Variation
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nasal vowels sometimes occur with a nasal appendix, characterized by the abrupt loss of any formant structure exceeding 1000 hertz and the appearance of a very low-frequency voiced nasal formant (Ohala & Ohala 1991). Given that nasal vowels are very often historically derived from nasal consonants in coda position, this appendix occurs in the same position as the nasal consonants still present in the language. French offers us an interesting situation in this regard, given the productive alternation between these two classes of segments. For example, many nouns and adjectives distinguish the masculine from the feminine by the alternation $V_{nas}\# \sim V + C_{nas}\#$, (1)a. Liaison shows the same alternation with or without denasalization of the vowel (1)b and c. Moreover, many nasal vowels are never involved in this kind of alternation, (1)d. Furthermore, certain varieties in the South of France produce nasal vowels as a sequence $V_{nas} + C_{nas}$ or $V + C_{nas}$, (1)e (Durand 1998).

(1)  a. $[bõ] \sim [bɔn]$  bon $\sim$ bonne ‘good’ (masc. and fem.)
   b. $[bɔn a m i]$  bon ami ‘good friend’
   c. $[s õ n a m i]$  son ami ‘his friend’
   d. $[l â s e]$  lancer ‘to throw’
   e. $[p ã n t] \sim [p a n t]$  pente ‘slope’

Given the data in (1), two questions arise. The first concerns the phonetic conditions contributing to the appearance of this appendix. The second concerns its phonological relationship with the nasal consonant that is both diachronically and synchronically linked to this position, particularly if the alternations illustrated above in (1)a and b are analyzed on the basis of phonological nasal consonants.

Our principal aim is to describe the distribution of the nasal appendix as a function of the immediate segmental environment as well as with regard to the origin of the nasality of the vowel. We examine the potential relationship of the appendix to an underlying nasal consonant in a corpus of French speakers from the Windsor region of Canada. Section 2 examines the presence of the nasal appendix in light of the phonetic analysis of Ohala and Ohala (1991). In section 3, we discuss the methodology. The results are presented in section 4, beginning with a discussion of the phonetic context surrounding the appearance of this nasal appendix with the aid of a multivariate analysis, followed by a study of the duration of the nasal appendix. The article closes with a discussion of our findings.
occurs after the vowel [ɛ] of the word *vin* ‘wine’, while the second occurs after the vowel [ã] of *blanc* ‘white’. In the first case, the following consonant is the voiced stop [b], a fertile context for the production of the appendix according to Ohala and Ohala (1991), while in the second case, the context to the right is the voiceless fricative [s], a context that is not reported in their analysis. For comparison purposes, a true nasal consonant [n] in postvocalic position is distinguished from the appendix by means of a longer duration and a larger nasal formant.

Ohala and Ohala (1991, 1993) discuss the nasal appendix in Hindi and in French from samples of monitored speech that use exclusively stops in the following context. These two languages both have nasal vowels that are historically derived from *V + C*nas sequences, all the while maintaining the possibility of true nasal consonants occurring in post-vocalic position. The authors therefore analyse the *V*nas + appendix + *C* sequences as cases of prenasalised stops, the appendix being the result of the incomplete raising of the velum leading to velar leak. Their analysis is as follows:

The question we need to answer is: ‘Why should voiced stops tolerate velar leakage during the first part of their closure and still be perceived as voiced stops?’ The reason may be that among the auditory cues for a voiced stop, there must be a discontinuity of the spectrum and amplitude with respect to neighbouring sonorants (if any), low amplitude voicing during its closure, and termination in a burst. These requirements are still met, even with velar leakage during the first part of the stop, as long as the velar valve is closed just before the release and pressure is allowed to build up behind the closure. However, voiceless stops have less tolerance for such...
leakage because any nasal sound—voiced or voiceless—undercuts either their stop or their voiceless properties. (1991:213)

Thus, if the consonant is a voiced noncontinuant, the appearance of the appendix is linked to the coarticulation of the nasal vowel and the following consonant, the prolonged nasality (or the incomplete closure of the velum) having no major consequences for perception. The authors do not exclude the possibility of the appendix occurring before a voiceless stop, but in this case the stop duration would be much shorter.

More recently, Adda-Decker et al. (2006) examine tokens of nasal vowels in six varieties of continental French, three of these from the South of France, taken from the *Phonologie du français contemporain* (PFC) surveys (reading passage for 36 speakers). More than 15% of the nasal vowels produced in the Northern France varieties show an appendix, compared to nearly 40% in the Southern varieties. In the majority of cases, the appendix is identified as [n] and sometimes [m] for speakers from the South. Moreover, nearly half of all tokens appear after [ã]. However, the authors indicate neither the context immediately following a nasal vowel token nor the duration of an appendix. Finally, the nasal appendix regularly occurs after a denasalized vowel.

Unlike the data from Adda-Decker et al. (2006), the nasal vowels of our corpus are not denasalized when accompanied by an appendix. In fact, the appendix is not perceived by native speakers and is therefore not identified as an [m] or an [n]. Furthermore, as is clear in the next section, the appendix even occurs occasionally before a fricative or a pause.

### 3. Methodology.

#### 3.1. The Data. Our four female speakers, ranging in age from 16 to 88, are drawn from the PFC-Windsor corpus (Poiré & Kelly 2003). The PFC project (Durand, Laks & Lyche 2003) is a vast dialectological survey initiated in 2000 which seeks to create a database of spoken French from all Francophone regions worldwide. Each survey includes twelve speakers who are asked to read a word list and a short text, as well as to participate in a semi-directed conversation and in a free conversation. For this study we examine data from two styles: the reading passage (400 words or two minutes in length) and the semi-directed conversation (five minutes of speech). In the case of the reading style, it is a matter of comparing the appendix from our corpus to those described in the literature (Ohala & Ohala 1991, 1993; Maddieson & Ladefoged 1993), which are usually drawn from corpora of monitored speech. We include an analysis of the second style in order to study the phenomenon in spontaneous speech.

The francophone community of Windsor, Canada exists in a minority situation, and for this reason a large number of its members show obvious signs of influence from English (Béniak & Mougeon 1989). Since nasal vowels are absent from the phonological inventory of the dominant language, it is possible that this influence shows up through a difference in vowel nasality (Delattre 1965) having a potential effect for the nasal appendix. Speakers AA1 and AA2 demonstrate a variety of French which shows a number of apparent traces of English; thus, the label AA, Anglais ‘English’ indicates an English dominant speaker showing obvious signs of influence from English. This is not, however, the case for speakers FF1 and
FF2, for whom the label FF indicates a French dominant speaker with no evidence of influence from English. For historical and social reasons, this factor of the influence of English is often correlated to the age of French-Canadian speakers in a minority situation. Our four speakers are respectively:

(2) AA1: 16 years; AA2: 41 years; FF1: 60 years; FF2: 88 years

The mono recordings (22,000 hertz) are analyzed using PRAAT. All the nasal vowels are segmented including nasal appendices, if any.

Table 1 shows the distribution of the data for each speaker across two styles. Of the 937 nasal vowels analyzed, 34% from the reading passage and 22% from the conversation show the presence of a nasal appendix.

### Table 1. Distribution of data from each speaker across two styles.

<table>
<thead>
<tr>
<th></th>
<th>+appendix</th>
<th>−appendix</th>
<th>total</th>
<th>+appen. (%)</th>
<th>−appen. (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=</td>
<td>%</td>
<td>N=</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA1</td>
<td>28</td>
<td>33 %</td>
<td>55</td>
<td>66 %</td>
<td></td>
<td>83</td>
</tr>
<tr>
<td>AA2</td>
<td>32</td>
<td>35 %</td>
<td>62</td>
<td>65 %</td>
<td></td>
<td>94</td>
</tr>
<tr>
<td>FF1</td>
<td>35</td>
<td>39 %</td>
<td>57</td>
<td>61 %</td>
<td></td>
<td>92</td>
</tr>
<tr>
<td>FF2</td>
<td>26</td>
<td>29 %</td>
<td>64</td>
<td>71 %</td>
<td></td>
<td>90</td>
</tr>
<tr>
<td>Conv.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA1</td>
<td>23</td>
<td>16 %</td>
<td>123</td>
<td>84 %</td>
<td></td>
<td>115</td>
</tr>
<tr>
<td>AA2</td>
<td>35</td>
<td>20 %</td>
<td>149</td>
<td>80 %</td>
<td></td>
<td>184</td>
</tr>
<tr>
<td>FF1</td>
<td>36</td>
<td>28 %</td>
<td>97</td>
<td>72 %</td>
<td></td>
<td>133</td>
</tr>
<tr>
<td>FF2</td>
<td>23</td>
<td>16 %</td>
<td>123</td>
<td>84 %</td>
<td></td>
<td>146</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>937</td>
</tr>
</tbody>
</table>

3.2. Coding the data. Many factors, both linguistically internal and external, are coded in our database; this allows for two types of analysis. The first is a multiple regression analysis using Goldvarb 2001 (Robinson et al. 2001), which allows us to determine the statistically significant factors in the presence of the nasal appendix. The second examines the duration of nasal vowels with and without an appendix. The structural factors coded are the following:

(3) a. presence / absence of the appendix (duration where applicable)
    b. the nasal vowel (and its duration)
    c. the following context (segments, pause)
    d. the nature of the following boundary
    e. the origin of the nasal vowel
Two of these factors require further explanation. First, we are attempting to verify if different types of boundaries occurring between the nasal vowel and the following segment play a role in the appearance of the appendix. If the appendix is viewed as the prenasalization of the following consonant (Maddieson & Ladefoged 1993), it is possible that a strong boundary (word boundary, for example) might impede or at least disfavor the appearance of the appendix.

Secondly, we pay particular attention to the phonological origin of the nasal vowel. Following Tranel (1992), we establish five categories of phonological origins for nasal vowels: derived or not from a nasal consonant, involved or not in morphological alternations, with or without denasalization in liaison contexts.

We also retain extralinguistic factors for the Goldvarb analysis:

\[(4)\]
\[
\begin{align*}
\text{a. speaker} \\
\text{b. age} \\
\text{c. influence from English} \\
\text{d. style}
\end{align*}
\]

Recall that our speakers form two groups with respect to the apparent influence of English on their French pronunciation. However, as we have already mentioned, in these communities, this factor is often related to the speaker’s age. We must then relativize this factor, particularly with such a small sample. But as we will see, neither age nor influence of English, nor the individual speaker’s grammar stand out as statistically significant in predicting the presence of this variable.

4. Results.

4.1. The linguistic context of the appearance of the nasal appendix. The Goldvarb program allows us to evaluate the relative significance of different linguistic and social factor groups in the appearance of a discrete independent variable. After several analyses, three factor groups are identified as having a statistically significant influence on the appearance of the nasal appendix. These are style, nasal vowel quality and the phonotactic context in the following position. Table 2 (overleaf) gives the details of this analysis.

A factor weight of 0.500 and greater favours the application of the variable, while conversely, factor weights inferior to 0.500 disfavor the application of the variable. The greater the range or difference in weight between the highest and the lowest factor in a group, the more significant the effect of that group of factors. Given the smaller, and therefore, less significant range for the factor groups of style and nasal vowel, the range of 53 for the following phonotactic context indicates that this group plays the most significant role in determining the application of the variable. Upon closer examination of the factors in this group, it is clear that a voiced stop remains the principal factor in the appearance of the appendix, which corresponds to the analysis of Ohala and Ohala (1991). However, we find some cases of a nasal appendix before voiceless stops, fricatives and even before pauses. Table 3 (overleaf) shows the distribution of all tokens of nasal vowels with and without a nasal appendix.
We can state, then, that if the consonant following the nasal vowel is a voiced stop, the appendix occurs in more than 50% of the tokens (66% for the reading passage, 56% for conversation). We note also that the fricatives show exactly the opposite situation to that of the stops; whereas voicing in stops favours production of the appendix, it is the lack of voicing that favours the production of an appendix for fricatives in the following context. Observe the absence of the appendix before sonorants and vowels.

<table>
<thead>
<tr>
<th>Input 0.279 NAPP</th>
<th>N</th>
<th>%</th>
<th>Factor weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>reading passage</td>
<td>120</td>
<td>302</td>
<td>39.7</td>
</tr>
<tr>
<td>conversation</td>
<td>122</td>
<td>435</td>
<td>28.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nasal vowel</th>
<th>NAPP</th>
<th>N</th>
<th>%</th>
<th>Factor weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>ã</td>
<td>141</td>
<td>376</td>
<td>37.5</td>
<td>0.571</td>
</tr>
<tr>
<td>ë</td>
<td>53</td>
<td>186</td>
<td>28.5</td>
<td>0.441</td>
</tr>
<tr>
<td>ë</td>
<td>11</td>
<td>42</td>
<td>26.2</td>
<td>0.431</td>
</tr>
<tr>
<td>ë</td>
<td>37</td>
<td>133</td>
<td>27.8</td>
<td>0.403</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phonotactic context (right)</th>
<th>NAPP</th>
<th>N</th>
<th>%</th>
<th>Factor weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>voiced stops</td>
<td>89</td>
<td>147</td>
<td>60.5</td>
<td>0.781</td>
</tr>
<tr>
<td>voiceless stops</td>
<td>81</td>
<td>228</td>
<td>35.5</td>
<td>0.549</td>
</tr>
<tr>
<td>voiceless fricatives</td>
<td>34</td>
<td>152</td>
<td>22.4</td>
<td>0.375</td>
</tr>
<tr>
<td>pause</td>
<td>30</td>
<td>144</td>
<td>20.8</td>
<td>0.365</td>
</tr>
<tr>
<td>voiced fricatives</td>
<td>8</td>
<td>66</td>
<td>12.1</td>
<td>0.247</td>
</tr>
</tbody>
</table>

Table 2. Occurrence of nasal appendix, NAPP = number of vowels with the appendix, N = total number of nasal vowels; % = percentage of nasal vowels with appendix. \( P = 0.009 \).

<table>
<thead>
<tr>
<th></th>
<th>+appendix</th>
<th>–appendix</th>
<th></th>
<th>+appendix</th>
<th>–appendix</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=</td>
<td>%</td>
<td>N=</td>
<td>%</td>
<td>N=</td>
<td>%</td>
</tr>
<tr>
<td>voiceless stop</td>
<td>38</td>
<td>40%</td>
<td>57</td>
<td>60%</td>
<td>43</td>
</tr>
<tr>
<td>voiced stop</td>
<td>44</td>
<td>66%</td>
<td>23</td>
<td>34%</td>
<td>45</td>
</tr>
<tr>
<td>voiceless fric.</td>
<td>17</td>
<td>43%</td>
<td>23</td>
<td>57%</td>
<td>17</td>
</tr>
<tr>
<td>voiced fric.</td>
<td>5</td>
<td>22%</td>
<td>23</td>
<td>78%</td>
<td>3</td>
</tr>
<tr>
<td>Sonorants</td>
<td>1</td>
<td>2%</td>
<td>55</td>
<td>98%</td>
<td>0</td>
</tr>
<tr>
<td>Vowels</td>
<td>0</td>
<td>0%</td>
<td>5</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Pauses</td>
<td>16</td>
<td>23%</td>
<td>56</td>
<td>77%</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 3. Distribution of the nasal appendix for following phonotactic context.

We can state, then, that if the consonant following the nasal vowel is a voiced stop, the appendix occurs in more than 50% of the tokens (66% for the reading passage, 56% for conversation). We note also that the fricatives show exactly the opposite situation to that of the stops; whereas voicing in stops favours production of the appendix, it is the lack of voicing that favours the production of an appendix for fricatives in the following context. Observe the absence of the appendix before sonorants and vowels.
The Goldvarb analysis also shows the relative significance of the nasal vowel quality itself. Table 4 shows the exact distribution of tokens for this factor.

While the vowel [ã] represents more than 50% of the nasal vowel contexts for both styles, it is also the favorable factor in this group, and it is likewise implicated in more than 50% of all tokens with appendix.

4.2. Duration of the Nasal Appendix. More than just favouring the production of a nasal appendix, voiced stops also play a significant role in the duration of the appendix: preceding appendices typically have a longer duration than that which we find for the appendix before a voiceless stop. We have therefore regrouped all tokens of the appendix with respect to voicing of the following consonant (stops and fricatives mixed). We also include the average values for the appendices produced before Pause. Figure 2 shows these results for duration.

We can state that for the four speakers across two styles, the average duration of the appendix is greater if the consonant that follows the nasal vowel is voiced. We also note that the Pause is associated with an average appendix duration that always exceeds that...
of the appendix which is followed by a voiceless consonant, and sometimes exceeds that of the appendix which precedes a voiced consonant. The significance of the following context appears to be confirmed as the principal factor in the production of the appendix and the determination of its duration.

In Figure 3, we compare the total duration $V_{nas} +$ appendix to the duration of nasal vowels that do not exhibit a nasal appendix, in an effort to verify at what point the appendix occurs during the production of the following consonant.

In all cases of the sequence $V_{nas} +$ appendix, the duration is greater compared to that of the nasal vowel that surfaces without the appendix. One possible analysis of the appendix would be to consider the presence of a partially debuccalised nasal consonant (see section 5.2).

5. Discussion and Conclusion.

5.1. The Duration of the Appendix. With respect to the duration of the appendix, there are two points to consider. The first concerns the difference in duration of the appendix preceding a voiced consonant versus that of an appendix preceding a voiceless consonant. Our data confirm that the appendix occurring before a voiced consonant is longer than that which occurs before a voiceless consonant. In addition, we describe the occurrence of the appendix before a pause where the duration is often longer than that of appendices occurring before a consonant. The second point concerns the combination $V_{nas} +$ appendix, where the duration is always greater than that of a nasal vowel occurring without an appendix.

5.2. The Distribution of the Appendix. The Goldvarb analysis identifies three factor groups that favour the production of the nasal appendix: style, vowel quality, and most significantly, the following phonotactic context. Given the small number of speakers in this corpus, we give minimal importance to the non-significance results for the external factors age, English influence and individual speaker. At present, we can offer no explanation for the fact that the reading style slightly favours the production of the nasal appendix over the conversation style. We suggest only that Adda-Decker et al. (2006), using the same reading
passage, also find a high rate of nasal appendix production. In their study, the nasal vowel [a] is involved in a majority of tokens, as is the case in our own analysis. Is this simply a product of the high frequency of this phoneme in French? We cannot say. It would require a much more detailed analysis of this nasal vowel’s quality. For example, in the varieties discussed, are we always dealing with the same back vowel? And why would such an articulation favour an incomplete velic closure? The question is particularly complex, given that Canadian French often discriminates between four possible timbres for a single speaker: [æ], [a], [ɑ] as well as a rounded version of the latter, [ɔ].

How do we interpret the fact that neither the following boundary nor the phonological origin of the vowel are found to be significant in the production of the nasal appendix? In the case of the former factor, an articulatory study might bring us closer to a response. As for the latter, a correlation between the phonological form and the phonetic form does not necessarily translate into an automatic realisation of underlying features.

With respect to the role of the following phonotactic context, our results broadly support the findings of Ohala and Ohala (1991), but unlike their data, our data show cases of a nasal appendix occurring before stops and fricatives, both voiced and voiceless, and even before pauses. With respect to the Windsor French data, voicing in the following segment is clearly not the only factor that determines the presence or absence of the appendix, particularly when the segment is a fricative. We can express the relative probability of seeing an appendix occur by way of a hierarchy as in (5).

(5) Voiced stop > voiceless stop > voiceless fricative > voiced fricative

How then do we reconcile our findings with those of Ohala and Ohala (1991)? We believe that their analysis holds, but we would add to the hypothesis that velic leakage is a frequent phenomenon, independent of the phonotactic context at the right of the nasal vowel, and that it seems to be governed by constraints linked to perception. The presence of the appendix before all consonants and even before pauses is thus not in contradiction with their analysis. It would then be necessary to explain the interaction between nasality and the voicing of the appendix and the perception of fricatives. However, at least for the variety of French in the Windsor region, it seems that another constraint is in play, which does not seem to be the case for the European varieties. This constraint might be expressed as follows: avoid the perception of the appendix as a nasal consonant. If the appendix surfaces before a pause, it does so while often exhibiting considerable duration (Figure 3); it remains nonetheless true that it is not perceived as a nasal consonant by native speakers.

We are presented with two possible analyses for the phonological conditioning of this appendix. The first is that the appendix is the result of coarticulation between the nasal vowel and the following consonant, which Ohala and Ohala (1991) refer to as velic leakage or an imperfect closure of the velum. They attribute the presence of the nasal appendix to a voiced stop in the following context. We can keep this analysis, specifying that the coarticulation effect—and, thus, the presence of the appendix—is conditioned by any following voiced or voiceless stop or fricative as well as before pauses. The second possible analysis postulates the presence of a partially realised phonological nasal consonant
diachronically or synchronically linked to this position (see (2) for examples). We can therefore compare the duration of the nasal appendix to that of the nasal consonants by calculating the duration of nasal vowels both with and without nasal appendices. If the durations of the appendices are comparable to those of the nasal consonants, we could postulate the realisation of a debuccalized phonological nasal consonant—that is to say, a consonant without a specific place of articulation (Harris 1997). This lack of articulatory information would explain the absence of formant structure beyond that of the nasal formant.

This explanation has the advantage of accounting for the fact that an appendix survives, even in the absence of a segment that is voiced and noncontinuant in the following environment. On the other hand, Figure 3 clearly shows that the appendix constitutes an augmented duration of the nasal vowel.

Many questions remain, and the data from a spontaneous speech corpus of this size do not allow us to answer them properly. One solution would be to use a larger corpus of monitored speech offering the same number of tokens for each context and for each nasal vowel. This is how we intend to proceed in the near future.

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1 We wish to thank Keren Rice for her comments at the annual meeting of Lacus, Toronto, August 2006. Thanks also to the anonymous reviewer of this paper for their valuable comments.

2 It is perhaps interesting to note here that, while no perception tests were done to ascertain the nature of the appendix, none of the native speakers of Canadian French for whom we have played samples of passages containing the nasal appendices have reported perception of this phenomenon. However, the appendices were first reported as perceptible by two Anglophone researchers. A future study could perform perception tests on the two groups of native speakers—those of varieties with nasal appendices and those of non-appendix varieties—in order to determine whether the two groups report similarly with respect to their perception of the Windsor appendix.

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REFERENCES


THE NASAL APPENDIX IN CANADIAN FRENCH


