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Research Article

Phonotactic restrictions condition the realization of vowel nasality and nasal coarticulation: Duration and airflow measurements in Québécois French and Brazilian Portuguese

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ABSTRACT

This study examines the nasal airflow and duration patterns of vowels and nasal appendices in Québécois French (QF) and Brazilian Portuguese (BP) in order to determine if phonotactic restrictions on nasal and nasalized vowels have an influence on the realization of nasality contrasts. Results show that QF nasal vowels in syllables with more possible contrastive structures (Ṽ$ vs. VN$) show less variability than nasal vowels in syllables with more limited contrasts (ṼC$ does not contrast with *VNC$). Furthermore, nasal airflow of VN sequences rises earlier in syllable structures in which the distribution of nasal and nasalized oral vowels is restricted (VN$, but *Ṽ N$) than in those in which the distribution is not restricted (V$N and Ṽ$N are both possible). BP, which has stricter phonotactic restrictions on vowel nasality than QF, exhibits greater overall variability in the nasal airflow of V$N sequences and in the duration of nasal appendices. This supports the hypothesis according to which contrast *in context* influences the realization of phonological contrasts as well as of coarticulation.

1. Introduction

In this paper, we examine the hypothesis that the phonotactic distributions of phonological nasal (Ṽ) and coarticulatorily nasalized vowels (VN sequences) in Québécois French (QF) govern the amount of phonetic variation and coarticulation they exhibit. Concretely, we aim to determine if contrast between phonological nasal vowels (Ṽ) and oral vowels followed by nasal consonants (VN sequence) *in the same phonotactic environment* constrains the amount and variability of coarticulation (*contrast-in-context* hypothesis), as opposed to other phonotactic environments in which the contrast is not found. We then compare QF with Brazilian Portuguese (BP), a language that has different phonotactic constraints on vowel nasality, to verify if the generalizations inferred from QF can be extended to other languages. Based on previous literature on contrast-related coarticulatory constraints (Choi, 1995; Dow, 2014; Manuel, 1990; Manuel & Krakow, 1984; Spears, 2006), we expect that the phonetic realization of coarticulatory nasalization is constrained by contrast, but that rather than merely counting contrastive units in raw inventories, one may have to look at the distribution of contrasts in specific phonotactic environments. We attempt to answer these questions by investigating nasal appendix duration and nasal airflow patterns in both QF and BP.

1.1. Phonetic implementation and coarticulation

It has long been suggested that phonological contrast forces phonetic distinctiveness (Brunelle, 2009; Choi, 1995; Manuel, 1990; Manuel & Krakow, 1984). For example, Manuel and Krakow (1984) compared English, Shona and Swahili, and claimed that vowel-to-vowel coarticulation is stronger in languages that have small inventories, since confusion could occur more easily when the vowel space is more crowded (Manuel, 1990; Manuel & Krakow, 1984). The claim that the size of inventories has a direct influence on coarticulation has since been revisited, and it is now uncontroversial that many other factors influence coarticulation (Beddor, 2009; Beddor, Harnsberger, & Lindemann, 2002; Iskarous & Kavitskaya, 2010; Mok, 2010, 2011, 2012; Recasens, Pallarès, & Fontdevila, 1997). For example, Mok (2011) investigated the effects of vowel duration and vowel quality on

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vowel-to-vowel coarticulation and found that although the phonological duration of Thai vowels did not impact coarticulation, /a/ was more susceptible to it than /i/ and /u/, a pattern that cannot be accounted for by the size of the inventory. There is also evidence that coarticulation is constrained by contrast in specific contexts or sub-inventories. For instance, Spears (2006) and Dow (2014) have found that the French high vowel /i/ can be more nasalized than other oral vowels, allegedly because it does not contrast with a nasal high front vowel */ĩ/.

Beyond contrast, it has been proposed that phonological vowel nasality is realized with a plateau-like pattern of nasal airflow throughout the vowel, while regressive coarticulatory nasalization is realized with a gradually rising nasal airflow (Cohn, 1990, 1993). However, recent studies have not systematically found a plateau-like pattern in French nasal vowels (Carignan, 2013; Delvaux, 2012; Delvaux, Demolin, Harmegniew, & Soquet, 2008) despite their contrastive status. Consequently, we do not assume that plateau-like patterns of nasal airflow will be found in QF phonological Ṽs, but we nonetheless expect that different patterns of nasal airflow in phonological Ṽs and coarticulatory VN sequences will maintain the contrast between the two vowel types.

In the current study, we explore the role of phonotactic restrictions in constraining the realization of vowel nasalization and nasality, focusing on nasal coarticulation by looking at patterns of nasal airflow and at the duration of nasal appendices, i.e. voiced nasal excrescences found between a phonological nasal vowel and an oral stop, in QF and BP. An ancillary aim of this study is to further investigate the patterns of vowel nasality in QF and BP to assess the distribution of plateau-like and cline-like nasal airflow patterns.

1.2. Vowel nasalization in (Quebec) French

QF, like other varieties of French, has Ṽs that are nowadays generally considered monophonemic (Paradis & Prunet, 2000 for a notable exception). There is for instance internal evidence that contrastive Ṽs are not underlyingly formed by a VN sequence, but are the surface realization of lexically-specified nasality on the vowel. For example, minimal triads of distinctive words containing an oral vowel, a Ṽ, and a VN sequence can be found: e.g. *pas* /pɑ/ ‘step’ ∼ *paon* /pã/ ‘peacock’ ∼ *panne* /pan/ ‘breakdown’.

As can been seen in Table 1, QF has twelve oral vowels (thirteen when including /ə/, see Martin, 1998) and four Ṽs (boldfaced) /ẽ, ã, ɔ̃, œ̃/. Note that the transcriptions provided in Table 1 do not necessarily correspond to the traditional notation used in the literature on QF phonology, but are meant to closely reflect the phonetic realization of QF vowels (e.g. /ẽ/ instead of /ɛ̃/). The symbol <ã> is also used throughout this paper to transcribe the vowel /ã/ and its positional allophone [ã], which appears in prosodic word-final open syllables.

Nasal vowels can be found in the nucleus of several syllable types in QF, either open (e.g. *banquet* [bã.kɛ] ‘banquet’; Ṽ$C) or closed (e.g. *banque* [bãk] ‘bank’; Ṽ C$). In open syllables, they are opposed to sequences of an oral vowel followed by a nasal consonant (VN$) (e.g. *camp* [kã] ‘camp’ ∼ *canne* [kan] ‘cane’; also within words *canton* [kã.tɔ̃] ‘township’ ∼ *caneton* [kan.tɔ̃] ‘duckling’). However, in closed syllables (Ṽ C$), they are not opposed to VN sequences (*VNC$), as coda clusters containing nasal consonants as their first element are not permitted in French (e.g. *banque* [bãk] ‘bank’ Ṽ C$ ∼ *[bank] *VNC$). Furthermore, it is worth noting that phonological Ṽs can be followed by a nasal consonant in a following syllable onset (Ṽ $N) in compounds (e.g. *grand-mère* [gʁã.mɛʁ] ‘grandmother’), in a limited number of lexical items (e.g. *ennuyer* [ã.nɥije] ‘to miss (something/someone)’) or when the French *liaison* process applies in a number of high-frequency clitics (e.g. after *un* [œ̃] ‘a/one’, as in the phrase *un ami* [œ̃.nami] ‘a friend’). These structures admittedly involve complex phonological patterns, but the resulting surface distributions are nonetheless common. Importantly, phonological Ṽs followed by a phonological nasal coda are unattested in French (*Ṽ N$).

Table 1
Québécois French phonemic vowel inventory (adapted from Martin, 1996, 2002).

	Front		Central	Back
	Unrounded	Rounded		
High	i	y		u
Mid-high	e/ẽ	ø		o
Mid-low	ɛ/ɛː	œ/**œ̃**	(ə)	ɔ/**ɔ̃**
Low			a/**ã**	ɑ

It is well established that the onset of nasalization starts relatively late in QF phonological Ṽs (Carignan, 2013; Léon, 1983). Consequently, phonological Ṽs and regressively nasalized vowels have similar rising nasal airflow contours, while progressively nasalized vowels are expected to have fairly distinct (falling) contours (see Delvaux et al., 2008). We will not look at progressive nasalization in this study because it should not threaten the contrast between nasalized oral vowels and phonological nasal vowels in QF. It would not allow us to address the theoretical question of the influence of contrast within syllabic contexts on the realization of phonological nasality and coarticulatory nasalization.

It is important to keep in mind that French Ṽs are more than just oral vowels with added velic movement. In addition to velum lowering, several other articulatory properties distinguish them from their oral counterparts, such as their tongue position and pharyngeal aperture. In his detailed investigation of twelve speakers of Northern Metropolitan (Paris) French, Carignan (2014) shows that for the vowel [ɛ̃], the tongue tends to be lower and more retracted than for its oral counterpart [ɛ]. Similarly, the tongue position is generally more retracted for [ɑ̃] than for [a] (for 11/12 speakers), while tongue-raising in [ɔ̃] is also attested but less consistent across participants. For the [o]-[ɔ̃] pair, speakers tend to produce the Ṽ with a lower tongue position than [o]. Other articulatory differences between nasal and oral vowels, such as the degree of lip rounding and of pharyngeal constriction, are also underlined by the author. Also note that research has shown that modifications in the articulation of phonological nasal vowels when compared to their oral counterparts have been observed in other languages such as Hindi (Shosted, Carignan, & Rong, 2012).

Studies on the articulation of Ṽs in QF are scarce and limited to small participant samples (see Delvaux, 2006, and Carignan, 2013). However, Delvaux (2006) analyzed lip rounding, tongue ultrasound and airflow data from five native speakers of (Montreal) QF and found that, compared to European French speakers, their Ṽs were generally less nasalized and