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PERCEPTION AND PRODCUTION OF UNFAMILIAR L2 SEGMENTS: USING TECHNOLOGY FOR TEACHING AND RESEARCH

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In this paper I discuss the first step in an ongoing empirical study on the perception and production of French nasal vowels in a classroom context. The first phase of the study, presented here, analyzes L1 English learners' perception and production of L2 French nasal vowels /ɑ̃/ and /ɔ̃/, an important contrast in spoken French, as it distinguishes between many minimal pairs in the lexicon as well as between gerundive and nominal forms of verbs. Since nasality is not phonemic in English, and because both L2 segments are open back vowels differing mostly in roundedness, learners have difficulty perceiving the difference between these segments. This leads to trouble pronouncing them as distinct phones in spontaneous production. Results from the pilot study reveal that, regardless of level, university-level French learners are not improving with regard to the target sounds in either perception or production.

In addition to presenting these findings, *Audacity* audio recording software, *Praat* speech analysis software, and *Qualtrics* survey software are discussed as a means of incorporating listening and pronunciation practice into classroom language learning in order to draw learners' attention to important phonetic features of the language and to improve their perception and pronunciation.

INTRODUCTION

While production is generally regarded as the hallmark of proficiency in second language performance, a question that is often overlooked in practice, if not in research, is whether the L2 speaker is correctly perceiving the sound she wishes to produce. If one cannot accurately perceive the acoustic-phonetic and articulatory properties of a sound, it may be difficult to accurately produce that sound. This is especially true in the case of sounds that occur in allophonic variation in the L1 but are phonemic in the L2, as in the case of native speakers of American English (AE) learning the four nasal vowels that are essential to the accurate pronunciation of L2 French.

Nasal vowels represent a possible area of difficulty for English-speaking learners of L2 French due to their lack of phonemic distinction in the L1. It can be difficult for L1 AE learners of French to perceive the contrast between oral and nasal vowels as well as the contrasts among the various nasal vowels, and this, in turn, may be related to difficulty producing nasal vowels in the appropriate phonetic environments. In this paper, I describe the results of a pilot study focused on L1 AE learners' perception and production of the French nasal vowels /ɑ̃/ and /ɔ̃/; how the acquisition of these phones is affected by typical classroom L2 instruction; and how the technological tools that were used in this research study can be implemented in the classroom in order to help learners improve their performance on nasal vowel contrasts.

REVIEW OF PREVIOUS LITERATURE

Perception and Production of French Nasal Vowels

Two issues are addressed in the current study: the relationship between perception and production of L2 segments and the ability of second language learners to improve their perception and production of French nasal vowels. Perception of segments in an L2 can have important effects on the speed of language processing (Munro & Derwing, 1995), the ease of word recognition (Bradlow & Pisoni, 1999), and the production of those segments (Rochet, 1995). There is no doubt that a link exists between perception and production; the nature of that link is, however, unclear. Perception is understood by some researchers to precede production in L2 acquisition (Flege, 1995), while others posit that the two processes occur in parallel (Best, 1995), and still others have provided evidence that production can in fact precede perception (Sheldon & Strange, 1982). The relationship between perception and production, and how these two skills interact in the language acquisition process, is an essential aspect of L2 proficiency.

As Zampini (2008) has observed, there is a notable lack of research into the production of L2 nasal vowels. Similarly, there appear to have been relatively few studies on the perception of nasal vowels among L2 learners. Where perception studies have been performed with oral vowels, the results have often differed considerably from those obtained from consonant perception studies. While scholars have generally found that improved perception resulting from the training of certain consonant contrasts can be transferred to untrained contrasts, perception of vowel contrasts has not proven as transferable (Nishi & Kewley-Port, 2008, p. 1480).

Research on the perception and production of French vowels has focused almost exclusively on oral vowel contrasts. For example, Levy and Law (2010) looked at the effects of language experience and consonantal context on the production of French /i – y – u – œ – a/ in bilabial and alveolar contexts. Rochet (1995) evaluated acquisition of the French /y/ by speakers of languages with only /i/ and /u/, both in terms of current ability and the potential of perceptual training. Perceptual training studies have also focused on important oral contrasts such as /y – u/ (Simon, Chambless & Ubirata Kickhoefel, 2010) and /ə – o/ (Brosseau-Lapre, Rvachew, Clayards, & Dixon, 2013). A notable exception is a study by Inceoglu (2016), which found that audio-only and audiovisual training both significantly improved L1 AE learners' perception and production of Parisian French nasal vowels /ɔ̃ – ɑ̃ – ɛ̃/ compared to a control group.

More research is necessary to identify areas of difficulty for L1 AE learners of French nasal vowels, specifically which contrasts are least easily acquired and how perception and production interact in this acquisition.

French Nasal Vowel Pair /ɑ̃/ – /ɔ̃/

French contains four nasal vowels: /œ̃/, /ɔ̃/, /ɛ̃/, and /ɑ̃/. The present study focuses on non-native listeners' perception of /ɑ̃/ and /ɔ̃/. These vowels are important in French because they represent a strong phonemic contrast. For example, the words *sans* /sɑ̃/ and *son* /sɔ̃/ (*without* and *his/her*, respectively) constitute a minimal pair with important semantic implications. Additionally, students demonstrate difficulty in perceiving these sounds correctly and producing them accurately. Finally, the oral counterparts of these vowels exist in the L1 English inventory while the nasal versions exist only in allophonic variation.

Results from an MRI study with cepstral analysis by Delvaux, Metens, and Soquet (2002) showed that /ɑ̃/ is articulated somewhat lower, more rounded, and more posterior than its oral counterpart /a/. An analysis of the /ɔ – ɔ̃/ pair revealed that the nasal vowel /ɔ̃/ is more rounded than its oral counterpart. The acoustic analysis for both pairs demonstrated a drop in F2 that corresponds to the shifting of the velum for nasal vowels. French nasal vowels thus demonstrate important acoustic-phonetic differences from their oral counterparts.

Following Flege's Speech Learning Model (SLM) (1995), it is likely that L1 English learners of French classify the French oral vowels /a/ and /ɔ/ as phones identical to those in their existing American English inventory. I propose that the French vowels /ɑ̃/ and /ɔ̃/ are categorized as similar L2 phones, making them more difficult to distinguish. First, since the oral vowels /ɑ/ and /ɔ/ exist in both the L1 and L2 inventories and are realized in phonetically similar ways, the articulatory and phonetic changes necessary to nasalize them may not represent a distinction sufficient for L2 learners to create a 'new' phonetic category.

It is also common in American English for vowels to be nasalized due to the phonetic environment or to individual differences in the realization of the phones. Oral and nasalized vowels in L1 AE do not represent a phonemic distinction, so these phonetic properties may not be salient to L1 AE speakers when listening in L2 French. Finally, the articulatory and phonetic changes that occur in the shift from oral to nasal vowels in French may mute the distinction between the two vowels for AE listeners. In other words, the perceptual distinction that exists between the oral vowels /ɑ/ and /ɔ/ may be lost in the movement, rounding, and drop in F2 values that occur when these vowels become nasal, leading to an inability to perceive the difference between /ɑ̃/ and /ɔ̃/.

Research Questions

1. Given their current instruction, are students progressing in their perception and production of French nasal vowels, specifically the /ɑ̃ – ɔ̃/ contrast?

2. Is there a demonstrable relationship between students' ability to discriminate between these sounds and their ability to produce them?

METHOD

The pilot study presented here was undertaken as the first step in a research project that will use high variability phonetic training (HVPT) (Logan, Lively, & Pisoni, 1991) to aid L1 English learners of L2 French in the development of the necessary perceptual skills to distinguish French nasal vowels. To establish the need for such a program, the pilot study assessed learners' acquisition of French nasal vowels at the beginning and end of a semester of typical instruction, with no experimental intervention.

Participants

The participants in the study were 33 L1 American English learners of French, ranging in age from 18 to 35 with an average age of 22. All reported normal hearing. In order to look at differences according to level of instruction, participants were recruited from three levels: 102 (second semester), n = 13; 202 (fourth semester), n = 15; and 302 (sixth semester), n = 5. One female native speaker of French served as the speaker for the perceptual tasks.

Materials

The perceptual stimuli consisted of 40 one- and two-syllable word pairs, embedded in individual words (30) and short sentences (10). Each word pair contained either the target contrast (/ɑ̃ – ɔ̃/) or a distractor contrast (/e – i/, for example). There was a total of 17 tokens of the target vowel contrast, 12 in the list of words and 5 in the list of sentences. For the production task, one word was chosen at random from the word pairs used in the perceptual task to create a list of 30 words and 10 short sentences to record. Participants were asked to perceive and produce words containing nasal vowels both in individual words and in short sentences in order to determine if the additional context of the phonetic environment in a sentence had an impact on their ability to discriminate and produce sounds. An example of a word pair used in the perceptual task is <violon> (/vjɔ.lɔ̃/, *violin*), which was contrasted with <violent> (/vjɔ.lɑ̃/, *violent*), a pair with important semantic implications.

Procedure

After the initial recruitment, participants scheduled two separate appointments. During the first appointment, after filling out a demographic questionnaire, they were sent a link to a *Qualtrics* survey containing a forced choice perception task in which they heard the series of randomized word pairs followed by the series of randomized short sentences. In each series, they were asked to indicate the word they heard from two choices. They were then provided the list of words and short sentences and asked to record these in two *Audacity* files, which were then analyzed using *Praat* speech analysis software. This procedure, with the exception of the demographic questionnaire, was also followed at the second appointment, which took place approximately ten weeks later.

RESULTS

Perception

Results from the perceptual task were inputted into IBM *SPSS Statistics* and were analyzed to determine whether there was a significant improvement from pretest to posttest on either word pairs or sentences at each level; how the different levels compared to one another at each time step (pretest and posttest); and whether improvement over time was significantly different among the class levels.

A series of paired-samples t-tests determined that the level of improvement from pretest to posttest was not significant for any class level in either phonetic context (see Table 1). A repeated measures analysis of variance confirmed that there were no significant differences based on class level for either words (p = .553) or sentences (p = .733). Similarly, there were no significant differences between groups with regards to improvement over time (posttest score – pretest score) for either words (p = .299) or sentences (p = .196).

Table 1

Paired-samples t-test results comparing perceptual results by class level over time (p-values)

Level	Words				Sentences			
	t	*M*	*SD*	*p*	*t*	*M*	*SD*	*p*
102	.65(12)	2.56	14.19	.527	1.08(12)	6.15	20.63	.303
202	1.78(14)	7.22	15.71	.097	-1.57(14)	-8.00	19.71	.138
302	-0.69(4)	-5.00	16.24	.529	0.34(4)	4.00	26.08	.749

Additionally, despite the lack of statistical significance among levels, the general trend shows that participants perceived vowel differences better overall (i.e., in all combined vowel combinations) than they did for the target nasal vowels as a subset. This was true at both the pretest and the posttest (see Tables 2 and 3). While students in second-semester French (102) did not see an improvement in nasal vowel distinctions in any context, fourth-semester (202) learners showed considerable improvement in target nasal vowel contrasts embedded in short sentences, while sixth-semester (302) students seemed to improve in target contrasts embedded in words. Only the sixth-semester students showed any improvement in the combined score.

Table 2 presents the pretest and posttest scores, along with improvement over time, on the perceptual task for vowel contrasts embedded in word pairs. "Target" scores represent performance only on the target vowel contrasts, while "Overall" scores represent all combinations including distractors (oral vowel contrasts as well as oral-nasal contrasts). Scores are represented here as the percentage of correct responses.

Table 2

Average performance on target contrasts embedded in words

Level	Pretest		Posttest		Improvement	
	Target	*Overall*	*Target*	*Overall*	*Target*	*Overall*
102	67.31	73.59	64.74	74.1	-2.57	0.51
202	76.11	80	68.89	76	-7.22	-4
302	66.67	76.67	71.67	80	5	3.33

Table 3 shows the pretest and posttest scores, along with improvement over time, on the perceptual task for vowel contrasts embedded in short sentences.

Table 3

Average performance on target contrasts embedded in short sentences

Level	Pretest		Posttest		Improvement	
	Target	*Overall*	*Target*	*Overall*	*Target*	*Overall*
102	69.23	76.92	63.08	72.31	-6.15	-4.61
202	66.67	77.33	74.67	80	8	2.67
302	68	76	64	72	-4	-4

Production

As mentioned earlier, Delvaux et al. (2002) have identified four elements that distinguish French nasal vowels from their oral counterparts. In terms of articulation, they are lower, more rounded, and more posterior. Acoustically, they tend to have a lower F2 value, an indication that the velum has lowered to allow air to pass through the nasal cavity. Since the current study did not make use of the MRI, in this section I will describe some general tendencies in the production of the vowels from participants in each class level.

To illustrate the differences between word-initial and word-final nasal vowels, I have chosen the words <angle> /ɑ̃gl/, <quand> /kɑ̃/, <onze> /ɔ̃z/, and <blond> /blɔ̃/. I carefully analyzed and transcribed the students' productions of these words and calculated the rate of correct responses on the basis of these analyses. The results are presented in Table 4 below. The scores represent the number of students at each class level who produced the nasal vowel correctly, irrespective of how they pronounced the other sounds in the word. The only exception to this rule is for those who produced the nasal consonant /n/ after the nasal vowel, since the addition of the consonant reduces the nasality of the vowel.

Table 4

Number of correct nasal vowel productions by class level

Level	angle	quand	onze	blond
102	9/13	5/13	7/13	11/13
202	11/15	6/15	5/15	10/15
302	2/5	3/5	2/5	3/5

Word-initial /ɑ̃/. While <angle> presented some problems for students at all class levels, the /ɑ̃ – ɔ̃/ distinction was not entirely to blame. One learner each in 102 and 302 produced a sound that fell between /ɑ̃/ and /ɔ̃/, and two learners each in 102, 202, and 302 produced the nasal consonant /n/ after the initial vowel, thereby reducing the vowel's nasalization. Two errors occurred in non-

target sounds, with the variants [ãgle] and [ãglo] being produced by 102 learners. Only two of the 302 students produced the nasal vowel correctly for this word; however, two of the incorrect responses were due to the addition of /n/ after the vowel. Since only five students from this level were included in the study, the percentages were easily reduced by these minor errors.

Word-final /ɑ̃/. <Quand> was the most difficult of the four words in terms of the variety of incorrect sounds produced. As expected, students in 102 experienced more difficulty than those in later stages of instruction, producing variants such as [kwan], [kɑ̃n], and [kɔ̃]. Seven of the 13 learners in this group produced a vowel sound other than /ɑ̃/, including /a/, /æ̃/, /ɔ/, and /ɔ̃/. Five of these learners added the /n/ sound after the vowel. Similarly, students from level 202 pronounced this word as [kɑ̃n], [kɑ̃nd], and [kɑ̃d], among others. In this group, six of the 15 learners produced a sound other than /ɑ̃/. In contrast to the 102 group, however, all 202 learners who used the wrong vowel produced it as /ɔ̃/. Three students in this group added either /n/ or /ŋ/ after the vowel. Finally, although this word provoked difficulty for the 302 students, their errors involved only the amount of rounding in the nasal vowel rather than incorrectly inserting consonants or using oral vowels like the learners from the lower levels did. That is to say, two of the 302 students produced the word as [kɔ̃] and the other three correctly pronounced [kɑ̃].

Word-initial /ɔ̃/. The word <onze> generated only minor errors for 102 and 202 students. In 102, the six learners who were marked wrong pronounced the nasal consonant /n/ after the nasal vowel: [ɔ̃nz]. No one in the group produced the vowel as the unrounded /ɑ̃/. In 202, of the 10 learners who were marked wrong, nine of them added the nasal consonant /n/. Only one 202 learner produced a vowel sound that fell between /ɑ̃/ and /ɔ̃/. Three students in 302 added /n/ after the nasal vowel; however, all of them produced the vowel itself correctly. That is to say, they were seemingly aware of using the necessary rounding, but failed to leave out the nasal consonant.

Word-final /ɔ̃/. <Blond> seems to have been the easiest of the four words to produce for 102 students. Eleven out of 13 produced it correctly, with only one student producing a nasal sound somewhere between /ɑ̃/ and /ɔ̃/ and one student adding /n/. Ten of the 15 students from 202 produced this sound correctly; of the five who did not, four pronounced the /ɔ̃/ as / ɑ̃/ and one added /n/. Three 302 students produced the sound correctly and the other two produced a sound in between /ɑ̃/ and /ɔ̃/. That is to say, while they may have been aware of the difference between the two sounds, they failed to fully round the /ɔ̃/.

Interestingly, the trends in perception do not line up with the trends in production for all words at all levels. For example, while <quand> appears to have been the most difficult word for 202 learners to produce, with six of 15 producing it accurately, the perception data suggest that it was among the easiest for them to perceive, with 11 of 15 participants correctly identifying it. Conversely, although <blond> seems to have been the easiest word for 102 learners to produce, with 11 of 13 students producing it accurately, it actually received the lowest scores on perception, with only seven of 13 students in 102 correctly identifying it. Despite the inconsistent, relatively inaccurate production performance of the 302 group, they performed better on the perception task, with four out of five students correctly perceiving all four words analyzed here. These results indicate a disconnect between perception and production for learners at all class levels regarding nasal vowels.

DISCUSSION

Perception

The results of the perceptual tasks demonstrate empirically what many French instructors have observed anecdotally in their classrooms: that students at all levels of instruction have a hard time distinguishing among the various French nasal vowels, in this case between /ɑ̃/ and /ɔ̃/. As expected, there were no statistically significant differences between groups or over time, despite the appearance of some divergent performance. This supports the hypothesis that learners are not progressing in their perception of nonnative L2 segments over the course of their typical classroom instruction.

Of note, however, are the results demonstrating that 202 students improved their perception in the context of short sentences while 302 students improved in distinguishing target contrasts in individual words. This could be because short sentences provide extra contextual and phonetic information whereas single words do not, potentially explaining why the advanced students improved in the more difficult context of single words while intermediate students required the extra contextual information provided by short sentences.

Despite some small differences among groups, the results of the perception tasks in this pilot study demonstrate that in the course of their normal instruction, learners are not advancing in their ability to perceive French nasal vowels. Future research should implement an instructional technique that provides learners with plentiful opportunities to hear French nasal vowels in varying phonetic contexts, and guides them in perceiving these differences. An improvement in perception compared to a control group may be accompanied by a parallel improvement in production of these segments.

Production

The production data presented here do not illustrate any consistent trends among levels or phonetic contexts. For example, while learners had difficulty with the word-final /ɑ̃/ in <quand>, they performed considerably better with word-final /ɔ̃/ in <blond>. This could be explained by first-language interference due to orthography, since <qu> in English is pronounced /kw/. However, whereas word-initial /ɑ̃/ in <angle> was produced correctly by most students, word-initial /ɔ̃/ in <onze> was frequently produced as [ɔ̃n].

The recordings used in this study provide general information about production trends based on class level as well as details of individual learners' productions. The inconsistent nature of these production results and their relative lack of correlation to performance on the perception task, provide evidence that sufficient progress is not being made in the case of nasal vowels.

Use of Technology in Teaching and Research

Many of the programs that we utilize as researchers can also be successfully implemented in L2 classroom instruction. Research has shown that metacognitive awareness can aid learners in recognizing weaknesses and improving the cognitive processes they use to process input (Vandergrift, 2002; Vandergrift & Tafaghodtari, 2010). To this end, survey software such as *Qualtrics* as well as audio recording programs such as *Audacity* and speech analysis software

such as *Praat* can be leveraged to give students the practice and the metacognitive tools to work on their perception and production.

Listening and pronunciation practice are two exercises that are frequently lacking in L2 classroom instruction where time is at a premium and the focus is generally on communicative learning. This is where online survey software like *Qualtrics*[1] can be utilized in conjunction with course management software to assign these types of activities as homework. *Qualtrics* allows for certain functions that aren't available in most course management programs, such as the embedding of audio files into questions, randomization of items, automatic scoring, and even somewhat primitive reaction time measures. The instructor can record items using *Audacity* and upload them into the *Qualtrics* library to insert them into future surveys. Perception of words and segments can be verified via multiple choice, short answer, and essay questions. A link to the *Qualtrics* survey can easily be embedded in the course management program. While the process of uploading audio files entails an initial output of time, this is mitigated by the ability to reuse audio files from semester to semester. Over time, various speakers can be recorded in order to build a database of audio excerpts that exemplify both phonetic and speaker variability.

Audacity[2] is a user-friendly audio recording program that is free to download, making it incredibly useful for L2 instructors and students. As a pronunciation exercise, for example, an instructor might make a recording of a list of words and phrases produced by several native (or nativelike) speakers and upload it to the course management system. Students could then be instructed to listen and repeat as often as necessary until they feel they have mastered the pronunciation, and then to record themselves reading the list and post it privately in the course management system for the instructor to listen and provide feedback.

For more advanced students, speech analysis exercises can be useful in analyzing their own pronunciation and having a visual representation of their progress. Without broaching advanced linguistic concepts, they can learn how to import their audio files into *Praat*, view and edit spectrograms, and compare them visually to their own previous recordings of the same items. They can experiment with different pronunciations and see how these compare to each other in *Praat*. For visual and kinesthetic leaners, this type of exercise has the potential to be a powerful tool to help them grasp how subtle differences in pronunciation can change output (Lambacher, 1999; Saito, 2007)

These programs, in addition to being useful in language acquisition research, allow educators to more easily incorporate listening and pronunciation practice into their courses despite time constraints. As an added benefit, aligning the programs we use in empirical studies with what we use in the classroom represents a step toward bridging the gap between theory and practice.

Further Research

Nasal vowels represent an area of particular difficulty for L1 American English learners of French. In this preliminary study I have provided evidence of the need for targeted instruction in the perception and production of these sounds, a task that can be made easier through the implementation of accessible online resources such as those used in the study. Moving forward, I

[1] Institutional subscriptions range from $500-$1000: www.qualtrics.com
[2] Free to download for PC and MAC at www.audacityteam.org

will also test whether HVPT (Logan et al., 1991) has the potential to provide the necessary input and cognitive and metacognitive procedures to lead to successful perception and production of unfamiliar L2 segments such as French nasal vowels.

In recent years, there has been increased interest in the concept of training learners to perceive differences in L2 vowel sounds (Nishi & Kewley-Port, 2008; Tajima, Kato, Rothwell, Akahane-Yamada, & Munhall, 2007; Thomson, 2012). Thomson (2012), for example, in his training of 26 Mandarin L1 speakers to perceive English vowels, found that learners' perception of English vowels had improved in the training context as well as in one novel phonetic context.

I posit that training L1 AE speakers to perceive French nasal vowel contrasts can be achieved via HVPT because it encourages the use of stimuli presented in multiple phonetic contexts and by multiple native speakers to build robust perception of target contrasts. The perceptual difficulty L1 AE learners have in acquiring French nasal vowels makes them particularly good candidates for the use of this type of training. Through repeated exposure to the target sounds in various phonetic contexts, learners may become more familiar with the acoustic-phonetic properties of these phones and develop the perceptual processes to distinguish among them in novel contexts.

CONCLUSION

In this study I have presented empirical evidence from three levels of French instruction to demonstrate that, given the current instructional paradigm, students are not progressing in their development of perception and production skills with regard to French nasal vowels. At all levels of instruction, performance on a perceptual task did not improve over time. Students at higher levels did not perform significantly better than those at lower levels either at pretest or at posttest Production performance was inconsistent in terms of phonetic context as well as relationship to perception.

Because French nasal vowels are likely assimilated as similar phones for L1 AE speakers, and because they have an impact on meaning due to their phonemic nature in the L2, it is imperative that L2 French listeners learn to differentiate between them, both in perception and production. Previous research has shown that perceptual training can have an impact on vowel perception; however, nasal vowels have remained relatively unstudied. The results of this pilot study support the need for effective pronunciation instruction, which will be studied further using high variability phonetic training.

ABOUT THE AUTHOR

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