Corpus-based L2 phonological data and semi-automatic perceptual analysis: the case of nasal vowels produced by beginner Japanese learners of French

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Abstract

Processing large amounts of non-native (L2) phonological data for acquisition-related research remains a challenging task, especially when acoustic analyses are not straightforward as is the case with nasal vowels. Within the *InterPhonologie du Français Contemporain* project (IPFC), we have developed a perceptual coding procedure and a piece of dedicated software aimed at providing an intermediate stage between fine-grained acoustic analyses and coarse-grained phonological categorization, such as 'substitution' or 'deletion', of non-native productions. Our code allows us to examine the left and right phonological contexts of the segment under scrutiny and assess the nasality, quality and potential consonantal excrescences of the non-native nasal vowels. We have applied this procedure to Japanese data collected in a longitudinal study of French interphonology, focusing on the vowels /A~/, /O~/, /E~/ produced by 22 beginner university students in a wordlist repetition and reading task. Our study reveals an overall good production rate in terms of nasality for such beginner learners but also a lower rate of quality accuracy for the three vowels, as well as better performances in the repetition task. We discuss our results in light of current L2 learning theories and the phonetic-phonological characteristics of Japanese.

Index Terms: L2 corpus, interphonology, Japanese learners, French nasal vowels

1. Introduction

The use of corpora in L2 phonology studies over the last decade has proved both promising and challenging, since several research teams started using the techniques and tools with seemingly successful results both in applied [1] and more theoretical [2] linguistics. In the case of French, the parallel development of native corpus phonology in large-scale projects such as *Phonologie du Français Contemporain* (PFC) [3][4] and its sociolinguistic extension to plurilingual populations (e.g. in Canada, Algeria, Mali) [5] have sparked similar interest in non-native speakers' phonological systems, and methodological adaptations have been introduced by some researchers to adjust recording and data processing protocols to the characteristics of non-native speakers. Comparable surveys among different populations of French learners across the world have been launched within the *InterPhonologie du Français Contemporain* (IPFC) project [6][7], filling in a field gap inasmuch as most studies in L2 corpus phonology had focused until then on English as the target language (e.g. [2][8]).

The present study is couched within the methodological framework of the above-mentioned IPFC project, for which a specific perceptual analysis procedure and corresponding software have been developed to tackle large amount of L2 phonological material. This procedure follows the same general principles as the ones that have been used for native speakers in the PFC project, fully rooted in the overall epistemological orientation of corpus phonology [9], envisaged from a variationist perspective [10], i.e. the empirical observation of emerging data patterns framed by as little theoretical pre-categorization as possible. These patterns can then be confronted with pre-established hypotheses and categories to test linguistic theories and psycholinguistic models. If such a procedure can be motivated and argued for in the case of native speakers, it is even more crucial, in our view, for non-native speakers, given the intrinsic characteristics of the emerging interphonological system of L2 learners, for whom the mapping between acoustic cues, articulatory realizations, and phonological categories between the L1 and the L2 are unstable and in the making. Furthermore, in an applied linguistic perspective (whether for educational or automatic speech processing purposes), the use of expert analytical devices (from elementary spectrograms to ultrasounds or piezoelectricity) to investigate or analyze our data does not provide, at this stage, the required system to assess the human-based evaluation of the well-formedness, acceptability or intelligibility of the non-native productions in human-to-human interactions, especially as the possibility of mismatches between articulatory strategies, acoustic realizations [11] and phonetic percepts is well-known. Even though, from a purely phonetic viewpoint, only the expert analysis of the acoustic/phonetic features of the speech signal with adequate tools can actually provide us with an objective description of the productions, it does not reveal how the non-native productions are actually psycholinguistically perceived and categorized by the community of native speakers. This is even more important when the structures under scrutiny are characterized by a large degree of native variation, as is the case with the nasal vowels in French. Therefore, the approach deliberately advocated here does not claim to be more than a first, yet essential, step towards subsequent finer-grained analyses aiming at determining the articulatory and acoustic correlates of these perceptual assessments (e.g. [12][13]). This step partly stems from the same rationale which lies behind the use of standard orthography instead of phonetic transcription in the initial encoding of our data [14], since phonetic labeling constitutes a pre-theoretical analysis of the phonetic-phonological mapping system. This is also why we have opted for an initial auditory rating in our coding procedure without spectrographic cues, since these visual cues may bias the

auditory judgments (for more details about these issues and the ensuing methodological choices, see [15]).

In this article, we illustrate our procedure with the first results (in production) of an ongoing longitudinal production-perception research project, designed to study the segmental and syllabic acquisition of French phonology by Japanese university students over two years (see the website of the project: www.clijaf.com). French nasal vowels have been one of our primary research targets essentially for two reasons: from a (psycho)linguistic viewpoint, French nasal vowels are typically difficult to acquire for many learners, being comparatively rare in the world's languages and phonologically marked; from a methodological viewpoint, the category of nasal vowels provides a good benchmark for our procedure, given their relative phonetic complexity for acoustic analyses on the one hand and the scarcity of studies devoted to L2 nasal vowel acquisition on the other hand. In this study, we concentrate on the current system in Reference French [16], in which /9~/ and /E~/ (in SAMPA phonetic alphabet, used throughout this article) have gradually merged in favour of the latter [17], resulting in a three-vowel system: /A~/, /O~/, /E~/.

If we set aside the generic input issue linked to phonological and phonetic variation in French (different systems in Reference French, Southern French and Canadian French for instance [4][5]), and the complexity of their morphophonological rooting (with a complex system of nasal/oral alternations as in the masculine and feminine forms of the adjectives *plein-pleine* ('full') /plE~/-/plEn/ *vs fin-fine* ('thin') /fE~/-/fin/ in the case of /E~/), the acquisition of nasal vowels by Japanese learners, both in perception and production, can be a difficult process for at least three other reasons. First, the absence of phonological nasal vowels in Japanese; second, the usual adaptation of nasal vowels in loanwords as a sequence of oral vowel + nasal consonant; third, the usual neutralization of the contrast between the French nasal vowels /A~/ and /E~/ into /aN/ sequences in loanwords (e.g. <Printemps> (brand name of a famous department store) /pRE~.tA~/ adapted as /pM.4a.N.ta.N/ [18][19]. If we look at the initial learning stage through the lenses of L2 speech learning mainstream models [20][21], taking into account previous results available in the literature about nasal vowel acquisition both with advanced Japanese learners [22] and other populations [23][24][25], we can hypothesize that the L1 system is fully transferred as a basis for L2 development, that /A~/ and /E~/ may be more prone to confusion than /O~/ in production (whereas /A~/ and /O~/ might trigger more confusion in perception), and that substitutions of nasal vowels by oral vowel + nasal consonant sequences are likely to take place. Still, the differentiated treatment of the three vowels under scrutiny is lacking in rich descriptions encompassing right and left segmental context as well as internal characteristics (i.e. nasality, quality, excrescences). Therefore, our aim in this article is to present the first stage of a perceptually rated corpus-based description of L2 nasal vowels (especially the three internal characteristics mentioned above) produced by beginner Japanese learners of French, which can be used to test L2 phonological models and hypotheses, to carry out subsequent finer acoustic analyses on data subsets or to serve as a rated database for automatic speech processing systems.

2. Method

2.1. Participants

Participants were 22 Japanese university students (mean age 19) who had been studying French as beginners for 4 months at Tokyo University of Foreign Studies at the time of the recording.

2.2. Procedure

Following the IPFC protocol, students carried out 4 tasks in a computer room with individual monitors, headphones and microphones: 1) repetition of a specific wordlist, 2) reading aloud of a generic wordlist, 3) reading aloud of the same specific wordlist, 4) reading aloud of a generic text. All tasks were performed on individual computers using a Moodle platform and data were stored on the university server. In the research reported here, we focus on task 1 (wordlist repetition: subjects had to listen to each word produced twice by a native speaker and repeat the word) and task 2 (wordlist reading: subjects had to read aloud the word displayed on their computer screen) only.

2.3. Material

12 monosyllabic words containing a nasal vowel: 6 with /A~/, 3 with /E~/ and 3 with /O~/, distributed in 6 pairs of words (*anse-once*, *panse-ponce*, *pan-pont*, *Andes-Inde*, *tante-teinte*, *tant-teint*).

2.4. Perceptual analysis and coding procedure

Following the IPFC protocol, the productions were orthographically transcribed and aligned with the signal in Textgrid files with Praat [26]. Then an alphanumeric code was manually inserted in the orthographic transcription after each target nasal vowel independently by two trained coders (double-blind annotation), on an auditory basis only (for reasons mentioned above). The code is made up of 3 descriptive and 3 evaluative fields, with set values. We give below a brief overview of the code [27]: 1) Target segment (i.e. [A~], [O~], [E~], [9~]); 2) Left target segmental context; 3) Right target segmental context (with a particular option in prevocalic position for the French sandhi phenomenon known as liaison which often entails a denasalization of the preceding nasal vowel); 4) Nasality assessment (i.e. whether the vowel has been realized as a nasal vowel, an oral vowel with subsequent nasalization, an oral vowel or not realized at all); 5) Quality assessment (i.e. whether the vowel quality is target-like or not); 6) Consonantal excrescences assessment (i.e. whether the vowel is followed by an excrescent nasal appendix or not). The data are then semi-automatically processed using the Dolmen software [28], an original open-source, cross-platform application for corpus linguistics with plugins and features specifically developed for the IPFC project, allowing for queries in the coded database and providing descriptive statistics for the whole dataset.

3. Results

For both tasks, 520 vowels were coded, and an intraclass correlation coefficient (ICC) was calculated to check the inter-coder reliability. Even though the ICC value is not high (0.369), it has proved to be statistically significant (p<0.001). For each of the three assessed characteristics (nasality, quality

and excrescence), a correct identification rate was calculated for each coder as a function of the nasal vowel (/O~/, /A~/, /E~/) and production task (repetition *vs* reading task). Statistical analyses were conducted for each coder separately using mixed-effects regression models [29], in which the participants and stimuli were entered as random terms. For nasality and quality, a global analysis shows, for each coder, a vowel and a task effect, as well as an interaction between vowel and task (except for one interaction for the nasality analysis which revealed no interaction for one coder, even though the percentages are coherent with the other coder's). For excrescences, a global analysis shows, for each coder, no vowel effect, but a task effect as well as an interaction between vowel and task.

3.1. Nasality analysis

For this analysis, the non-native productions were classified into two categories: nasal vowels and non-nasal vowels (including both oral realizations and oral + nasalization sequences). For both coders, the global rate of nasal realization is rather high: 93.06% and 84.62%. For each of them, the vowel effect reveals a bipartition between /A~/-/O~/ and /E~/ (/A~/ = /O~/ > /E~/, p<0.001 for the first coder and p<0.05 for the second one) as well as better productions in the repetition rather than in the reading task (p<0.001 for each coder). The interaction between vowel and task is significant only for one coder (p<0.001). In the repetition task, results show no distinction between the three vowels, but a confirmation of the global distinction between /A~/-/O~/ and /E~/ in the reading task (/A~/=/O~/, /A~/>/E~/ (p<0.001) and /O~/>/E~/ (p<0.01)). Even though the interaction between vowel and task for the second coder is not significant, results seem to follow a similar orientation for each task. Overall, we can say that nasality seems to be well acquired by the learners, with better results in the repetition task and a dominance of /A~/ and /O~/ over /E~/ in the reading task.

3.2. Quality analysis

For both coders, the global rate of target-like quality values is rather high (76.30% and 67.12%), but lower than the results for nasality. For each of them, the vowel effect reveals a similar bipartition between /A~/-/O~/ and /E~/ (/A~/=/O~/>/E~/, p<0.01 for one coder and p<0.05 for the other) as well as better productions in the repetition rather than in the reading task (p<0.001 for each). The interaction between vowel and task is significant for each coder (p<0.001 for the first one and p<0.01 for the other). In the repetition task, results show no distinction between the three vowels and a similar ranking of vowel productions in the reading task: /A~/=/O~/, /A~/>/E~/ (p<0.001 for each coder) and /O~/>/E~/ (p<0.001 for one coder and p<0.01 for the other one). Overall, we can conclude that no specific vowel seems to be better produced than the other in terms of quality distinction in the repetition task. In the reading task, /A~/ and /O~/ seem to be produced with similar rates of target-likeness (respectively 82.57% and 75.75% for one coder and 68.19% and 59.09% for the other), whereas /E~/ leads to poorer productions (39.39% for one coder and 34.84% for the other).

3.3. Excrescence analysis

For both coders, the global rate of target-like values (no consonantal excrescence after the vowel) is rather high (76.30% and 65.58%). For each of them, results show no vowel effect, but a task effect with better productions in the repetition task than in the reading task (p<0.001 for each coder). The interaction between the vowel and the task is significant for each coder (p<0.05 for the first one and p<0.001 for the other). For the second coder, in the repetition task, /O~/ is more target-like than both /A~/ (p<0.01) and /E~/ (p<0.05), with no difference between /A~/ and /E~/. In the reading task, there is no difference between /O~/ and /A~/, but both are more target-like than /E~/ (p<0.001). For the first coder, there is no difference between the three vowels in both tasks, even though the percentages are coherent with the other coder's, with the lowest rate for /E~/ in the reading task.

4. Discussion

The aim of the study reported here was to assess the realization of the French nasal vowels /A~/-/O~/-/E~/ produced by beginner Japanese learners in two tasks: repeating and reading a word list. Three features were perceptually evaluated for each vowel in terms of target-likeness: nasality, quality, consonantal excrescences. The main results discussed below are threefold: i) higher rates for nasality than for quality achievement; ii) little difference between /A~/ and /O~/ but lower rates for /E~/ in the reading task, whereas the distinction between the three rates is not significant in the repetition task (except in one case); iii) overall, better productions for nasality, quality and excrescences in the repetition rather than in the reading task. In what follows, we discuss these three main findings in connection with results from previous studies [30] in three steps: acquisition of nasality *vs* quality, inter-task asymmetry and excrescences.

Following the mainstream models of L2 phonology acquisition, we assume that the L1 system is initially fully transferred into the developing interphonological system of the learners, leading to perceptual interferences with the input, prior to the gradual emergence of new phonological categories and phonetic mappings, along with the development of a new L2 lexicon. In the case of Japanese learners of French, three aspects, at least, must be taken into account, when examining their acquisition of nasal vowels. First, from a phonological viewpoint, the particular status of the moraic underspecified nasal segment /N/. In that respect, we can consider the acquisition of nasal vowels as similar to the process of their historical development in French with a spreading of the nasal feature and a delinking of the nasal consonant (V(N) > Ṽ(N) > Ṽ) or as the opposite of the unpacking process found in loanword phonology whereby nasal vowels are realized as two segments VN [31][32]. In studies couched within the theoretical framework of constraint-based models such as Optimality Theory, we can interpret this as a demotion of the NONASALV constraint *Ṽ in the process of L1/L2 constraints rearrangement ([25], see also [33] for relevant considerations regarding the diachronic emergence of nasal vowels in French). Second, from a phonetic viewpoint, we must take into account the frequent nasalization of the vowel preceding the realization of /N/ and even the phonetic

realization of /N/ itself as a nasalized vowel, especially high ones such as [M~] or [i~], in particular contexts. The word 'phonology' /oNiN/ can thus be realized as [oi~iN] or [oi~?iN] [34]. Third, from a psycholinguistic viewpoint the importance of the loanword lexical stratum in the Japanese lexicon, with sociolinguistically established adaptation rules [35], possibly influencing the (re)production of foreign sounds, at least through the orthographic medium [36].

These three aspects (phonological, phonetics and psycholinguistics) have been used to account for the results obtained in previous studies with advanced learners of French [22][30], which we were expecting to find in the present research. First, a quality ranking in terms of rates of target-likeness (/O~/>/A~/>/E~/): our present results in the global analysis confirm the lower rate of /E~/, but show no difference between /O~/ and /A~/. Second, an inter-task asymmetry, i.e. higher rates of targetlike quality productions in reading than in repetition but more excrescences in reading than in repetition: our present global analysis reveals an opposite asymmetry for the quality but a similar trend for the excrescences. Interestingly, the partially different patterns found in the present study might represent the initial stage of the developmental path followed by the learners, while our previous results could reflect an advanced stage of learning.

Indeed, the quality ranking obtained earlier among advanced learners is much sharper than the one obtained here, which we may interpret as a gradual differentiation process, by which /O~/ would eventually be better produced than /A~/ (which might partly be explained either in terms of phonetic-phonological similarity with corresponding units in Japanese or in terms of usage-based psychoacoustic differentiation within the triplet {/O~/ /A~/ /E~/}), while /E~/ would remain the most difficult vowel especially in a reading task [23]. This might be linked to phonographemic factors since in French (and partly in our stimuli) there are fewer graphic forms for /O~/ (only bigrams) than for /A~/ (bigrams, apart from the not very frequent <AON>) and in turn than for /E~/ (bigrams and trigrams) [30]. If we consider that the rates of successful nasalization are higher than those of successful quality distinction in our study, and that no distinction is significantly noticeable both in terms of nasality and in terms of quality in the repetition task (which involves a higher degree of perceptual confusability as well as phonetic strategies), we may say that the inter-category distinction between oral and nasal vowel seems to be more rapidly acquired than the intra-category quality distinction. Depending on the (psycho)linguistic model we refer to, this can be interpreted in several, yet convergent, ways, as a perceptual single-category assimilation in the Perceptual Assimilation Model of Best [37], a gradual phonemic learning with regard to the L2LP model of Escudero [20], or a combined effect of divergent allophonic transfer (given the loanword adaptations of Ṽ into /VN/ in Japanese and the possible realization of /N/ as a nasalized vowel in Japanese words) and differential markedness, in inverted reference to the Differential Markedness Hypothesis of Eckman [38] (according to which, on the basis of the L1-L2 differences, the more marked the more difficult to learn a foreign element will be), since the feature [+nasal] is more marked (hence perceptually more salient in this context) than the features [+anterior] or [+high] for example.

The inter-task asymmetry found in our results is consistent with this view: since novice learners are characterized by a weak knowledge of graphophonemic correspondences (which in French are not transparent), it is not surprising that their productions may be better in the repetition task, since they can rely on purely phonetic strategies ('phonetic mimicry' [39]). On the other hand, the repetition task may involve top-down perceptual filtering of the acoustic input (especially when phonological units and lexical representations in L1 or in L2 are activated), whereas orthographic representations in the reading task can serve as cues to identify less perceptible features, such as the quality value of nasal vowels (for an illustration of the discriminatory role of the orthographic input see [40]).

The results of the excrescences analysis is convergent with our view in that fewer excrescences emerge in the repetition task (absent from the input), a characteristic which seems to be common to both novice and advanced learners, pointing to the impact of literacy on the production of consonantal excrescences (and therefore of the processing of nasal vowels as VN sequences), as is the case in the historical emergence of Southern French [41].

5. Conclusions

In this article, our aim was twofold: first, to present a procedure for semi-automatically processing corpus-based L2 phonological data in an applied perspective through a code-mediated perceptual analysis; second, to illustrate the results we can achieve with this procedure in the case of nasal vowels produced by beginner Japanese learners of French within the framework of the IPFC project. Our data was elicited during the first stage of a two-year longitudinal study, focusing on the nasality, quality and postvocalic consonantal excrescences of the non-native nasal vowels of monosyllabic words in two tasks (repetition and reading). Our results contrasted interestingly with previous data obtained among advanced Japanese learners of French. While both populations seem to exhibit more excrescences in the reading task, the assessment of their productions differed in terms of task-related vowel quality, which can partly be accounted for by differing strategies at each developmental stage. On the basis of the rates of target-likeness of their productions, we may hypothesize than novice learners are able to acquire the inter-category contrast between oral and nasal vowels faster than the finer-grained intra-category distinction between the three nasal vowels /A~/, /O~/, /E~/ and that the impact of the task may vary according to the learning stage. The subsequent analysis of the development of the learners' L2 nasal vowels, both in perception and production, through the data-comparable procedure established in the longitudinal survey in which the present study was embedded, will allow us to test whether their nasal system in French at a later stage actually corresponds to our initial assumptions or not.

6. Acknowledgements

7. References

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