THE ACQUISITION OF FRENCH NASAL VOWELS: FROM FIRST LANGUAGE ALLOPHONY TO SECOND LANGUAGE PHONOLOGICAL CONTRAST

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THE ACQUISITION OF FRENCH NASAL VOWELS: FROM FIRST LANGUAGE ALLOPHONY TO SECOND LANGUAGE PHONOLOGICAL CONTRAST

This dissertation examines the acquisition of French nasal vowels by American college students who are learning French as a second language. Nasal vowels in French are common and important, since they are phonemic. French has a phonemic contrast between oral and nasal vowel categories, e.g. pain [pɛ̃] "bread" vs. paix [pɛ] "peace". English does not: nasalized vowels are allophonic variants of the oral vowel categories. Nasal vowels present a persistent difficulty for learners, and their acquisition from the perspective of perception and representation is not well understood. To explore the developmental steps involved in this acquisition, this dissertation analyzes the connection between phonetic categorization and phonological contrasts in lexical representations for learners at various levels of proficiency. Naïve (no French knowledge) participants as well as intermediate and advanced learners of French and French native speakers participated in phonological processing tasks involving perceptual mapping, ABX categorization, and lexical decision. Since nasal vowels are not part of the English phonological grammar — as opposed to French /kɑ̃/ 'quand'—, learners will likely first "repair" such a disallowed feature combination (nasal+vowel) in perception, before being able to acquire a new underlying representation. Two possible acquisition strategies are outlined: nasal unpacking, in which learners attribute perceived nasality to a neighboring nasal consonant, and will assume the presence of a nasal consonant (e.g., they will "repair" /kɑ̃/ as /kɑn/); an alternative strategy is nasal-stripping, in which learners ignore nasality from the vowel representation, hence turning the nasal vowel into an oral vowel ("repairing" /kɑ̃/ into /kɑ/). The application of either strategy is probed via a discrimination task contrasting the predicted difficult pairs (/kɑ̃/ vs. /kɑn/); /kɑ̃/ vs. /kɑ/). The steps needed for the initial (repaired) representation to finally resemble the French native speakers' representations are outlined for each strategy. The results indicate that naïve listeners mostly heard French nasal vowels as sequences of oral vowel+nasal consonant, applying nasal unpacking. However, exposure to French instruction appears to modify the strategy: intermediate learners initially heard French nasal vowels as oral, thus applying the nasal stripping strategy. Eventually, advanced learners successfully perceive and acquire nasal vowels in terms of their phonological underlying representation. This dissertation makes significant contributions to the field by advancing our understanding of the underlying phonological representation of these complex sounds, and of their perceptual similarity across languages. It also deepens our understanding of the steps involved in acquiring a phonemic category in L2 for a class of sounds that are not phonemic (allophonic) in L1. Finally, it also provides theoretically important data on the relationship between perception and lexical representation of segments, an area which is currently understudied.

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Chapter 1

Introduction

Human beings are born with an incredible capacity to learn any language. Six-month old babies, for example, are able to discriminate many non-native sounds that adults cannot tell apart (Werker & Tees, 1984). This initial perceptual flexibility, however, does not last long. Children soon learn to discriminate only the speech sound categories that are relevant or meaningful in the language that they are acquiring: their first language (L1). Hence, discrimination abilities shift from quasi universal to L1-specific within the first year of exposure. In fact, some studies indicate that L1-vowel categories are established approximately at 6 months of age (Kuhl et al. 1992; Polka & Werker, 1994; Werker & Lalonde, 1988).

This shift, while necessary for optimal acquisition and processing of the L1 phonological system, comes at a price in the context of second language (L2) acquisition: as soon as the L1 system is established, the ability to discriminate certain sounds or phonetic dimensions that are not distinctive or relevant in the L1 is greatly diminished. Such discrimination ability can be relevant to distinguish certain pairs of phones in another language. As a consequence, later in life, when adults learn certain sounds of that new language, it can become a difficult task if such sounds are not present in their L1 or when they are similar to another existing sound of their L1 (Best, 1995; Flege, 1995; Cho & McQueen, 2006; Mcallister, Flege & Piske, 2002). This is the case, for instance, of /l/ vs. /r/ distinction for L1 Japanese speakers learning L2 English.

Each language has its correspondent phonological grammar, which encompasses the whole phonological system of this language, from segmental categories to prosodic and intonational units. One area of the phonological grammar also entails phonotactics, that is the way in which consonants and vowels can be combined in lexical representations. For example, in English there are words such as *school*, *stop* or *slide,* whereas Spanish does not allow such consonant sequences to start a word. This can be seen in the cognate Spanish word *escuela* 'school'. Interestingly, when a Spanish speaker learns to speak English, pronouncing the word *school* presents a specific difficulty, which the speaker usually solves by adding an initial vowel [e] during the pronunciation, such that words like *school*, or *star*, or *speech* become *[eskul], *[estaɹ] or *[espiːtʃ]. By adding the initial vowel /e/ to the consonantal cluster /sp/, /st/, or /sk/, a Spanish speaker learning English is able to respect her L1 phonological grammar. Another example is offered by L1-Japanese speakers who tend to insert an additional (prothetic) vowel — either /u/ or /o/— in places when the language they hear does not follow the phonotactic rules of Japanese (Dupoux et al. 1999). For instance, since the syllable structure for Japanese requires a consonant to be followed by a vowel, a French word such as *festival* [fɛstival] 'festival' will be pronounced as [fesutibaɾu]. The addition of the vowel /u/, the /v/ becoming /b/ and the /l/ becoming /ɾ/ make this word conform to the Japanese pattern.

It is understood that the L1 phonological grammar affects how an L2 is perceived. For instance, Carlson, Goldrick, Blasingame and Fink (2015) and Cuetos et al. (2011) have shown that Spanish speakers in fact perceive the prothetic vowel when presented with items such as *star*, containing an illegal word-initial /st/ cluster, perceptually repairing an illegal sequence. What happens then when a non-native contrast is perceived by an L2 learner? Is the learner mainly influenced by the low-level articulatory aspect of the speech signal (phonetics)? Or is it at the more abstract level involving phonological representations that the problem lies (phonology)? Could it be both?

The optimal language learner's goal is to realize important differences, which, if they are not clearly pronounced, can interfere with comprehensibility and intelligibility of the speaker. In English, for instance, if the /p/ sound in *a pea* /əpi/ is replaced by /b/ we obtain the word *a bee* /əbi/. The main difference between /p/ and /b/ is voicing (vibration of the vocal folds) in this intervocalic context, when not produced or perceived can lead to misunderstandings in communication. Research on L2 phonological acquisition has highlighted the difficulties of acquiring native-like phonological grammar and perception of L2 sounds by adult L2 learners (Baker et al., 2008; Cebrian, 2006). Authors such as Brown (1998, 2000) also claim that only those features that are relevant to distinguish L1 phonemes can be used to categorize a sound — the L1 phonology acting as a perceptual filter (Polivanov, 1931) from which it is difficult to recover.

Features can be understood as the most basic component of a speech sound and separates one phoneme from another (ref: Chomsky & Halle 1968; Clements, 1985). For example, in French, oral vowels can have features such as [+/-front], [+/- back], [+/- round] as part of the vocalic category (phoneme) indicating if the vowels are produced towards the frontal part of the mouth closer to the lips [+/- front], the back part of the mouth closer to the throat [+/- back] or whether the lips are well rounded or not rounded at all [+/- round]. The difference between the vowel /i/ and the vowel /y/ is the rounding of the lips. Both vowels share the features [+front], but the vowel /i/ is [-round], whereas the vowel /y/ is [+round].

In addition to these features, French vowels can possess the feature [+/- nasal]. Although English has such a feature for consonants such as /m/, /n/ or /ng/, it is not a contrastive feature for vowels. As a result, the nasal feature which may affect the realization of vowels in English will always come from a preceding or following nasal consonant. E.g.: *sing*, *pen*, *tuna*.

Therefore, nasality is not part of the vocalic categories (phonemes) in English and it is not available in the phonological representation, so when English-speaking learners of French hear a French nasal vowel, they might associate such feature to a consonant and not to the vowel. As will be explained below in more details, the French nasal vowels are distinctive sounds of the French language, and are called *phonemes*, whereas the English nasalized vowels are not considered phonemes in English. They are positional variants of the oral English vowels, and are called *allophones*. This example illustrates in simple terms how the perceptual sieve works.

Not all sounds, however, display the same degree of difficulty in perception. Depending on the combination of the L1 and the L2 of the learner some pairs might be easier or harder to be perceptually acquired. That is, certain L2 phones can be acquired at a native-like level, whereas others represent an almost-impossible deed. Certain models account for such relative ease or difficulty in learning the sounds in the L2: the SLM (Speech Learning Model, Flege, 1995) and the PAM-L2 (Perceptual Assimilation Model for a second language, Best & Tyler, 2007). They deal with how learners categorize the new L2 sounds they hear into their L1. It is assumed that the departing language is the learners' L1. Therefore, initially, learners tend to assign new sounds which they interpret as being more or less deviant instances belonging to their already established L1 categories. As an example, French nasal vowels can be perceived as similar to English vowels that became nasalized due to being preceded or followed by a nasal consonant in words such as *song*, *pun* or *ten*.

As learners fill the gap between their L1 and their L2 phonological systems they create what is called the interlanguage, a system that is half way between the L1 and the L2, and possesses its own characteristics. Some studies have examined the acquisition of interlanguage phonological representations in terms of not only the segments, but also aspects such as stress, intonation patterns or — as was seen above with Spanish and Japanese — also phonotactics (possible combination of sounds).

The acquisition of L2 French nasal vowels has not yet received much attention in second language acquisition research. Placed at the segmental and the phonotactic interface, their importance in research responds to theoretical and practical reasons:

a) Theoretical reasons: in general terms, it is not known with much certitude how an allophonic feature can turn into a contrastive one, and more specifically how a system with phonemic nasal vowels can develop out of a system with allophonic nasal vowels. Moreover, it is not well known how these nasal vowels will be perceived by L2 learners of French and how they will encode such vowels lexically in their mental representations.

b) Practical reasons: nasal vowels are difficult for L2 learners, but it is unclear where these difficulties come from. Are they perceptual, prosodic or due to lexical encoding in nature? Is the problem linked only to perception, production or both? Having an answer to these questions allows to see where the difficulties lie and makes possible to target instruction or training in a more efficient manner.

As briefly evoked above, in English, nasal vowels occur as allophones: the oral vowels receive their nasality from a preceding or following nasal consonant. Consequently, the nasality of a vowel, in English, depends on a phonological nasal consonant environment: the diphthong [ei] in the word *cane* becomes partially nasalized and the consonant is still pronounced — [kei˜n][1]). Hence, in English, nasality in vowels appear in complementary distribution, that is,

[1] In order to distinguish between partially nasalized English vowels and fully nasal French vowels, I will use the following notations for transcriptions: the nasal mark ~ following a vowel (e.g. [i~]) denotes a partially nasalized vowel, whereas the superscripted nasal mark (e.g. [ɛ̃]) denotes the French nasal vowels.

vowels become nasalized when they precede or follow a nasal consonant such as /m/ as in *Sam*, /n/ as in *pond* or /ŋ/ as in *song*. In English nasality can be contrastive only for words in consonants such as /m/, /n/ or /ŋ/: *some* vs. *son* vs. *sung*.

In contrast, French displays a different type of phonological activity and uses nasality phonemically in both consonants and vowels: *sonne* uttered [son] 'sounds, 3d. pers. sg.' vs. *somme* [som] 'amount'; *paix* [pɛ] 'peace' vs. *pain* [pɛ̃] 'bread'. In addition, French presents both oral vs. nasal vowel contrasts (eg. *mot* /mo/ 'word' vs. *mont* /mɔ̃/ 'hill') and masculine/feminine or verbal alternations (eg. *plein* /plɛ̃/ 'full, masc.' vs. *pleine* /plɛn/ 'full, fem.'; *vient* / vjɛ̃/ ' s/he comes' vs. *viennent* /vjɛn/ 'they come') that contrast a nasal vowel with an oral vowel followed by a nasal consonant. Therefore, French nasal vowels constitute a phoneme on their own (there is change of meaning if nasality is removed from the vowel or if you substitute one for the other) and are therefore representationally distinct from their oral counterparts. In French, the difference between oral and nasal vowels is phonemic, and can therefore distinguish different words. In addition — and unlike English — the sequence (nasal vowel) + (nasal consonant) is not allowed (e.g. *laine* pronounced as *[lɛ̃n], instead of as [lɛn]) in the same syllable[2].

Consequently, first, English speakers have to learn that not pronouncing nasal vowels correctly can have communicative consequences: if the nasal vowel of *quand* uttered [kɑ̃] 'when' is produced as oral ([ka]), it will become homophonous with *cas* 'case'; if it is pronounced as a sequence of oral or nasalized plus nasal consonant ([ka~n]), it will become homophonous with *canne* 'cane'; either of these differences — which may not matter for English ears — will create

[2] Phonetic studies show that there is a measurable degree of nasal airflow during the vowel (Dow, 2014) which is ignored by French native speakers' perceptual systems. There are, in addition, a few words such as *emmagasiner* [ɑ̃magazine], *emmancher* /[ɑ̃mɑ̃ʃe], *emmener* [ɑ̃məne], *ennuyer* [ɑ̃nɥije], *enneiger* [ɑ̃nɛʒe] or *ennoblir* [ɑ̃nɔbliR], where this sequence appears (See Douglas, 2009). However, they belong to different syllables and different morphemes: emmagasiner ([ɑ̃.ma.ga.zi.ne]) and they are rare.

some spurious homophony because these three pronunciations [kã], [ka] and [kan] correspond to three different words in French, which have three different meanings. Second, they must avoid the nasalization of the vowel preceding the nasal consonant (phonotactic inhibition) as it was just seen above for the word *laine* ‘wool’.

Knowing that in French nasal vowels are distinctive, we could assume that English-speaking students of French would be able to easily tell the difference (at least phonetically) between these two vowels, since nasality should be perceptually salient to them. Nonetheless, it is not fully clear yet how an L2-French nasal vowel is in fact perceived by an L2 learner. Would it be a judged as a bad exemplar of an oral vowel in L1 English, as a clearly different vowel belonging to another category or even as a good exemplar of the oral vowel with a slight nasal twang? How will learners categorize French nasal vowels at the phonetic level? What about the phonological and lexical levels: How will these vowels of French be represented in the phonological grammar of the interlanguage, and how will words with and without nasal vowels be stored in the mental lexicon?

In addition to this phonological categorization uncertainty for L2 learners, underlyingly French nasal vowels possess a complex structure on which not all phonologists agree (Paradis & Prunet, 2000). To add another layer of complexity, unlike for naïve listeners, phonological representations for learners of French are in flux, since learners are presumably in the process of developing a new phonological inventory for their L2 French. Since it is not known exactly if, when or how learners will create a new phonemic category, adapt the one that they have for their L2 or create some mixing of the two in their interlanguage, obtaining a clearer picture of their discrimination and categorization problems becomes crucial to understanding the developmental process in L2 acquisition.

Another cognitive burden comes from the fact that learners have to deal simultaneously with the phonetic, the phonological and the lexical levels. The latter level allows learners to interpret and extract meaning from the input they hear. Darcy, Dekydtspotter, Sprouse, Glover, Kaden, McGuire & Scott (2012) go beyond both the phonetic and the phonological levels and incorporate the lexical level in their acquisition model. They highlight the possibility that perceiving phonetic differences is not a *sine qua non* condition to acquire lexico-functional phonological distinctions. That is, being able to encode phonetic contrasts into the phonological representation of vowels seems to be independent from being able to discriminate two sounds at the phonetic level.

These authors propose the Direct Mapping of Acoustics to Phonology (DMAP) as a possible mechanism for the acquisition of L2 sound systems. They argue that successful phonetic category distinction is not a necessary condition for (adult) learners to develop an L2 phonemic inventory and L2 lexical representations. DMAP questions the presupposition that a contrast which cannot be appropriately categorized by the listener (in target-like fashion) can neither become part of his or her phonology nor be lexically encoded. DMAP examined the relationship between the acoustic signal and the phonological representations for French rounded vowels /y/ and /œ/ showing that, as opposed to advanced and French-natives, intermediates learners of French did not distinguish /u/ from /y/ in their lexical representations, despite an excellent phonetic discrimination between both sounds. Conversely, both intermediate and advanced learners were much less successful at distinguishing the contrast between the mid vowels /o/ and /œ/, and yet were shown to have successfully encoded this distinction in the phonological form of their lexical representations.

In the present dissertation, I address the question of the splitting of two allophones (oral and nasalized vowels of English) in the L1 into two different phonemes (oral vs. nasal vowels of French) in the L2 within the DMAP framework, and examine the consequences of such a split for categorization and lexical representation in L2 learners of French. Nasal vowels have the potential to clarify the question of the L1-induced response to L2 input in DMAP. This model argues for a process of phonological acquisition which happens independently of categorical phonetic perception, in which illicit feature clusters detected in the L2 input are initially corrected to conform to the specifications of the L1 phonological grammar. Over time, continued input forces an update of the phonological system: the acquisition process happens first and foremost at this phonological level, where new feature combinations become licensed and encoded in lexical representations, independently of categorization behavior at the phonetic level.

The study of the L2 acquisition of French nasal vowels can add to this research, as French nasal vowels represent one of the most characteristic traits of the French language. This dissertation about the L2 acquisition of French nasal vowels examines the connection between phonetics and phonology of the oral vs. nasal vowel contrasts. It also proposes a methodology for investigating the difference between learning a new phonemic category (nasal vowels in French) and unlearning (inhibiting) the inappropriate application of an L1 phonological rule (nasalizing the vowel followed by a nasal consonant as it is done in English, given that a sequence like /ãn/ is not permitted in French).

I examine how English-speakers learning French at different proficiency levels handle the difference between French oral and French nasal vowels at three different levels: a) phonetically: through a perceptual assimilation experiment; b) phonologically: through an ABX perceptual experiment; c) lexico-phonologically: via a lexical decision experiment. In doing so I investigate the question of how learners perceptually treat these two allophones of the same phoneme, the oral vowel and its nasal counterpart, and whether they learn to build two different vowel categories (oral and nasal) over time. The present dissertation also aims at examining the phonological representation of these nasal vowels for L2 learners of French, asking whether they are represented phonologically in a way similar to L1 (English), to the target language (French), or in a way that is neither English nor French-like, a special interlanguage representation.

Chapter 2 will review the existing literature on L2 sound acquisition. Chapter 3 will deal with the definition of nasal vowels and their acoustic properties (section 3.1); the phonological representation (section 3.2) of nasality in both English and French; how learners deal with phonological contrast; what strategies English speakers might use in their perception of the French nasal vowels and some possible steps that would lead them to a French native-like phonological structure of such nasal vowels (3.3). This chapter also explores the possible learnability issues that English speakers encounter in dealing with this contrastive feature of French phonology, along with other L1 allophonic-L2 phonological contrasts. In chapter 4, I will describe the methods used for my three experiments: 1) a perceptual assimilation experiment; 2) an ABX experiment; 3) a lexical decision with repetition priming experiment. Chapter 5 will show the results for these three tasks. Finally, in chapter 6, I will discuss the findings of the three experiments and will make sense of such results; I will summarize the findings of the study and address some limitations and recommendations for future research.

Chapter 2 L2 sound acquisition

2.1 Sound systems and sound acquisition

Languages differ in how they organize their sound systems. This variation occurs in areas that go from segments to prosody. An example of the segmental domain is found in French speakers having trouble pronouncing the /h/ sound in English. The absence of such segment in French might lead the sentence "I hear horses" to be uttered as [aɪ iːɹ ɔɹsɪz] instead of [aɪ hiːr hɔrsɪz]. Another example, this time at the prosodic level, is that in French words are generally stressed on the last syllable *sérénité* [seʀeniˈte], acceleration [akseleʀ aˈsjɔ̃], whereas in English stress not only might vary in syllable location, but in addition we can find primary (marked with ˈ) and secondary stress (marked with ˌ) within the same word: *serenity* [səˈɹɛnəti], *acceleration* [əkˌsɛləˈɹeɪʃən].

This dissertation will focus on two sub-areas of sound systems, which I describe now:

1. Phonemes vs. allophones: a phoneme represents a sound that is contrastive in a language. If we take the word *sound* and replace the sound /s/ by the sound /p/ we will obtain a new word with a different meaning, *pound*. The sounds /s/ and /p/ are said to be phonemes of English, since replacing one by the other changes the meaning of the word. However, if we focus now on the word *pound* and compare it to the word *spa*, we will notice that the pronunciation of the /p/ sound in the word *pound* has an aspiration [pʰaʊnd] that is not present the word *spa* [spɑː]. Both [pʰ] and [p] are said to be allophones of the phoneme /p/ in English and this difference in pronunciation does not bring a change in meaning.

2. Phonotactics is a subarea of phonology that refers to the organization of sound sequences or how different sounds are combined together in any given language. It comes etymologically from the Greek word *phone* “sound” and the word *taktikos* “arrangement”. It deals with possible combinations of syllable structure, consonant clusters and vowel sequences via phonotactic constraints that are language specific. In English, for example, the sound /h/ that is found at the beginning of the word *house* /haʊs/ cannot be found in coda position (following a vowel in a closed syllable). That is, a word like **cloh* /kloh/ would not follow the phonotactic rules of English and it would be “illegal”. In German, however, a related sound that is not present in English (/x/) is phonotactically acceptable since we find words like *Bach /bax/* ‘stream’ *or Buch* /bux/ ‘book’.

Taking into account that languages differ from one another, what happens then when the native language (L1) and the second language (L2) sound systems do not align? How do people perceive non-native sounds or structures that are “illegal” in their L1? Usually when the phonological properties (phonotactics) for the two languages do not coincide, beginning learners tend to perceptually adapt the L2 sound system to their L1 sound system. That is, learners transform non-native sounds or illegal structures into possible ones by repairing or elaborating perceptual strategies. One example occurs with the initial consonant clusters /tl/ and /dl/. When an English speaker encounters these clusters they are normally misperceived (repaired) as /tr/ and /dr/ because the former consonant clusters are not a possible combination in English (Pitt, 1998; Massaro & Cohen, 1983). That is, their English phonological grammar does not allow /dl/ and /tl/ clusters, in opposition to speakers of Hebrew, who accept such clusters (Hallé & Best, 2007). Similarly, French listeners (Hallé, Segui, Frauenfelder, & Meunier, 1998) perceive /dl/

and /tl/ as /gl/ and /kl/, respectively, in syllable-initial position to respect their French phonotactics, as the /dl/ and /tl/ clusters are not present in French.

Another illustrative example with syllable structure in perception and production occurs in Brazilian Portuguese. This language does not usually allow CVCC structures (consonant + vowel + word-final consonant cluster), and prefers syllables that are open (ending in a vowel such with a CV structure as in *blue* /blu/ or *sea* /si/). English on the other hand allows word-final consonant clusters since we find words like *worse* /wɝs/ or even *months* /mʌnθs/. In the CVCC structure the first consonant(s) is called *onset*, the vowel is the *nucleus* of the structure and the final consonants that close the syllable are the *coda* (see Figure 1) — here, a complex coda.

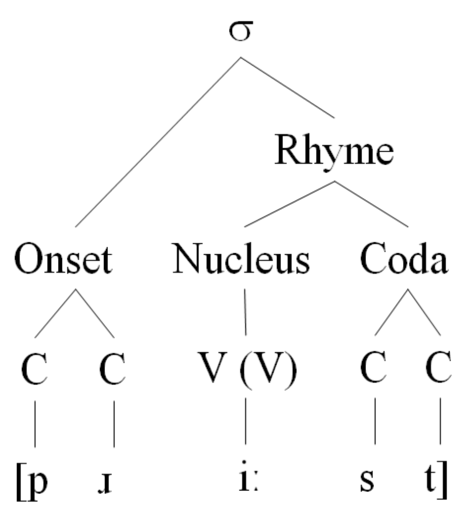

Figure 1. Representation of syllable structure (σ) for the word *priest*.

So when Brazilian Portuguese learners of English encounter this CVCC structure, they have to adapt it to their native language structure in some way. They usually do so by inserting an epenthetic vowel: a word like *ping pong* [ˈpɪŋpɒŋ] or picnic [ˈpɪknɪk] would be heard and pronounced as *[ˈpɪŋgipɒŋgi] and [ˈpɪkinɪki], respectively, by Brazilian Portuguese learners of English (Dupoux et al. 2011.)

As introduced in chapter 1, learners of a new language are highly influenced by the phonological grammar of their L1. Studies in cross-language speech perception have shown that linguistic experience can affect listeners' sensitivity to sounds that do not contrast in their native language. Specifically, learners experience more difficulties when the L2 sounds they hear are not contrastive (allophonic, without a change in meaning) in their L1 (Boomershine, Hall, Hume, & Johnson, 2008; Polka & Werker, 1994; Trubetzkoy, 1969).

This L1-based processing is so strongly associated with our perceptual activity that any subsequently learned language will be processed — at least initially — through the L1 representations (Polivanov, 1931). When we hear a non-native or second language, we are prone to experience:

a) Phonological deafness: occurs when listeners are not capable of distinguishing contrastive sounds. A well-known example of this phenomenon is the perception of /r/ and /l/ by Japanese and Korean listeners (Strange & Dittmann 1984; Ingram & Park 1998; Yamada & Tohkura, 1992). In Japanese there is no phoneme corresponding either to English /r/ or /l/. Instead, it features a sound similar to a tap [ɾ], which is perceived as intermediate between /r/ and /l/. As a consequence, Japanese learners of English display difficulties distinguishing these two sounds in perception.

b) Perceptual epenthesis: learners add a segment that is not truly present in the information they hear, in order to conform to phonotactic restrictions dictated by their L1. Japanese learners add an illusory epenthetic vowel /u/ to the end of closed syllables in words like "miracle" [mɪɹəkᵊɫ], which becomes *[mɪɾəkuɾu]. (Dupoux, Kakehi, Hirose, Pallier, & Mehler, 1999). The word-initial sC- cluster in English vs. esC cluster in Spanish is another example of epenthesis, this time in production. In Spanish this vowel-less initial cluster is not "legal" or "allowed". For that reason, native speakers of Spanish usually pronounce words such as *school* [sku:l], *star* [stɑːʳ] or *spa* [spɑː] as *[esku:l], *[estɑːʳ] and *[espɑː] respectively (Gibson, 2012). Similarly, the previously mentioned case of Brazilian speakers adding an extra [i] in words like *ping pong* or *picnic* are good examples of epenthesis in both perception and production (Dupoux et al. 2011).

c) Mutation: Korean learners turn /s/ into /ʃ/ when /s/ is followed by a high vowel such as /i/ or /u/. For example, *sea* /si/ would become *she* /ʃi/ and *sue* /su/ would become *shoe* /ʃu/ to agree with their L1 phonological grammar. Therefore such pairs of word pairs (e.g. *sea* and *she*) might become homophones to them based on their perceptual repairs. This type of difficulty is particularly relevant to the current dissertation, and has been mentioned by Weinreich (1953) while talking about transfer. He called it underdifferentiation: sounds are allophones in the learner's L1, but phonemes in the L2.

d) Segmental miscategorization: An example of this phenomenon is to be found with the French vowels /y/ and /u/, which are confusing for speakers of various languages due to the feature combination [+round; +front] present in French (front rounded vowels /y/, /œ/, /ø/) and absent in many other languages. Magnen, Billieres and Gaillard (2005) observed that Spanish speakers hearing French /y/ report hearing a combination of an /i/ plus an /u/ sound. In addition, other research findings (Darcy et al., 2012; Levy & Strange. 2008) indicate that English speakers tend to perceived /y/ as /u/, discarding the feature [+front] and favoring the feature [+round].

The source of these difficulties has been attributed to the L2 being processed through the L1 perceptual filter (Kuhl & Iverson, 1995; Polivanov, 1931; Trubetzkoy, 1939/1969). That is, the L2 sounds get mapped onto L1 sound category representations that resemble such sounds acoustically or articulatorily (Best, 1995; Best & Tyler, 2007; Flege, 1995). Therefore L2 learners hear their L2 using their L1 sound system. The difficulties seem so language-dependent that the field of cross-language speech perception emerged in order to make sense of what happened when learners of an L2 listened to a language with a different phonological structure.

Speech perception can be understood as the act of hearing words by attending to the physical properties of the sounds uttered and understanding what those words mean (Sebastian-Gallés, Echeverría & Bosch, 2005). Since different languages structure sounds in diverse ways, that is, they possess different phonological grammars, it is understandable that learners of a second language experience difficulties perceiving L2 contrasts (Flege, 1995; Goto, 1971; Werker & Tees, 1984). This seems to be due to the fact that L2 listeners do not have well-developed phonetic categories because of their lack of exposure to L2 input in terms of quality and quantity. Of note, exposure alone is not sufficient for learners to stop the L1 from influencing their L2 processing: there are numerous cases in which such perceptual difficulties — accompanied by production difficulties — persisted even when learners were immersed in L2 settings for considerable lengths of time (Flege & MacKay, 2004).

Several theoretical models have been proposed to account for the relative easiness or difficulty in learning the sounds in the L2: the SLM (Speech Learning Model) (Flege, 1995) and the PAM-L2 (Perceptual Assimilation Model for a second language) (Best & Tyler, 2007) are the two most relevant here. The former focuses more on the relationship between perception and production in experienced listeners, whereas the latter makes predictions about the possible discrimination and assimilation of non-native sounds in beginning L2 learners. Even though SLM focuses on phonetic categories without entering in detail into the phonological level and does not deal with discrimination of phonetic contrasts within the L2 (L2-L2), SLM is relevant because it examines the L1-L2 sound mappings, trying to outline precisely how an L2 sound is perceived as similar or different from an L1 sound. Flege uses the term "equivalence classification" to define perceived distance or similarity between phones of the L1 and the L2.

Neither the PAM-L2 nor the SLM models explicitly address the role of phonotactic constraints in interlanguage perception or production. SLM partially addresses this issue by talking about allophonic relationships defined by context (positional variants). However, since this dissertation focuses on learners' perceptual ability to discern L2 sounds at the phonological and lexical level, PAM-L2 will be used as a basic reference framework to generate possible predictions for perceptual difficulties by L2 listeners. In addition, one of the major experimental techniques that underlie perceptual assimilation data is cross-language mapping, which asks listeners to categorize a non-native sound into a set of native categories. When two or more sounds are mapped onto one native category, these sounds are said to "perceptually assimilate" to the native category. Perceptual assimilation is a central mechanism in L2 phonology which serves to predict perceptual difficulties with L2 contrasts.

The original PAM model (Best, 1995) was elaborated for naïve-listeners, that is, those who possess no knowledge of the L2. PAM posited that, when listening to a new L2 phone (sound), L2 learners *assimilated* it to their most articulatorily (phonetically) similar L1 (native) phoneme. Then, based on their L1 phonological inventory, such phones would be deemed as either "good" or "bad" examples along a continuum — and therefore would be categorized — or not.

In Best's model, naive listeners are confronted with two non-native contrastive phones that might create minimal pairs in the L2. That is, PAM presents pairs of L2 phones in different patterns and predicts their discriminability by the L2- inexperienced listener. When the two L2 phones are perceived as acceptable exemplars of two different L1 phonemes, good to excellent discrimination is predicted and they call this Two Category (TC) assimilation. In contrast, poor discrimination is expected for Single Category (SC) assimilation, in which the two L2 phones are accepted as either similarly good or bad tokens of the same L1 phone category. Discrimination is neither too difficult nor too easy in the category-goodness (CG) type. Here the two L2 sounds would belong to the same L1 category, but one is a "better" exemplar of that category than the other. Finally, PAM also mentions other sounds that might be perceived as an undefined L1 phone (uncategorized assimilation), or in rare occasions even as non-speech sounds (non-assimilable).

The PAM-L2 model (Best & Tyler, 2007) is an extension of the previous PAM model in which these categories that applied initially to naïve-listeners become also applicable to L2 learners who start acquiring their L2 as functional monolinguals. Therefore such listeners already have an L1 phonological system in place with preference for certain phonetic categories and will be changing such system as they learn and get exposed to the L2[3]. Best and Tyler (2007) predicted that if two L2 segments were assimilated to different L1 categories (TC assimilation) such discrimination would be easy. By contrast, two L2 sounds assimilating to the same L1 category (SC or CG assimilation) are predicted to be hard to discriminate, and more so if both L2 segments are considered good tokens of that L1 particular category (SC assimilation). This mechanism accounts well for the well-known example that L1 Japanese listeners of L2 English

[3] Some studies such as Grimaldi et al. (2014) claim that adults might not be capable of creating new categories if they are only learning in a classroom setting.

perceived the contrast between /l/ and /r/ rather poorly (MacKain, Best, & Strange, 1981), since such contrast does not exist in their L1, and both English phones are assimilated as good examples of the same phoneme in Japanese.

In their explanation of how English learners of French tackle the phonological level, Best and Tyler use the example of the French [ʀ] and English [ɹ]. They mention that English listeners recognize the French /r/ as being phonologically similar to English /r/ even though phonetically they are dissimilar (eg. the first one is a voiceless uvular fricative, whereas the second one is a retroflex approximant) and that this type of effect can also be found for allophones belonging to the L1 (e.g. non-contrastive aspirated [p^h] vs. unaspirated [p] in English). Hallé, Best and Levitt (1999) also suggest that articulatory and phonetic characteristics differing between the L1 and the L2 are important to consider on top of phonological similarities when predicting how L2 learners would perceive the L2 sounds. In their study using a two-choice identification test followed by an AXB discrimination test of the same series, French participants perceived American English (AE) approximant /r/ as /w/, rather than as a French [ʀ], therefore giving priority to phonetic characteristics: English /r/ is a different phoneme from /w/, but phonetically, both are approximants. The first one is an alveolar approximant and the second one is a voiced labio-velar approximant.

As we have seen, Best and Tyler's model recognizes that differences in the phonetic architecture of a segment cannot completely explain the difficulties that L2 learners undergo at the perceptual level. It is also essential to take into account the syllable structure of the L1 (as we saw with Brazilian Portuguese, Japanese and Spanish learners of English), the L1 phonotactic constraints (as we saw with Korean learners of English) or even individual differences among the listeners[4].

The Speech Learning Model by Flege (1995) focuses on L2 learning. This model hypothesizes that basic speech learning mechanisms (i.e. the ability of individuals to establish phonetic categories) are available across the life span. It also hypothesizes that L2 learners can establish new L2 phonetic categories if they detect phonetic differences between an L2 sound and the closest L1 sound. As a result, the SLM predicts that when the phonetic distance between the L2 sound and the closest L1 sound is larger their phonetic differences will be detected more easily by the listeners and they will be able to create a new phonetic category. It is assumed that such new categories will make L2 segmental perception more native-like because their perception will be based on the new L2 phonetic category and will not be influenced by the nearest L1 phonetic category. Using basically a similar mechanism to the SLM's equivalence classification, PAM-L2 focuses mainly on segmental phonetic and phonological categories and the distinction of contrasts within the L2. For this reason this model is useful in explaining the difficulties such as phonological deafness or perceptual miscategorizations encountered by L2 learners. However, these two important models do not make specific predictions regarding how learners encode these phonological categories in lexical representations. Both models implicitly assume that accurate perception is the pre-requisite and a guarantee for accurate lexical representations.

[4] Tyler, Best, Faber, & Levitt (2014) concluded that the PAM-L2 model could apply to vowels as well as to consonants. However, listeners were not consistent in their categorization of French, Norwegian and Thai vowels to their L1 English inventory. E.g. they categorized the French vowel /õ/ as English /u/, /on/ and /an/.

As recently shown by Weber and Cutler (2004), and Darcy et al. (2012), it is not necessarily the case that accurate phonetic perception guarantees accurate lexical representations.

Darcy et al.'s (2012) Direct Mapping from Acoustics to Phonology (DMAP) model deals more in depth with phonological acquisition at the lexical level. Such model is a potential mechanism to understand phonological-lexical underlying representations in second language development and it is based on the following four propositions (Darcy et al. 2012: 14):

1. L2 learners detect more acoustic cues in the raw percepts than what they use to perform a segmental categorization response.

2. Detected features trigger revisions of the interlanguage feature hierarchy in accordance with economy principles.

3. Phonological lexical representations consist of feature matrices dependent on the interlanguage feature hierarchy at the time of encoding.

4. Minimal changes in phonetic category definitions triggered by phonological contrast obey economy considerations at the phonetic level.

In this model, the first step implies perceiving the raw percepts (e.g. phonetic features and intonation), the impressions that learners obtain from listening to auditory stimuli and that are richer than what they require to categorize what they heard according to their available categories. Secondly, such feature detection would produce changes in the interlanguage of the L2 learner conforming to economy principles. That is, L2 learners reorganize their L1 phonology modifying as little as possible of their L1 phonology. Thirdly, such interlanguage (mixture of L1 and L2 phonology) will guide the group of features that will form the phonological representation of the sound to be acquired. Finally, this process must optimally conserve as much as possible the previous phonetic structures that the learner possessed (isomorphism hypothesis). Therefore, at this point category formation is not considered necessary for acquisition at the lexical level to take place.

This last model is relevant because phonological contrasts are important in any given language, since they serve the purpose of making significant lexical distinctions (*rock* vs. *lock*; *there* vs. *dare*).[5] If in other languages such purpose lacks significance, these differences will go unnoticed in those languages and listeners will gradually lose the ability to perceive and group the features into a phonological category which does not exist in their native language. Later in life they might realize that they need to create new phonological categories in order to make sense of such allophones and transform them into distinctive categories.

With these models in mind, I will now turn to some research dealing with the acquisition of phonotactics (section 2.2), allophones and phonemes (section 2.3). As a reminder, this dissertation explores L2 learning challenges such as epenthesis (sounds that are not really present in the L2) or mutation/underdifferentiation (sounds that are allophones in the learner's L1, but phonemes in the L2). The acquisition of French nasal vowels for English native speakers combines these two learning challenges: First, learners must realize that an allophonic distinction in L1 corresponds to different phonemes in the L2; second, they must also inhibit a phonotactic restriction which stipulates that vowels are nasalized in front of a nasal consonant. In L2 French, oral vowels are not nasalized in front of nasal consonants.

[5] To see the extent to which phonological contrasts (functional load) along with L1 frequency are relevant in L2 category formation, see Lan (2014).

2.2 The acquisition of L2 phonotactics

The acquisition of second language phonology has been investigated by authors who were mostly interested in the learning of new L2 phonological categories and the learners' representations of their sound inventory, such as consonants (Bohn & Best, 2102) or vowels (So & Attina, 2014; Escudero, Simon & Mitterer, 2012; Levy & Law, 2009). However there are other phonological areas that are hard to master by L2 learners beyond segments. In fact cross-language speech perception has been studied also with tones (So & Best, 2010), lexical stress (Jangjamras, 2011; Yu & Andruski, 2010) or lexical encoding (Pallier, Colomé & Sebastian-Gallés, 2001; Darcy et al. 2012).

Reaching native-like levels in perception is not an easy task, since such successful perception has been found to depend on many factors: the extent to which L2 learners keep using their L1 (Flege & MacKay, 2004; Flege, 2002); the individual motivation of the L2 learner (e.g., Bongaerts, van Summeren, Planken, & Schils, 1997; Flege & MacKay, 2004; Flege, 1988; Skehan, 1991); or the methodology employed in the experiments to measure the perceptual ability (Flege, 2003; Mack,1989). Therefore, knowing exactly what L2 learners hear and what they do with an L2 sound or sequence in order to maximize their learning might be a challenging task.

What research has revealed is that a complex issue that L2 learners generally encounter when learning a new sound system is how these L2 sounds group together (phonotactics). Phonotactic knowledge is usually acquired as early as 9 months of age, as Friederici and Wessels (1993) corroborated when they noticed that Dutch infants preferred to listen to "legal" (allowed) word boundary clusters versus "illegal" (not allowed) word boundary clusters. Adult L2 learners (and some children and teenagers) generally have difficulties acquiring the phonotactics of their L2, most of which occur below the level of consciousness. Such difficulties were illustrated through some examples above that involve perceptual epenthesis: Spanish speakers heard an extra [e] sound in English words with initial sC- clusters (school); Japanese learners tended to insert a [u] sound in two-consonant clusters (*miracle*); and Brazilian learners did the same with the vocalic sound [i] (*ping-pong*).

The pervasive influence of L1 phonotactics appeared in Weber and Cutler's (2006) study with real words embedded into nonsense words, which participants were asked to spot. They inferred that highly proficient German L2-English learners can acquire L2 phonotactics and use it for segmenting continuous speech, although interference from the L1 cannot be overcome in the L2 listeners. Similar results were obtained by Lentz and Keger (2015), who asked Japanese and Spanish learners of Dutch to perform a lexical decision with priming effect task containing /sC/ clusters, illegal in Spanish and Japanese. Although experienced L2-Dutch L1 Spanish speakers performed more accurately than those who were less proficient in Dutch, their L1 phonotactics still affected their responses. In a similar vein, Davidson (2011) investigated the interaction of phonetic, phonemic and phonological factors in the discrimination of non-native phonotactic contrasts. Listeners of Catalan, English and Russian discriminated the initial #CC-CeC contrast. She found some evidence suggesting that the existence of the phonotactic structure in the L1 language of the listener might be more important than either phonemic or phonetic information from the L2 input.

If indeed adults have lost early on their ability to perceive segment sequences that do not conform to their L1 phonotactics, there is still a possibility that initial difficulties in perception of the various L2 areas of phonology can be solved with more experience with the L2 (e.g.

Carlson et al., 2015). As L2 learners make progress in the acquisition of their target language, it is very possible that they will perceive sounds and sound combinations in way that resembles that of native speakers of the target language. In the same vein, Halicki's (2010) dissertation showed that intermediate and advanced learners of L2 French appeared to possess phonotactic knowledge similar to French-native speakers in the recognition of licit and illicit structures in French (consonant clusters, sonority assimilation and similarity avoidance).

2.3 Allophones vs. Phonemes

Turning now to the problem of allophonic split, this section reviews some findings related to the aforementioned case of mutation (when sounds are allophones in the learner's L1, but phonemes in the L2). Eckman, Elreyes, and Iverson (2001) studied allophonic split in Spanish and Korean L2 learners' production of L2 English. Allophonic split is the process by which L2 learners must split allophones of their L1 (native language) into separate phonemes for their L2 (second language). In Spanish the [d] and [ð] sounds are both allophones of /d/, whereas in Korean [s] and [ʃ] are allophones of syllable-initial /s/. In English, all four phones are phonemes. Thus, learners of these languages have to assign allophones in their L1 to phonemes in their L2. Participants were asked to produce L2 English words (in derived e.g. *grassy* and non-derived context, e.g. *grass*) that were elicited through written directions by showing them pictures to avoid the influence of spelling. They found that the target language's phonological contrasts are incorporated into the learners' interlanguages progressively and that such progression follows certain rules. One of these rules is called Structure preservation. It states that changes must be motivated as underlying phonological segments of the language. To take an example using French nasal vowels, if a nasal vowel is phonologically constituted of two segments, it will be adapted as two segments if another language borrows a term containing such nasal vowel (e.g.

word *consommé* in English borrowed from French). I will explain this rule and its relevance in more detail in section 3.2 of chapter 3, when I talk about the possible underlying representations that learners might have when they hear a French nasal vowel.

In her dissertation study dealing with the perception and production of L2 vowels, Nikolova-Simik (2010) confirmed that certain vowels were hard to perceive when they did not have phonemic status in the L1. Her results were obtained from twenty beginning and twenty-one advanced L1-Arabic learners of L2 English. These learners — in a phonemic identification task in which they had to circle the correct phoneme they heard — had difficulties perceiving those vowels that were allophones in Arabic, but phonemes in English. The vowels existing both in L1 and L2 were the easiest to perceive; the vowels that were similar (with only one feature difference) were the next easier to perceive; the vowels that were phonemes in English, but allophones in Arabic were more difficult to perceive; and the vowels which did not exist in Arabic were the most difficult to perceive

Vokic (2010) also carried out a study with twelve adult learners of Spanish having English as their L1, who read aloud stimuli containing [ð] or [ɾ] sounds in four sets of repetitions. The first sound is an allophone of Spanish but a phoneme in English, whereas the second sound (flap) is an allophone in English, but a phoneme in Spanish. The experiment tested if L2 learners could access their allophonic inventory and use this knowledge in L2 speech production to attain L2-like pronunciation. This author carried out a perceptual, spectrographic and statistical analysis of the data. She found patterns indicating that, although some participants were able to access L1 allophones to use them in their L2 speech production, such access might be limited and dependent on other variables such as L1 orthography, the L2 level, the functional load of the target sound or motivation.

Another well-known example of the difficulty of allophonic split is shown by Pallier, Colomé and Sebastian-Gallés (2001), in the case of Catalan /e/ and /ɛ/, which span the single Spanish /e/ category. These authors conclude that word recognition uses language-specific phonological representation and that lexical items are stored in abstract forms, as they found that, in a lexical decision task, early Spanish-Catalan bilinguals dominant in Spanish perceived /e/ and /ɛ/ to be homophonous, despite the fact that these two vowels are contrastive in Catalan (but not in Spanish). Therefore, the difficulty of allophonic split is likely to extend to the lexical encoding of words. Similarly, Darcy and Krüger (2012) observed that for 9-to-10 year old Turkish-speaking children who were intensively exposed to German in a half-and-half immersion school, and who had had early exposure to German from age 3, performed much less accurately in an oddity vowel discrimination task when the contrast involved a vowel pair that was allophonic in Turkish (but contrastive in German), whereas they were like the German monolingual control group on other contrasts.

In the other direction, from phonemic to allophonic pairs, the acquisition of allophony seems possible, at least in production, and when one member of the pairs does not resemble another L1 phoneme. Shea and Curtin (2011) studied the production of the Spanish allophones [b] [d] [g] vs. [β] [ð] [ɣ] with low intermediate and high intermediate level L1 English L2 Spanish learners. Learners with more experience in the L2 used the two cues employed by Spanish native speakers in their production (consonant intensity and release burst).

In perception, Boomershine et al. (2008) investigated Spanish and English speakers in their listening of [d], [ð] and [ɾ]. The pair [d]/[ð] is distinctive (they are two separate phonemes) in English, whereas they are allophones (non-contrastive) in Spanish. In turn, the pair [d]/[ɾ] is distinctive in Spanish, but the sounds are in allophonic relationship in English. On the other hand, the pair [ð]/[ɾ] is the same in both languages, contrastive at surface and phonemic levels: for English, they correspond to the phonemes /ð/-/d/, and for Spanish, the same sounds correspond to the phonemes /d/-/ɾ/. In a rating experiment, English natives perceived [ɾ] and [d] as more similar to each other than Spanish natives did, whereas [ð] and [d] were more similar for Spanish natives than for English natives. In another AX discrimination task, they also found the same pattern. These examples show the difficulty of accurately perceiving a distinction which we have learned to ignore (allophones) since infancy.

Interestingly, Ćavar and Hamann (2011) also found that the L1 phonological knowledge is used to distinguish unknown/new L2 sounds and, moreover, that phonological features played a more significant role in L2 perception than the presence vs. absence of corresponding phonemic categories. In their study, Croatian, German and Slovenian speakers without any knowledge of Polish heard Polish consonants (non-anterior sibilants). The Polish consonants under study were more similar phonetically and acoustically to Croatian than to the other languages. Consequently, the Croatian participants performed more accurately in a closed-set identification task even for those phonemes from Polish that were not present in Croatian but whose features were allophonically present in related consonants. Polish non-anterior coronal sibilant fricatives [ɕ] and [ʑ] do not exist as phonemes in Croatian. However in Croatian [ɕ] and [ʑ] are allophones of the existing phonemes /ʂ̺/ and /ʐ̺/, respectively, in prepalatal affricate context. The only difference is that [ɕ] and [ʑ] are [-back], whereas /ʂ̺/ and /ʐ̺/ are [+back]. Croatian listeners were able to distinguish [ɕ] versus [š] and also [ʑ] versus [ž]. Here is an example in Croatian from their article:

Table 1. Examples of phonetics, spelling and gloss for Polish non-anterior coronal sibilant fricatives [ɕ] and [ʑ] in prepalatal affricate context.

Phonetics	**spelling**	**gloss**
gro[ʑdʑ]e	grožđe	'grapes'
li[ɕtɕ]e	lišće	'leaves'

A similar picture is known from McAllister, Flege & Piske (2002) who show that when a feature is used to distinguish a contrast (e.g. vowel duration) in L2, the fact that this feature is also used to some extent in the L1 (even if it is not used to distinguish these specific L2 sounds) provides a benefit in perception as opposed to when the feature is not used at all in the L1. McAllister et al. called this phenomenon the "feature hypothesis", stating that "L2 features not used to signal phonological contrast in L1 will be difficult to perceive for the L2 learner and this difficulty will be reflected in the learner's production of the contrast based on this feature" (McAllister et al., 2002, p. 230). In their study, English participants were able to use the duration feature to perform the task somewhat more accurately than Spanish participants. In English, duration is used as a redundant feature, in addition to vowel quality, to distinguish between long and short high front vowels (/i/ and /ɪ/). This duration cue is not used in Spanish.

Beddor and Strange (1982) observed that English listeners are sensitive to vowel nasalization that occurs allophonically before nasal consonants and could successfully identify an 11-step synthesized oral-nasal vowel series, even though this is not a phonemic contrast in English. However, they required more nasalization (in the form of greater velar port opening in the articulatory synthesizer) to identify vowels as nasal than did Hindi listeners, who have a phonemic oral-nasal vowel contrast. This study suggests that nasality is perceived accurately even when there is no phonemic contrast between oral and nasal vowels.

However, this study does not — nor do the above-mentioned studies — address the underlying representation of such nasal sounds, nor does it address the issue of how English native speakers acquire phonemic nasal/oral contrasts over time.

Previous studies show that in some instances, both phonotactic regularities and allophonic splits can be successfully acquired in L2. What we do not know precisely is what happens perceptually over time (during L2 development) when a feature that is allophonically present in an L1 category is required for the acquisition of an L2 phoneme in which the same feature holds a phonemic status. In addition, it is not known how learners progressively learn to inhibit a phonotactic constraint that is producing this allophonic feature in L1.

In this dissertation I will deal with the acquisition of L2 French nasal vowels by L1-English learners. Nasality in French is a key phenomenon for cross-linguistic perception research: it encompasses two different interfaces, viz. phonemic status of segments (nasal vowels are phonemic in French) and phonotactics (in English oral vowels are nasalized when preceded or followed by a nasal consonant). Despite being one of the aspects that learners of French struggle with and being essential in the comprehension of a foreign language[6], the acquisition of L2 French nasal vowels has not been studied extensively in regards to the insightful interaction between phonology and phonotactics.

The perceptual challenge in such phonological learning is for French L2 learners to realize that nasality is a contrastive feature in French belonging to the vowel itself. These questions lead to our last section for this chapter.

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[6] Kewley-Port, Burkle, and Lee, J. H. (2007) found that, to understand well a sentence, vowel recognition is more relevant than consonant recognition and their contrasts are acquired earlier than consonantal contrasts (Davis & McNeilage, 1990).

2.4 Research questions

It is a common finding through research that learners of French have difficulties producing French nasal vowels regardless of their L1 (e.g. Berri & Pagel, (2003) for Brazilian Portuguese; Cichocki, House, & Lister, (1997) for Cantonese speakers; or Liddiard (1994) for English speakers) and much less is known about their perception in terms of second language acquisition.

Given that phonemic nasal vowels are not part of the English phonological system, it is likely that learners (at least the ones in the initial stages) who hear them will repair them and restore a structure that is permitted in English in perception. That is, they could perceptually transform /ã/ into either /an/ or /a/, but this is not certain. My first research question, therefore, is:

1. If learners start with their L1 phonological representations (e.g. Polivanov, 1931) at early stages of L2 learning, what do English listeners with no knowledge of French hear when they encounter L2 French nasal vowels?

My second research question deals with the strategies used by L2 learners of French:

2. Which perceptual strategy do learners use initially to adapt L2 French nasal vowels to their current L1-English underlying interlanguage representations? Will they be able to stop using such a strategy as they gain more experience with French and how does this happen?

As we will see in more detail in chapter 3 where specific hypotheses are outlined (section 3.3), there might be 2 possibilities, that is, they could extract two different representations from the French input: either they turn the French nasal vowel into a sequence of oral vowel followed by a nasal consonant (nasal unpacking) or they ignore nasality and treat it as an oral vowel (nasal stripping). This should depend on what representations were extracted from the French input.

My third research question relates to the acquisition given the detection of an L2 phonological representation that the current L1 phonological state fails to license (Darcy et al., 2012; Escudero, 2005). Therefore, we ask also:

3. What is the underlying representation of phonemic nasal vowels for L2 learners of French at different stages? We want to know if it is L1-like (English), L2-like (French) or neither L1 nor L2-like (interlanguage representation).

To respond to our second research question, we can assume that, if learners perform at the French-native level in our L2 tasks (ABX and lexical decision with repetition priming), it will be possible to say that they have perceived and represented the new phonemic nasal vowel. In the same manner, if there is a difference in performance between intermediate and advanced learners in error patterns we should be able to attribute it to differences regarding: 1) experience with the language in an in-class setting and in a francophone speaking country; 2) their ability to stop using either the nasal unpacking strategy or the nasal- stripping strategy as they hear the nasal vowel.

The question of the relationship between raw percepts, categorization and representations is addressed in DMAP (Darcy et al., 2012). In DMAP, what is needed for phonological acquisition is detection in the raw percepts which are assumed to activate features in the phonology. The L1-grammar may, however, act as a filter, and L2 phonological representations at the initial stage will respect the constraints of the L1 as well as general contrasts on phonological representations. One such constraint is the principle of structure preservation that we saw above. If this is the case, there should be evidence that nasality is lexically encoded such that lexical contrast is achieved, even if in non-target ways. However, it might not yet be encoded in the phonetic categorization of vowels. The development of a more target-like space would follow from a change in the representations.

Chapter 3 Nasal vowels in French and English

Understanding the difference between nasal vowels in English and French is relevant to this dissertation. For this reason I will first describe the main differences between these languages at the phonetic and phonological levels (section 3.1) and later deal with their phonological representation (section 3.2). Then, in the last section (3.3), I will outline two possible listening strategies that English learners of French initially apply based on their L1 (native language) phonological grammar when they hear L2 (target language) French nasal vowels. In this section (3.3) I will also address what it means to perceive and represent L2-French nasal vowels for L1-English learners.

3.1 Nasal vowels: Definitions and phonetic features

Articulatorily, nasal vowels are produced similarly to nasal consonants: the velum is lowered in both cases. However, for nasal vowels the oral cavity is not blocked and the air flows through both the oral and nasal cavities when the nasal port (abbreviated *Npt* on the right side of Figure 2) is open (Glass, 1982). The more the nasal port is open, the more nasal the vowel will be.

The following illustration, taken from Sampson (1999: 2), shows how the velum raises or lowers closing and opening the nasal cavity, respectively.

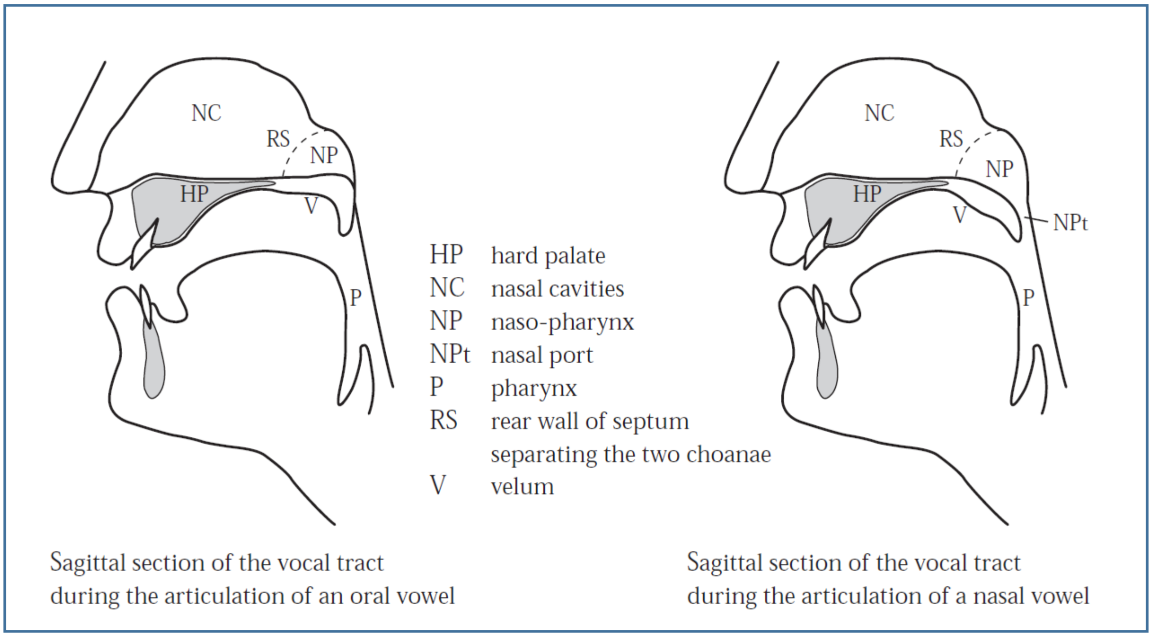


Figure 2. Vocal tract configuration during oral vowel (left) and nasal vowel (right) production. Reprinted with permission from Oxford University Press. Sampson (1999: 2). *Nasal Vowel Evolution in Romance*. New York: Oxford University Press.

The natural physiological state of the velum is in lowered position, as this is the way in which the air goes through the nasal cavity and into the larynx when we breathe in and out through the nose. When we pronounce the sounds to form vowels, consonants, words and sentences, the airstream comes from the lungs and the flow of air escapes mainly through the oral-pharyngeal cavity—at least in the case of oral sounds. In the case of nasal sounds (vowel or consonants) however, the air can be released either partially (the case of nasal or nasalized vowels) or completely (nasal stops *m* or *n*) through the nasal cavity. If the nasal port is open at the same time as the oral cavity, it results in nasality being added to the specific segment being pronounced, that is, nasal coupling.

Acoustically, vowel nasalization involves loss of intensity and spread bandwidth of the first formant spectral peak (F1) (for English: Delattre, 1954; House & Stevens, 1956; Chen, 1997); shifts in the center of gravity (the correlation of vowel height perception with the center of the first region of spectral prominence) of the low-frequency spectral prominence (Beddor, 1984) and presence of extra zeros (antiresonances occurring in the nasal cavity that cancel or damp any resonance energy close to their frequency).

According to Sampson (1999:1) nasal vowels exist in different languages phonemically (Albanian, Breton, French, Gaelic, Haitian Creole, Hindi, Irish, Portuguese, Mandarin Chinese, Polish, Vietnamese, etc.), and they occur as allophones (non-distinctive phonemes) in many others in the vicinity of a nasal consonant. Although vocalic nasality is not phonemic (distinctive) in languages such as English, Italian, Romanian or Spanish, the vowel preceding a nasal consonant displays a high level of allophonic nasality. By this Sampson refers not only to nasality due to articulation of an oral vowel located next to a nasal consonant, but also to the speakers' idea of how a nasalized vowel should be produced. In order to avoid any confusion, in this study I will refer to vowels with allophonic nasality due to coarticulation, as in English, as "nasalized vowels". By contrast, I will use the term "nasal vowels" for the phonemic nasal vowels of French.

The three Parisian French nasal vowels under consideration here are [ɔ̃], [ɛ̃] and [ɑ̃]. The vowel [ɑ̃] is produced with a protrusion and narrowing of the labial gap, which approaches a rounded vowel. The vowel [ɔ̃] is similar to the previous one, but more rounded and comparable to the mid-close vowel [o]. The last vowel here, [ɛ̃], is an unrounded open-mid vowel. These vowels differ in openness: [ɑ̃] is more open than [ɔ̃], which in turn is more open than [ɛ̃]; and also in the mouth position: [ɔ̃] and [ɑ̃] are back vowels, whereas [ɛ̃] is fronted. In French these vowels are important because one can find distinctive pairs of the type *seau* /so/ 'bucket' vs. *son* /sɔ̃/ 'sound', *raie* /rɛ/ 'ray' vs. *rein* /rɛ̃/ 'kidney' or *ça* /sa/ 'that' vs. *sans* /sɑ̃/ 'without'. The acquisition of this phonemic contrast between nasal and oral vowels in L2 French is central to this dissertation.

In English, any vowel in proximity of a nasal consonant may receive a certain degree of nasalization, as will be explained below.

From a phonological point of view, nasality is treated as a feature in the framework of feature geometry. *Feature geometry* (FG) is a term introduced by Clements (1985). FG claims that phonemes (sound structures) are constituted by features that are organized hierarchically in trees that have different tiers. According to Clements, distinctive features (such as vowel nasality in French) are structured hierarchically and in groups of features under nodes in a tree. The topmost node is called Root node and it encompasses features such as [consonantal], [sonorant] or [approximant]. The feature [nasal] for example, can be directly dependent on the Root node (as in Figure 3) or sometimes on the Laryngeal node, which includes other larynx laryngeal features such as [voice] or [constricted/spread glottis]. A visual representation of such geometry is included here for clarification (from Clements, 2006):

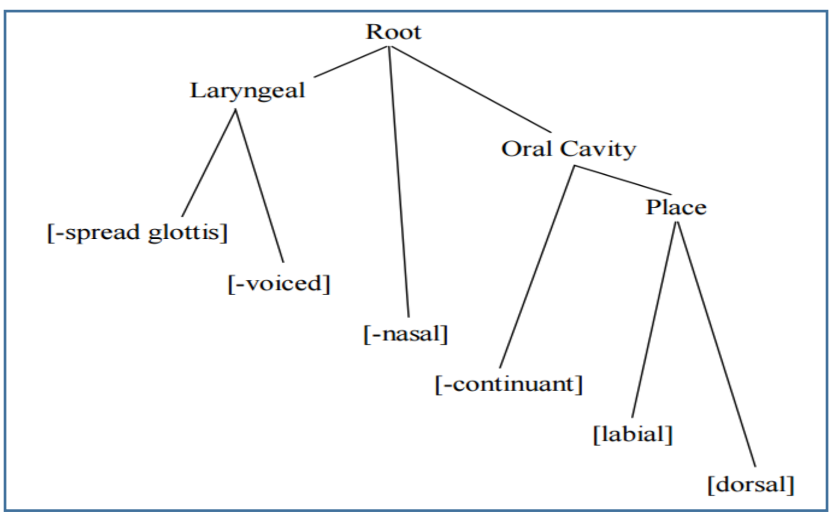


Figure 3. Feature Geometry structure example for the consonant [p]. Reprinted with permission from Elsevier Limited. Clements (2006: 435). *Encyclopedia of Language & Linguistics* (2nd Edition), Oxford: Elsevier Limited.

To more fully understand the phonetic/articulatory differences between French and English nasal(ized) vowels, and how this in turn shapes their phonological representations (see below), let's review relevant work by Cohn (1993). The FG framework is taken as a starting point by Cohn (1993) in her description of how phonology interacts with phonetics in the case of nasal vowels. The presence of nasalized vowels in English is conditioned by the occurrence of a nasal consonant in its immediate proximity, a phenomenon that she calls Anticipatory Nasalization. Despite this name, in English nasalized vowels are encountered in contexts in which a nasal consonant either precedes or follows an oral vowel (Tranel, 1987).

Cohn (1993) used a Rothenberg split-flow mask to collect nasal airflow measurements of production samples of English, French and Sundanese speakers. This technique has been employed as an indirect way to determine the velum position and therefore calculate the level of nasalization of a certain segment. She characterizes segments as oral, or [–nasal], when during the production of the segment (either consonant or vowel) there is no significant nasal airflow and nasality is found only during a portion of the segment in a cline-like pattern. By opposition she characterizes a segment as phonologically nasal, or [+nasal], when the segment displays a significant amount of nasal airflow temporally and spatially and also displays a stable plateau-like pattern of nasalization in an acoustic graphic representation. She observed that for French, both significant airflow and plateau-like pattern were present through the nasal vowel of words like *bonté* /bɔ̃te/ 'goodness' (see Figure 4a). In English, nasality was rather gradient, present only for a portion of the duration of the vowel. Nasal airflow increased when an oral vowel appeared before a nasal consonant as in *dean* /din/ (see figure 4b). Cohn concluded that this is an indication that the phonological rule of Anticipatory nasalization is not part of the phonology of English and that since nasality appears in a gradient manner during only of portion of the vowel, nasalization is the result of a phonetic implementation.

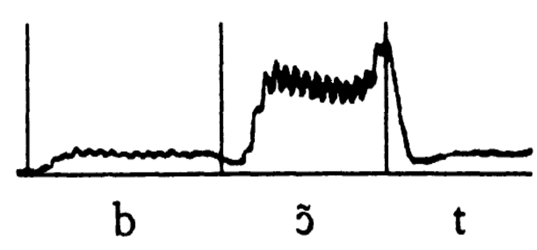
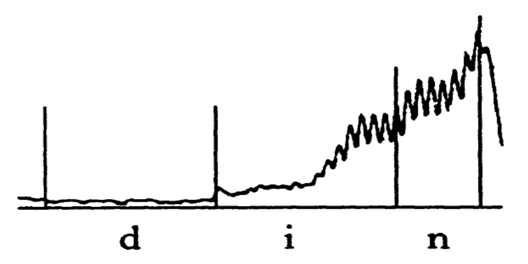
a) French word *bonté* /bɔ̃te/ ‘goodness’	b) English word *dean* /din/
	

Figure 4. Nasal airflow traces for the French word *bonté* /bɔ̃te/ ‘goodness’ (4a) and for the English word *dean* /din/ (4b). Reprinted with permission from Cambridge University Press. Cohn (1993: 52 and 60). Nasalization in English: Phonology or Phonetics. Phonology, Vol. 10 (1), pp. 43-81.

From this central phonetic difference in implementation between English and French follows a different feature specification. Within FG, the nasality feature can behave in two ways: it can be specified as [+nasal] or [–nasal]. From her comparison between English and French vowels, Cohn concludes that in English the feature [nasal] remains unspecified for vowels because there is no contrast between oral and nasal vowels ([Ønasal]; in French, nasal vowels are contrastive, and she concludes that nasal vowels are specified as [+nasal] and oral vowels are specified as [–nasal]). Furthermore, in English, only the [+nasal] value in the geometry is specified in the underlying representation of the consonant, in opposition to the oral vowels which are unspecified for nasality (a vowel in English is not phonemically nasal).

Ruhlen (1973: 5) also stated that, in general, phonemic nasal vowels would display greater nasality than their nasalized vowels counterparts and explained how the feature [+nasal] was only inherently part of a vowel if that vowel was phonemic. Sole (1992), however suggests that her production data for Spanish and American English speakers tell a different story. In her nasograph measures of three speakers of American English, she traced the position of the velum and noticed that—in an oral vowel followed by a nasal consonant in closed syllable position—

nasalization was present through the entire duration of the nasalized vowel across different speaking rates (from careful reading to very fast pace). This suggests that even in English, degrees of nasalization can vary, and while they are more likely to be less strong overall than in French, variation in the degree of nasalization is to be expected both within and across speakers, perhaps depending on context or vowel. By contrast, we can assume that strong nasality is more stable in French speakers across contexts and vowels.

It is important to make a difference here between progressive and regressive assimilation. Progressive assimilation occurs when the preceding segment influences the following segment. E.g. in the word *new* [nju˜], the nasality present in the vowel /u/ comes from the preceding nasal consonant /n/. By contrast, regressive assimilation takes place when the following segment influences the preceding one. In the case of nasalization, in the word *tan* [tæ˜n], the nasality present in the vowel /æ/ is assimilated from the following consonant /n/. The current dissertation only addresses the second type of assimilation: regressive nasal assimilation.[7]

Summing up, in English, words do not usually differ only in terms of vowel nasality/orality. In fact research dealing with nasality has agreed on the allophonic state of nasalized vowels in English (Cohn, 1990, 1993; Kahn, 1980; Malécot, 1960; Ruhlen, 1973; Seidl et al., 2009). In French, nasality in the vowel is phonemic (distinctive), it is phonologically represented by the nasality feature as [+] or [–] (Cohn, 1993), and might change the meaning of the word, as we saw above for Parisian French with different minimal pairs for the three nasal vowels under study.

In the next section (3.2) I will give a brief historical overview of French nasal vowels and will deal with the phonological representation of nasal vowels in English and French.

[7] When a vowel is adjacent to a nasal consonant in English, nasalization in the vowel lasts longer when the nasal consonant is postvocalic (e.g., *fun* [fʌ~n]) than when it is prevocalic (e.g., *narrow* [næ~rəʊ]) (Krakow, 1993).

3.2 The representation of nasal vowels in French and English

As indicated by Tranel (1987:74) nasal vowels originate historically from two phonetic processes that took place in Old French and Middle French. The first process occurred during the Old French period (IX-XIV centuries): vowels that were located right before a nasal consonant became strongly nasalized. E.g.: [an] → [ɑ̃n]; [on] → [ɔ̃n]. Then, the second process occurred during the Middle French period (XIV-XVII centuries): the nasal consonants were eliminated when they belonged to the same syllable as the nasal vowel. That is, at the end of a word (eg. *bon* [bɔ̃] 'good') or before another consonant that forms the onset of the next syllable (e.g. *bonté* [bɔ̃.te] 'goodness'). According to Sampson (1999: 25), it is during this Middle French second stage (when the nasal consonant ends the syllable or is followed by another consonant) that phonemic nasal vowels emerged. It is during this time that nasality in the vowel stopped being associated to the presence of a realized nasal consonant and became distinctive. Concurrently, if the nasal consonant belonged to the following syllable (if the nasalized vowel + nasal consonant preceded a vowel), then the nasal consonant was kept and the nasalized vowel lost its nasalization and became oral (e.g. denasalized [o] in *bonne* [bon] 'good').

Another historical important fact mentioned by Tranel is that vowel quality also changed, and several vowels merged with others as the initially large number of nasal vowels was gradually reduced: [ĩ] turned into [ɛ̃] (*fin* [fɛ̃] 'thin'), [ỹ] became [œ̃] and later [ɛ̃] (*un* [œ̃] or [ɛ̃] 'a'); and [ẽ] became [ɑ̃] an later [ɑ̃] (*vendre* [vɑ̃dr] 'to sell'). This is why today we find vowel alternations in French. For instance, /ɛ̃/ might alternate with /in/ as in *divin* [divɛ̃] 'divine (masc.)' ~ *divinité* [divinite] 'divinity', but also with /ɛn/ as in *vain* [vɛ̃] 'vain (masc.)'. *vaine* [vɛn] 'vain (fem.)'.

The phonological status and the history of nasal vowels in French have been examined by different researchers. Martinet (1945) pointed out that nasal vowels were independent phonemes and that when the nasal consonant following a vowel was released (produced) such sequence was to be interpreted as two phonemes, regardless of the nasality level appearing in the vowel.

Schane (1968), Dell (1973) and Selkirk (1972) proposed that the derived alternating nasal vowels that were mentioned in the previous paragraph (*divin* [divɛ̃] 'divine (masc.)'-*divinité* [divinite] 'divinity', *vain* [vɛ̃] 'vain (masc.)' - *vaine* [vɛn] 'vain (fem.)', etc.) originate from an underlying VN (oral vowel + nasal consonant) sequence through rules of nasalization coming from the nasal consonant. Schane (1968) argues that for a word like *don* /dɔ̃/ 'gift', if grammatical and lexical information is available, the word *donner* [done] 'to give' could be associated to a common phonological stem /don/. Then certain phonological rules that follow similar steps to the ones outlined before for the history of nasal vowels would apply in word-boundary position or before another consonant. As a result of applying these rules, the vowel in /don/ would be nasalized /dɔ̃n/ and finally the nasal consonant would be removed (/dɔ̃/).

By contrast Tranel (1981) argued against the two-root-node view and for the existence of a lexical underlying nasal vowel. In his explanations he mentions the fact that conflicting contrasts such as *bon ami* [bonami] 'good friend' and *mon ami* [mɔ̃nami] 'my friend' – where nasality in the vowel is preserved only in the second example – cannot be solved if surface nasal vowels were derived from underlying VN sequences, since the surface presence of a nasal consonant would denasalize the preceding vowel[8], which does not happen in the case of *mon ami* [mɔ̃nami] 'my friend'. A clearer illustration of how a specific language supports the one-root-node

[8] Alternatively and taking history into account, it is possible that nasality in the vowel would trigger deletion of the nasal consonant, which is not the case in *mon ami* [mɔ̃nami] 'my friend'

hypothesis is found in Haitian Creole. This language represents another challenge to a VN two-root-node underlying representation, since in this language there are minimal pairs in nasal contexts such as *pann* /pãn/ 'to hang' vs. *pàn* /pan/ 'breakdown', in which the nasality of the vowel seems to be part of the vowel and independent from the following nasal consonant.

Despite these different arguments for and against the existence of an underlying nasal vowel and given that the underlying representation of French nasal vowels vary depending on the researcher's theoretical background or the specific language under study, I will be adopting a two-root node approach here as a starting point, with the representation proposed by Prunet (1987) within a non-linear framework and supported by Paradis and Prunet (2000). This last study presents extensive evidence that French nasal vowels are adapted as two root nodes (that is, oral vowel followed by a nasal consonant sequence) in languages that lack a phonemic oral vs. nasal vowel contrast (Canadian English, Fula, Kinyarwanda, Lingala, and Moroccan Arabic).

For example, in Fula the French word *conseil* [kɔ̃sej] 'advice' is adapted as [kɔnsej] and in Canadian English, the French word *coupon* [kupɔ̃] 'coupon' is adapted as [kupɑn]. Paradis and Prunet conclude from such data that the loanword phonology is telling us that contrastive nasal vowels are best analyzed as oral vowel + nasal consonant sequences universally. They argue that most borrowings from French were adapted as a single native segment in different languages (e.g. the fronted rounded vowel /y/ as in *université* [ynivɛʁsite] 'university', became /i/ or /u/), whereas contrastive nasal vowels were transformed into a sequence of an oral vowel followed by a nasal consonant. They name this process "unpacking of the nasal vowel" and defend the Isomorphism hypothesis, which claims that the original phonological structure tends to be preserved when a term is borrowed. Consequently, "a one-root-node segment in L2 (the source language) is adapted as a one-root-node segment in L1 (the borrowing language) and a two-root-node segment in L2 is adapted as two root nodes in L1" (Paradis & Prunet, 2000: 332). An example of a two-root-node structure for the nasal vowel in French is presented in Figure 6b.

Following Clements & Kayser's CV phonology (1983) I will assume here that the mental representation of a word consists of syllables. As shown in Figure 5 (for the word *prendre* /prɑ̃ndr/ 'to take'), a syllable (δ) at the top node consists of the Onset (represented by the capital letter O) and the Rhyme (R). The Rhyme itself contains a Nucleus (N), and for closed syllables, a coda (C) (not represented in Figure 5). In French, the nasality on the vowel position is assumed to follow from a neighboring latent nasal consonant: here, vowel nasality is explained through the nasality parameter (cf. Fig. 5), which states that, in French, an underlying floating nasal consonant (/n/) may be associated to a nuclear position (/ɑ/)[9]. This association is represented by the dotted line. In this example, this association occurs because the second onset position is already occupied by /d/ and /r/, respectively. Each consonant (C) or vowel (V) represents a root node.

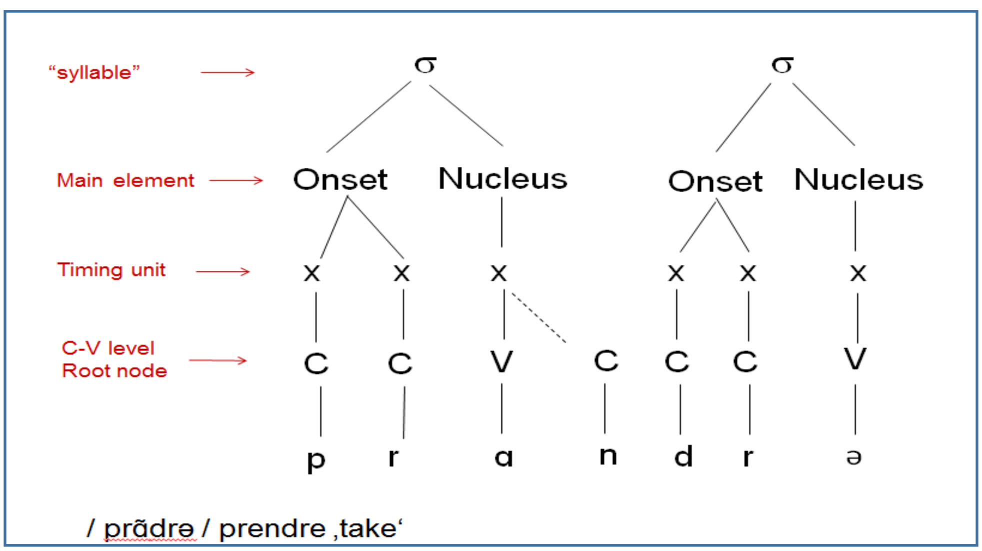


Figure 5. Representation of a floating nasal consonant /n/ attaching to the previous nucleus /ɑ/.

[9] For a more detailed description of vowel nasalization through the nasality parameter, see Prunet (1987: 228-229).

Prunet (1987) defends the claim that when the floating nasal consonant does not have any following nucleus to attach to through liaison or resyllabification (e.g. because of a following vowel-initial word, or via a following onset-less syllable), it regressively associates to the preceding oral vowel, which undergoes nasalization and becomes nasal at the surface level. This same floating nasal consonant that attaches to the preceding oral vowel in the masculine form of nouns and adjectives is the one that attaches to a following underlying (latent) schwa for the feminine forms in masculine/feminine adjectival/nominal alternations such as *musicien/musicienne*, [myzisjɛ̃]/[myzisjɛn] 'musician' *fin/fine* [fɛ̃]/[fin] 'thin' or *sultan/sultane* [syltɑ̃]/[syltan] 'sultan'. In our example above (see Figure 5), this schwa is not available and the nasal consonant cannot be realized as /n/, since no timing unit (x) is available for anchoring.

Several researchers have claimed that in order to establish certain contrasts, the different features must be organized following a given hierarchy (Clements, 2009; Keyser and Stevens, 1994). These features should be salient for the purposes of phonetic or phonological discrimination or lexical distinction if acquisition is to take place (Clements, 2001). Since nasality is a feature present in the English consonants /m/, /n/ and /ŋ/, it can be assumed that English listeners will be able to perceive nasality when it appears in a vowel as well. That is, there is a certain degree of saliency because the nasal feature exists and contrasts in minimal pairs such as *down* /daʊn/ vs. *noun* /naʊn/. But how is the nasal feature integrated into the phonological representation of English vowels that do not usually contain such a phonemic feature?

From a phonological perspective, in feature-geometric terms (Clements, 1985) and following Paradis and Prunet (2000), English nasalized vowels possess a structure similar to the one shown in Figure 6a (left panel). Such a representation is used by several authors for English (Encrevé, 1988: 206; Lahiri & Marslen-Wilson, 1991: 259) as shown below:

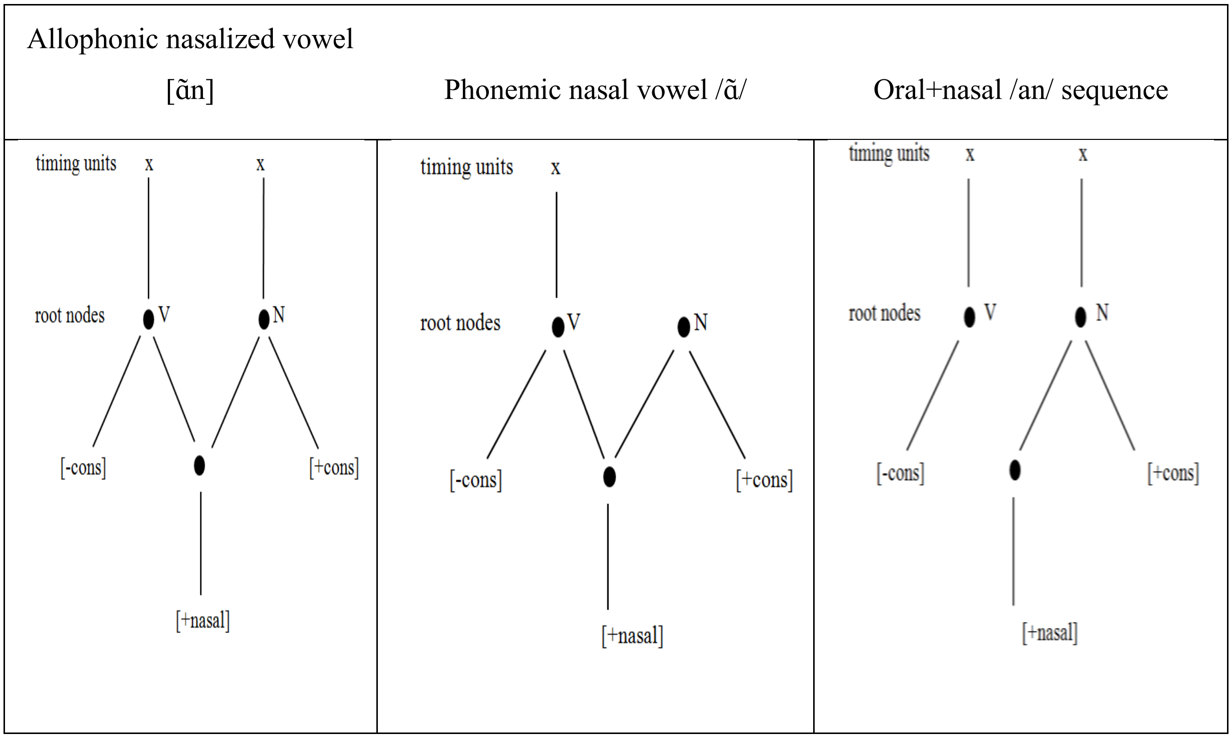


Figure 6. Phonological representation of the English allophonic nasalized vowel (6a: left panel), the French phonemic nasal vowel /ã/ (6b: central panel), and the /an/ sequence (6c: right panel).

In the case of the English allophonic nasalized vowel [ãn] (Figure 6a), the nasal feature on the vowel emerges from an adjacent nasal consonant, a process that Paradis and Prunet (2000: 340) denominate 'local' nasalization, and which is consistent with regressive nasal assimilation. In Figure 6a the nasality feature marking the following consonant (root node N) spreads to the preceding oral vowel root node (V), adding a nasal quality to the vowel at the surface level (allophonically) without eliminating the nasal consonant. Thus the nasal consonant remains separated from the vowel and is phonetically realized thanks to its attachment to a timing unit. Nasality is the only feature propagating from the closed-syllable nasal consonant to the preceding nasal vowel.

On the right panel of Figure 6 (6c), representing an oral + nasal /an/ sequence in French, we can see that the nasal consonant is completely separated from the oral vowel. Nasality is attached to the root node of the nasal consonant only (N). Both oral vowel and nasal consonant are phonetically realized thanks to the attachment of their root nodes to their respective timing units. It can also be observed that, when native speakers of French encounter the sequence /an/ (oral vowel + nasal consonant), a featural connection between the feature [+nasal] to the vocalic root node is absent. In other words, there is no phonological anticipatory nasalization (or regressive assimilation) of the feature [+nasal] to the preceding vowel, unlike in English. Thus, the vowel remains oral and the nasal feature belongs strictly to the nasal consonant. This structure occurs in words such as *panne* [pan] ‘breakdown’, *peine* [pɛn]‘sorrow’ or *tonne* [tɔn] ‘ton’. This is also substantiated by the nasal airflow data obtained by Cohn (1993: 52). I reproduce here one of her illustrations (Figure 7) that shows how the vowel /ɔ/ remains oral for most of its production and then nasal airflow increases significantly during the production of the nasal consonant in the phrase *bonne tête* /bɔn t(ɛt)/ ‘good head’.

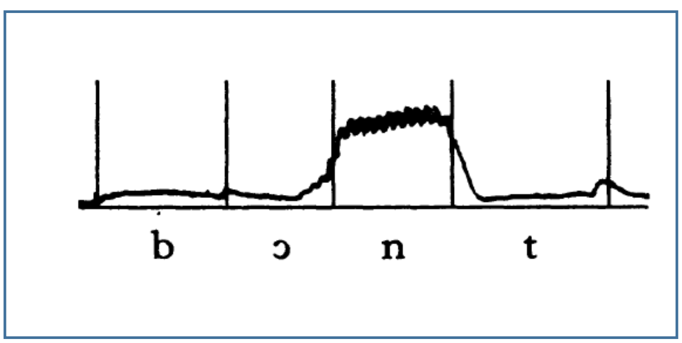


Figure 7. Nasal airflow traces for bonne tête /bon t(ɛt)/ ‘good head’. Reprinted with permission from Cambridge University Press. Cohn (1993: 52 and 60). Nasalization in English: Phonology or Phonetics. Phonology, Vol. 10 (1), pp. 43-81.

Figure 6b (central panel) presents the French phonemic nasal vowel representation according to Paradis and Prunet (2000: 340-41). The oral vowel root node is followed by a nasal consonant root node. For this reason they call it the two-root node view. However, here the consonant is unanchored and lacks a timing unit. Therefore, the nasal consonant is not produced at the surface level (it is not pronounced) and remains latent, as an unattached floating segment. Some examples appear in words such as *paon* [pɑ̃] ‘peacock’, *pain* [pɛ̃] ‘bread’ or *pont* [pɔ̃] ‘bridge’.

Across these three phonological representations, the common element seems to be a nasal consonant segment that either attaches to a timing unit (allophonic nasal vowels in English; oral vowel + nasal consonant sequence in French), allowing the nasal consonant to surface phonetically and being produced, or that does *not* attach to a timing unit (fully nasal vowels in French), remaining latent, whereas the nasality surfaces in the vowel.

In English, it is possible for a nasalized vowel to be followed by a nasal consonant —in fact, it is the only licensed representation of nasality on a vowel, since there is phonetic nasalization due to anticipation of the nasal consonant, as Cohn (1993) shown in her nasal airflow data. By contrast, such a sequence is not licensed in French: there is no possible representation of it underlyingly, due in part to the Obligatory Contour Principle, which states that two identical features should not occur in succession (Clements & Keyser, 1983). That is, nasality appears phonemically on either the vowel or the adjacent consonant, but not on both, and French does not allow words such as *[pɔ̃n][10]. Another aspect to take into consideration is that in such an unlicensed representation, there would be a total of three root nodes (as shown in Figure 8).

[10] There are some exceptions to this that can appear in morphological or lexical boundaries, as we saw previously in cases such as *mon ami* [mɔ̃nami]. For other examples please refer to footnote 2.

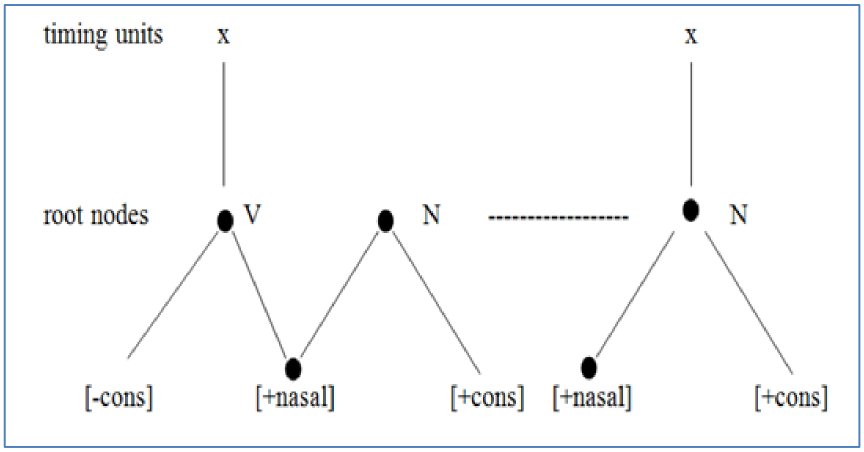


Figure 8. Phonological representation for */ãn/, not allowed in French.

It is important to notice that this principle is language-specific, and does not apply to all languages. Haitian Creole, for instance, does have sequences of nasal vowel + nasal consonant, which contrast with sequences of oral vowel + nasal consonant: *konn* /kɔ̃n/ 'to know' vs. *kòn* /kɔn/ 'horn'.

In the next section, I will address the central issue of this dissertation, namely what it means to acquire French nasal vowels for L1 English learners of French as a foreign language. I will also outline two possible perceptual strategies that learners could initially use when they hear French nasal vowels and how they can overcome these strategies in order to fully acquire L2 French nasal vowels.

3.3 The acquisition of French nasal vowels in L2 French

One crucial question that emerges from the discussion of underlying representations for nasal and nasalized vowels in French and English is about second language learners of French and English. How do French L2 learners of English learn to produce and represent allophonically nasalized vowels in English words? And of direct interest for this dissertation: How do English

L2 learners of French acquire the correct phonological representation for French nasal vowels? How can learners progress from the phonological representation of English nasalized vowels (c.f. the left panel in Figure 6a) to the French nasal vowel representation (c.f. the central panel in Fig. 6b)? The only difference between the representation of a nasalized vowel in English (Fig. 6a) and a nasal vowel in French (Fig. 6b) seems to be the presence of an extra timing unit in English. If so, then, how can learners of French remove the timing unit belonging to the nasal consonant, so that the nasal consonant is not pronounced and the nasal feature becomes an integral part of the vowel?

Coincidentally, several authors of phonetic corrective manuals for L2 French (Companys, 1966; Tranel, 1987; Valdman, 1993) also point out that the difficulty for English speakers is not primarily in the articulation of these nasal vowels themselves, but rather in the production of a non-nasal oral vowel when this sound is followed by a nasal consonant (cf. Fig. 6c). If this is so in production, one cannot help but wonder if learners have similar problems in perception as well. Yet, perception experiments providing insight into the phonological knowledge of L2 learners of French are rare. Relatively little is known about what is exactly acquired in the process or what factor(s) trigger the transformation of this allophonic feature into a phonemic one except for the attempts of the phonological models previously mentioned: PAM-L2 (Best & Tyler, 2007), the SLM (Speech Learning Model) (Flege, 1995) or the Direct Mapping from Acoustics to Phonology (DMAP) model (Darcy et al, 2012).

Several pieces of evidence indicate that nasal vowels seem to be hard to discriminate in nasal contexts (preceded or followed by nasal consonants) by native and non-native listeners, as nasal vowels are not perceived to be fully oral or nasal in such environment. Beddor and Krakow (1999) took naturally produced oral and nasal vowels (spoken by a male speaker of American

English), and cross-spliced them to be inserted in oral (C_C) or nasal (N_N) contexts, or presented in isolation. In one task, English and Thai listeners were asked to judge the nasality of different stimuli pairs. In the other discrimination task (4 Interval AX) they were asked to judge vowel similarity. In both tasks listeners encountered more difficulties to distinguish oral from nasal vowels in the nasal context. The inability to correctly perceive nasal or oral vowels in nasal contexts is attributed to a mechanism called perceptual compensation. This compensation leads listeners to perceptually reattribute a perceived segmental feature to another segment, if they are able to identify that segment as the source of the coarticulation from where the feature originates. In other words, listeners might attribute the perceived nasality on a vowel to coarticulation generated by a neighboring nasal consonant, and thus perceive the vowel as underlyingly oral. Listeners therefore appear unsure if the perceived nasality in that context originates in the nasal consonant or belongs to the vowel itself, which leads them to perform on average just slightly below chance level (at a range of slightly under chance level to over chance level). Unfortunately, as recognized in Beddor, Krakow and Lindemann (2001) in their review of different experiments dealing with coarticulatory compensation, it is hard to tell which nasal consonant would have more influence on the vowel due to their experimental design not having a C_N or N_C contexts. Despite the importance of perceptual compensation and the fact that listeners responded as though they were aware of the presence of some nasality on the vowel in nasal context, their response patterns did not indicate that they heard the contextually nasalized vowel as fully oral nor fully nasal. These authors interpret this as such compensation being partial and dependent on the patterns of articulatory nasalization of the listener's L1 (see also Darcy & Kügler, 2007, for evidence of partial perceptual compensation for voicing assimilation).

For the optimal acquisition of the French nasal vowels, in phonological terms, learners need to realize that the nasality feature — which in English is exclusively associated to the presence of a nasal consonant and does not carry lexical meaning for the vowel (e.g. the word *band* [bæ̃nd] does not change meaning if the vowel [æ] is pronounced more or less nasal) — becomes a *contrastive feature* that can alter the meaning of a word in their L2 (*baie* [bɛ] 'bay' vs. *bain* [bɛ̃] 'bath'). That is, they need to grasp that phonological distinctions are intimately linked to lexical differences. They also need to learn that nasality becomes significant and participates in the phonology of French not as the result of a given phonological environment (an oral vowel followed by a nasal consonant), but as an *independent trait* (floating nasal feature). In terms of the underlying phonological representation, this means that learners must also learn that this independent trait must be incorporated into the mental representation of the French L2 learner such that it becomes attached to the root node of the vowel at the same time that the timing unit (X) for the nasal consonant is removed (see Fig. 6, p. 49 from left to right: 6a turning into 6b).

English phonological specification associates the feature [+nasal] to the oral vowel if it is followed by a nasal consonant, since English has no phonemic nasal vocalic categories. As underlying nasal vowels do not exist in the English phonological inventory, we could expect then that English native speakers displaying no knowledge of French might initially use either one of the following two strategies to transform the nasal vowel into a form that agrees with their L1 phonological representation:

1) Repair the nasal vowel into a sequence of **oral vowel + nasal consonant**: /ɑ̃/ > /a+n/.

2) Repair the nasal vowel and turn it into an **oral vowel**: /ɑ̃/ > /a/.

Both strategies result in representations that are licensed in English. If the first strategy is how English native speakers approach French nasal vowels, they might perceive the nasality in the vowel and assume a nasal consonant might be at its source. In perception, they would therefore **repair** the nasal vowel into a sequence of **oral vowel + nasal consonant** (e.g. /ɑ̃/ > /a+n/. As mentioned above, the initial state of the L2 or interlanguage (IL) is the L1 (see Archibald, 1998; Escudero & Boersma, 2004 for backup data in perception; and Schwartz & Sprouse, 1996 for morphosyntax). In the initial stage of learning, L2-French L1-English learners might thus perceptually "repair" the phonologically illicit—to them—French nasal vowels /ɑ̃/, /ɛ̃/, /ɔ̃/ and mentally interpret them as the sequence /a/ + /n/[11] (oral vowel + nasal consonant) in their early lexical representations for words like *maison* 'house'. As a result, they might encode it as */mɛzɔn/ instead of /mɛzɔ̃/ 'house'. Such a possibility is suggested by some of the production data in Liddiard (1994), who shows that beginning L2 learners of French (one year at university level) are able to produce about half of their nasal vowels in a native-like way (44 % of correct pronunciation in a corpus of 39 words containing French nasal vowels recorded both by reading a story and then in an oral interview), but also experienced difficulties that the author connected to English being their native language: a) non-nasalization of the vowel (e.g. *brun* 'brown' was pronounced as *[brun] instead of [brɛ̃]); b) residual [n] or [m] (e.g. *compter* 'to count' was pronounced as *[kɔ̃ᵐte] instead of [kɔ̃te]; c) vowel substitution, where (e.g. *ombre* 'shadow' was pronounced as *[ɑ̃mbr] instead of [ɔ̃mbr] due to a perceptual confusion between /ɒ/ and /ɔ/ because of L1 English influence. The second of these findings also converges partially with Paradis and Prunet's (2000) findings for French words containing nasal vowels that are

[11] I will be using here the vowel /a/ for the examples for the sake of simplification, but this vowel reflects the same patterns for vowels /ɛ/ and /ɔ/.

borrowed into different languages, in which borrowers adapted French words to English phonology: *ensemble* [ɑ̃sɑ̃bl] ‘together’ adapted as [ɑnsɑmbəl].

This first strategy is called “nasal unpacking”. Naïve speakers will be sensitive to nasality but will repair the syllable structure by splitting it into two segments, in order to respect the biphonemic underlying structure of the nasal vowel. This strategy was also pointed out by Eckman, Elreyes and Iverson (2001) in their justification of the structure preservation principle. According to these authors, when Spanish speakers learn L2 English, they have to split the allophones [d] and [ð] (allophones in Spanish) into separate phonemes in English. They show evidence supporting the claim that one of the principles allowing such splitting to take place is the use of the Structure Preservation Principle. This principle states that representations within the lexicon may be composed only of elements drawn from the phonemic inventory. In this way it is understood that at the initial stages of acquisition, in which the L1 phonemic inventory predominates, English-native speakers of French split a nasal vowel into segments that already exist in their L1 phonological inventory: an oral vowel followed by a nasal consonant as we saw in Paradis and Prunet’s examples above.

According to the second strategy, English native speakers will categorize a French nasal vowel just as they would its oral counterpart, stripped from nasality. That is /ɑ̃/ might be equated with /a/. During perception, L2-French learners will initially **repair the nasal vowel and turn it into an oral vowel** (e.g., /ɑ̃/ > /a/. The nasality would consequently be lost in their early lexical representations for words like *maison* ‘house’. As a result, they might encode it as */mezo/ instead of /mezɔ̃/ ‘house’.

I will name the second strategy “nasal stripping”, since naïve speakers remove nasality from their perceptual interpretation of the input, replacing mentally the allophone [ɑ̃] by its oral counterpart [a]. This possible strategy derives from the fact that because listeners with no experience in French do not detect the presence of an adjacent consonant, their underlying representations suggests that the vowel is more likely oral, as in English, nasal consonants are the segments that can turn an oral vowel into a nasalized vowel[12]. Since in this case the nasal consonant does not surface (it is a floating, latent, not realized consonant), this absence may drive the application of this strategy. In this strategy, the original phonological structure of the French nasal vowel is not preserved: out of the two root nodes of the nasal vowel, only one would remain in the learners’ initial representations.

In order to test which of these two repair strategies English-native speakers apply initially, I have designed two tests: an ABX discrimination task and a lexical decision with repetition priming task. The design of these tasks will allow to us determine which strategy learners apply at which level by testing discrimination and lexical encoding of words and pseudo-words containing nasal vowels, oral vowels, and sequences of oral vowel + nasal consonant, such as in the triplet: /mezɔ̃/ ‘house’, */mezon/, and */mezo/. I will examine this for the three standard nasal vowels of French[13]. Chapter 4 describes the methods and specific predictions in more detail. In

[12] Sampson (1999:116) mentions that in parts of Picardy and in the Franco-Provençal zone of France there are sporadic cases of spontaneous nasalization, in which no nasal consonant is present, but the velum is still lowered.

[13] Although, originally French had four nasal vowels: /œ̃/, /ɛ̃ /, /ɑ̃/ and /ɔ̃/. Several authors, (Battye et al., 2000: 96-97; Tranel, 1987: 68) indicate that /œ̃/ and /ɛ̃ / have been merged in favor of /ɛ̃ / in Northern Metropolitan French, the variety one could describe as standard. Therefore, I only examine these three nasal vowels: /ɛ̃ /, /ɑ̃/ and /ɔ̃/.

order to examine whether learners successfully recover from either hypothesized strategy, learners of French at different proficiency levels were tested.

First however, a perceptual assimilation experiment examines how American English (AE) vowels map to French vowels for English native speakers without French experience. This task establishes a perceptual baseline which might prepare the terrain for the application of one or the other strategy. In doing so, I will be able to see which perceptual assimilation patterns are mapped to which strategy as learners start to learn French.

The following section will sketch the representation assumed in either strategy and outline the possible pathways for recovery from these two repair strategies.

3.3.1 Representation as "nasal unpacking" and recovery from the Nasal- Unpacking strategy

In the case in which English learners choose the unpacked nasal vowels route, a possible developmental sequence of their phonological representation would be:

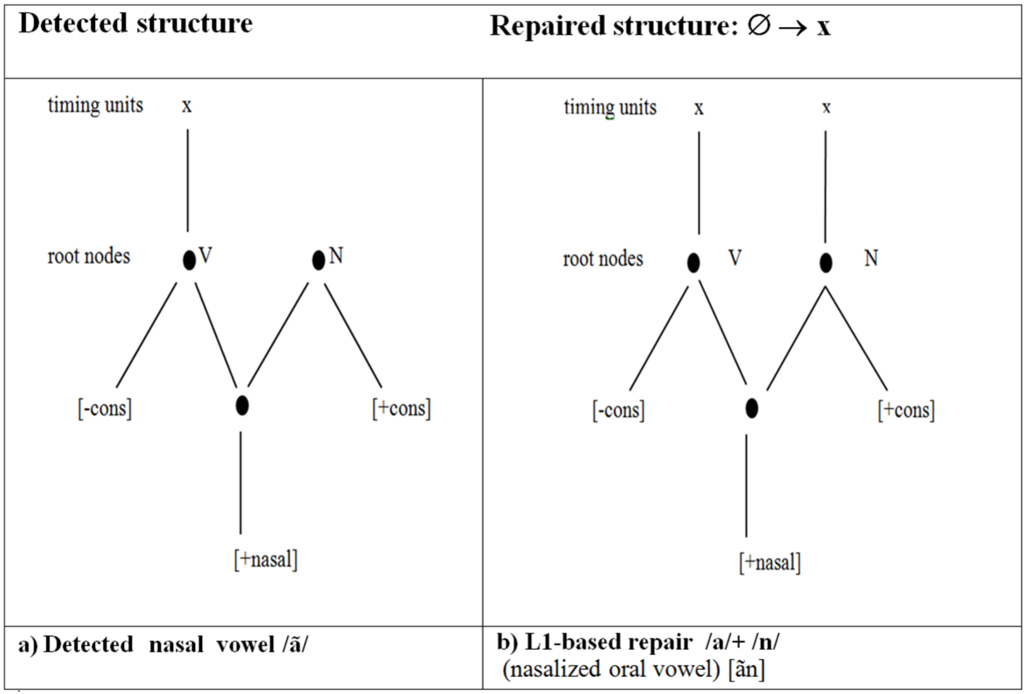


Figure 9. Speculative nasal unpacking strategy: learners detect the phonemic French nasal vowel /ɑ̃/ and transform it into an L1-English oral vowel followed by a nasal consonant sequence /an/.

In figure 9a it can be seen how successful learners would have an L2-like underlying representation that equals those of French-native speakers, where the nasal consonant is not phonetically implemented and is disconnected from the vowel and the nasality feature forms an integral part of the vowel. The nasal consonant would remain as a floating consonant that would be reattached to its timing unit if certain phonological conditions are met, such as fully oral realization of the vowel (e.g. *couronne* [kuʁɔn] ‘crown’, *pleine* [plɛn] ’full’). Figure 8b) shows an underlying representation that is allowed in the L1 English phonology. L1-English learners of L2-French tend to find a felicitous representation for the French nasal vowels they hear. In this case the sequence of an oral vowel followed by a nasal consonant: /an/. The nasality of the vowel is allophonic and could appear in it in different degrees. The main difference between figure 9a and figure 9b consists of a timing unit being added to the phonological representation which implies that the nasal consonant passes from being a floating segment to becoming a consonant realized at the surface level. The addition of such timing unit preserves the nasality feature.

Over time, to recover from this initial representation and to acquire the French nasal vowel, learners need to hypothetically follow a reverse path to the one shown in figure 9 for the nasal unpacking strategy. In order to be able to obtain the representation of the nasal vowel of French-native speakers, L2 learners could follow the following process: to recover from the unpacking nasal repair strategy, learners would have to remove the timing unit they had initially added, so in this way the vowel would have the nasal feature attached to the vocalic root node, but the consonant would not be realized (see figure 8 but reading from right (9b to left 9a). Acquiring the nasal vowel would mean discontinuing the use of such nasal-unpacking repair strategy when learners detect nasality on the French nasal vowel.

3.3.2 Representation as "nasal stripping" and recovery from the Nasal Stripping strategy

Those learners beginning with initial nasal stripping would equally adapt the French nasal vowel phonological representation to another more suited to their L1 (Figure 10). In 10a) learners would start with a French-like underlying representation of the phonemic nasal vowel. In this structure the nasal consonant is not realized and serves to lend its nasal feature to the previous adjacent initially-oral vowel. Nasality remains a floating feature attached to the root node of the floating nasal consonant. Figure 10b) represents the result of cutting off the floater (indicated in Figure 10a) by the dotted line). Learners now remain with an oral vowel in which the nasal floater is completely absent. That is, their repair strategy consists of removing entirely the nasality from the original French nasal vowel. This nasal-stripping strategy assumes that learners are not able to represent floating nasal consonants and instead of adding an extra timing unit, as they did for the nasal unpacking strategy (see Fig. 9b), they eliminate the floater to preserve a licensed structure in their L1 English. Both are phonologically licensed; both exist in the grammar of French. Lexical floaters motivated by alternation *enfant/enfantin* [ɑ̃fɑ̃]/[ɑ̃fɑ̃tɛ̃] 'child/childish' are post-lexically eliminated as in Clements & Keyser (1983) and floaters receive timing slots by morpho-phonological processes.

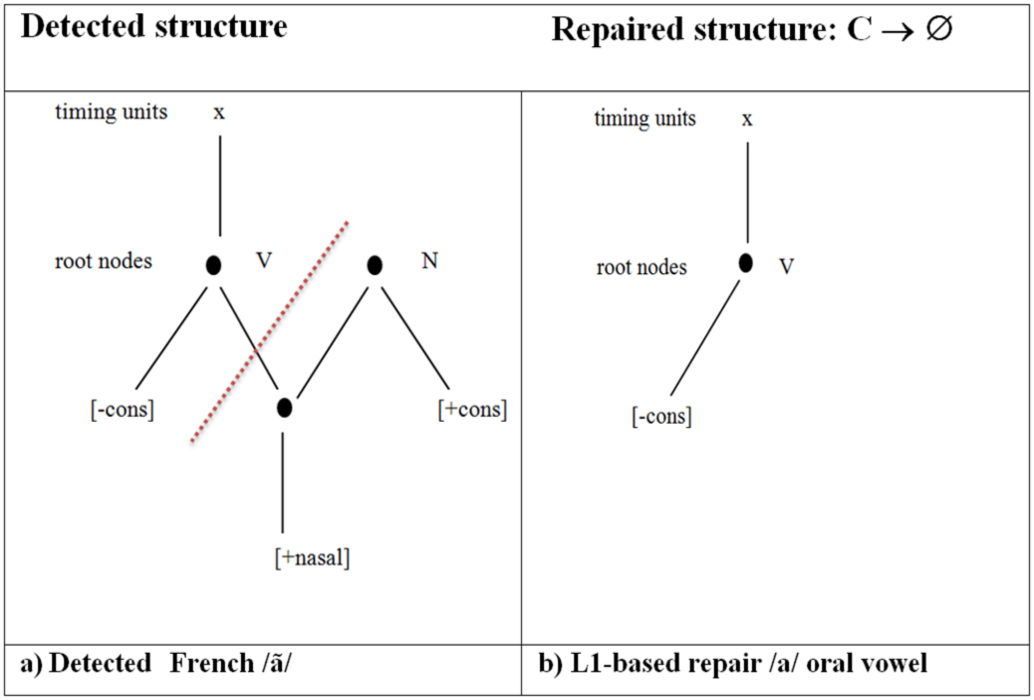


Figure 10. Speculative nasal-stripping strategy or merger: learners detect the phonemic French nasal vowel /ɑ̃/ and transform it into an L1-English oral vowel /a/.

Over time, to recover from this initial representation from the point of view of acquisition, learners need to hypothetically follow a reverse path to the one shown in figure 10: the repaired fully-oral vowel goes through a process of underlying nasalization to counteract the nasal-stripping strategy used by learners of French. This entails that a root node and floating segment, the nasal floating consonant, are added to the oral vowel (see figure 10, but reading from right [10b] to left [10a]), lending its nasality to the vowel without the consonant surfacing phonetically (since the consonant is not anchored to a timing unit).

It is also noticeable that the propositions mentioned in the previous chapter by Darcy et al. (2012) come into play as well because: 1) English learners of French detect the nasality of the French nasal vowel, an acoustic cue that is not necessary in their L1 for segmental categorization; 2) after many instances through exposure to French language minimal pairs, L2 learners review their interlanguage feature hierarchy taking into account economy principles; 3) the nasality feature starts to be associated to and included into the feature matrices of vowels in addition to those of consonants; 4) phonetic categories for vowels might begin including the nasality feature as part of their definition.

In sum, from a structural point of view, there are two different repair strategies in response to a French nasal vowel input: a) learners might unpack the nasal vowel /ɑ̃/ into a sequence of oral vowel followed by a nasal consonant /an/. Here they would add a timing unit to which the floating nasal consonant could attach and therefore surface phonetically as /an/, while still keeping certain degree of nasality in the vowel and preserving the two root node structure that was proposed by Paradis & Prunet (2000) and Eckman and Iverson (1997); or b) they might strip nasality from the French nasal vowel. Here they would eliminate the floating nasal consonant completely and therefore the nasality feature attached to it. A successful acquisition means that, as soon as they hear a French nasal vowel, learners of French stop applying either one of these strategies. That is they do not use their L1-English perceptual phonological filter because they have managed to incorporate the nasal feature into their mental representation of the L2 French nasal vowels. They would then reinterpret the input in the light of the new phonological grammar.

In chapter 4, I will describe the methods used for my three experiments: 1) a perceptual assimilation experiment; 2) an ABX experiment; 3) a lexical decision with repetition priming experiment.

Chapter 4 Methodology

The present dissertation investigates the perceptual acquisition of L2 French nasal vowels /ɛ̃/, /ɑ̃/ and /ɔ̃/ by L1-English learners of French and the effects of exposure to the L2 in classroom and second-language settings. As described in Chapter 3, nasal vowels in English are allophonic and appear only when preceded or followed by a nasal consonant, whereas in French nasal vowels are phonemic and present lexical distinctions when the nasality feature is part of the vocalic category. That is, when the oral vowel is replaced by a nasal vowel we obtain different words: *seau* /so/ 'bucket' vs. *son* /sɔ̃/ 'sound'; *raie* /rɛ/ 'ray' vs. *rein* /rɛ̃/ 'kidney' or *ça* /sa/ 'that' vs. *sans* /sɑ̃/ 'without'.

As we saw in section 3.3 when I described the acquisition process of French nasal vowels, Liddiard (1994) found that L1-English learners of French at the beginning level (1 year) tended to produce a residual nasal consonant (/n/ or /m/), produced inaccurate points of articulation and lacked appropriate denasalization in VN (oral vowel + nasal consonant) sequences such as *bonne* /bon/ 'good'. Based on Liddiard's findings, if one of the errors L2-French learners make in production is the insertion of a residual nasal consonant, there is a possibility that they perceive a nasal consonant as well and that's why they insert an epenthetic nasal consonant (e.g. *pain* 'bread' would be pronounced *[pɛ̃^{n}] instead of [pɛ̃]). This is also potential evidence suggesting a bi-phonemic underlying representation of French nasal vowels. To acquire nasal vowels at the phonological level then, L1-English learners of French would only need to remove a timing slot from the underlying representation, so that the nasal consonant is not produced (see Figures 6a and 6b on page 49 in Chapter 3 for allophonic and phonemic nasal vowels' representations, respectively).

Given that the participants in Liddiard's experiment were all at the beginner's level and produced nasal vowels, it remains unclear how the perceptual skills of more advanced L2 learners of French develop: those who have taken more French courses at university (intermediates), or those who have taken numerous classes (5 or more) and have spent a substantial amount of time in a French-speaking country (at least a semester or four months). We do know, thanks to Inceoglu's study (2014) with American learners of French, that perception of French nasal vowels (/ɔ̃/, /ɛ̃/, /ɑ̃/) can improve. At least this is what she found, especially for /ɛ̃/, through a 3-week training in three modalities: audiovisual, visual and auditory. Additionally, we do not know exactly what the mental representation of the learners in Liddiard's study is.

Studies like Liddiard's reveal the difficulties that learners of French experience in acquiring phonemic nasal vowels. In order to better understand such difficulties I will target two gaps in knowledge in the present dissertation:

1. How English learners of French perceptually acquire nasal vowels at different proficiency levels.

2. What kind of underlying representations they start with, and what kind they acquire over time.

In order to fill these gaps, three research questions are formulated, respectively:

1. If learners start with their L1 phonological representations (e.g. Polivanov, 1931) at early stages of L2 learning, what do English listeners with no knowledge of French hear when they encounter L2 French nasal vowels?

2. Which perceptual strategy do learners use initially to adapt L2 French nasal vowels to their current L1-English underlying interlanguage representations? Will they be able to stop using such a strategy as they gain more experience with French and how does this happen?

3. What is the underlying representation of phonemic nasal vowels for L2 learners of French at different stages? We want to know if it is L1-like (English), L2-like (French) or neither L1 nor L2-like (interlanguage representation).

The focus of the dissertation will be the three standard nasal vowels of French /ɛ̃/, /ɑ̃/ and /ɔ̃/. The perception of French will be studied in different phonetic nasal contexts with both words and non-words and with participants with no knowledge of French, as well as intermediate and advanced levels of French, and French native speakers.

In order to answer research question (RQ) 1, we need to first establish a baseline of perception with naïve participants, who have no knowledge of French. That is, we need to first know what these listeners — who possess only an English phonological grammar or at least with a language possessing no phonemic nasal vowels — are exactly hearing when they encounter a French nasal vowel. In order to do so, a perceptual assimilation experiment was conducted (see section 4.1). Then, to answer RQ 2 learners of French at different levels (intermediate and advanced) carried out two tasks. Having different proficiency levels allows us to gain insight into their stage of acquisition and compare it to that of naïve listeners and also to French natives. The first task involved an ABX discrimination task to assess phonetic discrimination (see section 4.2) between oral and nasal vowels. The second task consisted of a lexical decision with repetition priming task, which allows us to see phonological discrimination and also lexical encoding of different contrasts (see section 4.3). That is, we want to observe whether they manage to incorporate the nasality feature to the representation of vowels and differentiate the type of oral/nasal contrasts that we saw at the beginning of this chapter.

Combining the findings of phonetics (ABX experiment) and phonology (lexical decision with repetition priming experiment) I expect to trace the phonological representation of nasal vowels at different stages of development and in doing so being able to provide an answer for RQ 3.

In this chapter, I describe the methodology used for the three experiments conducted. First, in section 4.1 I present the experimental design, subjects and procedure for the perceptual assimilation task. Secondly, section 4.2 presents the participants, materials and experimental procedure for an ABX discrimination task. Finally, in section 4.3 participants, materials and procedure for a lexical decision with repetition priming task are presented.

4.0 General testing procedures

The order and the specific tasks performed by the experimental groups are outlined below in Table 2:

Table 2. Experiments carried out by each of the participating groups with the sample size (N) for each experiment.

Groups	**Experiments**	
No-French	ABX (N = 25)	Perceptual Assimilation (N = 10)
Intermediate	ABX (N = 79)	Lexical Decision (N = 79)
Advanced	ABX (N = 28)	Lexical Decision (N = 28)
French-natives	ABX (N = 24)	Lexical Decision (N = 24)

The different groups followed the ensuing procedure:

1) All participants read and signed a consent form explaining the procedure of the experiment, which tasks they would carry out and how long each task would take. This took approximately 5 minutes.

2) Participants filled out a language background questionnaire. This took approximately 10 minutes.

3) The intermediate, advanced and French-native groups performed the ABX and lexical decision tasks. Participants took 10-15 minutes for the ABX task and 25-35 minutes for the lexical decision one depending on how long they decided to make pauses in between experimental blocks.

4) The no-French group took part in the ABX and perceptual assimilation tasks (the latter took around 15-25 minutes to complete), since neither of these tasks required any previous knowledge of French to be performed. The same items were used for these two experiments; all items were non-words in both French and English.

All procedures described in this dissertation have been approved by the Indiana University Institutional Review Board (protocol number: 1110007232).

4.1 Experiment 1: Perceptual Assimilation Task

The purpose of this experiment was to assess the perceived relation between American English and French vowels through two kinds of auditory tasks. The method used closely followed the one described in Guion et al. (2000). First, native speakers of English were presented French vowels and were asked to identify each token as an example of some American English vowel category. Then, immediately after, they were asked to rate the token for goodness-of-fit to the recently-selected English category. Right after their categorization, they were asked to rate the vowel they heard in a 1-5 scale, 1 being a bad example of the category they chose and 5 being a good example. The following figure shows the screen that participants saw while performing the categorization task:

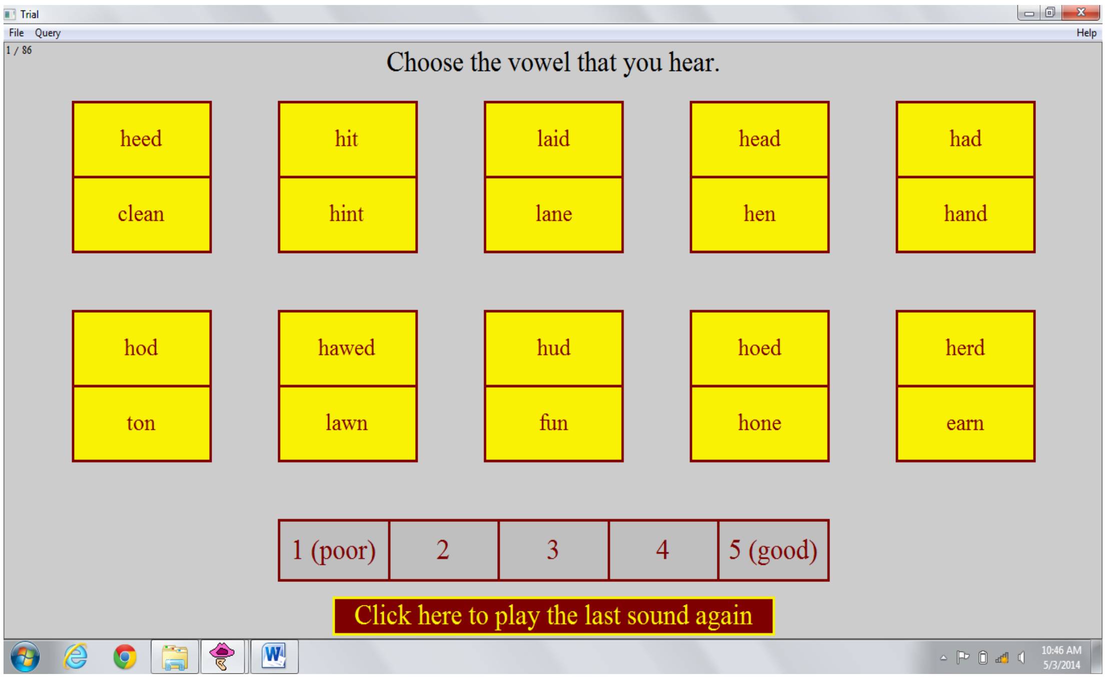


Figure 11. Screenshot that participants see during the perceptual assimilation task.

Participants

A subset of the no-French group (n = 10, 1 male) who took part in the ABX experiment (see section 4.2) was subsequently tested in this perceptual assimilation experiment. The no-French group were US-English speakers with no exposure to any language containing phonemic nasal vowels. They were mostly either undergraduate or graduate students at the time of testing. Their mean age was 27.6 (range 21-60). No hearing problems were reported.

Materials

For this task, I used 43 out of the 55 monosyllabic non-words used for the ABX experiment (see below) in order not to fatigue the participants and induce a decline in the quality of their responses given the length of the task (See Appendix I). Out of the 43 stimuli selected for the perceptual assimilation task, 25 contained nasal vowels used in the ABX experiment (see section 4.2). A range of stimuli were taken from each ABX condition: 9 for the consonant control condition; 9 for the vowel control condition; 7 for the [ɑ̃] test condition; 6 for the [ɑ̃n] test condition; 6 for the [a] test condition; 6 for the [an] test condition; This was done because this experiment was the baseline to determine what learners of French would start with, namely what English listeners perceive when they hear a French nasal vowel in different phonetic contexts (see Table 2 for ABX conditions in section 4.2). At the same time using items for all the test conditions equally allows us to better understand and pinpoint the difficulties that learners of French encounter in the different conditions for the ABX task. This categorization method is similar to the one used by Tyler et al. (2014) and Levy (2009) for adult L1-English participants.

Unlike in the ABX experiment, where stimuli were presented in sequences of three tokens, for this perceptual assimilation task the tokens were presented individually. Each item used for this task was repeated once to ensure that the quality of the vowel was heard in the same manner. Hence there were a total of 86 stimuli items: 43 items x 2. Nonetheless — and similarly to what was done for the ABX experiment ($A_1B_1A_2$: where A_1 and A_2 referred to the same non-word but came from different recordings) — the repeated stimulus item came from a different audio file. E.g. the two stimuli items for the non-word *stann* [stɑ̃n] came from two different recordings from the same Haitian Creole speaker.

The 86 stimuli items were divided into 4 blocks, containing 21 tokens each, except for the last block that contained 23 items. Each block was separated by a pause. These blocks were randomized to ensure that the two audio files for the same stimulus item would not be played immediately one after the other.

Procedure

The computer software Praat (version 5.3 by Boersma & Weenink, 2013) was used to administer this task and collect the answers. As mentioned above, some of the participants belonging to the *no French* group took part in the perceptual assimilation task after completing the ABX task. For this task, they were first asked to read out loud the same English words that they would use to categorize the vowel they would hear subsequently. They read 20 American English (AE) keywords (heed, clean, hit, hint, laid, lane, head, hen, had, hand, hod, ton, hawed, lawn, hud, fun, hoed, hone, herd, earn). These keywords contain 10 English vowels, all of them also presented in a nasal context (bolded): /i/, /i**n**/, /ɪ/, /ɪ**n**/, /ɛ/, /ɛ**n**/ /eɪ/, /ei**n**/, /æ/, /æ**n**/, /ɒ/, /ɒ**n**/, /ɔ/, /ɔ**n**/, /ʌ/, /ʌ**n**/, /əʊ/, /əʊ**n**/, /ɜʳ/, /ɜʳ**n**/. These nasal contexts were included because vocalic nasality exists in English mainly due to the coarticulation effect of a following nasal consonant. Providing these contexts allowed us to know if listeners heard nasality in the vowel or not, since if they did, in order to match their English phonological grammar, they were likely to categorize nasal vowels as a sequence of oral vowel followed by a nasal consonant. In addition, these nasal-context categories were also included in previous perceptual assimilation studies, such as Tyler et al. (2014).

Their pronunciation was recorded. Choosing among the wide range of the American English (AE) vocalic inventory could have overwhelmed the participants. For that reason, only this set of possible vowel response categories was considered based on the results of a pilot experiment.

The pilot used American English orthographic transcription of the stimuli to determine which American English oral vowels — or oral vowel followed by nasal consonant sequences — should be presented to the participants as possible response options. In addition, these keywords had been used in previous studies with a similar methodology because they provide a vast array of vowel possibilities.

After reading the keywords to familiarize themselves with their vowels, the participants were instructed to listen via headphones to the experimental nonwords, and to pay attention to the vowels contained in them (see section 4.2). Participants were instructed to select one of the 20 AE keywords that contained the most similar to the vowel they heard in the monosyllabic non-word. They chose the vowel by using the mouse to click on the category of their choice on the screen (see Figure 11). Immediately after having categorized the vowel, they were asked to rate their choice from 1 to 5, 1 being a very bad exemplar of the category they chose and 5 being a very good exemplar of such category. Participants' categorization answers and goodness ratings were recorded.

The test lasted about 15-25 minutes, given that they could listen to the tokens a maximum of five times and take as much time as they needed to choose their categories from the 20 available on the screen. There was neither a practice session nor any type of feedback, since the main goal of the experiment was to see how they would assimilate the vowels they heard into a vowel in their L1. There were two breaks, located every 21 items in between blocks.

4.2 Experiment 2: ABX discrimination

In this experiment I examine the ability of the participants to perceptually discriminate oral vowels from nasal vowels in different phonetic contexts. The method used for this task is an ABX discrimination task, which allows examining the degree to which participants have acquired perceptual categories. In a typical ABX task (as in Levy (2008) and Darcy et al. (2012) for adult L1-English learners of L2 French) participants are asked to indicate if out of a sequence of three invented words, the third non-word sounds more like the first one or like the second one they heard.

Participants

A total of 156 participants were tested. They were mostly born either in the US or in a French-speaking country and they were studying and/or working at colleges in the US at the time of data collection.

These participants were divided into 4 groups: a first group that had no knowledge of French or any other language containing phonemic nasal vowels (e.g. Portuguese or Haitian Creole): the *no-French* group, which acted as a control group. A second group that possessed some knowledge of French and had taken three or four semesters of French instruction at university: intermediate learners of French (*intermediate*). A third group that had received at least five semesters of French instruction and had been living in a francophone country for at least 4 months: advanced learners of French (*advanced*). Finally a fourth group consisting of French native speakers: the control group (*native speakers*).

The no-French group (n = 25, 7 males) were US-English speakers with no exposure to any language containing phonemic nasal vowels. They were mostly either undergraduate or graduate students when they were tested. Their mean age was 33.3 (range 20-71). No hearing problems were reported.

The intermediate learners (n = 79, 23 males) had English as their native language. They started learning French at the age of 12 or later. Their proficiency was estimated based on the French courses they were taking at the time of the experiment. They were enrolled in their third or fourth semester of French in college at a US university. Their mean age was 21.2 years (range 17-35). None of them had spent more than 2 weeks in a French-speaking country. None of them spoke another foreign language that contained phonemic nasal vowels. No hearing problems were reported.

Advanced learners (n = 28, 10 males) were advanced undergraduate students, graduate students or French professors at the same US university. They started learning French after the age of 11 or later. Their mean age was 31.4 years (range 23-58). All of them had spent some time in a minimum of one French-speaking country, ranging from one semester (4 months) to 6 years. They were all English-native speakers and none of them grew up in a bilingual environment. Some of them reported having some knowledge of other languages, but not at an early age. No hearing problems were reported.

Native speakers of French (n = 24, 11 males) worked either as faculty or studied as graduate students at an American university when the experiment was carried out. They used their French in their daily lives at work, at home or both. Their mean age was 29.7 years (range 22-48). No hearing problems were reported.

Materials

For this ABX discrimination experiment, 55 monosyllabic non-words with a (C)CV or (C)CVC structure were created. None of the items was a real word in English or French. Non-word stimuli were chosen over real words in order to avoid issues related to lexical frequency and familiarity and to reduce the impact of orthography knowledge on behavior.

There were 2 different items (two pairs) per vowel (e.g. /spon/-/spɔ̃/ and /bron/-/brɔ̃/ for /ɔ̃/) each of which could have different combinations to form triplets[14] (sequences of three non-words): ABA, ABB, BAA and BAB. To illustrate, an ABA trial for the pair /bron/-/brɔ̃/ for /ɔ̃/ would consist of the sequence /bron/-/brɔ̃/-/bron/, whereas a BAA trial would consist of the sequence /brɔ̃/-/bron/-/bron/. Since there are three vowels under study, we have a total of 24 triplets per condition: 2 different pairs X 4 different triplets per pair X 3 different vowels = 24 triplets. Given that there were 6 different conditions (see below, and table 1), 24 triplets X 6 conditions, we obtain a total of 144 trials created for this task (See Appendix II). From these 144 trials, 96 (24 triplets X 4 test conditions) corresponded to sequences that included the nasal vowels under investigation (/ɔ̃/, /ɑ̃/ and /ɛ̃/), whereas the other 48 trials constituted either consonantal (e.g. [spod]-[spok]) or vocalic (e.g. [brit]-[bret]) distractors, that is, the 2 control conditions.

The four test conditions were designed to see which perceptual strategy applies in the different groups. We saw in the previously reported findings about the production of nasal vowels by learners of French (Liddiard, 1994) and by speakers of different languages with French borrowings (Paradis & Prunet, 2000), that there are different outcomes in their attempts

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[14] In this experiment, the word *triplet* is used as a synonym for *trial*. Both refer to a sequence of three non-words.

to reproduce a French nasal vowel. I hypothesize that if such outcomes occur in production, there is a possibility that listeners actually perceive French nasal vowels in a similar manner, applying some perceptual repair strategy. Therefore listeners could perceptually:

1. Apply nasal unpacking: Treat the nasal vowel as sequence of an oral vowel followed by a nasal consonant (turning /ɑ̃/ into /an/), hence the [an]-[ɑ̃] test condition.
2. Apply nasal stripping: Remove nasality from the vowel (turning /ɑ̃/ into /a/), hence the [a]-[ɑ̃] test condition.
3. Keep nasality in the vowel and add some residual nasal consonant (e.g. turning [ɑ̃] into *[$\tilde{\text{ɑ}}^{n}$]) or lack denasalization of the vowel in French when the nasal vowel is followed by a nasal consonant (e.g. turning [ɑ̃] into *[ɑ̃n]); hence the [ɑ̃n]-[ɑ̃] and [ɑ̃n]-[an] test conditions.

As a result, the following experimental conditions were chosen (Table 3):

Table 3. Conditions and examples for the ABX task.

	Condition	Number of triplets	Example
test	**[an]-[ã]** pairs (oral vowel followed by nasal consonant vs. nasal vowel).	24	[stan] – [stã] followed by either [stan] or [stã].
	[a]-[ã] pairs (oral vowel vs. nasal vowel).	24	[sta] – [stã] followed by either [sta] or [stã].
	[ãn]-[ã][15] pairs (nasal vowel followed by a nasal consonant vs. nasal vowel).	24	[stãn]-[stã] followed by either [stãn] or [stã].
	[ãn]-[an] pairs (nasal vowel followed by a nasal consonant vs. oral vowel followed by a nasal consonant).	24	[stãn]-[stan] followed by either [stãn] or [stan].
control	**[V]-[V]** pairs (only a vowel changes)	24	[brit] – [brat] followed by either [brit] or [brat].
	[C]-[C] pairs (only a consonant changes)	24	[spok] – [spod] followed by either [spok] or [spod].

Note: [n] = nasal consonant; [a] = oral vowel [C] = other consonant distractor; [V] = other oral vowel distractor; [ã] = nasal vowel. **N** is the total number of triplets for each condition. Hence 2 different vowel pairs X 4 different combinations per pair (ABA, ABB, BAA, BAB) X 3 different vowels = 24 triplets.

As mentioned above, these stimuli were presented in four different pairings for each triplet: ABA, ABB, BAA and BAB for each condition. These sequences were randomized and presented to the participants in 4 blocks containing a total of 36 trials (sequences of three non-words) each. Even though the non-words recorded came from the same speaker, the A or B responses in the X position of the ABX came from a different recording (different audio files) of that speaker than the one presented in A or B position. An example would be $A_1B_1A_2$: where A_1 and A_2 referred to the same non-word but came from different recordings.

[15] Although I use here the vowel /a/ for the sake of simplicity, the reader should keep in mind that these pairs also refer to vowels /ɛ/ and /o/.

The randomization ensured that there were no BAA and BAB pairs corresponding to the same non-words on the same block. Each block was separated by a pause. Each experimental trial presented the three stimuli separated by an interstimulus interval (ISI) time of 800 ms and the trials were separated by an interval of 2000 ms. This was the maximum amount of time that the participant had available to give a response by pressing the corresponding key.

As mentioned in Darcy et al. (2012), an ABX task unites both discrimination and categorization without having to necessarily identify any given word, given that the stimuli were non-word items. In this task I only used stimuli produced in a sound-isolated recording booth by a male adult native speaker of Haitian Creole who was fluent in English, French and Haitian Creole. All the stimuli for this experiment were recorded three times. Having a native speaker of Haitian Creole allowed us to obtain sequences of a nasal vowel followed by a nasal consonant (/ãn/), which do not exist phonemically in the same syllable in French, but are allowed and contrastive in Haitian Creole. E.g.: *kòn* /kon/ 'horn' vs. *konn* /kõn/ 'to know'.

If learners use the nasal unpacking strategy discussed in chapter 3 (see section 3.3.1) I predict that they will have difficulties distinguishing the [ã]-[an] pairs (nasal vowel vs. oral vowel + nasal consonant; e.g.: [stã] vs. [stan]). However, if they employ the nasal-stripping strategy (see section 3.3.2), this would mean that the problems arise when discriminating the [a]-[ã] pair (oral vowel vs. nasal vowel; e.g.: [sta] vs. [stã]). The other testing conditions, [ãn]-[ã] and [ãn]-[an], were introduced as more exploratory. The predictions were left open since I did not know how either French natives or learners would react to such sequence. The sequence [ãn] might pose French-native speakers some problem given that, as we saw above and also in Chapter 3 (see Figure 7), such a sequence is not phonologically allowed in French. However, I wanted to take such conditions into account because literature has shown that English-speaking learners of

French produce such illegal sequences (as we saw above in Liddiard's study) and it could offer some insight into what is happening in their representation of nasal vowels in different environments.

Regardless of what strategy they use, the percentage of errors should decrease with experience with French, as I expect proficiency level to be the determinant factor that teases the groups apart. Therefore, the no-French group should display more errors than the intermediate group. In turn, I expect the intermediate group to make more errors than the advanced group, who in turn is also expected to be less accurate than the French-native speakers if their acquisition process is not completed yet. French natives should not have any major problems in either of the first two contrasts, namely [ɑ̃]-[an] and [a]-[ɑ̃], as all of them are part of their phonemic inventory. However, as mentioned above, the [ãn]-[ã] and [ãn]-[an] test conditions could offer unexpected results due to the phonological illegality of the *[ãn] sequence for France-French listeners.

It is possible that advanced learners will perform similarly to French-native speakers overall, thanks to their academic preparation (at least 5 semesters at university level) and linguistic exposure (at least four months in a French-speaking country). A similar performance to the French-native speaker group in accuracy could thus be interpreted as advanced learners having fully and successfully acquired the French nasal vowel categories. The latter could be understood as evidence that learners can successfully acquire a phonemic contrast (oral vowel vs. nasal vowel in French) from an allophonic one (nasalized vowels in English).

Procedure

The stimulus presentation software DMDX (Forster & Forster, 2003) was used to administer the perceptual ABX task. After participants offered their consent and filled out the background questionnaire, this was the first experimental task all the groups carried out. This questionnaire (see Appendix IV) was conducted in order to gather detailed information about the linguistic history of the participants. Such questionnaire allowed the researcher to: 1) classify the participant into the correct experimental group; 2) make sure that full and complete information about the participant's history did not disagree significantly from other participants within the same experimental group.

Participants were told that they would listen to a series of three made-up words in a language related to French, and were then informed that the test consisted of two sections: 1) a short practice session, to familiarize them with the procedure, during which they would receive explicit feedback; 2) four blocks of 36 trials; at the end of each block they would able to take a break if they wished to do so.

The listeners were instructed to decide whether the third non-word was more similar to the first one (A) or to the second one (B). They were told to press pre-labeled buttons on the computer keyboard to make their answer (buttons were located on the left for A answers, and on the right for B answers). The ABX experiment lasted an average of 14 to 16 minutes, depending on whether the participant decided to take a small break in between blocks or not. Responses were recorded and reaction time was measured from the onset of the X stimulus in the X position of the ABX trial. However, RTs were collected, but not analyzed.

4.3 Experiment 3: Lexical Decision with repetition priming

The method used for this task was adapted from Pallier et al. (2001) and Darcy et al. (2012). The goal of this experiment was to evaluate participants' ability to lexically encode — to process mentally and give a phonological meaning — the /ɑ̃/-/an/ and the /ɑ̃/-/a/ contrasts. To this end, a lexical decision task was administered in which participants were asked to decide if a stimulus word they heard via headphones was a real word in French or a made-up word. Later on further down the list of stimuli, the same target items or their minimal pairs were presented. For that second item, the task of deciding whether the word they heard is real or not is supposed to be faster if listeners hear the exact same item a second time, because they activate the same lexical representation as they activated shortly before. Therefore a priming effect means that the reaction time for the second time they hear the same word should be lower (participants react faster). It is expected that such priming only occurs when the participant hears the same item (e.g.: *quand* /kɑ̃/ - *quand* /kɑ̃/ 'when') again. No priming is expected when the items are minimal pairs (e.g.: *quand* /kɑ̃/ 'when' - *cas* /ka/ 'case'), since they access two different lexical representations. However, if nasal vowels are not clearly encoded in lexical representations — that is, if a learner encodes both *quand /kɑ̃/* 'when' and *cas /ka/* 'case' as homophones — repetition priming may be observed for the minimal pair condition in the learner groups. This would be interpreted, along the same lines as Pallier et al. (2001) and Darcy et al. (2012), as indication that the contrast between nasal and oral vowel is not accurately represented in lexical representations for this group.

Participants

The same participants who took part in the ABX experiment were also tested in this lexical decision experiment, with the exception of the no-French group, since this task required some knowledge of French. The total number of participants for this task was initially 125: 75 intermediate learners, 28 advanced learners and 24 French-native speakers. However 47 participants were excluded from the intermediate group, since their error rate was higher than 30% (see next chapter section 5.3 for more discussion regarding this exclusion).

Materials

The stimuli used for this experiment constituted a list of 438 items of words and non-words (See full list in Appendix III). Many of the words were common, and were taken from the textbook *Chez Nous* (Valdman et al., 2009). It was expected that learners would be more familiar with the vocabulary from this manual, as this was used as textbook at Indiana University for beginner- and low-intermediate-level students of French during their first through second semesters of higher education. All the stimuli used were produced by the same male adult native speaker of Haitian Creole from the ABX experiment. He recorded three times all stimuli used.

From the 438 items, 180 were target stimuli. 90 stimuli corresponded to real words and the other 90 to non-words. Within the 90 real words there were 30 belonging to each of the nasal vowels under investigation (/ɔ̃/, /ɑ̃/ and /ɛ̃/). For each vowel there were 10 minimal pairs for the /ɑ̃/-/an/ test contrast (nasal vowel vs. oral vowel + nasal consonant), 10 minimal pairs for the /ɑ̃/-/a/ test contrast (nasal vowel vs. oral vowel) and 10 minimal pairs for the /i/-/u/-/a/ control contrast (word containing either the vowel /i/ or the vowel /u/ vs. word containing the vowel /a/).

The remaining 258 lexical items constituted distractors, from which 40 items were repetitions (218+40).

To get a RT difference for the priming measure, the test words and non-words were repeated in two different combinations: either as a minimal pair (either as /ɑ̃/-/an/ or /ɑ̃/-/a/, see Table 3) or as a repetition of the same item. To control for order effects on this repeated measure experiment, and to avoid presenting to the same participant any word in both combinations (that is, followed by both its minimal pair and itself), four different counterbalanced lists of 438 items each were created and subjects were randomly assigned one of the four lists. In each list, one member of each minimal pair would appear (e.g. *quand* /kɑ̃/ 'when') and was followed, eight to 20 stimuli further, either by the other item in the minimal pair (e.g. either *cas* /ka/ 'case' or *canne* /kan/ 'cane') or by itself (e.g. *quand* /kɑ̃/ 'when'). The lists were first constructed without the second occurrence of the experimental items, and were randomized. Then, the paired member for each experimental item was manually inserted into the list, anywhere between 8 to 20 items further down the first occurrence of the pair. Random number generation between 8 and 20 was used to assign how many items should separate the two members of a given pair. The members of a given minimal pair were counterbalanced across the lists (AA, AB, BB, BA). The pseudorandom order of items for each list was kept constant for all participants.

To examine which strategy underlies lexical encoding for learners, two different test conditions were constructed, each corresponding to a different strategy. Some examples of the different conditions are presented in Table 4.

Table 4. Contrasts and examples for the lexical decision with repetition priming task in the *minimal pair* condition and their corresponding predictions.

Condition	Example Words	Example Non-words	Prediction
Test 1 /ã/-/an/	*quand* /kã/ 'when' vs. *canne* /kan/ 'cane'	/vlã/ vs. /vlan/	Homophony if nasal unpacking strategy
Test 2 /ã/-/a/	*quand* /kã/ 'when' vs. *cas* /ka/ 'case'	/vlã/ vs. /vla/	Homophony if nasal stripping strategy
Control /i/-/u/-/a/	*gris* /gʀi/ 'grey' vs. *gras* /gʀa/ 'fatty'	/ʒolu/ vs. /ʒola/	No homophony expected for any group

I established the following predictions: if the test condition 1 (/ã/-n/) is the most difficult for our L2 participants (e.g. there is priming in the minimal pair condition), then it can be inferred that they are using the nasal unpacking strategy for the nasal vowel at the lexical level, and lexically encode a nasal vowel as an oral one followed by a nasal consonant. This would lead them to access both representations for *quand* /kã/ 'when' and *canne* /kan/ 'cane' when hearing either word (see Pallier et al., 2001), each word matching both representations, since both words might be erroneously encoded as homophonous (spurious homophony).

An alternative prediction states that if the test condition 2 (/ã/-/a/) is the hardest for intermediate learners of French and hence priming occurs in the minimal pair condition, then we can assume that they are using the nasal-stripping strategy when they lexically encode a nasal vowel. In this setting, they would interpret the nasal vowel as a possibly deviant oral vowel resulting in homophonous encoding of both words *quand* /kã/ 'when' and *cas* /ka/ 'case'. Repetition priming would take place between *cas* and *quand* in this case for both conditions *minimal pair* and *repetition* condition. French-native speakers should not display any spurious homophony in neither the */ã-an/* nor the */ã-a/* contrast in the *minimal pair* condition for all contrasts. They are expected to show facilitation in the *repetition* condition only. They will have faster reaction times than French learners when hearing the second token in the minimal pair condition. Finally, it is possible that both learner groups behave alike, or alternatively, that we observe development: Advanced learners might also possibly display RTs similar to those of French-native speakers and no spurious homophony (no priming in the *minimal pair* condition).

Procedure

The DMDX software (Forster & Forster, 2003) was also employed for this task. After completing the ABX task, participants took part in the lexical decision task. They were asked to indicate whether each item they heard was a real French word or a non-word by pressing a button on the keyboard as soon as possible. If the token was a word, the right control key was pressed ("yes"). If the token was judged as a non-word, the left control key was pressed ("no"). Participants' responses were recorded and reaction time measured from the onset of the stimuli.

There were ten practice trials, for which subjects received feedback, in order to familiarize them with the task and the level of phonemic precision for the decision about lexical status. The main experimental part consisted of a total of 438 items, divided into four experimental blocks of approximately 110 stimuli each. Blocks were separated by a brief pause. No feedback was provided during these four blocks. The test lasted an average of 25-35 minutes, depending on how long or short a break participants took in between blocks. Each trial was separated by a 3000ms interval. This was the maximum amount of time that the participant had available to give a response by pressing the correspondent control key. The next trial was initiated after this time was up.

Chapter 5 Results

5.1 Perceptual assimilation categorization

The purpose of this experiment was to assess the perceived relation between French and English vowels in oral and nasal contexts, and to provide insight into the perception of French nasal vowels by native speakers of English with no knowledge of French. To do so, a perceptual assimilation task was conducted, in which native speakers of English identified French vowel stimuli — both oral and nasal — in terms of American English (AE) vowel categories, thus giving an indication of perceptual similarity between French and English vowels. Then they rated the same stimuli for goodness-of-fit to the AE category. None of the participants were excluded since all the answers were considered a possible outcome and all participants understood the task to be performed.

The frequencies of selecting a particular response category in this perceptual assimilation task were tallied for each vowel type (in total: 14; see methods section 4.1): The three nasal vowels (/ɑ̃/, /ɛ̃/, /ɔ̃/) appeared in two different contexts: a) in final position (e.g. [spɔ̃]); b) followed by a nasal consonant (e.g. [spɔ̃n]). The oral vowels (/a/, /ɛ/, /o/, /i/) appeared in three contexts: a) in final position (e.g. [spo]); b) followed by a nasal consonant (e.g. [spon]); c) followed by an oral consonant (e.g. [spok]). The total number of judgement opportunities depended on the given vowel (e.g.: each listener gave 6 responses for French /ɑ̃/ but 4 responses for French /ɛ̃/ and /ɔ̃/) or the given phonetic context (e.g.: each listener gave 8 responses for /o/ but 6 responses for /on/). They all added up to a total of 86 judgments per listener (43 stimuli X 2 recordings: see Section 3.1 of chapter 3).

The mean percentage of keyword selections for each stimulus vowel is presented in table 4, along with mean category goodness ratings for those selections (below their corresponding mean percentage). These mean percentage values were obtained by adding all the responses from all 10 participants for a given French category and attributing the corresponding percentage. That is, if for the nasal vowel /ɑ̃/ there was a total of 60 items and 15 responses were categorized as /ʌn/ across all participants, that indicated that such AE category had been selected 25% of the time. On the left-hand column of the table the French vowels (oral and nasal) for the different test conditions are listed. On the first row the different AE keyword categories are displayed together with word examples for each vocalic category. **Boldfaced** values indicate the most frequent identification choice for a given French vowel. The goodness ratings represent the average of goodness ratings for the trials in which each AE response category was selected. These goodness ratings ranged from 1 to 5: 1 being a bad example and 5 being a perfect example of the chosen AE vocalic category. Those AE vowel responses chosen in 2% or less of trials were removed from this table.

Table 5. Mean percent identification and goodness ratings (below percentage) of French vowel stimuli group in terms of American English vowels.

French vowels	English Vocalic Categories																			
	heed	clean	hit	hint	head	hen	laid	lane	had	hand	hod	ton	hawed	lawn	hud	fun	hoed	hone	heard	earn
	/i/	/in/	/ɪ/	/ɪn/	/e/	/en/	/eɪ/	/eɪn/	/æ/	/æn/	/ɒ/	/ɒn/	/ɔ/	/ɔn/	/ʌ/	/ʌn/	/əʊ/	/əʊn/	/ɜ˞/	/ɜ˞n/
ã											6.7	13.3	8.3	10	15	**41.7**				
											3	4.3	3.8	2.3	3.4	3.7				
ãn											2.5	32.5		5		**60**				
											3	4.7		2.5		4.3				
a									**57**	12	16		8	5						
									3.2	2.9	3		2.87	2.6						
an						3			22	**52**	11			6						
						3			3	4	2.4			3.3						
ɛ̃			2.5	10	25	**42.5**	17.5													2.5
			1	2.2	3.6	4.3	3													2
ɛ̃n			5	5		**72.5**	2.5	15												
			3.5	4.5		4.5	3	3.7												
ɛ			5		**54**	22	8	9												
			3		4	3.8	3.4	4.3												
ɛn			3	4	6	**79**	4	3												
			2.7	4.2	4.3	4.7	3.5	4.3												
ɔ̃											7.5	10		**30**	2.5	2.5	20	27.5		
											1.3	3.5		3.8	2	4	3.4	3.9		
ɔ̃n											2.5	20		**30**		10	12.5	25		
											4	3.6		3.4		2	2.8	4.5		
o											21.2	3.7	22.5	12.5	2.5		**25**	12.5		
											3.5	3.67	3.5	3.6	3		3.9	4.5		
on												23.3		**36.7**		3.3	5	28.3		
												4.7		4		3	3.7	3.8		
i	**75**	10	10	5																
	4.5	5	5	4																
in	12.5	**85**		2.5																
	4.4	4.7		4																

The data in Table 5 is analyzed descriptively below. First, patterns relating to nasality or non-nasality heard are discussed. Then, data will be discussed in terms of vowel quality.

1. Nasal vowels (/ɑ̃/, /ɛ̃/, /ɔ̃/) in final position. The general tendency of the no-French group participants when they hear a phonemic nasal vowel is to associate it with an oral vowel followed by a nasal consonant (VN). For /ɑ̃/ this happened 65% of the time (merging the percentages for *fun* /ʌn/, *lawn* /ɔn/ and *ton* /ɒn/); for /ɛ̃/ such sequence was chosen on 52.5% of occasions (*hint* /ɪn/, *hen* /ɛn/) and for /ɔ̃/ 70% (*ton* /ɒn/, *lawn* /ɔn/, *fun* /ʌn/, *hone* /əʊn/). Their oral counterparts were heard 30% (*hod* /ɒ/, *hawed* /ɔ/, *hud* /ʌ/), 45% (*hit* /ɪ/, *head* /ɛ/, *laid* /eɪ/) and 30% (*hod* /ɒ/, *hud* /ʌ/, *hoed* /əʊ/) of the time for /ɑ̃/, /ɛ̃/ and /ɔ̃/, respectively.

2. Nasal vowels followed by nasal consonant (/ɑ̃n/, /ɛ̃n/, /ɔ̃n/). Similarly to the previous context, the participants in this task mostly chose the sequence of an oral vowel followed by a nasal consonant. This time, since the nasal consonant was actually phonetically implemented, listeners chose mostly the VN sequence: 97.5% (*ton* /ɒn/, *lawn* /ɔn/, *fun* /ʌn/), 92.5% (*hint* /ɪn/, *hen* /ɛn/, *lane* /eɪn/) and 85% (*ton* /ɒn/, *lawn* /ɔn/, *fun* /ʌn/, *hone* /əʊn/) for /ɑ̃n/, /ɛ̃n/ and /ɔ̃n/, respectively. The categorization into AE oral vowels is relatively scarce: 2.5% (*hod* /ɒ/) for /ɑ̃n/, 7.5% (*hit* /ɪ/, *laid* /eɪ/) for /ɛ̃n/ and 15% (*hod* /ɒ/, *hoed* /əʊ/) for /ɔ̃n/.

3. Oral vowels (/a/, /ɛ/, /o/): when faced with vowels devoid of nasality, participants mostly chose oral vowels by 81% (*had* /æ/, *hod* /ɒ/, *hawed* /ɔ/), 67% (*hit* /ɪn/, *head* /ɛ/, *laid* /eɪ/) and 71.2% (*hod* /ɒ/, *hawed* /ɔ/, *hud* /ʌ/, *hoed* /əʊ/) for /a/, /ɛ/, /o/, respectively. Interestingly, for oral vowels some VN sequences were chosen as well: 17% for /a/ (*hand* /æn/, *lawn* /ɔn/), 33% for /ɛ/ (*hint* /ɪn/, *hen* /ɛn/, *lane* /eɪn/) and 28.7% for /o/ (*ton* /ɒn/, *lawn* /ɔn/, *hone* /əʊn/).

4. Oral vowels followed by nasal consonant (/an/, /ɛn/, /on/). The most chosen for this context was the VN sequence. It was selected 65% of the time for /an/ (*hen* /ɛn/, *hand* /æn/, *ton* /ɒn/, *lawn* /ɔn/, *fun* /ʌn/), 86% of the time for /ɛn/ (*hint* /ɪn/, *hen* /ɛn/, *lane* /eɪn/) and 91.6% for /on/ (*ton* /ɒn/, *lawn* /ɔn/, fun /ʌn/, *hone* /əʊn/). Some participants selected the oral vowel 35% of the time for /an/ (*had* /æ/, *hod* /ɒ/, *hawed* /ɔ/), 13% for /ɛn/ (*hit* /ɪ/, *head* /ɛ/, *laid* /eɪ/) and 5% for /on/ (*hoed* /əʊ/).

Regarding the quality of the vowel, listeners were mostly sensitive to differences along the front/back dimension, and the rounded/unrounded dimension:

1. Nasal vowels (/ɑ̃/, /ɛ̃/, /ɔ̃/) in final position. The open back rounded nasal vowel /ɑ̃/ was mostly categorized as the English open-mid back unrounded vowel /ʌ/ (56.7% if we merge *hud* /ʌ/ and *fun* /ʌn/), but also as the open back rounded vowel /ɒ/ (20% merging *hod* /ɒ/ and *ton* /ɒn/) and open-mid back rounded /ɔ/ (18.3% if *hawed* /ɔ/ and *lawn* /ɔn/ are combined). Therefore, even though mostly the open-mid back unrounded vowel /ʌ/ category was chosen (with or without nasal consonant), other back rounded vocalic categories were heard. As for the open-mid front unrounded nasal vowel /ɛ̃/ the spectrum of vowel choice included: English open-mid front unrounded /ɛ/ (67.5% combining *head* /ɛ/ and *hen* /ɛn/), close-mid front unrounded lax /ɪ/ (12.5% merging *hit* /ɪ/ and *hint* /ɪn/) or the close-mid front unrounded diphthong /eɪ/ (17.5%). The open-mid back rounded nasal vowel /ɔ̃/ was categorized as open-mid back rounded vowel /ɔ/ (30% from *lawn* /ɔn/), as open central unrounded diphthong /əʊ/ (47.5% combining *hoed* /əʊ/ and *hone* /əʊn/), as open back rounded /ɒ/ (17.5% uniting *hod* /ɒ/ and *ton* /ɒn/), or open-mid back unrounded vowel /ʌ/ (5% adding *hud* /ʌ/ and *fun* /ʌn/). It is curious to note here that for this nasal vowel the open-mid back rounded oral vowel /ɔ/ in *hawed* was not selected.

2. Nasal vowels followed by nasal consonant (/ɑ̃n/, /ɛ̃n/, /ɔ̃n/). Here the English vocalic categories selected remained very similar to the previous for final nasal vowels. However there was an increase in the VN sequences chosen. For the open back rounded nasal vowel /ɑ̃n/, listeners heard mostly the English open-mid back unrounded vowel /ʌ/ (60% from *fun* /ʌn/), followed by the open back rounded vowel /ɒ/ (35% merging *hod* /ɒ/ and *ton* /ɒn/) and then open-mid back rounded /ɔ/ (5% from *lawn* /ɔn/ only). Similarly to the previously described final nasal vowel endings, for the open-mid front unrounded nasal vowel sequence /ɛ̃n/ listeners chose English open-mid front unrounded /ɛ/ (72.5% only from *hen* /ɛn/), close-mid front unrounded diphthong /eɪ/ (17.5% combining *laid* /eɪ/ and *lane* /eɪn/) and close-mid front unrounded lax /ɪ/ (10% merging *hit* /ɪ/ and *hint* /ɪn/). For the open-mid back rounded nasal vowel sequence /ɔ̃n/ was categorized as open-mid back rounded vowel /ɔ/ (30% from *lawn* /ɔn/ only), as open central unrounded diphthong /əʊ/ (37.5% combining *hoed* /əʊ/ and *hone* /əʊn/), as open back rounded /ɒ/ (22.5% uniting *hod* /ɒ/ and *ton* /ɒn/) or open-mid back unrounded vowel /ʌ/ (10% from *fun* /ʌn/ only).

3. Oral vowels (/a/, /ɛ/, /o/): in this case the open front unrounded vowel /a/ was classified as open front unrounded oral vowel /æ/ (69% from *had* /æ/ and *hand* /æn/), as open back rounded vowel /ɒ/ (16% from *hod* /ɒ/ only) or as open-mid back rounded vowel /ɔ/ (13% merging *hawed* /ɔ/ and *lawn* /ɔn/). The open-mid front unrounded oral vowel /ɛ/ categorization included mainly English open-mid front unrounded /ɛ/ (76% combining *head* /ɛ/ and *hen* /ɛn/), close-mid front unrounded diphthong /eɪ/ (17% combining *laid* /eɪ/ and *lane* /eɪn/) and close-mid front unrounded lax /ɪ/ (5% from *hit* /ɪ/ only). The mid back rounded back oral vowel /o/ categorization included: open-mid back rounded vowel /ɔ/ (35% from hawed /ɔ/ and *lawn* /ɔn/ together), open back rounded /ɒ/ (24.9% uniting *hod* /ɒ/ and *ton* /ɒn/), open central unrounded

diphthong /əʊ/ (37.5% combining *hoed* /əʊ/ and *hone* /əʊn/) and minimally open-mid back unrounded vowel /ʌ/ (2.5% from *hud* /ʌ/ only).

4. Oral vowels followed by nasal consonant (/an/, /ɛn/, /on/). Here the open front unrounded vowel sequence /an/ was heard as open front unrounded oral vowel /æ/ (74% from *had* /æ/ and *hand* /æn/), open back rounded /ɒ/ (11% from *hod* /ɒ/ only), open-mid back rounded vowel /ɔ/ (6% as lawn /ɔn/) or English open-mid front unrounded /ɛ/ (3% from *hen* /ɛn/). The open-mid front unrounded oral vowel sequence /ɛn/ was mostly heard as English open-mid front unrounded /ɛ/ (85% combining *head* /ɛ/ and *hen* /ɛn/), close-mid front unrounded diphthong /eɪ/ (7% combining *laid* /eɪ/ and *lane* /eɪn/) and close-mid front unrounded lax /ɪ/ (7% from *hit* /ɪ/ and *hint* /ɪn/). The mid back rounded back oral sequence /on/ was heard as open-mid back rounded vowel /ɔ/ (36.7% from *lawn* /ɔn/ only), open central unrounded diphthong /əʊ/ (33.3% combining *hoed* /əʊ/ and *hone* /əʊn/), open back rounded /ɒ/ (23.3% from *ton* /ɒn/ only) and and some open-mid back unrounded vowel /ʌ/ (3.3% from *fun* /ʌn/ only).

5. The control condition close front unrounded vowel /i/, /in/. For the French vowel /i/ the most chosen AE category was English close front unrounded /i/ (85% *heed* /i/ *and clean* /i/ combined), followed by close-mid front unrounded lax /ɪ/ (15% from *hit* /ɪ/ and *hint* /ɪn/). For the VN sequence /in/ the most selected AE category was close front unrounded tense vowel /i/ (97.5% for *heed* /i/ and *clean* /in/ combined) or scarcely as closed front unrounded lax /ɪ/ (2.5% from *hint* /in/ only).

Overall, the results show that the highest goodness of fit rating (the best fits for the category chosen) tends to be given to the most frequently chosen categories as well. For instance for /ɛ̃/ the most frequent chosen category was /ɛn/ 42.5% of the time and the goodness rate was 4.35 out of 5. I remind the reader here that a rating of 5 means that these two vowels match perfectly according to the listener. Nonetheless in the case of /ɑ̃/ the widest choice (41.7%) was /ʌn/, which was rated on average 3.68, whereas the categorization as /ɒn/ — chosen 13.3% of the time — received a rating of 4.33. It is important to notice that although some variation occurs depending on the test condition, the most frequently chosen categories (indicated in bold in Table 5) received at least a rating of 3.

5.2 ABX discrimination task

In this experiment, I examined the ability of the participants to perceptually distinguish between nasal and non-nasal vowels. In a typical trial, participants hear a sequence of three items, and are asked to indicate whether the third one was equal to the first sound or to the second one. The first two items always represent different categories, which must be discriminated in order to make a correct response. A high error rate on the test condition where the dimensions of interest are contrasted indicates a lack of discrimination between the categories. In this manner, the error rate on this task offers insight about what learners of French perceive at the acoustic level through segmental discrimination of non-words.

Out of the total of 156 participants, 6 were excluded from the analysis because they were neither English-natives nor French-natives in their respective groups (4 non-native speakers of English, for the learners of French and 1 non-native speaker of French for the French-native group) or they did not understand the task to be performed (1 participant of the no-French group): the wrong key was consistently pressed while performing the task. Another participant was excluded because she had spent a considerable amount of time in India during her childhood and adolescence (5 years). Therefore the total number of participants whose data were analyzed was 149: 75 intermediate learners (*intermediate*), 27 advanced learners (*advanced*), 23 French-native speakers (*native speakers*) and 24 English-native monolinguals (*no-French*).

The error rate (percentage of incorrect responses) of the participants was analyzed as the dependent variable. For the purpose of analysis, the four test conditions were grouped into one overarching ‘test’ condition, and the two control conditions (vowel and consonant) were grouped into another overarching ‘control’ condition.

In a first Generalized Estimated Equation (GEE) model analysis with subjects as random effect, I first compared condition (within-subject; test vs. control), group (between-subject; intermediate, advanced, native speakers, no-French) and their interaction for error rate. There was a main effect of condition ($F(1, 145) = 197.63$, $p < .001$). That is, there were more errors in the test condition than in the control condition. Test: M = 17%; Control: M = 4.25%. But there was no main effect of group ($F(3, 145) = 5.52$, $p = .137$) nor a significant interaction between group and condition ($F(3, 145) = 0.163$, $p = .983$) in this initial analysis with overarching conditions test vs. control. This suggests that all groups showed the same pattern: higher error rates on the Test condition and lower error rates on the Control condition. However there was no vast difference in this pattern among the groups. Figure 1 graphically shows the observed pattern.

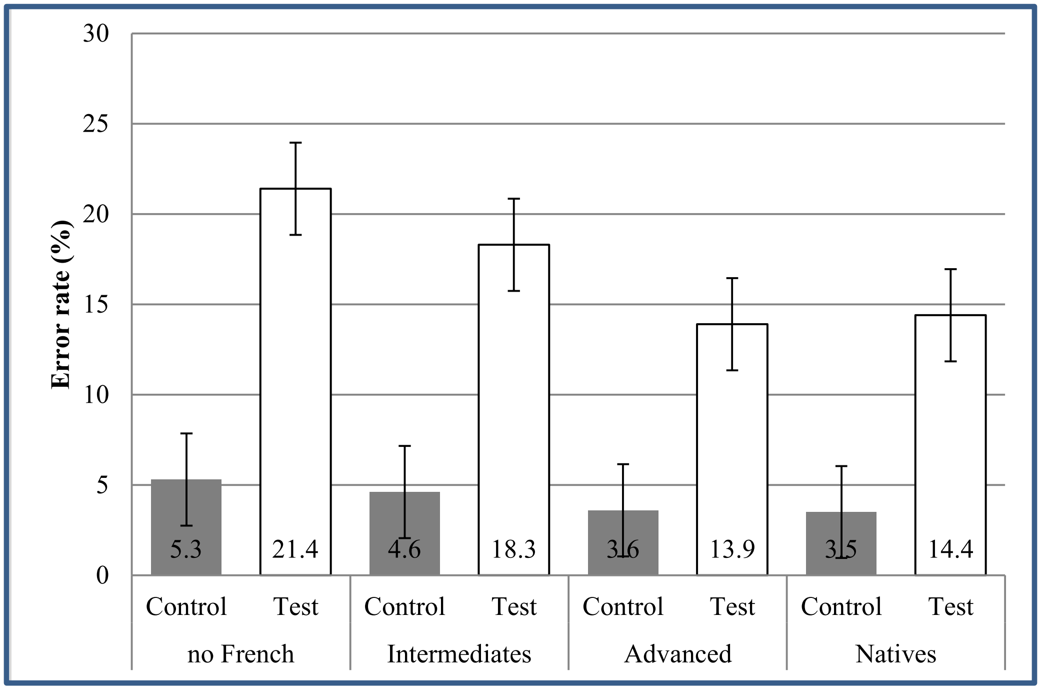

Figure 12. Error rate (%) by group in the test vs. control conditions. The grey bar represents the control conditions, whereas the white bar represents the test conditions. Error bars display the standard error.

In a second analysis, the six conditions (four test conditions + two control conditions) were kept separate. In this analysis, there was an interaction between group and condition ($F(3, 145) = 33.15$, $p < .05$). In addition, there was a significant effect of condition ($F(5, 145) = 485.92$, $p < .001$) and a significant effect of group ($F(3, 145) = 8.73$, $p < .05$). This pattern suggests that all groups behave differently on the various conditions and that within each condition some groups differed from each other. In order to unpack the significant interaction, the following pairwise comparisons were conducted, examining the presence of significant differences between groups within each condition, as well as selected comparisons examining, within a given group, differences between conditions. Table 6 presents the mean error rate in each condition for each group.

Table 6. Error rates (Err) in percentage by group and by condition in ABX.

		Group											
		no French			**Interm.**			**Advanced**			**French native speakers**		
	Condition	**Err**	***95% Wald CI***		**Err**	***95% Wald CI***		**Err**	***95% Wald CI***		**Err**	***95% Wald CI***	
			Low	*Up*		*Lower*	*Upper*		*Low*	*Up*		*Low*	*Up*
Test	**[an]-[ã]**	8.51	*.05*	*.14*	7.24	*.06*	*.09*	4.65	*.03*	*.08*	3.99	*.02*	*.07*
	[ã]-[ãn]	12.3	*.09*	*.17*	8.39	*.07*	*.11*	5.61	*.04*	*.08*	7.97	*.05*	*.12*
	[ãn]-[an]	38.5	*.35*	*.42*	38.9	*.37*	*.41*	34.8	*.32*	*.38*	32.8	*.29*	*.36*
	[a]-[ã]	26	*.21*	*.32*	18.6	*.17*	*.21*	10.4	*.07*	*.15*	12.9	*.09*	*.17*
Control	**Consonant**	5.56	*.03*	*.11*	4.99	*.04*	*.07*	3.85	*.02*	*.07*	4.17	*.02*	*.07*
	Vowel	5.03	*.02*	*.11*	4.11	*.03*	*.06*	3.37	*.02*	*.05*	2.90	*.02*	*.05*

The overall test results by condition and group showed that groups did not differ from each other in the [an]-[ã] test condition ($F(3, 145) = 6.64$, $p > .05$).

For the [ã]-[ãn] condition, there was an effect of Group ($F(3,145) = 9.49$, $p < .05$), for which pairwise comparisons indicate that only the no-French (12.3% error rate) and the advanced (5.6%) groups differed significantly from each other ($p < .05$): the advanced group was more accurate than the no-French group. No other group comparison reached significance.

For the [ãn]-[an] condition, groups also differed ($F(3, 145) = 11.39$, $p < .05$). In this condition only the intermediates (38.9% error rate) and the French-native (32.8%) groups differed from each other ($p < .05$), the intermediate group being less accurate than the French-native group. No other group comparison reached significance.

It must be noted that even French native speakers encountered difficulties in this [ãn]-[an] condition, since their error rate (see Table 6) was close to 33% (32.8%). Despite their high number of errors, listeners of all groups were somewhat sensitive to the difference between [ã] and [a] in this nasal context (both vowels were followed by a nasal consonant). The advanced group was slightly more accurate (34.8%) than the intermediate (38.9%) and the latter was as accurate as the no-French group (38.5%). However, none of these slight differences reached statistical significance. Overall all groups displayed a high error rate in this [ãn]-[an] condition. French native speakers outperformed all the groups (they displayed the lowest percentage of errors: 32.8%), but, as mentioned above, this difference in error rate was only statistically different ($p < .05$) from the intermediate group (38.9%), but not significant from the advanced (34.8%) nor the no-French (38.5%) groups.

Finally, the condition in which the groups differed most clearly was the [a]-[ã] condition ($F(3, 145) = 27.9$, $p < .001$). For this last condition the no-French group was significantly ($p < .001$) less accurate (26% error rate) than the advanced learners (10.4%) and the French natives (12.9%) ($p = .001$), but not statistically different from the intermediate group (18.6%) ($p = .099$). Intermediate learners were also significantly less accurate than advanced ($p = .001$) and marginally less accurate than natives ($p = .056$). No statistically significant difference was found between the advanced learners' performance and that of the French natives.

As for the consonant and vowel control conditions no group comparison reached significance, and error rates were low for all groups.

Focusing on the learners, both intermediate and advanced learners reacted similarly to French-native speakers in all testing conditions except for condition [a]-[ã]. This was the condition in which the GEE model showed a significant difference between the groups ($F(1, 3)$, $p < .001$). Intermediates made fewer errors (18.6%) than the no-French group (26%) whereas advanced learners displayed even fewer errors (10.4%) than French-native speakers (12.9%). A post hoc Pairwise Comparison allowed us to see that in the [a]-[ɑ̃] condition, although the no-French group did not score significantly less accurately than the intermediate group, the latter made significantly more errors than the advanced learners ($p < .001$) as well as the French-native group, but this difference was marginal ($p = .056$).

Making a comparison with the results in the perceptual assimilation task, the no-French group tended to assimilate nasal vowels (/ɑ̃/, /ɛ̃/, /ɔ̃/) in final position mostly to VN sequences and French oral vowels to English oral vowels (see section 5.1 above). In the ABX experiment the only two conditions in which the no-French group differed significantly from the other three groups under study were the [ɑ̃]-[ɑ̃n] and the [a]-[ɑ̃] conditions. This could imply that participants from the no-French group have trouble attributing nasality to the vowel itself and this shows to some extent in the misperception of nasal vowels as a deviant form of the oral vowel in the [a]-[ɑ̃] condition (26% error rate) and possibly to the attribution of nasality to the nasal consonant in the [ɑ̃]-[ɑ̃n] condition (12.3% error rate). Given that advanced learners of French did not statistically differ from French natives, it could also be implied that such initial perceptual difficulties can be overcome.

5.3 Lexical Decision with Repetition Priming task

In this experiment, I examined the ability of the participants to distinguish between French words from non-words and observe if they could lexically encode the contrast between an oral and a nasal vowel in French. They were asked to indicate whether each item they heard was a real French word or a non-word by pressing a button on the keyboard as soon as possible. If the token was a word, the right control key was pressed (“yes”). If the token was considered a non-word, the left control key was pressed ("no"). Participants' responses were recorded and reaction time measured from the onset of the stimuli.

Trials that presented a display error as well as trials with RTs under 300ms or over 3,000ms were discarded (149 trials out of 55454 total trials, that is 0.27%). The participants that were removed for the ABX experiment were not included in this Lexical Decision with Repetition Priming (LDRP) experiment either. Reaction times (RT) were measured from the beginning of each item (word or non-word), but only for those trials that were correctly identified as either word or non-word.

The reason for this is that only correct answers can be interpreted as evidence that the nasality feature is lexically encoded into the learner's mental representation for French words. For example, an incorrect answer to a real word suggests that the word in question was either not accessed, or is not known, and thus, the RT for an incorrect answer is uninterpretable for this purpose. Therefore, since we compute a reaction time difference in the activation of real words, it is important to only consider RTs to correct answers. RT's to real words and non-words are analyzed separately. In addition, reaction time differences should not be computed including the incorrect answers, because this usually increases the SD of the mean RT (since RT on incorrect answers can be longer or shorter than others and are thus uninterpretable for the purpose of this task).

Acknowledging that there is normally a trade-off between RT and accuracy — faster reaction times might imply lower accuracy and vice versa — I placed the threshold of 30% as the maximum level of error rate for the LDRP experiment: those participants who exceeded such percentage (31% or higher) were excluded from the analyses. This decision was made based on similar parameters for previous studies (Darcy et al., 2012; White et al., 2010) and on the minimal number of participants that would allow us to reliably establish a statistically robust group pattern. From the original 149 participants, 24 did not take part in this task because they had no knowledge of French, which leaves us with 124 subjects.

Some items received high error rates in the native French speaker group. Those for which this group displayed error rates above 39.38% (2 Standard Deviations below the mean of 74.73%) were removed from the analysis. Then all groups were cross-tabulated without these items and any participant with an overall error rate of 31% or above was eliminated (48 out of the 75 intermediate learners). Out of a total of 124 participants for the LDRP experiment only 76 remained[16] for data analysis: 27 intermediate learners of French, 26 advanced learners of French and 23 French native speakers. None of the participants in the native or the advanced group were excluded due to high error rates.

For every experimental pair of words in the lists, the mean RT was computed across participants, separately for each group, for the first occurrence of the word in a pair, and for the second occurrence. For example, for the pair /ka/-/kɑ̃/, which is a minimal pair, the mean RT across participants was computed for the first occurrence of this pair /ka/, and for the second /kɑ̃/.

The results are shown as the priming effect for both words and non-words. This priming effect is represented by the difference between the RT_2 (reaction time for the second time a token was heard) and RT_1 (reaction time for the first time a given token was heard). If RT_2-RT_1 is a negative number ($RT_2 < RT_1$), this implies a facilitation effect. That is, the participants' response

[16] Results for participants 90 and 93 (both belonging to the intermediate group) were missing.

was faster the second time they heard the same stimulus (for instance, in the repetition condition: *quand* vs. *quand* /kɑ̃/ 'when'). If the value for RT_2-RT_1 is a positive number, this means that there is an inhibition effect: the participants' response was slower ($RT_2 > RT_1$) the second time they heard the stimulus. Finally, if the resulting number is about 0, it suggests that there was no facilitation (no priming) between the two words.

Table 7 below shows the reaction time for words in the two conditions "minimal pair" and "repetition", and as a function of the contrast, for each group. We can see four different reaction times (RT) for every group and contrast: two belong to the condition repetition (rep) and two belong to the condition minimal pair (mp). In the condition *repetition* the word is repeated, whereas in the condition *minimal pair* the two words are contrastive. Priming refers to the subtraction of the second minus the first occurrence ($RT_2 - RT_1$) and is measured in milliseconds.

Table 7. Mean reaction times (ms), standard error and priming (Prim.) size (negative number = facilitation; positive number = inhibition) by group (intermediates, advanced and French-native speakers) and contrast (/i/u/-/a/, /ɑ̃/-/an/ and /ɑ̃/-/a/) for each condition (minimal pair vs. repetition) for words only.

			Intermediates			**Advanced**			**French Native speakers**		
Contrast	Cond.	Order	RT	SE	Prim.	RT	SE	Prim.	RT	SE	Prim.
/i/-/u/-/a/	Rep	RT_1	1271	28.5	-106.8*	1154	28.9	-115.9*	1035	28.2	-69.1^
	Rep	RT_2	1164	28.5		1038	24.7		966	18	
	Mp	RT_1	1290	39.1	-8.78	1189	33.2	-21.6	1113	31.7	-52.8
	Mp	RT_2	1282	34.4		1168	35.3		1061	34	
/ɑ̃/-/an/	Rep	RT_1	1229	22.7	-51.1^	1202	30	-65.6^	1101	28.2	-105.4*
	Rep	RT_2	1178	31.5		1136	34.5		995	25.6	
	Mp	RT_1	1267	32.9	35.97	1203	37.3	86.7*	1085	29.3	56.9
	Mp	RT_2	1303	31.4		1278	44.6		1142	26.1	
/ɑ̃/-/a/	Rep	RT_1	1174	32.1	-40.6	1144	38.1	-92.3*	1033	35.9	-67.5^
	Rep	RT_2	1134	28		1052	23.9		965	27.9	
	Mp	RT_1	1214	31.3	18.8	1190	32.6	-49.1	1056	35.1	-0.7
	Mp	RT_2	1232	33.4		1141	43		1055	30.4	

Note: mp = *minimal-pair* condition; rep = *repetition* condition **$*p < .05$ $\^p < 0.1$**

RTs of the first and the second occurrence of a word pair were compared within each group in a linear mixed model analysis. RT was the dependent variable and there were three factors: *contrast* (ɑ̃/-/an/ test contrast; /ɑ̃/-/a/ test contrast; /i/-/u/-/a/ control contrast), *pairing condition* (minimal pair, repetition) and *group* level. With subjects as random effect, I first compared pairing condition (within-subject; minimal pair vs. repetition), group (between-subject; intermediate, advanced, native speakers) and contrast (within subject: vowel condition), and their interaction. Table 8 shows the fixed effects and the interactions obtained from this model.

Table 8. Main effects of group, pairing, contrast, and other interactions for RTs.

Type II Tests of Fixed Effects				
Source	Numerator df	Denominator df	F	Sig.
Intercept	1	514	22.114	.000
Group	2	514	.603	.548
Pairing	1	514	31.929	.000
Contrast	2	514	4.377	.013
Group * Pairing	2	514	.104	.901
Group * Contrast	4	514	.938	.441
Pairing * Contrast	2	514	2.428	.089
Group * Pairing * Contrast	4	514	.913	.456

In the preceding table 8 it can be seen that for the main effects, the mean RTs for each Group (French level) overall do not differ from the others ($F(2,514) = 0.60$, $p = 0.548$). The Pairing condition (repetition vs. minimal pair) has a significant effect on RTs overall ($F(1,514) = 31.92$, $p < 0.001$) and Contrast (control i/u-a; /ɑ̃/-/an/; /ɑ̃/-/a/) also significantly impacted the RTs ($F(2,514) = 0.438$, $p = 0.013$). For the two-way and three-way interactions, none of them are significant except for Pairing and Contrast, a marginally significant interaction ($F(2,514) = 2.43$, $p = 0.089$).

Let's now look at the overall priming effect (RT2-RT1 difference) for each group. It is important to indicate here that only those priming effects followed by an asterisk sign (*) are statistically significant ($p < .05$), whereas those followed by a ^ sign are marginally statistically significant ($p < 0.1$). As expected, we see negative numbers in the repetition condition for all three test contrasts. This indicates priming, that is, participants responded faster correctly the second time they heard the exact same word. In most of the repetition condition there is some sort of statistical or marginal significance, whereas in the minimal pair condition, only in the contrast /ɑ̃/-/an/ do we see a statistically significant inhibition for the advanced group, which shows in the positive figure (86.7ms). Even though for the /ɑ̃/-/a/ both advanced learners and French-native speakers have negative figures in the minimal pair condition (-49.1 and -0.7ms respectively), indicating priming (spurious homophony), these are not statistically significant.

Figures 13-15 display the priming effect (RT_2–RT_1) obtained for words indicating whether there was facilitation ($RT_2 < RT_1$: negative bar) or not ($RT_2 > RT_1$: positive bar) in the words correctly identified by the three groups under study (French-native speakers, 13; advanced learners, 14; and intermediate learners, 15).

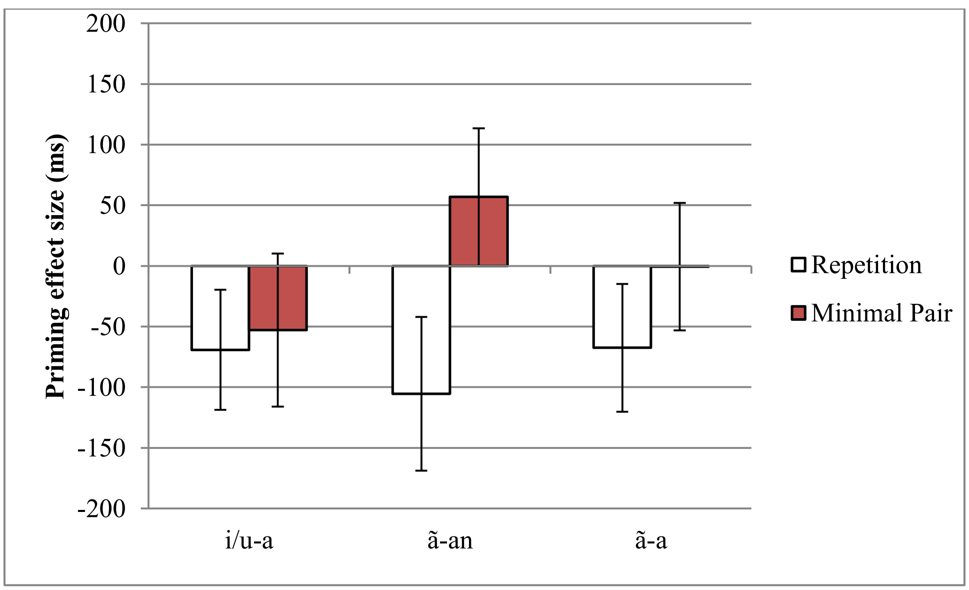

Figure 13. Priming for each condition and contrast in the native speaker group.

In figure 13, the RT's of the first vs. the second appearance of the token are compared for the French-native group. The white bars (on the left for each contrast) represent the priming for the repetition condition (two occurrences of the same exact word). The dark bars (filled and placed on the right) represent the priming for the minimal-pair condition. A positive or zeroapproaching priming value means no facilitation, whereas a negative value means reduction in RT, i.e. a priming effect. In the French-native group the majority of participants in the repetition condition displayed facilitation. In the minimal pair condition there is unexpected, but non statistically-significant facilitation in the control contrast i/u-a (-52.8 ms). There is some non-significant inhibition for the test contrast /ɑ̃/-/an/ (56.9 ms) and neither inhibition nor facilitation in the test contrast /ɑ̃/-/a/ (0.7 ms).

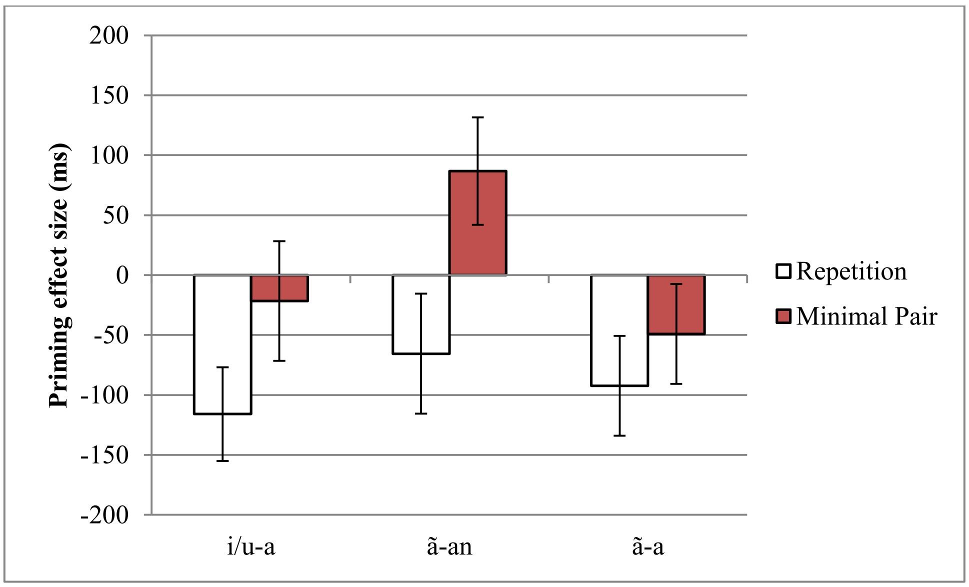

Figure 14. Priming for each condition and contrast in the advanced learner group.

For the advanced group (Figure 14) there is also facilitation across all the three contrasts for the *repetition* condition (-115.9 ms, -65.6 ms, -92.3 ms), whereas for the minimal-pair condition they show some non-significant facilitation in the /i/u/-/a/ control contrast (-21.6 ms), statistically significant inhibition in the /ɑ̃/-/an/ condition (86.7 ms) and non-significant facilitation in the /ɑ̃/-/a/ contrast (-49.1 ms). The fact that the advanced group displays some facilitation in the minimal-pair condition for the /i/u/-/a/ and /ɑ̃/-/an/ contrast implies that, on these contrasts, there were certain tokens that triggered spurious homophony and such lexical items were perceived as being the same token. Both French-native speakers and advanced learners have larger priming on the *repetition* condition, indicating that the task works as expected for these groups.

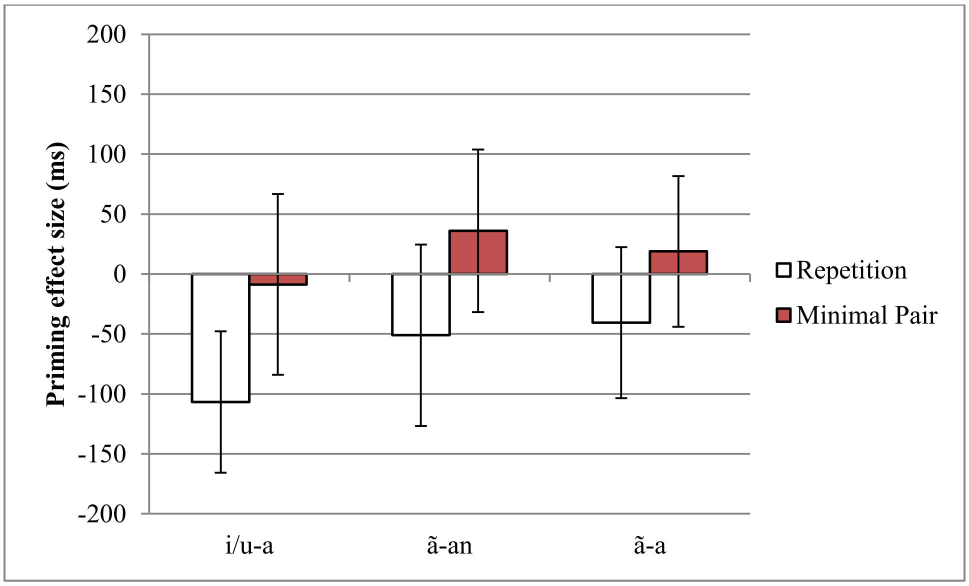

Figure 15. Priming for each condition and contrast in the intermediate learner group

The pattern obtained for intermediate learners (Figure 15) is similar to the two previous groups: negative priming (facilitation) in the repetition condition; some marginal facilitation on the minimal pair condition on the control contrast (-8.8 ms) or inhibition in the /ɑ̃/-/an/ and /ɑ̃/-/a/ test contrasts (36 ms and 18.9 ms respectively). However none of these RT2-RT1 differences reached significance except for the priming in the control condition for repetition pairs. This pattern of results makes it difficult to generate strong conclusions from the intermediate learners, who might have been too uncertain regarding the lexical status of the stimuli, which resulted in high standard deviations for the reaction times, therefore rendering the priming patterns somewhat unclear. In order to examine the distribution of the data, boxplots were created for the three groups. In these boxplots it can be seen that the number of outliers gets reduced as the level of French improves (from left to right), with a higher number of outliers in the intermediate groups, lower number of outliers in the advanced learner group and only three outliers in the French-native speaker group.

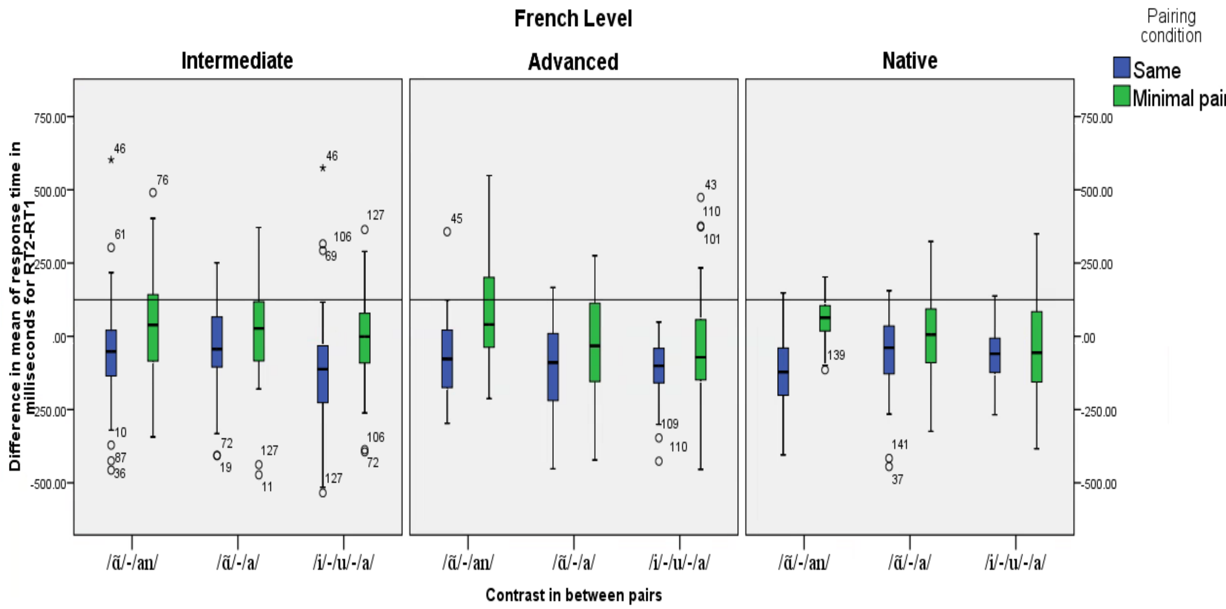

Figure 16. Boxplots indicating the number of outliers and the priming median distribution for each group for each condition and contrast.

Summing up, these results do not let us perceive any clear differences between these groups overall. Let's remember here that, as we saw in table 3 chapter 4, we expected spurious homophony in learners for the minimal pair condition in the /ɑ̃/-/an/ test contrast if learners applied the nasal-unpacking strategy. This did not occur for any of the learner groups. Quite the contrary, the general tendency (although not significant) was an inhibitory effect. On the other hand, if the nasal-stripping strategy had been applied we expected spurious homophony in the /ɑ̃/-/a/ test contrast in the minimal pair condition. This did not occur for the intermediate group — but given the variability of their RT patterns, any conclusions are difficult to draw from this group. However, a very interesting trend towards spurious homophony was observed in the advanced learners: their RTs were faster (although not globally significantly so) on the second occurrence of a minimal pair containing this contrast.

In conjunction with the ABX results we can interpret the present lexical-decision-task results as follows: Intermediate learners are indeed using the nasal stripping strategy initially (ABX) in categorization. Advanced learners have recovered from this miscategorization and have apparently established a new (phonetic) category for nasal vowels, which allows them to categorize nasal vowels differently from oral vowels. They are not different from the French native speakers. At the phono-lexical level, data suggest that the same advanced learners are showing signs of having successfully updated their lexical representations and have reorganized their categories. These data indicate that at the phonetic level, the initial use of the nasal stripping strategy (due to categorization) can be overcome with more exposure, perhaps as the phonological contrast is established. Such clear between-group patterns are not visible anymore at the phono-lexical level, where differences between the groups are not so clear-cut. As mentioned above, this might be mainly due to the more variable behavior of the intermediate learners on the one hand (which makes strong conclusions difficult even if their trends seem similar), and the fact, on the other hand, that the advanced learners have possibly already reorganized their lexical representations and reduced the incidence of spurious homophony.

As we saw in chapter 3, given these results the DMAP model (Darcy et al., 2012) becomes relevant because: 1) English learners of French detect in the raw percepts the nasality of the French nasal vowel, an acoustic cue that is not necessary in their L1 for segmental categorization; 2) after many instances through exposure (repetition) to French language minimal pairs, L2 learners review their interlanguage feature hierarchy taking into account economy principles; 3) the nasality feature starts to be associated to and included into the feature matrices of vowels in addition to those of consonants; 4) phonetic categories for vowels begin including representing the nasality feature contrast (between oral vs. nasal vowel) reflecting their phonological-lexical representational distinctions. Perception is finally adjusted to conform to phonological knowledge.

Chapter 6 Discussion and conclusion

6.1 Discussion

In chapter 5, I presented the results from three perception experiments. In this chapter 6 I will attempt to synthesize the findings and situate them in the broader context of the research questions, in order to ultimately provide a specific answer to the research questions based on the results obtained.

The first research question addressed in the present dissertation was:

1. If learners start with their L1 phonological representations (e.g. Polivanov, 1931), what do English listeners with no knowledge of French hear when they encounter L2 French nasal vowels?

Naïve listeners of French took part in two out of the three dissertation experiments. The first experiment in which an answer could possibly be found is the perceptual assimilation experiment. In this experiment the main goal was to assess the perceived relation between French and English vowels in oral and nasal contexts, and to provide insight into the perception of French nasal vowels by native speakers of English with no knowledge of French. In general, listeners assimilated word-final nasal vowels to AE VN sequences, to oral vowels followed by nasal consonants. As it was shown in chapter 5 (section 5.1), this occurred 65% of the time for /ɑ̃/ and 70% of the time for /ɔ̃/. It is also worth noticing, however, that this assimilation depended on the vowel under study, since for /ɛ̃/ a VN sequence was chosen on 52.5% of occasions. It is possible that the frontness of /ɛ̃/ could have something to do with this difference in assimilation, since /ɑ̃/ and /ɔ̃/ are back vowels and the VN sequence was more widely chosen. Incidentally, in Inceoglu's (2014) perceptual training study by English-speaking listeners, the vowel /ɛ̃/ was the one that improved the most out of the three. These results mostly show, however, that the nasality feature is part of the raw percepts in the treatment of the input, and that listeners are compelled to choose categories that implement this feature. This effect can be seen as similar to the importance of the feature [+round] when listeners categorize /y/ as /u/ (Darcy et al., 2012).

Connecting these data with the results for the ABX task, since the no-French group listeners map /ɑ̃/ onto VN sequences in the perceptual assimilation task, we could expect them to have difficulties discriminating between [an] and [ɑ̃]. Their accuracy level on that condition was also the lowest out of the four experimental groups. However, their score did not differ statistically from any of the other three groups tested for the [an]-[ɑ̃] test condition, and therefore should be considered an interesting numerical trend.

It seems that overall, in making perceptual decisions in the assimilation task, when the nasal vowel [ɑ̃] appears word-final in an isolated word, the no-French group tends to think that nasality comes from a following nasal consonant (as in /an/) and chose that category; However, in the ABX task, when discriminating random sequences of [an] and [ɑ̃], they categorize the nasal vowel [ɑ̃] as a deviant form of the oral vowel [a] and this allows naïve listeners to perform well in their discrimination from [an] (8.51% error rate in the [an]-[ɑ̃] condition), but poorly in their discrimination from [a] (26% error rate in the [a]-[ɑ̃] condition).

That nasal vowel [ɑ̃] is also perceived as a deviant form of the oral vowel [a] seems to be the plausible tendency for two reasons: a) in the perceptual assimilation experiment, nasal vowels were also classified as oral vowels relatively often (30%, 45% and 30% for /ɑ̃/, /ɛ̃/, /ɔ̃/, respectively). b) In the [a]-[ɑ̃] condition for the ABX experiment, the no-French group was less accurate than the other three groups, even if this accuracy difference only reached significance when the no-French group was compared to the advanced and marginally to the French-native groups, but not with the intermediate group. It would seem here that language experience in the classroom (intermediate learners) and, especially, immersion in a French setting (advanced learners) had an impact in the learners' ability to detect and phonetically categorize the French nasal vowel in a way similar to French-native speakers.

The picture gets more complex when vowel-quality is taken into account. Whereas for the oral vowel /a/ listeners chose the front vowel /ae/ 57% of the time, for its nasal counterpart /ɑ̃/ they chose the oral back vowel /ʌ/ 56.7% of the time. This also shows that in French the nasal vowel /ɑ̃/ is indeed more posterior than the French oral vowel /a/ and naïve listeners appear to be sensitive to this difference. The other two vowels did not differ as much in vowel quality perception. Both /e/ and /o/ vowels remained front and back, respectively, regardless of nasality or lack thereof in the vowel. Therefore, for the pair /a/-/ɑ̃/, it is possible that the No-French group performs more accurately because these two stimuli are mapped onto two different AE vowels. For the other two vowel pairs (/ɛ/-/ɛ̃/, and /ɔ/-/ɔ̃/), discrimination in the ABX task might be less easy. However, given power considerations and the low number of data points, this analysis was not carried out in the present experiment, and will need to be left for future research.

Let's remember that the test condition in which groups differed the most for the ABX experiment was the [a]-[ɑ̃] condition. In fact, the no-French group was significantly less accurate (26% error rate) than the advanced learners (10.4%) and marginally less accurate than the French natives (12.9%), but not statistically less accurate than the intermediate group (18.6%). This non-significant difference in accuracy (7.4%) between the no-French and the intermediate groups can be applicable to exposure to French in a classroom setting, as this is the main criterion that separates these two groups. The data from these experiments suggest that, phonetically, French nasal vowels are initially mostly categorized as VN sequences (65% of the time for /ɑ̃/; 52.5% for /ɛ̃/ and 70% for /ɔ̃/, respectively) or as less-good exemplars of oral vowels (30% for /ɑ̃/, 45% for /ɛ̃/ and 30% for /ɔ̃/, respectively). Combined, these two effects may be the reason why naïve English listeners encountered difficulties distinguishing between an oral and its nasal counterpart (and possibly more so for the non-low vowels, /ɛ/-/ɛ̃/, and /ɔ/-/ɔ̃/) in the ABX experiment, and also some assimilated French nasal vowels as AE oral vowels in the perceptual assimilation experiment.

The stimuli containing nasal vowels followed by nasal consonants tipped the balance even more on the side of the VN sequence: 97.5%, 92.5% and 85% for /ɑ̃n/, /ɛ̃n/ and /ɔ̃n/, respectively, were interpreted as VN sequences. It seems that the release of the nasal consonant helped the No-French group in perceptually corroborating the notion that nasality in English vowels occurs when a nasal consonant is next to it (see Figure 5a in chapter 3). The categorization as AE oral vowels for these stimuli was relatively scarce: here: 2.5% for /ɑ̃n/, 7.5% for /ɛ̃n/ and 15% for /ɔ̃n/. However, as shown in chapter 4, this condition was specifically designed for the ABX experiment, and these {nasal vowel}+{nasal consonant} sequences are not used contrastively in French.

Summing up, nasal vowels are either assimilated by naïve listeners of French as a VN sequence or as a deviant form of the oral vowel. When the nasal vowel /ɑ̃/ appears next to a pronounced nasal consonant (/ɑ̃n/), the no-French group clearly assimilates it as a VN sequence. The perceptual assimilation task reveals that American English listeners who do not know any French can detect the nasal feature on the French vowels, although their assimilatory behavior depends on vowel quality and context. This experiment is agnostic about the nasal-unpacking or nasal-stripping strategies used by learners of French.

Our second research question was:

2. Which perceptual strategy do learners use initially to adapt L2 French nasal vowels to their current L1-English underlying interlanguage representations? Will they be able to stop using such a strategy as they gain more experience with French and how does this happen?

Two possible repair strategies that learners of French could use when they hear a French nasal vowel have been outlined in this dissertation (see chapter 3 for more details) and seem compatible with the behavior of naïve listeners revealed in the perceptual assimilation experiment discussed above. One possibility is related to allophony and involves the nasal-unpacking strategy, in which learners transform a French nasal vowel into an AE oral vowel followed by a nasal consonant: /ɑ̃/ becomes /an/ (this is derived from their L1-based English allophony). Another possibility involves the nasal-stripping repair strategy, in which learners remove the nasality from the vowel and transform it into an oral vowel: /ɑ̃/ becomes /a/ (L1-based phonetic categorization as observed in the ABX task).

Focusing on the intermediate and advanced learners of French, we will first consider the findings of the ABX phonetic categorization experiment, and analyze two test conditions that can give a straight answer to this second research question.

In chapter 4 (section 4.2, see p. 74), I predicted that if English learners of French display difficulties in the [an]-[ɑ̃] test condition, this behavior could then be taken to mean that learners are using L1-based phonetic categorization, that is, the nasal-unpacking strategy. In contrast, if learners of French display more difficulties in the [a]-[ɑ̃] test condition, it could then be inferred that learners are using the nasal-stripping strategy. Critically, pairwise comparisons between learner groups and the French native speaker group provided evidence about recovery from L1-based phonetic categorization in the advanced group.

The results for the [an]-[ɑ̃] test condition indicate that none of the four groups was statistically different from the others. That is, they all displayed a similar and low error rate hovering around 5.68%. There were, however, clearer differences between groups in the [a]-[ɑ̃] test condition. In this condition, the No-French and the intermediate learner groups did not differ from each other, and both were significantly less accurate than the advanced learners and the native French group. The difference between the intermediate and the French native speakers was marginal (p = .056) but suggestive of a still not fully-robust French-like category for oral and nasal vowels phonetic categorization, and reminiscent of the nasal stripping strategy. Finally, the advanced group numerically outperformed the native group, but the two groups were not statistically different. These findings tell us that in the beginning stages of learning French, learners could still have English-like phonetic vowel representations. But with substantial exposure to French, learners stop applying their L1 phonological grammar and attain French-native-like levels of perception.

Our third research question was:

3. What is the underlying representation of phonemic nasal vowels for L2 learners of French at different stages? We want to know if it is L1-like (English), L2-like (French) or neither L1 nor L2-like (interlanguage representation).

I now turn to the discussion of the results for the lexical decision task. This experiment used similar conditions as in ABX to examine to what extent learners also distinguish nasal and oral vowels in their lexical representations, and whether or not perceptual behavior impacts lexical encoding. The critical conditions were: /ɑ̃/-/an/ (nasal vowel vs. oral vowel followed by nasal consonant) and /ɑ̃/-/a/ (nasal vowel vs. oral vowel). It was predicted that if learners apply nasal stripping during lexical encoding, repetition priming would be observed on the minimal pair condition for the contrast /ɑ̃/-/a/. By contrast, if learners apply nasal unpacking, priming would be observed on the minimal pair condition for contrast /ɑ̃/-/an/. Thus, it appears that L2 learners are capable of representing nasal vowels. The results from ABX suggested that, initially at least, learners phonetically categorize nasal vowels as oral vowels (nasal stripping) in their perception. Logically, if such perceptual categorization also determines lexical encoding, we should expect to find more repetition priming in minimal pairs containing a contrast of the type /ɑ̃/-/a/.

Let us look at these two conditions in turn: for the nasal stripping /ɑ̃/-/a/ condition, the picture reveals that the advanced learners seem to display a tendency towards this pattern. They show repetition priming for the /ɑ̃/-/a/ minimal pairs. This pattern is different from the French natives, and contrasts with the ABX data which showed that advanced learners possessed a very high accuracy at phonetically distinguishing the [a]-[ɑ̃] stimuli pairs. Regarding the /ɑ̃/-/an/ condition, both the advanced and the French native speakers behave similarly in that they show inhibition in the case of minimal pairs. Concretely, this means that both groups respond more slowly to items in that condition when encountering them the second time. Such inhibition could be interpreted as indicating that listeners detect a difference between the second word of the minimal pair and the first, but that these two members of the pair compete with each other. A possible explanation is that there is competition in the mental lexicon (for both advanced learners and native speakers) due to morphological alternations involving the {nasal vowel} vs. {oral vowel + nasal consonant} (/ɑ̃/-/an/) contrast, such as plein /plɛ̃/ 'full, masc.' vs. pleine /plɛn/ 'full, fem.'; vient / vjɛ̃/ 's/he comes' vs. viennent /vjɛn/ 'they come', mentioned in chapter 1. Crucially, no evidence of repetition priming can be seen here. This inhibition in the advanced group fits well with results in the ABX experiment, since all groups performed very accurately, and similarly, for this pair. Taken further there could be a difference between the phonetic and the phonological levels. Future studies could throw some light on this matter.

What these results do indicate is that, at least at the phonetic level, learners start by phonetically categorizing nasal vowels as oral vowels (partially consistent with allophony). This is noticeable because intermediate learners, although not significantly more accurate than naïve listeners of French, still do numerically better (18.6% vs. 26 % error rate, respectively) in the [a]-[ɑ̃] condition. The influence of allophony might begin to be overcome at the phonetic level as early as of the first years into the study of French (remember that intermediate learners had studied three or four semesters of French by the time the experiments were carried out). However, recovery from allophony is not completely overcome until learners reach advanced levels in French: advanced learners were even slightly more accurate than native speakers in error rate percentage, 10.4% vs. 12.9%, respectively for the [a]-[ɑ̃] condition; and significantly more accurate than intermediates.

As for phono-lexical representations, the significant high level of inhibition shown by advanced learners in the /ɑ̃/-/an/ contrast might indicate that, at least at the phonological level, learners might be having competition between morphological alternations, which was also seen in French native speakers. However, the fact that there is no consistent significant spurious priming for any of the learner groups in the contrasts under study, does not allow us to affirm that either one of these strategies was being used by the learners. Given that French natives also displayed some inhibition (although not significant: 56.9 ms for the /ɑ̃/-/an/ condition), it might be a question of adjusting the mental representation by removing the timing slot that was seen in the phonological representations of Figure 8 (see section 3.3.1. in chapter 3 and reproduced below in this chapter).

On the one hand, if we followed a bottom-up approach we would expect that, as learners hear a nasal vowel, they can detect nasality in the vowel. Such approach would argue that in order to acquire the L2 phonological representation for the nasal vowel, learners need to be able to create a new phonetic category in their perceptual space as they stop assimilating nasal vowels to oral vowels. On the other hand, Direct Mapping of Acoustics to Phonology (DMAP) claims that such accurate phonetic categorization is not a prerequisite for learners to create a new L2 phono-lexical representation. Learners would initially use allophony (from a preceding or following nasal consonant) as a way to perceptually explain the nasal feature. Later on, the main goal for the learners would be to stop applying L1-repair strategies at the phono-lexical level. That is, learners should be able to lexically encode nasality in the vowel.

In chapter 3 I described three possible phonological representations (see Figure 6). It seems that, in hearing a French nasal vowel, naïve listeners of French start with an English-like representation in which they interpret the nasal vowel as the oral vowel being influenced by the adjacent nasal consonant (allophonic nasal vowel) and represented phonologically as follows (Figure 6a, which I reproduce here from chapter 3, p. 46):

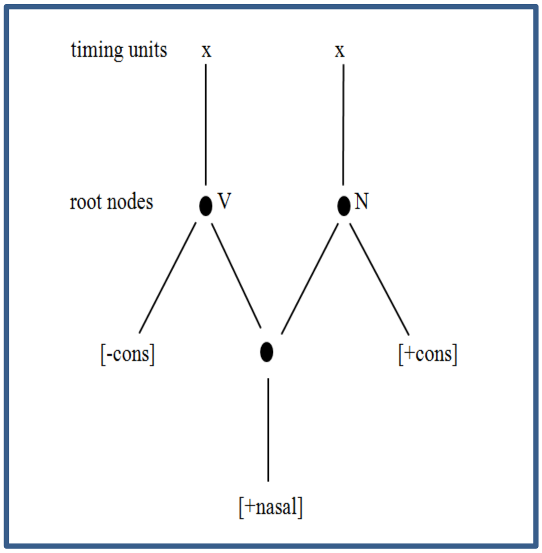

Figure 6a. Phonological representation of the English allophonic nasalized vowel.

The representation in Figure 6a can be derived from the fact that, in the perceptual assimilation task, the no-French group categorized nasal vowels mostly as VN sequences, and it makes sense to have such a representation as a starting point, as for them nasality is mostly part of the nasal consonant that regressively assimilates to the previous vowel. This representation coincides with one of Liddiard's (1994) production errors (nasalized vowel produced with a residual nasal consonant). In the same manner, its biphonemicity agrees with the Structure Preservation rule pointed out by Eckman, Elreyes and Iverson (2001) and mentioned in chapter 3 and also with Paradis & Prunet's (2000) nasal-unpacking strategy. This was represented in Figure 9, which I reproduce here:

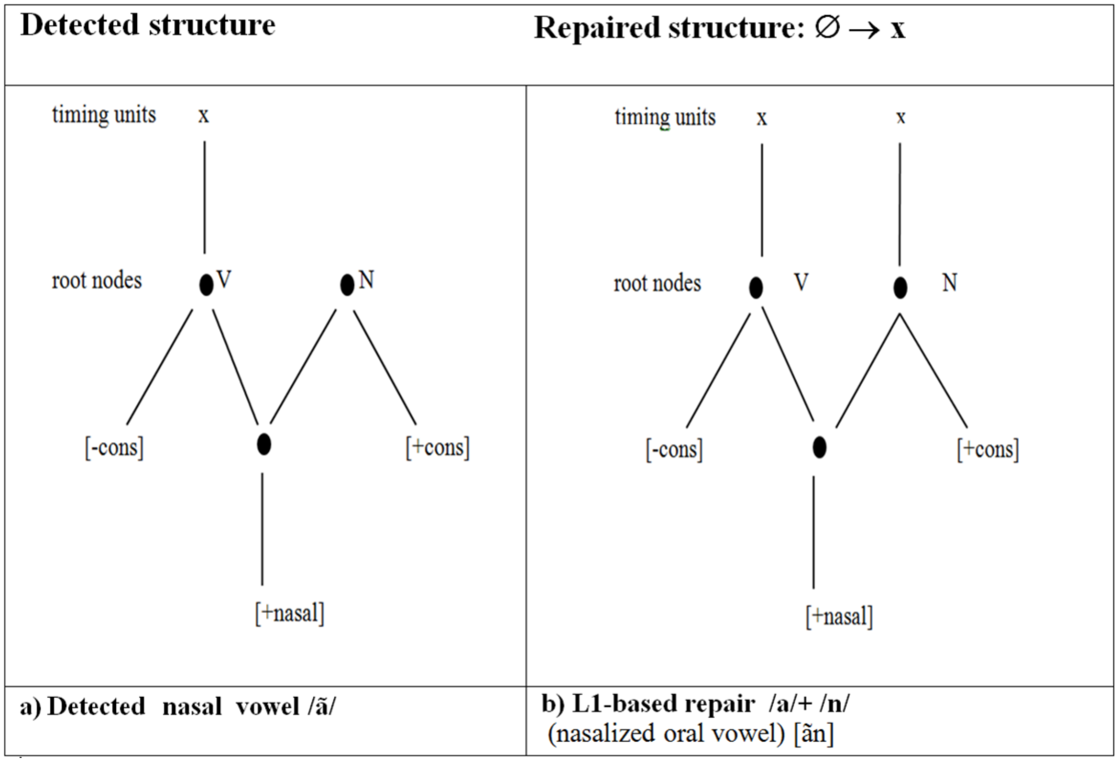

Figure 9. Speculative nasal unpacking strategy: learners detect the phonemic French nasal vowel /ɑ̃/ and transform it into an L1-English oral vowel followed by a nasal consonant sequence /an/.

However, the group of naïve listeners also heard nasal vowels as oral vowels in a substantial number of cases. In fact, as learners gain exposure to the French language and hear the nasal vowel more frequently, it seems that they initially apply a nasal-stripping strategy (at least at the phonetic level for the ABX task) that turns the phonemic nasal vowel into an oral vowel as it was seen in Figure 10, which I reproduce here. According to DMAP, this should be due to allophony which is still present in the intermediate group in terms of phonetic categorization, and lasts until learners reach an advanced level in which they use nasality contrastively.

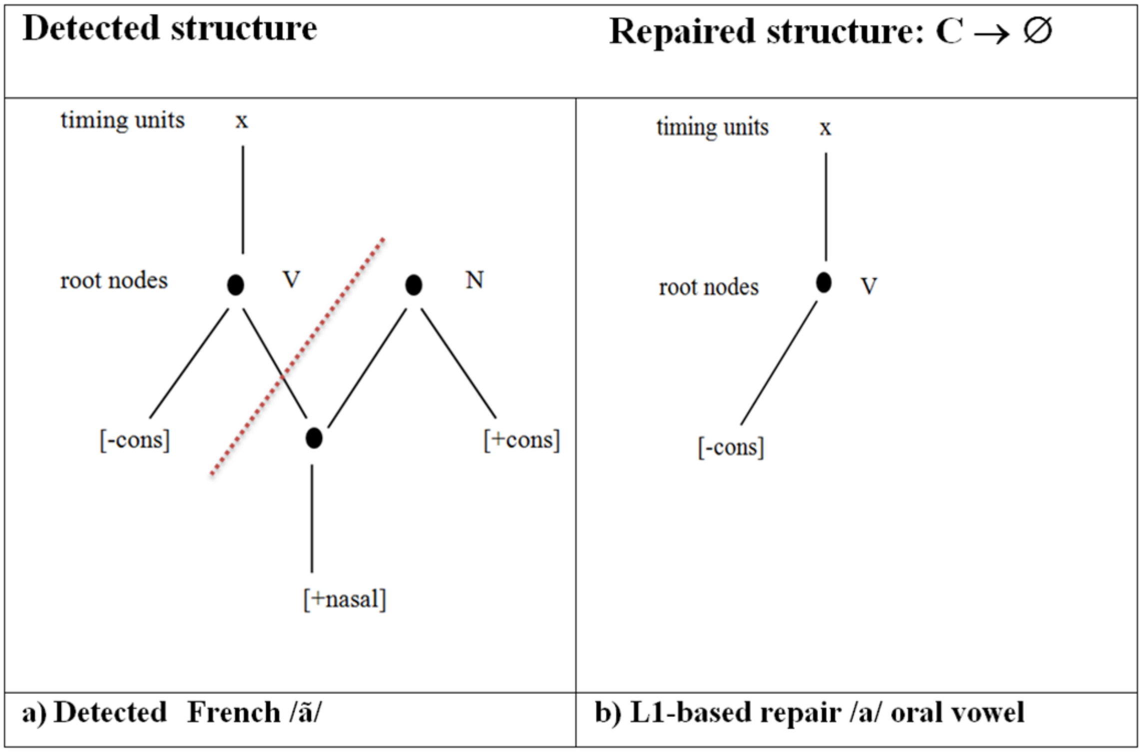

Figure 10. Speculative nasal-stripping strategy or merger: learners detect the phonemic French nasal vowel /ɑ̃/ and transform it into an L1-English oral vowel /a/.

Given that the advanced and the French-native groups did not differ significantly in terms of accuracy for either of the ABX test conditions and that in the lexical decision task there were no significance differences between them either, it is likely that the advanced learners' French-nasal-vowel representation is similar to that of French natives. Such a representation is illustrated in Figure 9a above, which is the one that French natives would possess in their mental lexicon.

In summary, the oral vowel phonological representation, once the nasal-stripping strategy is applied by learners, seems more plausible at the beginning of French learning, since in the ABX task intermediate learners had significantly more difficulties in the [a]-[ɑ̃] test condition than advanced learners. This is also hinted at in the lexical decision task by advanced learners, who showed some facilitation (in terms of a numerical trend) in the /ɑ̃/-/a/ test contrast (-49.1ms). The influence of the L1 phonology may incite learners to begin with an oral vowel phonological representation as they start their path into acquiring an L2 phonological representation of the nasal vowel.

The following table offers a general view of what the underlying phonological representations might be for French nasal vowels based on the results obtained for this dissertation:

Table 9. Possible underlying representation for experimental groups and inferred meaning.

	Effects of tasks	Inferred meaning
Naïve listeners	AE phonetic space + non contrastive nasality	Two alternatives are available: /an/ and /a/. /an/ predominates. Uncertainty with respect to the timing unit (1 or 2). Perceived nasality.
Intermediate learners	ABX = L1-based phonetic space Lexical Decision = no spurious homophony	On their way to /ɑ̃/ representation (Interlanguage). One timing unit (despite un-faithful lack of nasalization) is preferred (nasal stripping)
Advanced learners	ABX = target-like categorization Lexical Decision = no spurious homophony	Representation similar to French natives. Successful addition of the nasality root node to the vowel root node

These results are in apparent agreement with other findings such as those reported in Paradis and Prunet (2000) or with data suggesting a dual timing slot representation in production (Liddiard, 1994), at least initially: learners produce the nasal as if it had its own timing unit. I argue here that the influence of orthography is a factor that should be taken into account. As I attempted to answer research question one, it was mentioned that naïve listeners of French either heard nasal vowels as VN sequences or as deviant forms of the oral vowel. As learners of French are receiving instruction in French, not only are they exposed auditorily to nasal vowels, they also read and are presented with the written forms, which coincides with the phonological two-timing units V+N sequence form or nasal-unpacking. At this point they already start making the connection between the nasal vowels they hear and their graphic representation. The nasal consonant is written (e.g. /ɔ̃/ in *maison* [mezɔ̃] 'house'). It is possible that, as learners improve their knowledge of French, they stop seeing nasal vowels as deviant forms of oral vowels and start accepting the fact that nasality could be featurally a part of the vowel. That is, L2 learners keep the vowel (one timing unit) and the nasality feature of the nasal consonant without having to add the nasal consonant timing unit into their L2 phonological representation (see Fig. 9a above). Further testing is required to verify if this is the case. Interestingly, the current findings extend this possibility of initial two-node representations by outlining a possible acquisition path which first seems to go through a reduction of timing units (removing the nasal consonant node), and then addition of the nasality feature.

We now need to ask how advanced learners modify their representations from that of intermediate learners. It appears that — if we can postulate that advanced learners are former intermediate learners — they must have "re-added" nasality after having removed it from representations (using the nasal stripping strategy). This apparently is made possible thanks to their higher-level instruction, along with some time in a French-speaking country. What do they do, if they started with /a/, to successfully "re-add" nasality as a second root-node afterwards? (see reproduced Figure 10 from right to left).

I think that DMAP (Darcy et al. 2012) can throw some light on this matter. As we saw in chapter 2 this model has four propositions, which are contextualized for the current case of nasal vowel acquisition below:

1. Learners might perceive nasality but may be initially unable to categorize it or map it onto the vowel time slot, since they detect more acoustic cues in the raw percepts than what they use to perform a segmental categorization response. Remember that naïve listeners mostly attributed the nasal feature to the nasal consonant, hence their VN choices for French nasal vowels. (see Figure 9b)

2) Over time, learners first learn to develop a faithful "structural" representation corresponding to a single vowel timing unit, but which still lacks the nasality feature in the double root node VC representation. That is, they still need to rearrange their feature hierarchy and possible combinations, since at this point, the combination of {+vocalic} and {+nasal} is not licensed. This possibility would account for the difficulties of intermediate learners in the [a]-[ɑ̃] test condition for the ABX task.

3) Later on, as they advance more, they manage to "re-add" the nasal feature to the vocalic slot by licensing this combination of features which they already had available in their L1 (nasality) as allophones. Learners review and update the phonological features of their interlanguage (as was mentioned already for intermediates interlanguage in the table above).

4) With the previous revisions and new information (through French instruction and direct exposure to French through study-abroad) they then need to keep this single timing unit but add the nasality feature (in form of the added root-node). This change triggered by phonological contrasts (*paix* [pe] 'peace' vs. *pain* [pɛ̃] 'bread') is done minimally via the addition of the nasal feature. This stage of acquisition is represented by advanced learners, who perform similarly to French natives in the ABX and the lexical decision tasks. (See Figure 9a)

In terms of timing units and taking DMAP into consideration, it is important to remember the Structure Preservation Principle mentioned in chapter 3 (Eckman, Elreyes & Iverson (2001), and which we apply to the timing units in this case. The main difference between the two repair strategies is that nasal stripping preserves the structure by privileging the single timing unit and temporary ignoring of the nasality. The other, nasal unpacking, preserves "surface" nasalization of the consonant and ignores the timing unit level, since the realization of the nasal consonant implies another extra timing unit (see Figure 9b). Since naïve listeners of French have a two-root node two-timing-unit representation (see Figure 9b) in their English L1, they need to transform it into a two-root node one-timing-unit representation (see Figure 9a). These dissertation data suggest that first learners start with the one-root node one-timing-unit representation of an oral vowel, therefore respecting their L1 structure (see Figure 10b). Then, as their French improves, they gradually manage to incorporate the second root node (N) containing the nasal feature (see Figure 9a). It is important to keep in mind that in the three experiments the stimuli were recorded by the same Haitian Creole speaker. Although the original idea was for the listeners to hear stimuli produced by a native speaker — remember that /ãn/ sequence is not legal in French but it is in Haitian Creole —, it is true that such sequences are not used in the lexical decision experiment. Therefore, despite the fact of the speaker being trilingual in English, French and Haitian Creole, one of the limitations of the study is to not have recorded a monolingual or French-dominant native speaker to create stimuli for the lexical decision task. If this had been the case the results might have been more consistent, since the French-native speaker control group consisted of French-native speakers from continental France and learners were learning France-French as a foreign language.

Another factor to take into account is that a phonetic analysis for the data was not performed and such information could have been useful in order to better understand the level of nasality contained in the stimuli used for the three experiments.

It is true also, that although four different groups participated in my three experiments (no-French, intermediate, advanced and French-native groups), beginning-level learners were not tested. We already saw above that on Liddiard's (1994) study first-year learners of French displayed an error rate of 44% in their production of nasal vowels. If we could attribute such errors to their inability to categorize them correctly, I would hypothesize that they could have a performance similar to (but probably not statistically different from) intermediate learners. Nonetheless more experiments should be run to be able to affirm it with more certainty.

6.2 Conclusion

Previous research dealing with the perception of French nasal vowels did not thoroughly study the difference in their acquisition stages and did not focus on perception or on phonological representations. In answering the research questions I have tempted to throw some light on the perception and possible phonological representations of French nasal vowels by English-native speakers at different learning stages.

Paradis & Prunet (2000) showed evidence of the nasal-unpacking strategy in borrowings from French into other languages; however, their study did not deal with acquisition. Liddiard (1994) found that English-learners of French displayed some difficulties in the production of nasal vowels, since they produced a residual nasal consonant, altered the quality of the vowel or removed nasality from the vowel. However, the perception component was missing. Tyler et al. (2014) saw that the nasal vowel /ɔ̃/ was heard either as a VN sequence or as an oral vowel.

However the lexical representation was not investigated. In order to simultaneously investigate the acquisition, perception and lexical representation components of L2 French nasal vowels by L1-English learners I carried out three perception experiments in my dissertation that yielded the following results:

1) English speakers with no previous experience in French detected the acoustic cues of the nasality feature in the raw percepts even with no previous exposure to French. However, the no-French group participants, on the one hand, unpacked the nasal vowel into an oral vowel followed by a nasal consonant; on the other hand, they removed nasality from the vowel in some instances. Therefore, they perceive nasality, but do not necessarily know how to categorize it in terms of their L1 phonological grammar.

2) English-speaking intermediate-level learners of French have an interlanguage phonological grammar that fails to license nasality as being part of the vowel. This is why they still make some errors in their phonetic distinction between /ɑ̃/ and /a/ at the phonetic level. The nasal vowels are phonetically categorized as oral vowels by their L1-based interlanguage phonology. This agrees with the economy principle as well as changes that are not justified by the L1 language. At the phonological-lexical level (targeted in the lexical decision experiment), it seems that nasality is lexically encoded as being part of the vowel, since intermediate learners did not display any spurious homophony in the minimal pair condition. This is contrary to Brown (1998, 2000), who claimed that a feature that is not contrastive in the L1 could not be used to distinguish L2 phonemes; but it agrees with Clements (2001) in that such feature remains latent and can be activated later with L2 exposure. This successful lexical encoding supports Darcy et al's DMAP model in that the creation of a phonetic category is not a necessary condition to correctly encode nasal vowel contrast in L2 lexical representations.

3) Advanced learners not only overcame the miscategorization of nasal vowels as oral vowels at the phonetic level, but they were also similar to French natives in lexically encoding French nasal vowels. Although it has been shown that it takes advanced learners significantly longer time to respond to the /ɑ̃/-/an/ contrast and this could indicate that they're still struggling with the formation of the L2 representation for the nasal vowel, or that they experience competition due to the possible effect of morphological alternation. Advanced learners approach very closely the representation of French natives for nasal vowels, although they might have some reminiscent influence of their L1 oral vowel underlying representation, given the slight priming effect found in the /ɑ̃/-/a/ test condition for the lexical decision. Therefore there is a possibility that, although similar, their nasal vowel representation at every level does not exactly match that of French natives. Nonetheless, it appears that at this level lexical contrasts between oral and nasal vowels have been firmly established.

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Appendix I (Perceptual Assimilation Experiment)

List of non-words chosen

Test items			
V^n	**VN**	**V^nN**	**V**
stɑ̃	stan	stɑ̃n	sta
trɑ̃/brɑ̃	bran	brɑ̃n	tra
spɔ̃	spon	spɔ̃n	spo
brɔ̃	bron	brɔ̃n	bro
skɛ̃	skain	skɛ̃n	skai
blɛ̃	blen	blɛ̃n	blai
Fillers			
stak	stag	stan	
brit	bret	brat	
spok	spod	spon	
klan	klin	klen	
vlet	vled	vlen	
plem	plim	plam	

Appendix II (ABX Experiment)

List of non-words involving the three nasal conditions and the oral condition

Test items			
V^n	**VN**	**V^nN**	**V**
stɑ̃	stan	stɑ̃n	sta
brɑ̃	bran	brɑ̃n	bra
spɔ̃	spon	spɔ̃n	spo
brɔ̃	bron	brɔ̃n	bro
skɛ̃	skain	skɛ̃n	skai
blɛ̃	blen	blɛ̃n	blai
Fillers			
stak	stag	stan	
brit	bret	brat	
spok	spod	spon	
klan	klin	klen	
vlet	vled	vlen	
plem	plim	plam	

Triplets used in ABX

Test triplets			Filler triplets		
stan	stã	stan	stak	stag	stak
bran	brã	bran	stan	stak	stan
spɔn	spɔ̃	spɔn	spɔk	spɔn	spɔk
brɔn	brɔ̃	brɔn	spɔd	spɔk	spɔd
skɛn	skɛ̃	skɛn	vlɛn	vlɛt	vlɛn
blɛn	blɛ̃	blɛn	vlɛd	vlɛn	vlɛd
stã	stãn	stã	brit	brɛt	brit
brã	brãn	brã	brat	brit	brat
spɔ̃	spɔ̃n	spɔ̃	klan	klin	klan
brɔ̃	brɔ̃n	brɔ̃	klɛn	klan	klɛn
skɛ̃	skɛ̃n	skɛ̃	plɛm	plam	plɛm
blɛ̃	blɛ̃n	blɛ̃	plim	plɛm	plim
stãn	stan	stãn			
brãn	bran	brãn	tra	trã	tra
spɔ̃n	spɔn	spɔ̃n	spɔ	spɔ̃	spɔ
brɔ̃n	brɔn	brɔ̃n	brɔ	brɔ̃	brɔ
skɛ̃n	skɛn	skɛ̃n	skɛ	skɛ̃	skɛ
blɛ̃n	blɛn	blɛ̃n	blɛ	blɛ̃	blɛn
sta	stã	sta			

Apendix III (Lexical Decision with Repetition Priming Experiment)

WORDS

Test Priming 1		**Test Priming 2**		**Control i-a/u-a**	
Vn	**VN**	**V**	**Vn**	**u/i**	**a**
quand	canne	cas	quand	chou	chat
paon	panne	pas	paon	pourri	pourra
flan	flâne	tas	tant	brie	bras
an	âne	gras	grand	roux	rat
savant	savane	etat	etang	papi	papa
lin	laine	lait	lin	poux	pas
rhein	reine	raie	rhein	sou	ça
vin	veine	fait	fin	plie	plat
marin	marraine	marais	marin	dégout	dégât
pain	peine	paix	pain	vie	va
thon	tonne	tot	thon	lit	la
courons	couronne	chevreau	chevron	tabou	tabac
rond	Rhône	rot	rond	gout	gars
fond	faune	peau	pont	gris	gras
tronc	trône	trop	tronc	tout	tas

Note: Vn = nasal vowel; VN = oral vowel + nasal consonant; V = oral vowel.

NONWORDS

Test Priming 1		**Test Priming 2**		**Control i-a/u-a**	
Vn	**VN**	**V**	**Vn**	**u/i**	**a**
vlant	vlanne	vlat	vlant	vlit	vlat
siant	sianne	sias	siant	fias [fja]	fiou
brant	branne	goua	gouan	clas	clis
vrand	vranne	vras	vrand	vras	vrou
fégan	fégane	féga	fégan	fegou	fega
klin	klaine	glai	glain	stoupe	stape
vlain	vlaine	vlai	vlain	blie	bla
quegnain	quegnaine	quegnais	quegnain	quegnou	quegna
midin	midenne	midais	midin	midou	mida
chouain	chouaine	chouais	chouain	slik	slak
glon	glonne	glo	glon	smif	smaf
tilon	tilonne	tilot	tilon	tilou	tilas
vilon	vilone	vilot	vilon	joloux	jola
dron	dronne	dro	dron	scrou	scra
pagon	pagone	pagot	pagon	pagui	paga

Word fillers

plan	plat	ton	trop	train	lave
grand	gras	clon	gros	gain	feuille
champ	draps	don	îlot	fin	phare
clan	sac	sont	complot	teint	fleur
plan	fade	flacon	beau	malin	pied
temps	bras	profond	rot	pret/praie	fête
sans	classe	rond	faim	vrai	pain
gant	chasse	peau	clin	trait	glace
branche	selon	seau	bain	palais	place
haie	mouche	cloche	science	datte	voie
balai	bague	mare	canne	griffe	classe

Non-word fillers

bousse	diège	glège	chide	breuls	koufan
roupe	gune	bripe	prade	drousse	zan
gleche	dene	nogue	tode	freques	tran
brite	vade	sique	kide	liede	rilan
noque	niède	lude	tiane	jasse	fanche
sigue	prêpe	chame	bune	grettes	kesan
lube	broule	bromme	domme	drafe	peran
chane	sanne	dière	loite	lige	boulan
brone	dutte	lette	noin	duche	flanche
paze	vière	jotte	meffe	triffe	kla
pouge	pielle	pratte	maite	chable	tra
rouke	louaire	vrette	bige	dolle	pra

List of some test word pairs for lexical decision

Vn-VN contrast	V-Vn contrast	Control
quand-canne	cas- quand	chou-chat
lin-laine	lait-lin	poux-pas
ton- tonne	tot-ton	lit-la

Note: Vn = nasal vowel; VN = oral vowel + nasal consonant; V = oral vowel.

List of some test non-word pairs for lexical decision

Vn-VN contrast	V-Vn contrast	Control
vlant-vlanne	vlat-vlant	vlit-vlat
klin-klaine-	glai-glain	stoupe-stap
glon-glonne	glo-glon	smif-smaf

Note: Vn = nasal vowel; VN = oral vowel + nasal consonant; V = oral vowel.

List of some word distractors for lexical decision

complot	jupe	bec
faim	balai	graine
palais	mouche	home
glace	bague	pipe
pomme	tasse	haie

List of some non-word distractors

fevon	volon	jerin
pouge	rouke	lube
glège	bripe	roudai
drai	zouto	vilon
jage	kaflon	klate

Appendix IV

Language Background Questionnaire for American English native speakers

Subject's ID: ______________

From English allophony to French phonology

1. Date of experiment: __________________

2. Current course: ____

3. Native Language(s): ____

4. Country of origin: ____

5. Major(s): ___________________________________ Undergraduate / Graduate

In my _____________ year of study

If not, what is your occupation? ___________________________________

6. Gender: M / F Date of birth: ___________________

7. Are you dyslexic? Yes / No

8. If you were born outside of the USA, state your **age of arrival** in the US:

Number of **years of formal education** in the U.S. _________ and/or in another country ___________.

9. If you had formal education in other countries, which countries are they and how many years?

Country: ______________ Years: _____________ Country: ______________ Years: ___________

Country: ______________ Years: _____________ Country: ______________ Years: ___________

If you need more space, please use the backside of the questionnaire.

10. What is (or was/were) your occupation?

11. If you know **any languages other than your native language**, list the language(s) and estimate your ability to speak, understand, read and write the language(s) on a scale from "1" (i.e., your ability is very poor) to "7" (i.e., your ability is very good). Please include English if it is not your native language.

Language																							
Ability	1	2	3	4	5	6	7		1	2	3	4	5	6	7		1	2	3	4	5	6	7
Speaking																							
Understanding																							
Reading																							
Writing																							
Age when you started using it																							
Age of first exposure																							

If you need more space, please use the backside of the questionnaire.

12. Have you ever had any kind of a speech or hearing disorder? Yes No

If "Yes", please explain: ....
....

13. Please list the places (in the US or abroad) you have lived more than 6 months in chronological order:

- Where I have lived (earliest to most recent): From (year) to (year):

1……………………………………………………………………………………………..
2..……………………………………………………………………………………………
3……………………………………………………………………………………………..
4……………………………………………………………………………………………..
5……………………………………………………………………………………………..
6……………………………………………………………………………………………..

If you need more space for this question, you may write on the back of this questionnaire.

The following questions are only for those who have studied French as a foreign language.

14. How did you learn French? (e.g., home, guest family, school, friends, business, etc.)

………………………………………………………………………………………………………..

15. What variety or varieties of French pronunciation did you learn? (e.g.,Canadian, Northern France, Southern France, Belgium, Switzerland, other...)

………………………………………………………………………………………………

16. Pre-college French experience:

Please indicate the number of years you have studied French at the following levels:

Elementary School	1	2	3	4	5	6
Middle School	1	2	3	4	5	6
High School	1	2	3	4	5	6

College French experience:

How much college French have you had? _____________ semesters / quarters / years

17. Experience in French-speaking countries:

How long have you spent (in months and years) in French-speaking countries (please indicate country), and in what capacity (were you studying, working, etc.)?

18. How would you rate your ability to read fluently in French?

0 1 2 3 4 5 6 7 8 9

Very slow reader very fluent reader

19. How good are you sounding out French words?

0 1 2 3 4 5 6 7 8 9

Very poor very good

20. On a typical day, how many hours do you spend:

a) watching television in French?
b) listening to the radio in French?
c) reading in French?
(including books,magazines, websites, etc.)
d) speaking French with your friends?
e) interacting in French with native speakers of French?

21. Please indicate what you think about the following statements on an eleven-point scale

(1 = strongly disagree; 11 = strongly agree)

a. It is important to speak French grammatically

1 2 3 4 5 6 7 8 9 10 11

b. I enjoy learning new words and new ways of saying things in French

1 2 3 4 5 6 7 8 9 10 11

c. It is important to pronounce French correctly

1 2 3 4 5 6 7 8 9 10 11

d. I want to improve my pronunciation of French

1 2 3 4 5 6 7 8 9 10 11

e. I try to have as many French friends as possible

1 2 3 4 5 6 7 8 9 10 11

f. I believe that French natives will respect me more if I use correct French grammar and vocabulary

1 2 3 4 5 6 7 8 9 10 11

g. I believe that French natives will respect me more if I pronounce French well

1 2 3 4 5 6 7 8 9 10 11

h. I believe that French is important for my success at work/school

1 2 3 4 5 6 7 8 9 10 11

Language Background Questionnaire
for French native speakers

Subject's ID: _____________

From English allophony to French phonology

1. Date of experiment _________________

2. Current course: ______________________________________

3. Native Language(s): ____

4. Country of origin: ____

5. Major(s): _________________________________ Undergraduate / Graduate

In my ____________ year of study

If not, what is your occupation? _________________________________

6. Gender: M / F Date of birth: __________________

7. Are you dyslexic? Yes / No

8. If you were born outside of the USA, state your **age of arrival** in the US:

Number of **years of formal education** in the U.S. _________ and/or in another country ___________.

9. If you had formal education in other countries, which countries are they and how many years?

Country: _____________ Years: ____________ Country: _____________ Years: __________

Country: _____________ Years: ____________ Country: _____________ Years: __________

If you need more space, please use the backside of the questionnaire.

10. What is (or was/were) your occupation?

11. If you know **any languages other than your native language**, list the language(s) and estimate your ability to speak, understand, read and write the language(s) on a scale from "1" (i.e., your ability is very poor) to "7" (i.e., your ability is very good). Please include English if it is not your native language.

Language																							
Ability	1	2	3	4	5	6	7		1	2	3	4	5	6	7		1	2	3	4	5	6	7
Speaking																							
Understanding																							
Reading																							
Writing																							
Age when you started using it																							
Age of first exposure																							

If you need more space, please use the backside of the questionnaire.

12. Have you ever had any kind of a speech or hearing disorder? Yes No

If "Yes", please explain: ……………………………………………………………

………………………………………………………………………………………

13. Please list the places (in the US or abroad) you have lived more than 6 months in chronological order:

- Where I have lived (earliest to most recent): From (year) to (year):

1……………………………………………………………………………………..

2……………………………………………………………………………………..

3……………………………………………………………………………………..

4……………………………………………………………………………………..

5……………………………………………………………………………………..

6……………………………………………………………………………………..

If you need more space for this question, you may write on the back of this questionnaire.

14. How did you learn English? (e.g., home, guest family, school, friends, business, etc.) ……

………………………………………………………………………………………

15. What variety or varieties of English pronunciation did you learn? (e.g., Canadian, the US, England, Australia, other...)

……………………………………………………………………………………………………..

16. Pre-college English experience:

Please indicate the number of years you have studied English at the following levels:

Elementary School	1	2	3	4	5	6
Middle School	1	2	3	4	5	6
High School	1	2	3	4	5	6

College English experience:

How much college English have you had? _____________ semesters / quarters / years

17. Experience in English-speaking countries:

How long have you spent (in months and years) in English-speaking countries (please indicate country), and in what capacity (were you studying, working, etc.)?

18. How would you rate your ability to read fluently in English?

0 1 2 3 4 5 6 7 8 9

Very slow reader very fluent reader

19. How good are you sounding out English words?

0 1 2 3 4 5 6 7 8 9

Very poor very good

20. On a typical day, how many hours do you spend:

e) watching television in English?

f) listening to the radio in English?

g) reading in English?
(including books,magazines, websites, etc.)

h) speaking English with your friends?

e) interacting in English with native speakers of English?

21. Please indicate what you think about the following statements on an eleven-point scale

(1 = strongly disagree; 11 = strongly agree)

i. It is important to speak English grammatically

1 2 3 4 5 6 7 8 9 10 11

j. I enjoy learning new words and new ways of saying things in English

1 2 3 4 5 6 7 8 9 10 11

k. It is important to pronounce English correctly

1 2 3 4 5 6 7 8 9 10 11

l. I want to improve my pronunciation of English

1 2 3 4 5 6 7 8 9 10 11

m. I try to have as many English friends as possible

1 2 3 4 5 6 7 8 9 10 11

n. I believe that English natives will respect me more if I use correct English grammar and vocabulary

1 2 3 4 5 6 7 8 9 10 11

o. I believe that English natives will respect me more if I pronounce English well

1 2 3 4 5 6 7 8 9 10 11

p. I believe that English is important for my success at work/school

1 2 3 4 5 6 7 8 9 10 11

Curriculum Vitae

Education

Ph.D. Dec. 2016
Department of French & Italian, Indiana University-Bloomington, Indiana

Master of Arts Apr. 2008
Department of French & Italian, Indiana University-Bloomington, Indiana

Bachelor of Arts Sep. 2003

Translation and Interpretation Major, Concentration in French and German,
Facultad de Traducción e Interpretación, Universidad de Granada (Spain) and Rouen (France).

Current Position

Spanish Lecturer Aug. 2016 – Present
Department of Arts & Letters, Universidade Estadual da Paraiba, Campina Grande, Brazil

- Teaching, evaluating and fostering the Spanish language and culture through regular on-campus instruction at all undergraduate levels.
- Supplemental support to undergraduate students through office hours and tutor labs on a weekly basis.
- Coordination and monitoring of Spanish-major students as they teach lower-division levels of Spanish.

Teaching Experience

Spanish Associate Instructor Aug. 2012 – May 2016
Department of Spanish & Portuguese, Indiana University, Bloomington, IN

- Teaching, evaluating and fostering the Spanish language and culture through regular on-campus instruction.
- Supplemental support to undergraduate students through office hours and tutor labs on a weekly basis.

Public Relations Coordinator and French Grammar teacher Jun. – Jul. 2015
IU Honors Program for Foreign Languages, Brest, France

- French Grammar teacher for groups of teenagers aged 15 to 18 participating in a 7-week intensive immersion program abroad.

Responsible for handling potential difficulties students may encounter at the emotional, academic or cultural level.

Public Relations Coordinator and Spanish Linguistics teacher Jun. – Jul. 2014
IU Honors Program for Foreign Languages, Oviedo, Spain

- Spanish linguistics teacher for groups of teenagers aged 15 to 18 participating in a 7-week intensive immersion program abroad.
- Responsible for handling potential difficulties students may encounter at the emotional, academic or cultural level.

Public Relations Coordinator and Spanish Linguistics teacher Jun. – Jul. 2013
IU Honors Program for Foreign Languages, Oviedo, Spain
- Spanish linguistics teacher for groups of teenagers aged 15 to 18 participating in a 7-week intensive immersion program abroad.
- Responsible for handling potential difficulties students may encounter at the emotional, academic or cultural level.

Faculty Teaching Fellow Aug. 2011 – May 2012
Department of International Language and Culture Studies (IPFW), Fort Wayne, IN
- French instructor for Introduction to French syntax, morphology, sociolinguistics and phonology. Taught one section of 5 students.
- Instructor of French for first and second semester undergraduate students covering the basic grammar, conversation and cultural aspects of French-speaking countries. Taught two sections of about twenty students.

Instructor Jan. – May 2011
Department of Spanish & Portuguese, Indiana University, Bloomington, IN
- Teaching, evaluating and promoting the Spanish language and culture through regular on-campus instruction for S105 (Intensive Spanish)
- Supplemental support to undergraduate students through office hours and tutor labs on a weekly basis. Taught 2 sections of approximately 23 students

Instructor Aug. 2009 – Dec. 2010
Department of French & Italian, Indiana University, Bloomington, IN
- Teaching, evaluating and promoting the French language and culture through regular on-campus instruction.
- Supplemental support to undergraduate students through office hours and tutor labs on a weekly basis. Taught 2 sections of approximately 22 students

Student Coordinator and French teacher Jun. – Jul. 2010
IU Honors Program for Foreign Languages, Saint-Brieuc, France
- French conversation teacher for groups of teenagers aged 15 to 18 participating in a 7-week intensive immersion program
- Responsible for handling potential difficulties students may encounter at the emotional, academic or cultural level.

Language Assistant Oct. 2003 – Apr. 2004
Lycée Jean-Lurçat and Paul Langevin, Martigues, France
- Assistance to professors of Spanish in their conversation groups of teenagers aged 15 to 18.

- Promotion of the Spanish language and culture through discussions in groups of 10 to 15 students.

Air France Ground Personnel Oct. 1999 – May 2001 JFK International Airport New York, NY

- Internship as part of the ground staff: assistance to passengers through immigration, baggage claim and check-in.

Publications

Márquez Mártinez, MA. 2009. La perífrasis estar + ndo en puertorriqueños bilingües con residencia en Estados Unidos. *Boletín de Filología* XLIV (2), 2009, p. 119-134.

Márquez, Miguel. 2015. *Do you speak Felicidad?* Bubok Publishing.

Fellowships and Grants

Grant-in-Aid of Doctoral Research from Indiana University. Spring 2014 [1000$]

Future Faculty Teaching Fellowship, Department of International Language and Culture Studies (IPFW), Fort Wayne, IN 2011-2012 to teach in a different college environment to facilitate transition into faculty positions.

Graduate school grant from Spanish Ministry of Education, Department of French & Italian, Indiana University-Bloomington, 2005-2009.

Scholarship awarded by the Spanish Department of Education for an English course at the Boston School of Modern Languages, Boston, MA. August 2003

Scholarship awarded by the Instituto de la Lengua Gallega for a Galician course in Santiago de Compostela, July 2003.

Scholarship awarded by the DAAD for a German course in Mannheim (Germany), September 2002.

Scholarship awarded by the Spanish Ministry of Education for a French course in Aix-en-Provence (France), July 1996.

Scholarship awarded by the Spanish Ministry of Education for a French course in Foix (France), July 1995.

Awards

2-week course of French in the Alliance Française of Nice (France): prize of "Le petit reporter de la langue française" awarded by Le Petit journal. August 2008

Foreign languages

Spanish: mother tongue
French: near-native
English: near-native
Portuguese: Intermediate. Intensive Portuguese course in Coimbra (Portugal) at the Faculdade de Letras. Jun 22-Jul 30 2011.
German: Intermediate. *Sehr gut* score at Deutsch Zertifikat in Goethe Institut.
Haitian Creole: Intermediate. 4 semesters at Indiana University.
Italian: Intermediate. Accelerated course at Indiana University.

Service

Ritmos Latinos Group, Indiana University, Instructor of salsa, bachata and merengue.
Fall 2009 – Spring 2015
Coordinator of group *La Hora Hispana* at Universidade Estadual da Paraiba (Brazil).
Spring 2017