THE CONTEXTUAL EFFECTS OF NASAL VOWELS ON VELOPHARYNGEAL OPENING IN QUÉBÉCOIS FRENCH

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1 Introduction

In oral sound production, the velum is typically held against the posterior pharyngeal wall (PPW), separating the oral and nasal cavities, while for nasal sounds there is a velopharyngeal opening (VPO), allowing sound to resonate in the nasal cavities [1].

Though nasality may be phonologically characterized as a binary feature (e.g., [+nasal] vs. [-nasal]), the phonetic realization of nasalisation is dependent upon a host of other properties both within the segment itself (e.g., vowel height, consonant voicing) and combined with surrounding segments (e.g., coarticulation) [2]. Contextual nasalisation is the coarticulatory nasalisation of a speech segment due to the nasality of the surrounding environment. The nasalisation of an oral sound preceding a nasal segment is referred to as anticipatory nasalisation while the nasalisation of an oral sound following a nasal is referred to as carryover nasalisation [3].

Coarticulation studies attempting to provide insight into the complex interactions of linguistic and physiological factors required for nasalisation have frequently compared the velum's behaviour during anticipatory and carryover nasalisation [2 - 5]. French is the language of reference in the literature due to the contrast in oral and phonemically nasal vowels. Existing literature suggests that the carryover phenomenon demonstrates a greater degree of nasalisation than its anticipatory counterpart for both nasal vowels and nasal consonants [3 - 5]. However, the generalization of such results is limited by indirect measurements of VPO (e.g. airflow, electromagnetic midsagittal articulography), and/or small numbers of speakers incorporated in the methodology.

To verify existing claims regarding the VPO during contextual nasalisation in French, the present study applies a more direct measurement of VPO—the distance between the velum and the PPW—from X-ray data across a larger number of speakers. Furthermore, our data samples come from sentence-level speech, unlike the previous studies which used isolated words, syllables, or vowels. As such, the following experiment investigated the effect of phonemically nasal vowels on the VPO of oral vowels that precede (carryover) or follow (anticipatory) them.

2 Method

2.1 Database

For this experiment, we used the Université Laval X-ray cinefluorographic database [6] of speakers recorded in 1974. We analysed the films of 9 speakers (4 female) of Québécois French aged 19-30 years at the time of data collection.

2.2 Measurement

In order to measure the VPO for each segment we extracted the frames from each video at a rate of 30 fps. In ImageJ [7], we drew a line for the best "path of velum" across the VPO, determined by inspecting stacks of images (See Figure 1). The posterior coordinates of the line were where the velum met the PPW and the anterior coordinates were set at the portion of the velum at rest that first started to move towards the PPW. The number of black pixels along this line was used to determine the degree of opening for each frame (more black pixels = greater opening). The number of pixels was converted to a ratio for each speaker, where 1 = maximally open and 0 = maximally closed.

Figure 1: Example of a "path of velum" line for one speaker.

For segment identification we extracted the audio from the videos, transcribed at the breath-group level, and then ran it through Montreal Forced Aligner [8] to label each segment. Manual adjustments were made as needed. Using a custom Praat [9] script, we extracted the timing and labeling information for each segment. This information, along with the timing of the degree of VPO at each frame was combined and analysed.

2.3 Statistical analysis

Using R [10] we analysed the contextual effects of nasal vowels on oral vowels. As the segments spanned multiple frames, a single VPO measure was calculated by taking the mean VPO across the whole segment. As mentioned before, we looked only at oral vowels that either preceded (anticipatory nasalisation) or followed (carryover nasalisation) phonemically nasal vowels. Instances where there was a nasal segment preceding and following the oral vowel were excluded

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(i.e. ṼVṼ), as to not double count the segments. We ran linear mixed effects models (lmerTest) and an ANOVA to conduct a likelihood ratio test and check for interaction effects. The predictor model had Nasal Context and Sex as fixed effects and intercepts for individual speakers as random effects. P-values were obtained by comparing the predictor model with models without the fixed effect in question.

3 Results

Overall, the average VPO for anticipatory nasalisation (M = 0.28, SD = 0.15) was higher than that of carryover nasalisation (M = 0.22, SD = 0.10) with an indication that the pattern is consistent across both sex groups.

Figure 2 shows the distribution of VPO in anticipatory nasalisation (N = 108) and carryover nasalisation (N = 87) in an oral vowel adjacent to a nasal vowel. The y-axis represents the mean VPO ratio. The x-axis is participant sex.

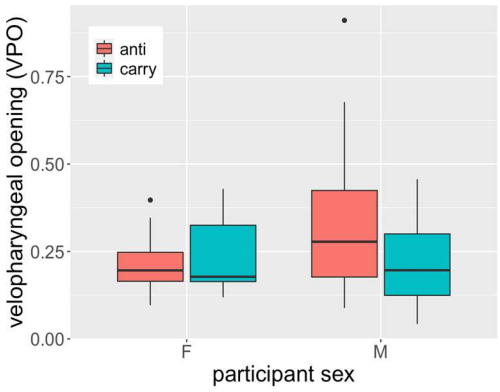

Figure 2: Boxplots of VPO ratio by gender (4F, 5M), for anticipatory and carryover nasalisation due to nasal vowels.

The linear mixed effects analysis revealed a significant interaction effect between Sex and Nasal Context ($\chi 2$ = 10.96, df = 1, p < .001). The summary of the predictor model revealed no significant main effect of Sex or Nasal Context, but there was a significant Nasal Context-Sex interaction effect (df = 188.09, t-value = -3.34, p < .001). For males, the VPO for anticipatory nasalisation (M = 0.31, SD = 0.16) was significantly larger than for carryover nasalisation (M = 0.21, SD = 0.10).

4 Discussion

Overall, our results suggest that in Québécois French, males have greater VPO for anticipatory nasalisation than for carryover nasalisation, contradicting past results in other French studies [3 - 5]. A possible reason for sex differences are that males are reported to have more coronal velic closures, while females are reported more circular closure [11]. Due to the angle of the videos, we are only able to measure from a sagittal perspective and may not capture a more circular closure.

Limitations

Our research is confined by the database, which was recorded nearly fifty years ago. As such, there is potential that our results may not apply to present day Québécois French. As well, the conditions of read speech in a lab, in contrast to natural running speech, may have had an impact on the results. Lastly, our study was on Québécois French alone, while past studies have also looked at Belgian French and Standard French.

Acknowledgments

The authors would like to thank Chiachih Lo, Ernest Tse, Hillary Smith and Erin Mawhinney for their assistance with data preparation and Yadong Liu and Jacqueline (Ama) Murray for assistance with editing and formatting. Work funded by the NIH grant number DC-002717 to Haskins Laboratories and NSERC Discovery grant RGPIN-2021-03751 to Bryan Gick.

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