Perceptual Compensation for Acoustic Effects of Nasal Coupling by Spanish and Portuguese Listeners

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1. Introduction

The spectral effects of vowel nasalization show primarily in the *F*1 region of the vowel spectrum, the same region in which vowel height differences are registered. Nasalization has been shown to affect perceived vowel quality, in particular vowel height, due to the presence of an extra peak in the region associated with vowel height (Beddor, 1993; Chen, 1997; Krakow, Beddor, Goldstein, & Fowler, 1988). When two adjacent peaks in a vowel spectrum are close in frequency, listeners determine vowel quality based on some weighted average of the two peaks, or center of gravity, and not on the frequency of individual peaks (Chistovich & Lublinskaya, 1979). The result of an extra nasal peak in the region associated with vowel height is a shift in the perceived height of nasal vowels.

Wright (1975, 1986) studied American English listeners' perception of oral and nasal vowels (e.g., [o] vs. [õ]), and found that listeners perceived high vowels and some mid-vowels as lower and low vowels as higher. This follows from the magnetic effects of the nasal formant, which appears at frequencies between the middle to lower extreme of the spectral region associated with vowel height. The weighted average of a low frequency oral formant and a slightly higher frequency nasal pole results in listeners perceiving a peak that is slightly higher in frequency than the oral formant, which corresponds to perceiving the vowel quality as slightly lower. Likewise, the "center of gravity" between a high oral formant *F*1 plus a mid-frequency nasal pole will result in the perception of a slightly lower peak, corresponding to a somewhat higher vowel.

Krakow, Beddor, Goldstein & Fowler (1988) set out to determine whether coarticulatory influences of nasalization are affected by the context in which the nasal vowel appears. They found that English speakers were able to "undo" the coarticulatory effects of nasal coupling with the vowel under certain conditions, namely, when the listener could attribute nasalization to an adjacent tautosyllabic nasal consonant. English speakers were tested on their perception of the /ɛ/-/æ/contrast in oral ([bɛd]-[bæd]), non-contextual nasal ([bɛ̃d]-[bæ̃d]) and contextual nasal conditions ([bɛ̃nd]-[bæ̃nd]). Listeners showed a lowering effect (that is, they reported hearing /æ/ more often) for only the non-contextualized nasal vowels while their perception of contextualized nasal vowels did not differ significantly from that of oral vowels.

Krakow et al. take their findings to suggest that English speakers, due to their lack of experience with phonemic nasal vowels, interpreted the spectral effects of nasalization in the non-contextual nasal vowel condition as a difference in vowel height. In other words, they assume that English speakers' inability to assess nasal vowel height in the non-contextual condition is a result of their L1 experience (or inexperience). However, based on just these results, it is not clear that coarticulatory influences on the perception of nasal vowels are language specific, as Krakow et al. (1988) suggest.

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If coarticulatory influences on the perception of nasal vowels are universal, speakers of all languages would be expected to accurately perceive nasal vowel height only when the effects of nasalization are attributable to an adjacent nasal consonant, i.e., the coarticulatory effects of nasalization would surface in the same contexts as Krakow et al. found for English speakers. Thus, the English speaker results are congruent with both possibilities.

If, on the other hand, coarticulatory influences on the perception of nasal vowels are language specific, we would expect cross-linguistic differences in the context effects on the perception of nasal vowels. Specifically, speakers of a language that has phonemic and allophonic nasal vowels (i.e., contextual and noncontextual nasal vowels) would be expected to accurately perceive nasal vowel height in both contextual and noncontextual nasal conditions, due to their experience with nasal vowels in both environments. By the same token, speakers of a language that does not nasalize vowels in any context should always resolve the spectral effects of nasalization in terms of tongue/jaw configuration (i.e., there should be lowering or raising effects for both contextual and noncontextual nasal vowels).

The patterns of nasalization in Spanish and Portuguese present an opportunity to investigate the roles of language experience and coarticulation in the perception of nasal vowel height further. Using a nasograph, Solé (1992) showed that, regardless of speech rate, Spanish speakers lower their velum at roughly the same time before the onset of a nasal consonant, about 20ms before the onset. Furthermore, Spanish speakers show very little overlap between articulation of the vowel and lowering the velum for the nasal consonant[1]. These results support that for Spanish speakers, lowering of the velum before the onset of a nasal consonant is due to mechanical demands of articulation, and thus is not a phonological process, but rather a phonetic outcome due to physiological time constraints involved in lowering the velum (Solé, 1992). Because the overlap between articulation of the vowel and velar aperture is minimal (especially compared to languages like English), and because Spanish does not have distinctive nasalization of vowels, it might be expected that Spanish speakers[2] lack the experience (or the necessity) of teasing out the coarticulatory effects of vowel nasalization when followed by a nasal consonant.

Portuguese[3], in contrast, has both allophonic and contrastive nasalization. Allophonic nasalization occurs when stressed vowels appear before a nasal consonant (e.g., [ˈɡõmʌ] *goma* ‘starch’ vs. [goˈmadu] *gomado* ‘starched’). The lexical representation of contrastive nasal vowels in Portuguese is the subject of much controversy among Portuguese linguists. The existence of minimal pairs like *lã* ‘wool’ and *lá* ‘there’ have prompted many linguists (Hall, 1943; Hammarström, 1962 and others) to analyze nasalization in this context as part of the lexical representation of the vowel, while others call for analyzing contrastive nasal vowels as syllables closed by some nasal element, either a nasal consonant (Quicoli, 1990; Reed & Leite, 1947) or a nasal mora (Wetzels, 1997). Regardless of whether contrastive nasal vowels are analyzed as oral vowels followed by nasal mora or underlying nasal vowels, on the surface there are minimal pairs such as [sej] (*sei* ‘1 sg. know’) vs. [sẽj] (*sem* ‘without’) and [u] *livro* (*o livro* ‘the book’) vs. [ũ] *livro* (*um livro* ‘a book’); thus, Portuguese speakers have experience *perceiving* the oral-nasal vowel contrast even when nasal vowels are not followed by a nasal consonant in production.

Let us review the predictions of each hypothesis. If the ability to perceptually compensate for the effects of coarticulation on nasalized vowels is universal (and not dependent on language experience), we would expect that speakers of all languages do so only when there is a nasal consonant to which the nasalization can be attributed. On the other hand, if the ability to perceptually compensate for the effects of nasalization is due to language experience, we would expect that speakers of different languages exhibit raising/lowering effects for nasal vowels based on the phonological distribution of nasal vowels in their language. Note that the question is not whether listeners perceive the difference

[1] Except when between nasal consonants, as in comṵ́n, where the /u/ is nasalized (Schwegler et al., 2010).
[2] Note that some dialects of Spanish, e.g., Caribbean dialects, exhibit nasalization patterns more like those found in English; here we are only concerned with patterns of nasalization found in what Harris (1984) calls “non-velarizing” dialects of Spanish.
[3] Unless otherwise stated, all references to Portuguese refer to Brazilian Portuguese.

between oral and nasal vowels, as this distinction seems to be one that speakers of all languages are able to make (Beddor & Strange, 1982). The question here is whether or not listeners are able to accurately perceive the *height* of a nasal vowel as compared to its oral counterpart in certain contexts, namely before a tautosyllabic nasal consonant or not. Figure 1 below illustrates the predictions of these two hypotheses.

Universal

	Accurately perceive contextual nasal vowel height	Accurately perceive noncontextual nasal vowel height
English	✓	X
Spanish	✓	X
Portuguese	✓	X

Language-dependent

	Accurately perceive contextual nasal vowel height	Accurately perceive noncontextual nasal vowel height
English	✓	X
Spanish	X	X
Portuguese	✓	✓

Figure 1: Comparing predictions of hypotheses that coarticulatory effects on perception of nasal vowel height are universal vs. language dependent.

Note that the predictions of both hypotheses are the same for English speakers, and that these predictions are consistent with Krakow et al.'s (1988) findings. The current study will test for context effects on Spanish and Portuguese speakers' perception of nasal vowel height in order to determine whether coarticulatory influences on the perception of nasal vowel height are universal or dependent on linguistic experience. If the effects of coarticulation on nasal vowel perception are universal, crosslinguistic effects of context should mirror the results found by Krakow et al. (1988) for English speakers. Specifically, here speakers of both Spanish and Portuguese would be expected to "tease out" the coarticulatory acoustic effects of nasalization only when there is an adjacent nasal consonant to which these effects can be attributed (i.e. in the contextual nasal condition). If, however, these effects are language-dependent, Spanish speakers should perceive a shift in nasal vowel height, as compared to oral vowel height, regardless of context. Portuguese speakers, on the other hand, should accurately perceive nasal vowel height in all contexts, since they have experience with both contextual and noncontextual nasal vowels.

2. Methodology

2.1. Stimuli

Because the subjects of this study are from different language backgrounds, non-words that conform to the phonotactic constraints of Spanish[4] and Portuguese were chosen to test the /u/-/o/ distinction. The stimuli for this experiment consisted of synthesized non-words in which vowel height and degree of nasalization were manipulated. The choice of synthetic or modified natural speech tokens (or hybrid tokens) depends largely on the type of distinction being examined, and each comes with its own advantages and disadvantages. Unfortunately, natural speech tokens, unlike synthetic tokens, do not permit total control over variations in the acoustic signal. While synthetic stimuli may not succeed in representing some perceptually relevant properties of the signal (Beddor & Gottfried,

[4] It should be noted that while Spanish allows syllables of the shape CVns (e.g., cons-tan-te), there are very few, if any, monosyllabic words with this shape. A possible exception is the pronunciation [tons] for 'entonces.'

1995), a positive correlation between perception of natural and synthetic speech has been attested (Werker & Lalond, 1988; Yamada & Tohkura, 1992).

Stimuli were synthesized using the program Synthworks®, a KLATT based parallel speech synthesizer with up to 48 manipulable parameters. Natural tokens of the endpoints [gos], [gus], [gõns] and [gũns] provided the basis for synthesizing the basic shape of the stimuli, including parameters such as segment length, formant transitions for initial /g/, voicing cues, total utterance length, etc. The fundamental frequency (F0) of all utterances began at 100 Hz and fell linearly to 85 Hz over the first 200 ms of the utterance and remained there until the end of the utterance. The vowels were generated by first synthesizing the endpoints /u/ and /o/ and then manipulating the first formant (F1) in equal increments to synthesize five intermediate shapes in order to ultimately create a seven-step vowel continuum from /u/ to /o/ (see appendix A for formant frequencies of stimuli). The seven vowel heights were used in the three synthetic continua: oral [gos]-[gus], contextual nasal [gõns]-[gũns] and noncontextual nasal [gõs]-[gũs].

For the two nasal conditions, five degrees of nasalization were synthesized in order to account for possible speaker variability in the degree to which vowels must be nasalized to be perceived as nasal and also to permit examination of this effect on perceived vowel height. The primary cues for nasal coupling are reduction in amplitude of the first formant, an increase in $F1$ bandwidth of up to 60 Hz as well as the introduction of two nasal peaks, one at around 1000 Hz and another between 250 and 450 Hz (Chen, 1997). Nasalization was synthesized by introducing nasal poles and zeros at varying frequencies, depending on the level of nasalization. In addition, the amplitude of the first oral formant was decreased in the nasal continua. Nasality judgments have been correlated with the magnitude of $F1$ amplitude reduction (Chen, 1997; House & Stevens, 1956), thus, the lower and middle degrees of nasalization were synthesized with a 6 dB, 7 dB and 8dB reduction in F1 amplitude, respectively, and the highest two degrees of nasalization were synthesized with a reduction in F1 amplitude of 8 dB. Finally, the amplitude of the nasal pole increased from 30 dB to 60 dB over the duration of the (nasal) vowel. (See appendix A.)

The stimuli consisted of 77 utterances in all, separated into 3 sets as shown in Table 1. After all stimuli were synthesized, they were converted into .wav audio file format.

Table 1: Three stimulus sets synthesized for identification task.

Stimulus sets
1. Oral condition [gus]-[gos]
7 tokens (seven vowel heights)
2. Contextual nasal condition [gũns]-[gõns]
35 tokens (seven vowel heights X five degrees of nasal coupling)
3. Noncontextual nasal condition [gũs]-[gõs]
35 tokens (seven vowel heights X five degrees of nasal coupling)

2.2. Procedure

Subjects were tested using a forced-choice task run in Praat in which they listened to the stimuli and chose whether they heard ‘o’ or ‘u.’ The stimuli were counterbalanced across ten blocks so that the subjects heard each stimulus a total of ten times during the experiment. In addition, the order of the stimulus sets was counterbalanced across subjects. Subjects heard the stimuli over headphones, and used the mouse to click on “buttons” on the computer screen to indicate whether the vowel they had heard was [u] or [o]. To avoid the possible confound of orthography, the entire word was not spelled out. These response choices posed no difficulty for the subjects, because both Spanish and Portuguese orthography is more phonetically reliable than languages like English, for example, and because [u] and [o] correspond to orthographic ‘u’ and ‘o’ respectively in both languages. Each condition was preceded by a short practice session. The stimuli for the practice sessions contained the endpoint vowel heights as well as the next closest vowel height for each set, in other words, vowel heights 1, 2 6, and 7 from the seven-step vowel continuum. No feedback regarding the subjects' performance was given after the practice sessions.

Subjects were tested in groups of 1-4 in a quiet environment. The experimenter read instructions in the subjects' native language which indicated that they would hear a series of "invented" words, and to imagine that these words were new words of their language. They were instructed to use a mouse to click on the 'u' button or 'o' button on the screen to indicate which vowel they thought best fit the vowel they heard. The pace of the experiment was determined by how quickly the subject chose each response, but the entire experiment generally took between 50 and 70 minutes.

2.3. Subjects

Twelve speakers of Castilian Spanish and twelve speakers of Brazilian Portuguese were tested. All subjects were native speakers of their prospective language and reported no hearing impairments. An effort was made to ensure that the subject groups were as homogenous as possible in terms of their linguistic background, both L1 and L2. The Spanish subjects were all speakers from Barcelona, Spain. While it may seem strange to choose to conduct an experiment of this sort in an area of bilingualism, the Solé (1992) experiment measuring Spanish speakers' production of vowels before tautosyllabic nasal consonants was carried out in this region. In addition, all subjects reported being Spanish dominant.

It was somewhat more difficult to maintain such a high level of homogeneity within the Portuguese group. All subjects were Brazilians living in Los Angeles and had learned English as adults. All reported using Portuguese on a regular basis. Subjects were from Porto Alegre (n=2), São Paulo (n=3), Rio de Janeiro (n=3), Minas Gerais (n=2), Recife (n=1) and Maceió (n=1).

3. Results

Statistical analyses were carried out based on values obtained by a Probit Regression Analysis for the 50% crossover from /u/ to /o/ calculated for each subject's judgments in each continuum. Crossover values were based on a scale of 1 to 7 corresponding to the seven vowel heights. On this scale, 1 corresponds to the /u/ endpoint (F1 frequency of 225 Hz) and 7 corresponds to the /o/ endpoint (F1 frequency of 450). The 50% crossover values corresponding to Figures 2 and 3 are shown below in Table 2.

Table 2: Mean crossover values for Spanish and Portuguese listeners corresponding to the identification results of the [gus]-[gos], [gũns]-[gõns] and [gũs]-[gõs] continua.

Crossover values across language groups		
Condition	Spanish Group	Portuguese Group
[gus]-[gos]	3.90	3.77
[gũns]-[gõns]	4.71	3.86
[gũs]-[gõs]	4.53	3.95

A two-tailed Analysis of Variance (ANOVA) supports that Spanish speakers reported significantly more /u/ responses in both nasal conditions as compared to the oral condition (p = .017), which translates into a raising effect for the nasal vowel conditions only. Post hoc paired-samples t-tests confirmed that both contextual and noncontextual nasal vowels were perceived as significantly different (higher) than oral vowels of the same height (t -2.564, p = .026, t -4.232, p = 001, respectively), but not significantly different from each other (t 1.038, p = .321). This corresponds to a perceptual raising effect such that Spanish speakers interpreted the coarticulatory effects of nasalization as a difference in vowel height. Thus, Spanish speakers were unable to perceptually factor out the effects of nasalization in either nasal condition, regardless of whether there was an adjacent nasal consonant to which nasalization could be attributed.

Figure 2 illustrates Spanish speakers' rate of /u/ responses in each condition. Here the percentage of /u/ responses as a function of vowel height collapsed over degree of nasalization (for nasal stimuli) is shown. The figure represents the pooled responses of all 12 subjects. The figure illustrates that Spanish speakers recorded more /u/ responses in both of the nasal conditions as compared to the oral condition. That is, given two vowels with the same *F*1 frequency, the nasal vowel was more often perceived as /u/ (regardless of its context) as compared to its oral counterpart.

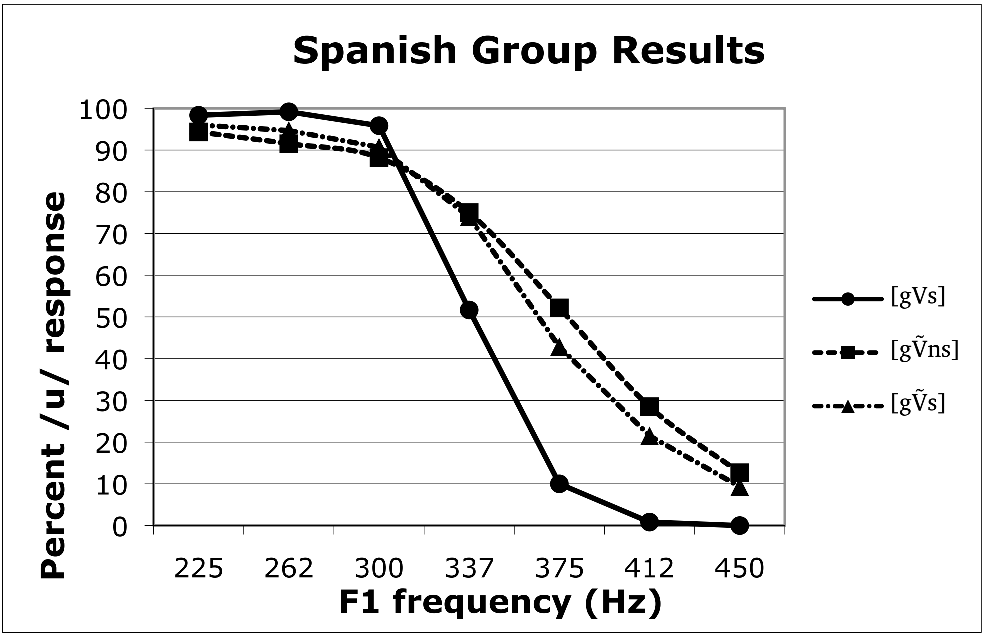

Figure 2: Identification responses to the oral [gVs], contextual nasal [gṼns], and noncontextual nasal [gṼs] continua for Spanish speakers.

In contrast to the Spanish results, a two-way ANOVA revealed that the number of /u/ responses for the Portuguese speakers was not significantly different in any context (p = .520). Post hoc paired-samples t-tests confirmed that Portuguese speakers' perception of vowels in the contextual and noncontextual conditions did not significantly differ from those in the oral condition (t -.562, p = .586, t -.966, p = .355, respectively) nor from each other (t -.742, p = .474). These results support that in both nasal contexts, Portuguese speakers were able to perceptually "undo" the effects of nasalization in order to accurately assess the height of the vowel. Figure 3 shows the rate of /u/ responses across vowel height frequency values in each condition for Portuguese speakers. Like Figure 2, Figure 3 represents the pooled responses of all 12 subjects.

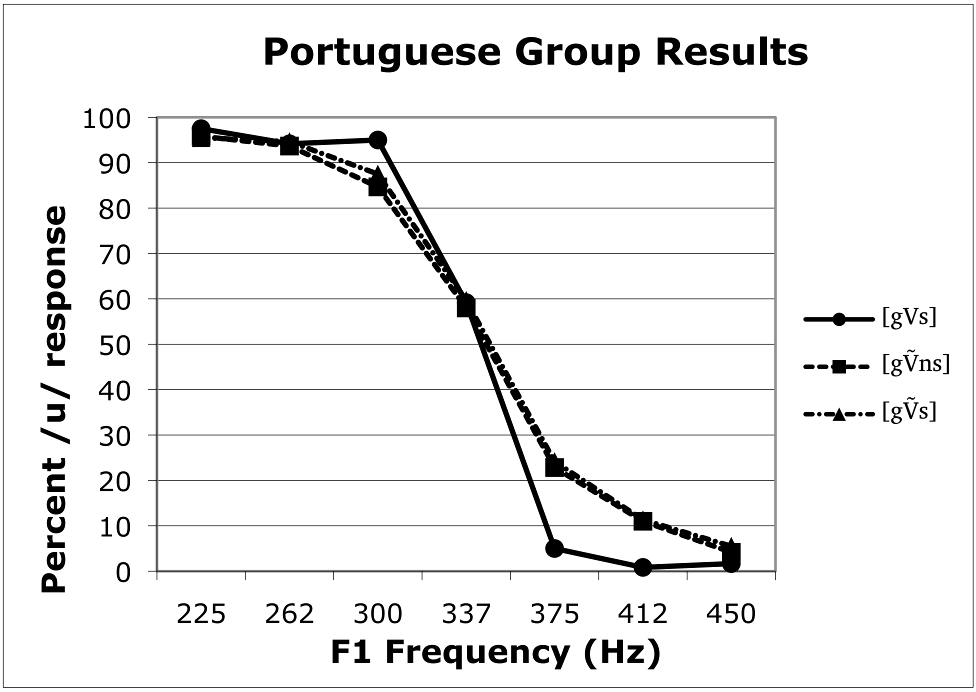

Figure 3: Identification responses to the oral [gVs], contextual nasal [gṼns], and noncontextual nasal [gṼs] continua for Portuguese speakers.

4. Discussion and Conclusion

The results of the experiment showed that Spanish speakers produced more /u/ responses in both nasal conditions than in the oral condition. Portuguese speaker responses, on the other hand, did not differ significantly in any of the conditions. The fact that Spanish speakers resolved the effects of nasalization as a difference in vowel height supports that they were unable to perceptually undo the effects of nasal coupling in either nasal condition. Portuguese speakers demonstrated that they were able to factor out the effects of nasal coupling with the vowel as evidenced by the fact that they accurately perceived the height of nasal vowels in both nasal contexts. These results in conjunction with the results of Krakow et al. (1988) support that linguistic experience plays a direct role in how speakers resolve the acoustic effects of nasal coupling with the vowel. In each case, listeners were able to perceptually undo the coarticulatory effects only in the environments in which they have experience with nasal vowels. Thus, it would seem that a speaker’s language experience determines the types of coarticulatory influences she is able to perceptually factor out, although other types of coarticulartory influences should be studied to verify this.

The role of language experience in perceiving effects of coarticulation has implications for the fields of second language (L2) acquisition and diachronic sound change. Ohala (1993) notes the parallels between phonetic variation and sound change. For example, allophonic nasalization of vowels before nasal consonants is the environment which most often results in distinctively nasal vowels via sound change (Ohala, 1993). In terms of L2 learners and models of L2 acquisition of phonology, it stands to reason that failure to factor out the effects of coarticulation due to lack of experience with such effects could result in L2 learner difficulty in perceiving certain L2 distinctions. More research is needed to fully understand these implications.

Appendix A

Table AI shows the frequency values for the first three oral formants in all 7 stimuli.

Stimulus	F1 (Hz)	F2 (Hz)	F3 (Hz)
1	225	750	2800
2	262	750	2800
3	300	750	2800
4	337	750	2800
5	375	750	2800
6	412	750	2800
7	450	750	2800

Table AI: F1, F2 and F3 frequency values for seven vowel configurations.

Table AII shows the frequency of the nasal pole (fnp) and zero (fnz) as well as the amount of reduction in F1 amplitude (AF1). In addition, the amplitude of the nasal pole increased from 30 dB to 60 dB over the duration of the (nasal) vowel.

Degree of Nasalization	fnp (Hz)	fnz (Hz)	AF1 (dB)
a	250	310	-5
b	265	365	-6
c	290	420	-7
d	305	475	-8
e	315	528	-8

Table AII: Frequency of nasal pole zero pairs and amount of amplitude reduction of oral F1 for all degrees of nasalization.

References

Beddor, Patricia S. (1993). The perception of nasal vowels. In M. Huffman & R. A. Krakow (Eds.), *Nasals, Nasalization and the Velum* (pp. 171-196). San Diego: Academic.

Beddor, Patricia S., & Gottfried, T. (1995). Methodological issues in cross-language speech perception research with adults. In W. Strange (Ed.), *Speech Perception and Linguistic Experience: Issues in Cross-language Research*. Timonium, MD: York Press.

Beddor, Patricia, & Strange, Winefred (1982). Cross-language study of perception of the oral-nasal distinction. *Journal of the Acoustical Society of America, 71*(6), 1551-1561.

Chen, Marilyn (1997). Acoustic correlates of English and French nasalized vowels. *Journal of the Acoustical Society of America, 102*(4), 2360-2370.

Hall, R. A. (1943). The unit phonemes of Brazilian Portuguese. *Studies in Linguistics, 1*, 1-15.

Hammarström, G. (1962). Review of Carvahlo. *Romance Philology, 15*(3), 350-356.

Harris, James (1984). Autosegmental phonology, lexical phonology and Spanish nasals. In Mark Aronoff & Richard Oehrle (Eds.) *Language, Sound, Structure: Studies in Phonology Presented to Morris Halle by his Teacher and Students*. Cambridge: MIT Press.

House, A. S., & Stevens, K. N. (1956). Analog studies of the nasalization of vowels. *Journal of Speech and Hearing Research, 21*, 218-232.

Krakow, Rena, Beddor, Patricia, Goldstein, Louis, & Fowler, Carol (1988). Coarticulatory influences on the perceived height of nasal vowels. *Journal of the Acoustical Society of America, 83*(3), 1146-1158.

Lotto, Andrew, & Kluender, K. (1998). General contrast effects in speech perception: Effect of preceding liquid on stop consonant identification. *Perception & Psychophysics, 60*(4), 602-619.

Mann, Virginia (1986). Distinguishing universal and language-dependent levels of speech perception: Evidence from Japanese listeners' perception of English "l" and "r". *Cognition, 24*, 169-196.

Ohala, John (1993). The phonetics of sound change. In C. Jones (Ed.), *Historical Linguistics: Problems and Perspectives* (Vol. xiii, pp. 237-277). London: Longman.

Quicoli, A. Carlos (1990). Harmony, lowering and nasalization in Brazilian Portuguese. *Lingua: International Review of General Linguistics, 80*, 295-331.

Reed, D., & Leite, Y. (1947). The segmental phonemes of Brazilian Portuguese: Standard Paulista dialect. In K. Pike (Ed.), *Phonemics*. Ann Arbor: MI: University of Michigan Press.

Schwegler, Armin, Juergen Kempff & Ana Ameal-Guerra (2010). Fonética y fonología españolas, 4th ed. Hoboken, NJ: John Wiley & Sons, Inc.

Solé, Maria-Josep (1992). Phonetic and phonological processes: The case of nasalization. *Language and Speech, 35*(1-2), 29-43.

Werker, Janet, & Lalond, Chris (1988). Cross-language speech perception: Initial capabilities and developmental change. *Developmental Psychology, 24*(5), 672-683.

Wetzels, Leo (1997). The lexical representation of nasality in Brazilian Portuguese. *Probus, 9*, 203-232.

Wright, James (1975). Effects of vowel nasalization on the perception of vowel height. In C. A. Ferguson, L. M. Hyman & J. Ohala (Eds.), *Nasalfest: Papers from a Symposium on Nasals and Nasalization* (pp. 373-388). Stanford, CA: Stanford.

Write, James (1986). The behavior of nasalized vowels in the perceputal vowel space. In J. J. Ohala & J. J. Jaeger (Eds.) *Experimental Phonology* (pp. 45-67). Orlando: Academic.

Yamada, Reiko, & Tohkura, Yohichi (1992). Perception of American English /r/ and /l/ by Native Speakers of Japanese. In Y. Tohkura, E. Vatikiotis-Bateson & Y. Sagisaka (Eds.), *Speech Perception, Production and Linguistic Structure* (pp. 155-174). Tokyo: IOS Press.

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