WHAT'S WITH YOUR NASALS? PERCEPTION OF NASAL VOWEL CONTRASTS IN TWO DIALECTS OF FRENCH

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ABSTRACT

We present the results of a forced-choice gating experiment to test the accuracy of same- and cross-dialectal perception of phonemic nasal vowel contrasts in two dialects of French. We found that contrasts were identified with high accuracy, but differences in the phonetic realizations of vowels involved in ongoing chain shifts lead to confusion between competing vowel pairs in the directions consistent with each shift. The effects of age, an apparent time indicator of ongoing change, gender, and dialect experience are evaluated based on the results of a generalized linear mixed-effects model.

Keywords: age, dialect, nasal, perception, vowel shift

1. INTRODUCTION

Nasality is contrastive in every dialect of French, but different nasal sub-systems are known to have distinct vowel inventories, whose phonetic realizations vary considerably. Dialects of Quebec French (QF) and Southern French (SF), for instance, have front, back, central and front rounded nasal vowels [1] [2] [3] [4], while varieties of Northern Metropolitan French (NMF), the historical basis of standard French, has a three-vowel system, with the two front nasal vowels merged into a single vowel [5]. Previous studies suggest that nasal vowels in QF and NMF are involved in ongoing chain shifts in opposite directions along the peripheral tract of the vowel space: the three nasal vowels in NMF form a counter-clockwise 'push-shift' triggered by the merger of the two front nasal vowels, while the same three vowels in QF move clockwise, 'pulled' by the front nasal whose oral articulation is more fronted and closed than in NMF [6] [7] [8]. These shifts can result in confusion between adjacent vowels impeding on each other's vowel spaces and manifest in overlapping formant frequencies between the shifting vowels /ɛ̃/ and /ɑ̃/ in NMF and /ɑ̃/ and /ɔ̃/ in QF. The vowel spaces of /ɔ̃/ in NMF and /ɛ̃/ in QF, the endpoints of each shift, typically show less overlap [3]. To date, however, the perceptual salience of these distinctions has not yet been systematically investigated.

In this paper, we seek evidence for the perceptual relevance of phonetic differences in the realizations of nasal vowels in QF and NMF. We hypothesize the following: (1) Nasal vowels and their corresponding oral counterparts /ɛ/-/ɛ̃/, /a/-/ɑ̃/, and /o/-/ɔ̃/ will be identified with high accuracy across all vowel pairs in all conditions, as they cue phonemic differences in the language. (2) The front (/ɛ̃/) and open (/ɑ̃/) nasals in NMF and the open (/ɑ̃/) and back (/ɔ̃/) nasals in QF, involved in ongoing shifts, will be identified with less accuracy than other vowels due to overlaps in their phonetic realizations. (3) Less familiarity with each dialect should result in greater difficulty distinguishing vowel contrasts cross-dialectally. (4) Given that "nasalization increases throughout the duration of the nasal vowels" in some dialects of French [4]:87, increased vowel duration should help accuracy in QF where progressive increase in the degree of nasalization has been attested [3]. (5) Overall, same-dialect accuracy rates should be higher than cross-dialect accuracy rates.

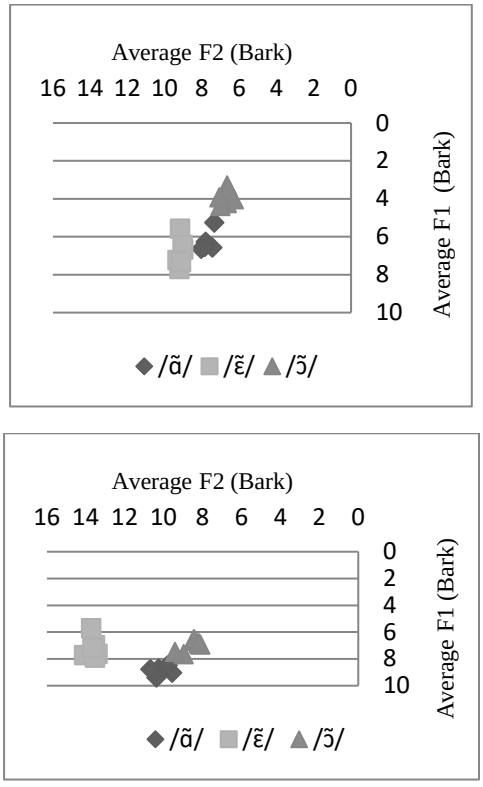
2. METHODOLOGY

Seventy listeners took part in a computerized forced-choice gating experiment constructed in E-Prime 2.0. They came from the Saguenay-Lac-Saint-Jean dialect area in Quebec (19 women and 12 men) and the greater Paris area in France (20 women and 19 men). They were recruited in public places and via word-of-mouth and received a small gift for their participation. They were divided into four groups based on their age and degree of integration in the job market: students (18-31 years), young actives (23-34 years), middle-aged actives (35-54 years), and old actives (55-64 years). These age groupings were based on the age categories of the Canadian Census (2017).

The listeners heard target words with nasal vowels produced by two female native speakers, born and raised in the same two dialect areas. The speakers were recorded prior to this experiment as part of a production study [3] [8]. They were selected for the purposes of this study due to their similar age range (20's and 30's) and configurations of their lingual vowel spaces showing evidence of dialect-specific vowel shifts (Figure 1).

Six target words and six distractor words were used to build the experiment. Target words with a word-initial /p/ or /t/ were followed by one of the three nasal vowels: the front nasal vowel /ɛ̃/ in *pain* 'bread' and *teint* 'complexion', the open nasal vowel /ɑ̃/ in *paon* 'peacock' and *temps* 'time', and the back nasal vowel /ɔ̃/ in *pont* 'bridge' and *thon* 'tuna'. The rounded nasal vowel /œ̃/ was excluded from the experiment because it is no longer distinctive in both dialects. The six distractor words contained the oral counterparts of each nasal vowel: /ɛ/ in *paix* 'peace' and *taie* 'pillowcase', /a/ in *pas* 'step' and *ta* 'your', and /o/ in *pot* 'container' and *tôt* 'early'.

Figure 1: Formant frequencies of NMF (top) and the QF (bottom) vowels used in the experiment.



The target words were presented using the gating paradigm [9] [10]. At the first gate, listeners heard the first half of the vowel, at the second gate, they heard the full vowel, and at the third gate, they heard the full word that included the onset consonant. At each gate, they were given a binary forced choice between the target words (with a nasal vowel) and competitor words (with a nasal or oral vowel). They were asked to identify which of the two words they heard. The segmentation of each gate aimed at providing acoustic information progressively and with sufficient duration for the listeners to hear relevant variability in the acoustic signal. There were three repetitions of each of the twelve words containing the target nasal vowels pronounced by the two speakers, which yielded a total of seventy-two target words. These words were presented in six separate randomized and counterbalanced lists in which the target words were presented with a nasal or an oral competitor word. No participant heard the same target word contrasted with more than one competitor. The trials were presented in a random order and split into two sessions with a small break in between.

3. RESULTS

3.1. Generalized linear mixed-effects model

A generalized linear mixed-effects model was run using the lme4 package in R. *Age, Gender, Dialect, target-competitor vowel pair, and the interaction between dialect* (that participants heard) *and vowel pair* (two vowels to choose from) were included as fixed effects. *Participant* was included as a *random intercept.* In order to determine the significance of fixed effects, the mixed function from the afex package was used. The effects of dialect, target-competitor vowel pair, and the interaction of dialect and target-competitor vowel pair on accuracy of vowel contrasts were significant. The effect of age on accuracy varied depending on the dialect and was not as robust for native dialect identification in the NMF as in the QF group. Gender was not significant.

3.2. Accuracy rates: the NMF group

With a few misidentifications of /a/ for /ɑ̃/, in their own dialect NMF listeners distinguished target words with nasal vowels from target words with oral vowels categorically (Table 1). Of the three nasal vowels, the back nasal /ɔ̃/ was the most reliably identified (100%). The accuracy rates went down for with /ɛ̃/ and /ɑ̃/. When NMF listeners heard the NMF speaker pronounce a word with the front vowel /ɛ̃/ and saw a word with the competitor vowel /ɑ̃/ on the screen, they correctly identified the target word only in 71% of the time. The opposite was not true: NMF listeners never selected /ɛ̃/ when they heard /ɑ̃/. The nasal vowel /ɑ̃/ was the least reliably identified. When target words with /ɑ̃/ were contrasted with /ɔ̃/, accuracy rates were only 64%. This is greater than chance, but the high rates of confusion with /ɔ̃/ together with the complete lack of confusion with /ɛ̃/ point to asymmetrical errors that are consistent with a counter-clockwise shift in progress. Younger NMF listeners tended to be more accurate than older listeners. Although this age difference did not reach statistical significance on its own, the interaction of and target-competitor pair was statistically significant (p=.002).

NMF listeners could not easily distinguish nasal vowels when presented with their oral counterparts as

competitors in QF. This is consistent with predictions of lower accuracy in cross-dialectal identifications in general. Cross-dialectal accuracy rates for nasal vs. oral contrasts among NMF listeners was the lowest across all test conditions. Confusions involved primarily the front nasal vowel /ɛ̃/ (mistaken for /ɛ/ in 22% of the time), and the open nasal vowel /ɑ̃/ (mistake for /a/ in 27% of the time). The vowel /ɛ̃/ was categorically identified cross-dialectally, but the accuracy rates for the open nasal vowel /ɑ̃/ and the back nasal vowel /ɔ̃/ were not reliably identified. QF target words with /ɑ̃/ competing with /ɛ̃/ were misidentified /ɑ̃/ as /ɛ̃/ in 72% of the time, although /ɑ̃/ was distinguished nearly categorically (96%) from competitor words with /ɔ̃/. The vowel /ɔ̃/ in QF target words had a relatively high accuracy rate (81%) when contrasted with /ɛ̃/, but it was misidentified in 56% of the time when contrasted with /ɑ̃/. The interaction of age group and target-competitor contrast was statistically significant (p<.001).

Table 1: Aggregate accuracy rates at the third gate: NMF listeners identifying NMF vowels (top) and QF vowels (bottom).

Stimuli		Responses					
Target	**Comp.**	**/ɛ̃/**	**/ɑ̃/**	**/ɔ̃/**	**/ɛ/**	**/a/**	**/o/**
/ɛ̃/	/ɑ̃/	71	29				
	/ɔ̃/	98		2			
	/ɛ/	100			0		
Total acc. %		**90**					
/ɑ̃/	/ɛ̃/	0	100				
	/ɔ̃/		64	36			
	/a/		99			1	
Total acc. %			**88**				
/ɔ̃/	/ɛ̃/	1		99			
	/ɑ̃/		1	99			
	/o/			100			0
Total acc. %				**100**			

Stimuli		Responses					
Target	**Comp.**	**/ɛ̃/**	**/ɑ̃/**	**/ɔ̃/**	**/ɛ/**	**/a/**	**/o/**
/ɛ̃/	/ɑ̃/	99	1				
	/ɔ̃/	99		1			
	/ɛ/	78			22		
Total acc. %		**92**					
/ɑ̃/	/ɛ̃/	72	28				
	/ɔ̃/		96	4			
	/a/		73			27	
Total acc. %			**66**				
/ɔ̃/	/ɛ̃/	19		81			
	/ɑ̃/		56	44			
	/o/			89			11
Total acc. %				**71**			

3.4. Accuracy rates: the QF group

As predicted, QF listeners distinguished words with nasal vowels from words with oral vowels with high accuracy in their own dialect (Table 2). The vowel /ɔ̃/ was never mistaken for its oral counterpart, but there was more uncertainty for /ɛ̃/ that was identified as /ɛ/ in 3% and /ɑ̃/ that was mistaken for /a/ in 10% of the time. QF listeners also identified /ɛ̃/ correctly in every context. Accuracy rates, however, were lower for /ɑ̃/: when contrasted with words with /ɛ̃/, listeners correctly identified /ɑ̃/ only in 78% of the time. Although not categorical, this accuracy rate is still much higher than NMF listeners' accuracy rate of only 28% for the same vowel-stimuli pair in QF (Table 1). The vowel /ɑ̃/ was categorically perceived as distinct from /ɔ̃/ (99%) and the vowel /ɔ̃/ was accurately identified most of the time (74%) by QF listeners. Native QF listeners' accuracy rates stood in sharp contrasts with the much lower rates of listeners of the other dialect. Younger listeners were more accurate than older listeners at correctly identifying the nasal vowel contrasts in their own dialect, and this age difference was statistically significant (p<.0001). The interaction of age group and target-competitor contrast pair was significant (p<.001).

Table 2: Aggregate accuracy rates at the third gate: QF listeners identifying QF vowels (top) and NMF vowels (bottom).

Stimuli		Responses					
Target	**Comp.**	**/ɛ̃/**	**/ɑ̃/**	**/ɔ̃/**	**/ɛ/**	**/a/**	**/o/**
/ɛ̃/	/ɑ̃/	99	1				
	/ɔ̃/	100		0			
	/ɛ/	97			3		
TOTAL acc. %		**99**					
/ɑ̃/	/ɛ̃/	22	78				
	/ɔ̃/		99	1			
	/a/		90			10	
TOTAL acc. %			**89**				
/ɔ̃/	/ɛ̃/	2		98			
	/ɑ̃/		26	74			
	/o/			100			0
TOTAL acc. %				**91**			

Stimuli		Responses					
Target	**Comp.**	**/ɛ̃/**	**/ɑ̃/**	**/ɔ̃/**	**/ɛ/**	**/a/**	**/o/**
/ɛ/	/ɑ̃/	28	72				
	/ɔ̃/	90		10			
	/ɛ/	99			1		
Total acc. %		**72**					
/ɑ̃/	/ɛ̃/	2	98				
	/ɔ̃/		22	78			
	/a/		99			1	
Total acc. %			**73**				
/ɔ̃/	/ɛ̃/	2		98			
	/ɑ̃/		1	99			
	/o/			99			1
Total acc. %				**99**			

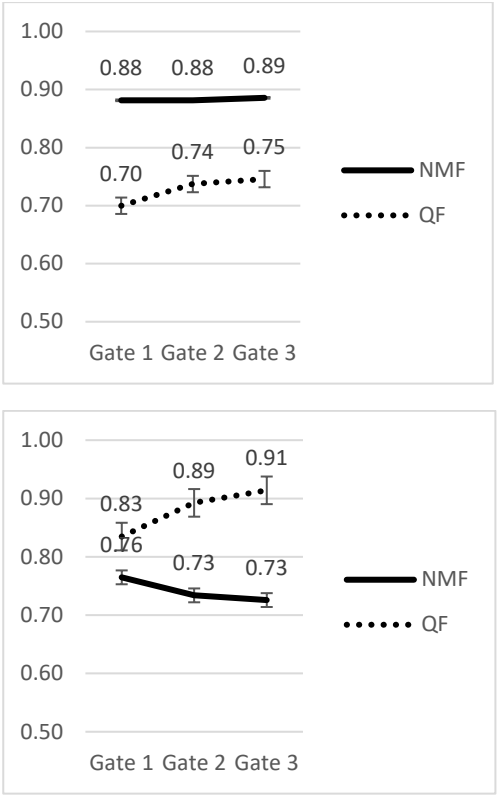
QF listeners were better at distinguishing nasal vowels from their oral counterparts in NMF than in their own dialect. This was especially true for /ɑ̃/ that was misidentified as /a/ in 10% of the time in QF (Table 1) but only in 1% of the time in NMF. QF listeners had very low accuracy rates for both the front /ɛ̃/ and the open /ɑ̃/ nasal vowels cross-dialectally: /ɛ̃/ was correctly identified only in 28% of the time and /ɑ̃/ only in 22% of the time. There was no confusion for /ɔ̃/, however, that was identified

categorically (99%). The effect of the interaction of age and target-competitor pair on accuracy was statistically significant ($p<.001$), though the effect of age on its own was not.

3.5. Accuracy rates at the three gates

Listeners from both dialects performed well above chance at each gate and in each dialect (Figure 2). As predicted, they were better at identifying nasal vowel words in their own dialect than in the other dialect, which suggests that, despite ongoing changes in the nasal vowel systems of the two dialects, mutual intelligibility is never at stake.

Figure 2: Accuracy rates at each gate: NMF listeners identifying NMF and QF words (top), QF listeners identifying QF and NMF words (bottom).



Across the three gates, i.e. at half of the vowel's duration, at the end of the vowel, and at the end of the word, NMF listeners identified nasal vowels in their own dialect with 88% accuracy starting from the first gate. Their nearly identical accuracy rates across all three gates suggest that greater vowel duration did not help disambiguate perceptual overlaps. When listening to QF vowels, NMF listeners' accuracy increased from 70% to 75% from the first through the last gate, indicating that dynamic information about nasalization and voice qualify, among other possible correlates, had an effect on accuracy.

The Quebec listeners were also more accurate in identifying the nasal vowel words in their own dialect than in the other dialect (Figure 2). As with NMF listeners, QF listeners' accuracy increased between gates when listening to their own dialect, as shown by the range of increase from 83% to 91% across the three gates. Increase in target vowel duration, on the other hand, resulted in some confusion for QF listeners whose accuracy rates from the first to the third gate decreased. Their aggregate accuracy rate at the third gate was, in fact, slightly lower (73%) than NMF speakers' at this gate cross-dialectally.

6. DISCUSSION

(1) As predicted, the three nasal vowels and their oral counterparts were identified with high accuracy within each dialect. (2) As hypothesized, /ɛ̃/ and /ɑ̃/ in NMF and /ɑ̃/ and /ɔ̃/ in QF, involved in ongoing shifts, were identified with less accuracy than other target vowels. In NMF heard by NMF listeners, the confusions point to an ongoing counter-clockwise shift: (i) /ɛ̃/ was often mistaken for /ɑ̃/, but the opposite was never true, (ii) /ɑ̃/ was frequently misidentified as /ɔ̃/, while /ɔ̃/ was always accurately identified when competing with /ɑ̃/, and (iii) /ɔ̃/ was identified with high accuracy. Cross-dialectally (NMF heard by QF listeners) these patterns held true, except for /ɑ̃/ that provoked confusion when contrasted to /ɔ̃/. In QF, accuracy/error rates were also consistent with the hypothesis of an ongoing - clockwise - shift. When QF listeners of heard QF: (i) /ɔ̃/ was often misheard for /ɑ̃/, but not the other way around, (ii) /ɑ̃/ was difficult to distinguish from /ɛ̃/, and /ɛ̃/ was identified nearly categorically. Cross-dialectally (QF heard by NMF listeners), there was considerable confusion, as accuracy rates were below chance for each contrast involved in the clockwise shift, but very high for vowel contrasts that were not affected by the shift. (3) As expected, there was more confusion cross-dialectally than in within dialects, especially when NMF listeners listened to QF, which might be due to unfamiliarity with the rural variety of QF used in the experiment. (4) As predicted, NMF listeners benefitted from longer stimuli in QF, and showed higher accuracy. However, increased vowel durations proved less useful for QF listeners listening to NMF throughout the three gates.

While our hypotheses were generally confirmed, additional studies are needed to determine the independent effects of the timing and the degree of nasalization on oral formant frequencies [11] and, thus, the configuration and mechanisms of change in nasal vowel systems over time [12] [13].

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