP vs. IP	–0.1068	0.0570	100.0	–1.873	0.0480	*
AP&IP vs. Comma	–0.0387	0.0479	93.3	–0.808	0.4215	
Base-final penult	–0.2454	0.0438	109.7	–3.317	0.0012	**
Closed final syllable	–0.9202	0.0911	197.2	–10.101	< 0.0001	***
Closed penult	0.6992	0.0710	137.7	9.845	< 0.0001	***
Heavy final vowel	–0.2662	0.0864	201.4	–2.376	0.0184	*
Heavy penult vowel	0.1881	0.0602	91.8	3.126	0.0024	**
Superheavy final syllable	0.4866	0.1412	210.2	3.447	0.0006	***

Data availability statement

The corpus is available through the *Phonologie du français contemporain* project website (https://www.projet-pfc.net/).

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Competing interests

The authors have no competing interests to declare.

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