NEW CALEDONIAN FRENCH NASAL VOWELS: AN ACOUSTIC STUDY

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ABSTRACT

This paper investigates, via acoustic analysis, the realisation of nasal vowels in New Caledonian French. Formant and durational results for six speakers confirm the previously-described merger of /ɛ̃, œ̃/ in the variety, and also indicate some neutralisation of /ɑ̃, ɔ̃/ – although this is less complete than has previously been suggested. Further, some interspeaker variation is noted with respect to the degree of spectral distinctness maintained between both /ɛ̃, œ̃/ and /ɑ̃, ɔ̃/. In terms of their phonetic qualities, /ɛ̃, œ̃/ are typically realised as central and near-open (i.e. [ɐ̃]), while the back vowels /ɑ̃, ɔ̃/ have average qualities of [ɔ̜, o̜]. These findings contribute to our understanding of this under-described variety.

Keywords: French, New Caledonia, nasal vowels, acoustic phonetics, phonetic variation

1. INTRODUCTION

New Caledonia is a special collectivity of France, located in the south-west Pacific. New Caledonian French (NCF) remains an under-described regional variety. Previous (predominantly impressionistic) descriptions of NCF phonology have highlighted nasal vowel realisation as a point of difference between NCF and other regional varieties of French.

1.1. French nasal vowels

The nasal vowel system of Reference French comprises three-to-four nasal vowel phonemes: /ɛ̃, (œ̃), ɑ̃, ɔ̃/ (as in e.g. *bain*, *un*, *banc*, *bon*) [10]. The phoneme /œ̃/ has merged with /ɛ̃/ in many varieties of French, including those spoken across much of metropolitan France [27]. The same merger is also underway, although less advanced, in Belgian and Swiss varieties [8, 26]. By contrast, in the south of France, and in francophone Canada, all four phonemes are usually retained [9].

The contrast between the two back vowels, /ɑ̃, ɔ̃/, has also been documented to sometimes be neutralised in production in some varieties [5, 6, 7] (and by French children [19]). This is less common than /ɛ̃, œ̃/ merger, however, most likely due to the higher functional load of this contrast (e.g. [12]).

While the symbols /ɛ̃, œ̃, ɑ̃, ɔ̃/ are conventionally used to represent the French nasal vowels, their contemporary phonetic qualities generally differ somewhat from those implied by these symbols. In Northern Metropolitan French (NMF), for instance, a chain shift is taking place, whereby /ɛ̃/ (already a more open [æ̃], [27]) retracts towards /ɑ̃/, /ɑ̃/ raises and rounds towards /ɔ̃/, and /ɔ̃/ in turn raises and further rounds to (auditory) [õ] [13]. As a result, the acoustic qualities of the vowels /ɛ̃, ɑ̃, ɔ̃/ in NMF are now documented to be [ɐ̃, ɔ̜̃, õ̜], respectively [3].

1.2. Nasal vowels in NCF

Past descriptions of NCF phonology (e.g. [15, 23]) have documented a reduction in the variety's nasal vowel system relative to that of Reference French, such that it contains only two phonemes: one front and one back. In addition to the (cross-varietally common) merger of /ɛ̃/ and /œ̃/, this comprises a merger of the back vowels /ɑ̃/ and /ɔ̃/. Hollyman [15] suggests that this involves a loss of the more open phoneme, /ɑ̃/. Pauleau [23, 24] instead describes frequent confusion of the two phonemes in NCF, in both directions (i.e. /ɑ̃/ realised [ɔ̃], and /ɔ̃/ realised [ɑ̃]). She notes that this is a stereotypical feature of the local accent.

Very little description exists as to the specific phonetic qualities of NCF nasal vowels. Pauleau [23] reports that the front vowel /ɛ̃/ is realised with an auditory quality of [æ̃] in the variety; at the same time, the formant values she lists for an illustrative example of this vowel are similar to those listed for the oral vowel [a] (as produced by the same speaker of NCF profiled in her study). No detail is known regarding the exact phonetic qualities of the back vowels /ɑ̃, ɔ̃/, beyond their frequent confusion in the variety.

2. AIMS

In light of the claims outlined in previous work on NCF, as well as changes over time observed for French nasal vowels more generally, the current study aims to investigate the realisation of nasal vowels in NCF, specifically:

- Are the contrasts /ɛ̃, œ̃/ and /ɑ̃, ɔ̃/ maintained by NCF speakers?
- What are the acoustic phonetic qualities of the nasal vowels in NCF?

3. METHOD

3.1. Speakers

Six speakers of NCF (3 F, 3 M) were recorded for this experiment. All were students at the Université de la Nouvelle-Calédonie (UNC) and aged 18 – 20 years at the time of recording. All speakers were born and completed all schooling in New Caledonia. French was the first language of five of the six speakers. The sixth speaker spoke Nengone, an indigenous kanak language, as her L1 and acquired French from school-age. Another of the six participants was bilingual in Javanese, and one further speaker reported receptive knowledge of the kanak language Paicî.

3.2. Stimuli & recording procedure

Recordings took place in an unused meeting room at the UNC, using a Zoom H4N portable recording device (sampling rate 44.1kHz/16-bit) and an AudioTechnica AT892c ear-mounted microphone. Elicitation materials were presented to speakers as a PowerPoint presentation, displayed on a laptop computer. Lexical items containing the four possible nasal vowel phonemes were elicited in a frame (*Je dis __ parfois*), then in citation form immediately afterwards. This occurred four times per item, in random order, resulting in 8 tokens per word (4 phrase-medially, 4 in citation form). Target words for this experiment were primarily monosyllables of the form /CṼ/ (where C = /p, b, t/). The phonemes /ɛ̃, ɑ̃, ɔ̃/ were all elicited in this context. Due to its very low frequency of occurrence in French [12], /œ̃/ was elicited only in the item *un* (i.e. without an onset).

For the phonemes /ɛ̃, œ̃/, an inadequate number of tokens were elicited during the above elicitation task. Citation form tokens (3 repetitions/speaker) of the minimal pair *brin-brun*, recorded in a separate word-list task during the same recording sessions, were therefore added to the dataset. This resulted in a total of 468 nasal vowel tokens across the experiment (144 each for /ɑ̃, ɔ̃/, 114 for /ɛ̃/, 66 for /œ̃/).

Phoneme	Lexical items
/ɑ̃/	*pan, banc, temps*
/ɔ̃/	*pont, bond, ton*
/ɛ̃/	*pain, bain; brin (WL)*
/œ̃/	*un; brun (WL)*

Table 1: Lexical items elicited for nasal vowels (*WL* indicates items added from word-list task)

For comparison purposes, the oral vowels /i, e, ɛ, y, ø, œ, a, ɔ, o, u/ were also elicited, in real or nonsense words of the form /pVp/ (8 tokens/speaker); due to the effects of syllable type on mid vowel realisation in NCF [17], the close-mid vowels /e, ø, o/ were instead elicited in open-syllables (i.e. /pV/).

3.3. Analysis

Using Praat [2], the vowels of interest were manually segmented, and annotated according to their phonemic identity in Reference French. Alongside vowel onsets and offsets, formant steady states were manually identified for each token.

In response to the challenges posed by spectral analysis of nasal vowels (e.g. [20]), extraction of formant data was carried out using a semi- (rather than fully-) automatic Praat script [22]. This allowed formant tracking to be visually inspected for each vowel token prior to its extraction; settings were then adjusted, and formants re-tracked, where necessary. Frequencies of the first two formants were extracted at the midpoint of the annotated formant steady states. While potentially relevant to the contrasts of interest, F3 was not included in this analysis, as this formant is known to be severely affected by nasalisation [8]. Formant data was speaker-normalised [18] with rescaling to Hz values, using the *norm()* function in the R package *emuR* [29]. Vowel duration was also extracted, using a separate Praat script [14]. Analysis and plotting were then carried out in R [25, 28].

Linear mixed-effects models (LMEMs) were used to assess the relationship between the main effect PHONEME (/ɛ̃, œ̃, ɑ̃, ɔ̃/) and the dependent variables F1, F2, duration. The R packages *lme4* [1] and *lmerTest* [16] were used for model construction and selection, respectively.[1] Bonferroni corrected post-hoc comparisons were then run to compare individual pairs of phonemes. Pillai scores [11] were also calculated to quantify, for each of the six speakers, the degree of distinctness in F1~ F2 distribution for each vowel pair (i.e. /ɛ̃/ vs. /œ̃/ and /ɑ̃/ vs. /ɔ̃/).

4. RESULTS

4.1. Formant characteristics

Figure 1 presents an ellipse plot indicating the distribution of each phoneme in the normalised F1~F2 space (all speakers' data are plotted together here, due to the statistical non-significance of gender as a fixed effect on both F1 and F2). For each vowel, the mean F1 and F2 values are represented via the placement of the relevant IPA symbol; these mean values, and standard deviations, are also provided in Table 2. Ellipses represent the distribution of tokens for each phoneme (95% CIs, 2 SDs). The point vowels /i, a, u/ appear as dark grey ellipses, and the remaining oral vowels as light grey ones. The nasal vowels appear as ellipse outlines of varying colours and line types.

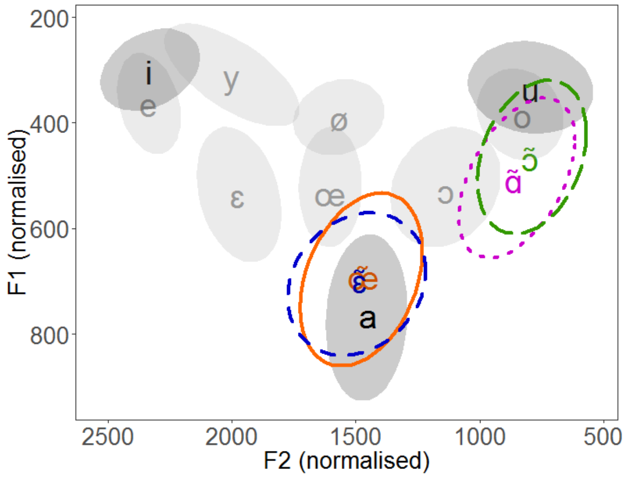

Figure 1: NCF speakers' nasal & oral vowel distributions in the normalised F1~F2 space

The orange (solid) and purple (dashed) ellipses representing /ɛ̃/ and /œ̃/ overlap entirely, indicating that these two vowel categories are realised with the same F1 and F2 frequencies. This is also reflected in the near-identical mean F1 and F2 values seen for these vowels in Table 2. As anticipated, PHONEME has a significant main effect on the frequency of both formants (F1: $\chi^2(3)=15.69$, $p=0.001$; F2: $\chi^2(3)=19.7$, $p=0.0002$). However, post-hoc comparisons confirm that there is no significant difference between /ɛ̃/ and /œ̃/ in either F1 or F2 frequency. Both vowels have an average quality of approximately [ɐ̃], but vary in F1, such that some tokens are realised as (central) [ã].

Phoneme	*F1 (sd)*	*F2 (sd)*
/ɛ̃/	698 (64)	1482 (128)
/œ̃/	692 (83)	1471 (113)
/ɑ̃/	509 (72)	860 (115)
/ɔ̃/	467 (70)	794 (108)

Table 2: Nasal vowels' mean F1 & F2 values

The back vowels /ɑ̃, ɔ̃/, represented by the pink (dotted) and green (long-dashed) ellipses, also display considerable – but less complete – overlap in the F1~F2 space. The distribution of /ɑ̃/ extends slightly lower and further left (i.e. higher in both F1 and F2) than that of /ɔ̃/. Post-hoc comparisons for this pair reveal no significant difference in F2 frequency. There is, however, a significant (albeit relatively small) difference in F1: /ɑ̃/ is an estimated 40 ± 9 Hz higher in F1 than /ɔ̃/. In terms of their acoustic phonetic qualities, /ɑ̃/ and /ɔ̃/ have very similar average qualities of (backed) [ɔ̨̃] and [ǫ̃], respectively. Both phonemes can be observed to vary to some extent in height (F1): /ɑ̃/ ranges from [ɔ̨̃] to [õ], while /ɔ̃/ ranges from [ɔ̃] to [õ] or even [ũ].

4.2. Duration

Table 3 presents average durations and standard deviations for the nasal vowels /ɛ̃, œ̃, ɑ̃, ɔ̃/. Statistical analysis indicates that PHONEME is not a significant predictor of nasal vowel duration ($\chi^2(3)=1.02$, $p=0.8$).

Phoneme	*Duration (ms)*	*(sd)*
/ɛ̃/	156	(28)
/œ̃/	156	(26)
/ɑ̃/	151	(31)
/ɔ̃/	149	(35)

Table 3: Nasal vowels' mean durations

4.3. Interspeaker variation

The LMEMs best fitting this experiment's data suggest that individual speakers respond differently to the fixed effect PHONEME (by-speaker random slopes for the effect of PHONEME appear in all models selected by *step()*). Pillai scores were therefore calculated to assess the degree of distinctness between /ɛ̃, œ̃/ and /ɑ̃, ɔ̃/ in each speaker's productions. Table 4 presents these scores: figures closer to zero indicate more likely merger between the two compared vowel categories, while figures closer to one suggest that the categories are more distinct for the relevant speaker.

Speaker	/ɛ̃, œ̃/	/ɑ̃, ɔ̃/
AD	0.03	0.16
BB	0.21	0.02
EK	0.09	0.07
JV	0.09	0.17
QM	0.55	0.49
YT	0.02	0.32

Table 4: Pillai scores for individual speakers' productions of /ɛ̃/ vs. /œ̃/ and /ɑ̃/ vs. /ɔ̃/

(Male) speaker QM's scores for both contrasts are substantially higher than for all other speakers (0.55 for /ɛ̃, œ̃/, 0.49 for /ɑ̃, ɔ̃/), indicating that these vowel pairs are both kept somewhat distinct for this speaker. This is also apparent in an individual vowel plot for QM (Figure 2) in which /œ̃/ occupies a slightly higher position in the vowel space (i.e. lower F1) than /ɛ̃/, and /ɑ̃/ is generally higher in both F1 and F2 than /ɔ̃/.

As a point of comparison, a vowel plot is also provided for (female) speaker AD (Figure 3), whose Pillai scores are among the lowest for both contrasts (0.03 for /ɛ̃, œ̃/, 0.16 for /ɑ̃, ɔ̃/). Accordingly, this speaker's vowel plot displays a much higher degree of overlap between the ellipses of /ɛ̃, œ̃/ and /ɑ̃, ɔ̃/; the front vowels occupy the same position in the F1~F2 space, while her back vowels differ only slightly in height (but share most of their distribution).

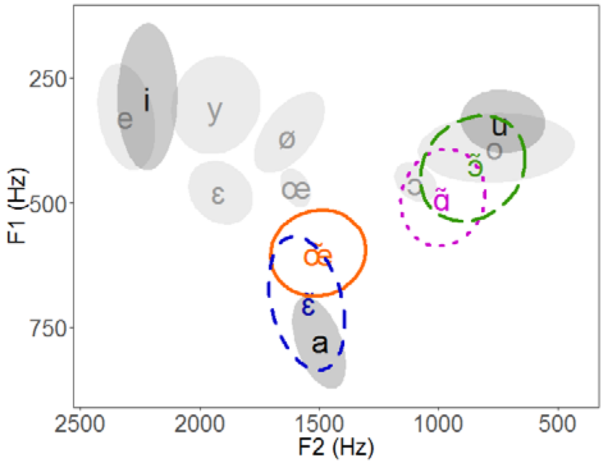

Figure 2: Individual F1~F2 plot for speaker QM

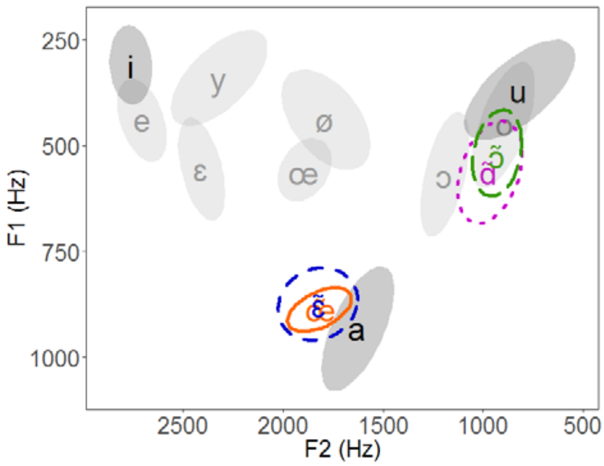

Figure 3: Individual F1~F2 plot for speaker AD

5. DISCUSSION & CONCLUSIONS

Acoustic investigation of nasal vowel production in NCF confirms that there is, overall, a merger of the front vowels /ɛ̃, œ̃/, as previously described for the variety [15, 23] and documented for many other contemporary varieties of French. Results also provide some evidence for the anticipated merger of the back vowels /ɑ̃, ɔ̃/ in NCF; however, although these vowels overlap much more in the acoustic space than they do in e.g. NMF [3], a small but significant difference in F1 was located between this pair. It is unknown to what extent, if at all, this difference is exploited by speakers/listeners of NCF – a perception experiment would certainly help to elucidate this. It is also possible that the salience of this merger as a stereotypical feature of NCF [24] leads speakers to consciously maintain some contrast in such careful speech. Future investigation of nasal vowel production in less controlled speech styles is necessary to ascertain whether this is the case.

Nasal vowel production in NCF is, further, found to be subject to interspeaker variation: some speakers maintain more acoustic contrast between /ɑ̃, ɔ̃/ and /ɛ̃, œ̃/ than others. While Pillai scores are typically low for both contrasts, one speaker – QM – has overlap levels of only ~50% for each contrast. This speaker is one of two in this sample with a parent originating from metropolitan France (and therefore likely to maintain contrast between /ɑ̃, ɔ̃/, although not necessarily /ɛ̃, œ̃/). It is unclear whether this may have influenced his production of these vowels, or whether this is perhaps an effect of the read speech style.

In terms of the phonetic qualities of nasal vowels in NCF, the "front" vowel(s) /ɛ̃, (œ̃)/ might more accurately be described as "central" in NCF, with an average quality of approximately [ɐ̃], and a distribution ranging from [ɐ̃] to (central) [ã]. However, these vowels' position in the front-back axis is further forward than that observed for /ɛ̃/ in NMF, another variety for which the notation [ɐ̃] has been proposed [3]. This difference is also potentially understated here, given that some of the lexical items elicited for /ɛ̃, œ̃/ in the present study contained a contiguous /ʁ/, a context likely to lower F2 frequency [21]. NCF /ɛ̃/ does not, however, appear to be realised as far forward as is documented for Belgian speakers, for whom the same vowel is realised [æ̃] [8].

The NCF back vowels /ɑ̃, ɔ̃/ are relatively similar in backness to their NMF counterparts (i.e. similar F2 values to /o, u/) but diverge somewhat in their heights. NCF /ɑ̃/ is typically realised [ɔ̝̃], slightly higher than its NMF equivalent [ɔ̞̃] (and considerably higher than Belgian French [ɑ̃ - ɒ̃]) [3, 8]. /ɔ̃/, on the other hand, occupies a more open position than the same vowel in NMF: typically [õ̞] rather than [õ̝]. Both /ɑ̃/ and /ɔ̃/ vary substantially in F1 in the combined speaker data, however, such that their distributions both span the open-mid and close-mid regions of the (back) vowel space. This variability may reflect further interspeaker variation in NCF nasal vowel realisation.

The findings yielded by this experiment contribute to our understanding of the phonetics and phonology of NCF, which remains an understudied regional variety. The present study is, of course, limited in its small sample size. Further work analysing more data from a larger number of NCF speakers is therefore needed to confirm the tendencies observed here. Given the known limitations of acoustic analysis in providing information about nasal vowel articulation (e.g. [4]), future articulatory studies of NCF nasal vowels are also necessary, in order to determine how the reported acoustic qualities are achieved by speakers of the variety.

6. REFERENCES

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[1] The final models selected by *step()* were:

F1 / F2 ~ PHONEME + CONTEXT + PRECEDING CONSONANT + DURATION + (PHONEME | SPEAKER);

DURATION ~ PRECEDING CONSONANT + (PHONEME + CONTEXT | SPEAKER)

(where “context” = phrase-medial or citation form).