Are /n+j/ and /ɲ/ Neutralized in Buenos Aires Spanish? An Initial Acoustic Analysis

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1. Introduction

Spanish has three nasal phonemes that contrast by place of articulation: the bilabial nasal, the alveolar nasal, and the palatal nasal. These phonemes contrast only in syllable-initial position, as in ca[m]a 'bed', ca[n]a 'white hair' and ca[ɲ]a 'sugar cane'. In the syllable coda only /n/ is possible, which assimilates to the point of articulation of the consonant that follows. For example, "informe" '*report'* is articulated as [iɱforme], whereas "angel" '*angel*' is [aŋxel] (Hualde, 2005: 174). As a result, Spanish nasals are neutralized in the syllable-coda. Research in Spanish nasals has provided formal (Harris, 1984) and experimental (Kochetov & Colantoni, 2011b) accounts of this (regressive) assimilation process. Another type of assimilation of syllable coda nasals that has been examined is related to the phonologization of vowel nasalization in Romance languages (Hajek, 1997; Sampson, 1999).

The term neutralization refers to the loss or absence of a phonological distinction. The present study examines a reported case of neutralization of Spanish nasals. However, the nasal consonants in this case occupy the syllable onset. Several authors (Malmberg, 1950; Quilis, 1993; Shosted & Hualde, 2010; Tiscornia, 1930) have reported a tendency in Buenos Aires Spanish (BAS) to merge the palatal nasal, /ɲ/, and the sequence alveolar nasal plus palatal glide, /n+j/, such that *uranio* 'uranium' and *huraño* 'unsociable' are neutralized. The study reported here investigates these claims of neutralization of /ɲ/ and /n+j/ in BAS by examining three acoustic cues: duration of the nasal segment, duration of the following vocalic portion, and difference in intensity as a correlate of degree of oral impedance in the target nasal segment.

The following section presents the relevant previous literature motivating the present study. Section 3 addresses the goals of the study and research questions. Section 4 presents the methodology. The results are reported in Section 5 and discussed in Section 6. Finally, final remarks are presented in Section 7.

2. Previous literature

2.1. /ɲ/ as /n+j/ in Buenos Aires Spanish

As early as 1930, Tiscornia (1930) commented on the alternation between nasals in Gaucho speech registered in 19th century Gaucho literature, a literary movement that purported to use the language of the Argentine gauchos. Gaucho refers to residents of the South American pampas, who became an important part of Argentine cultural tradition. Tiscornia posited two groups of nasal alternations: [n+j] becoming [ɲ], as in *demoño* /demónio/ 'demon' and *opiñón* /opinión/ 'opinion', and [n] becoming [ɲ], such as *ñudo* /núdo/ 'knot' and *giñebra* /xinébɾa/ 'gin'. Observations of this variation were also reported in works that take a dialectological perspective. For example, Henríquez Ureña (1938) reported cases of depalatalization in the Northeastern portion of Argentina, where *niño* /níɲo/ 'child' becomes [nínjo]. In contrast, Malmberg (1950) reports that the sequence [n+j] in Argentina does not present special characteristics when compared to other dialects. He observes that an accidental palatalization in fast and relaxed speech is common even among educated speakers. As a result, *Alemania* /alemánia/ 'Germany' is realized as [alemáɲa]. Malmberg points out, however, that this palatalization disappears in slow or emphatic speech. More recently, Kochetov and Colantoni

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(2011a), in an electropalatographic study with five speakers of BAS, found that some speakers maintain the distinction, some speakers realize /ɲ/ as /n/, and some speakers produce both /ɲ/ and /n/ as palato-alveolars. In sum, these works show that there is variation in the realization between /ɲ/ as /n+j/ and that this variation is (potentially) leading to neutralization of the contrast between /ɲ/ as /n+j/.

2.2. Neutralization and Incomplete Neutralization

A loss of contrast means the absence of a phonological distinction. For example, we see a case of neutralization between /θ/ and /s/ in Latin American Spanish. While Peninsular Spanish contrasts these two sounds, Latin American Spanish has merged them. As a result, *casa* /kása/ 'house' and *caza* /káθa/ 'hunt' in Latin American Spanish are rendered as /kása/, and they are phonetically indistinct. However, research on neutralization shows that sometimes contrast reduction is not complete. Instead, speakers produce differences, but these differences are very small. This is termed incomplete neutralization (Port & O'Dell 1985).

Incomplete neutralization has been thoroughly examined in languages with stop coda devoicing. For example, in German, the voicing contrast between obstruents is maintained word medially, such as in *alben* 'elves' and *alpen* 'mountain pastures', but it is neutralized in their singular counterparts, *alb* and *alp*, respectively, where the obstruent is word-final. In both cases, the word-final obstruent is realized as voiceless, that is, as *al[p]*. Research by Port and O'Dell (1985) shows that the vowel before the underlying voiced stop is longer, and the stop closure shorter. Even though these differences are small, they are statistically significant, which means that speakers demonstrably produce differences. In Spanish, we see a case of incomplete neutralization in coda liquids in Puerto Rico Spanish (Simonet, Rohena Madrazo & Paz, 2008). Simonet et al (2008) found that although coda /r/ resembles /l/, there were systematic durational and spectral differences. More specifically, /l/ was longer than /r/, and /r/ had a higher F1, and a lower F3 than /l/. Thus, it is evident that neutralization of two categories can be partial. Incomplete neutralization is also characterized by the fact that listeners are often able to perceive the small acoustic differences, though their performance in perceptual tasks is slightly better than at chance level (Port & O'Dell, 1985; Warner, Jongman, Sereno & Kemps, 2004, among others) This suggests that, although listeners can tell apart the merging sounds, it is not a typical phonemic distinction, which listeners can distinguish very clearly.

The goal of the present paper is to offer an initial acoustic characterization of /ɲ/ and /n+j/. For this reason it will not explore the perception of the /ɲ/ - /n+j/ distinction, as it falls beyond the scope of the study. In order to examine more closely the reports of neutralization of /ɲ/ and /n+j/ mentioned earlier, this study compares productions of these two categories by native speakers of BAS by examining acoustic correlates that previous research has reported as phonetic cues used to implement the contrast. The next section reviews studies that contribute to our knowledge of the acoustic characteristics of nasal Spanish nasals, and /ɲ/ and /n+j/ in particular.

2.3. Acoustic characteristics of /ɲ/ and /n+j/

The present study constitutes a preliminary analysis as it only explores three acoustic correlates: duration of the nasal segment, duration of the following vocalic portion, and degree of oral impedance. Other potential cues include formant transitions into the following vocalic portion, spectral characteristics of the nasal segment, and anti-resonances. These will not be explored in the present study and will be addressed in future research.

Several studies examining the acoustics of nasal segments include the duration of the nasal segment as a contrasting feature. Figure 1 summarizes the findings in Albalá (1992), Massone (1988), Machuca Ayuso (1991), and García and Rodríguez (1998). Overall, they show that the palatal nasal is consistently longer in phonetic duration than the bilabial and alveolar nasals. These studies differ by dialect of Spanish studied and elicitation techniques, which may account for the differences found in the values reported. In all cases, values represent the duration of the Spanish nasal phonemes in intervocalic position and in unstressed syllables. Given that Machuca Ayuso (1991) incorporates two tasks (spontaneous and laboratory speech), there are two bars that represent the data in said study.

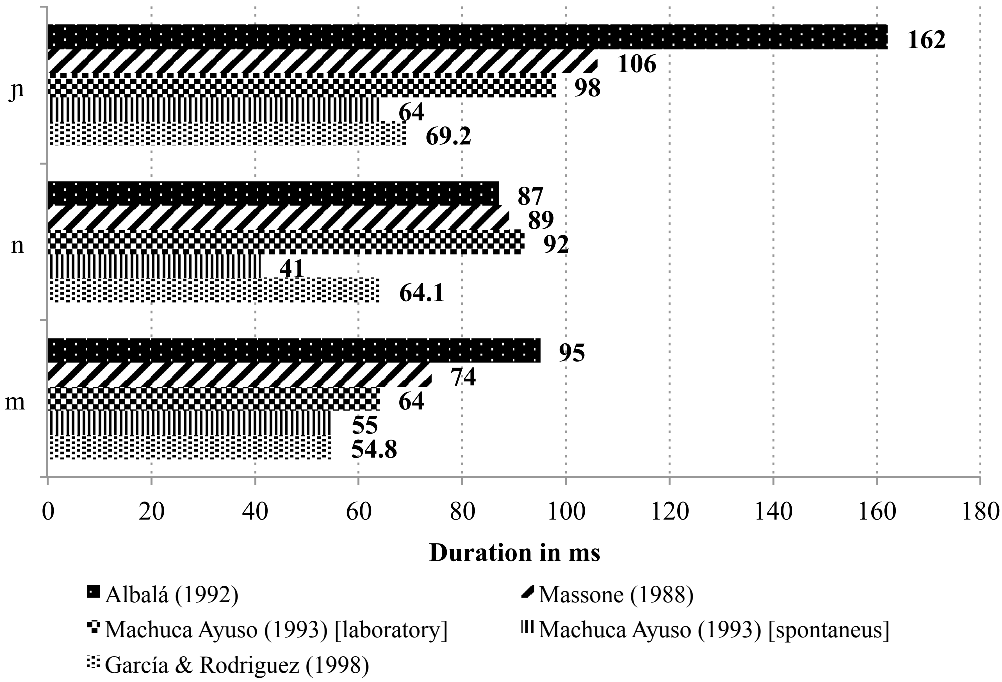

Figure 1. Duration of nasal segments in Albalá (1992), García Rodríguez (1998), Machuca Ayuso (1991), and Massone (1988)

In addition to duration of the nasal segment, the experimental literature also comments on the duration of the following vocalic portion. The categories under analysis diverge in terms of the following vocalic portion. The palatal nasal is followed by a monophthong, whereas the alveolar nasal in the sequence /n+j/ is followed by a diphthong. For Martínez-Celdrán and Fernández Planas (2007), the differences in pairs such as *ge[nj]o-empe[ɲ]o* 'genius-determination' are not only phonological, but also phonetic. The sequence /n+j/ incorporates a glide element that constitutes a full glide (*semivocal plena*). The palatal nasal, on the other hand, can incorporate [j] as a glide element (*elemento semi-vocálico*), but this glide is solidly connected to the palatal nasal. According to Martínez Celdrán and Fernández Planas (2007: 127), the full glide in /n+j/ is 98ms long, while the duration of the glide element is 59ms. Additionally, the following vowel is longer with /ɲ/, which measures 79ms, compared to that in /n+j/, which is 49ms long. Thus, the duration of the following vocalic portion (the vowel or the glide and the vowel) constitutes a compensatory strategy for maintaining the contrast.

Another acoustic cue that has been explored is the degree of oral impedance. In a recent study, Shosted and Hualde (2010) investigated differences in intensity as a correlate of the degree of oral constriction in palatal consonants in Brazilian Portuguese (BP) and Puerto Rican Spanish (PRS) with airflow and acoustic measures. The aim of their study was to examine the occlusive characteristics of <*nha*>, whether articulated as [ɲ] or [j̃], and *nia* in BP by contrasting it with Spanish <*ñ*> and <*nia*>, respectively. The idea is that the nasal consonant would present higher degrees of constriction when compared to a nasalized glide. For this purpose, the degree of oral impedance was determined by measuring the minimum intensity value in the production of the nasal segment and the maximum intensity value in the following vocalic portion, and calculating the difference between these two measurements. Higher intensity difference values indicate greater oral impedance. In their results, they found that that /ɲ/ is more occluded than /n+j/, which in turn is more occluded than /j/. In other words, differences in intensity between the nasal segment and the following vocalic portion were larger with /ɲ/ than with /n+j/. However, these differences were only statistically significant for the BP data. Nevertheless, the study shows that the trend holds for PRS.

To sum up, the cumulative message in these studies is that two sound categories that have been reported as merging can still show acoustic differences on a number of phonetic cues to implement the contrast. To this end, the next section introduces the research questions and the hypotheses under examination.

3. Aim of the study

The aim of this study is to provide a preliminary acoustic characterization of BAS /ɲ/ and /n+j/ by investigating duration of the nasal segment, duration of the following vocalic portion and degree of oral impedance. The previous research indicates that /ɲ/ is longer, and more occluded than /n/. In addition, the vocalic portion following /ɲ/ is longer than what follows /n/ in the sequence alveolar nasal plus palatal glide, /n+j/.

The research question that guides this investigation asks whether there are differences between /ɲ/ and /n+j/ in terms of the three acoustic cues mentioned above. There are three hypotheses. The first hypothesis says that that /ɲ/ and /n+j/ are completely neutralized. In this case, speakers would show no acoustical differences in their production; /ɲ/ and /n+j/ would not be different in terms of the duration of the nasal segment or the following vocalic portion, nor with regards to the degree of oral impedance. The second hypothesis is that /ɲ/ and /n+j/ are not neutralized (i.e., they are fully contrastive). This hypothesis would mean that speakers produce robust differences in the acoustic cues studied here. Finally, the third hypothesis is that /ɲ/ and /n+j/ are incompletely neutralized. In this case, there would be small, yet significant (i.e., systematic), acoustical differences between the categories.

4. Methodology

4.1. Participants

The informants for the study were six speakers, three women and three men, from Buenos Aires, Argentina. At the time of recording, their ages ranged between 28 and 30 years and they were attending college or pursuing graduate studies. Three of them lived in the Federal District (speakers ML, AIM and MJM) and three of them in the greater Buenos Aires area (speakers GM, NM and MFS). All had prior knowledge of foreign languages (English or French). The informants were recruited through social networks of the author. Table 1 summarizes the information regarding the informants.

	Speaker	**Sex**	**Education**	**Age**
1	ML	Male	College in progress	31
2	GM	Male	College completed	29
3	NM	Male	College in process	29
4	AIM	Female	College completed	29
5	MFS	Female	College completed	28
6	MJM	Female	Graduate school in progress	30

Table 1. Description of participants

4.2. Data elicitation

4.2.1. Recording

The data were recorded in Buenos Aires during July and August of 2012, in the home of the participants. Elicited speech was recorded using a Shure WH20 head-mounted microphone connected to a TASCAM DR-100. The recording session began with a brief interview to familiarize the informants with the microphone. During this time, participants completed the background questionnaire and signed a statement of informed consent. Next, participants read carrier phrases with embedded target words.[1]

[1] Speakers 4 (AIM) and 5 (MFS) also completed a contextualized picture-description task presented in PowerPoint and read a list of nonce words. The current analysis considers only the data elicited from the carrier phrases.

4.2.2. Materials and corpus

Participants read three repetitions of the target words embedded in the carrier phrase *Digo {target word} para ti* 'I say {target word} for you'. The target words consisted of the same stimuli used by Shosted and Hualde (2010), which include the palatal nasal and /n+j/ in unstressed position followed by [a]. The segments preceding /ɲ/ were /a e i o u/. For /n+j/, the alveolar nasal was preceded by /a o e/[2]. Words in (1) below present examples of the stimuli. Words in column (a) include the palatal nasal, indicated orthographically with "ñ", whereas column (b) presents words with /n+j/, indicated orthographically with "ni".

(1) a.	*araña*	'spider'	b.	*Alemania*	'Germany'
	leña	'firewood'		*Armenia*	'Armenia'
	doña	'Mrs'		*colonia*	'cologne'

The set of carrier phrases elicited a total of 120 tokens per speaker. However, some participants made mistakes with words such as *venia* 'authorization' and *tenia* 'tapeworm', which they read as *venía* 's/he arrived' and *tenía* 's/he had', and therefore, these tokens were excluded from the analysis. A total of 716 tokens were extracted. Of those 716 tokens, 18 tokens were eliminated from the analysis given that they lacked clear closure and/or release (72% of the eliminated tokens were produced by male speakers). Therefore, a total of 698 tokens were analyzed using Praat (Boersma and Weenik, 2010, version 5.2.0.7).

4.3. Instrumental analysis

For the durational measurements, the nasal segment was defined by the visual presence of an abrupt change in the spectrogram (Ladefoged, 2005) and lower formant frequencies. A decrease of amplitude in the waveform was also taken into consideration to confirm the spectrogram readings.

As previously mentioned, /ɲ/ is followed by a monophthong whereas that following /n+j/ is a dipthong, namely [ja]. Given that previous research (Kochetov & Colantoni, 2011; Massone, 1988; Martinez Celdrán & Fernandez Planas, 2007) has referred to a potential intermediate glide /ɲ/, for this study, it was decided not to divide the diphthong after /n+j/. Therefore, the duration of the following vocalic portion represents [a] in the case of /ɲ/, and [ja] in the case of /n+j/. In order to take durational measurements, the onset of the vocalic portion was defined as the point of release of the constriction of the previous nasal consonant, as indicated by an increase in energy in the region of F2. The vowel offset was defined as the point of complete constriction of the following consonant, /p/, defined as the end of energy in the region of F2.

Measurements of relative intensity as a correlate of degree of oral impedance were calculated following Shosted and Hualde (2010). Acoustic intensity curves were generated for the target nasals using the standard settings in Praat 5.2.0.7. Next, maximum intensity value during the vocalic portion and the minimum intensity reading in the target nasal were measured, as shown in Figure 2, and the difference between the two calculated. Figure 2 below identifies the measurement landmarks discussed above.

[2] As a preliminary analysis, this study followed previous studies closely, including using the stimuli from previous research. However, it is a limitation of this study that the vowels preceding each category differ. In future research, the contexts surrounding the two categories under investigation will be balanced and examined more carefully.

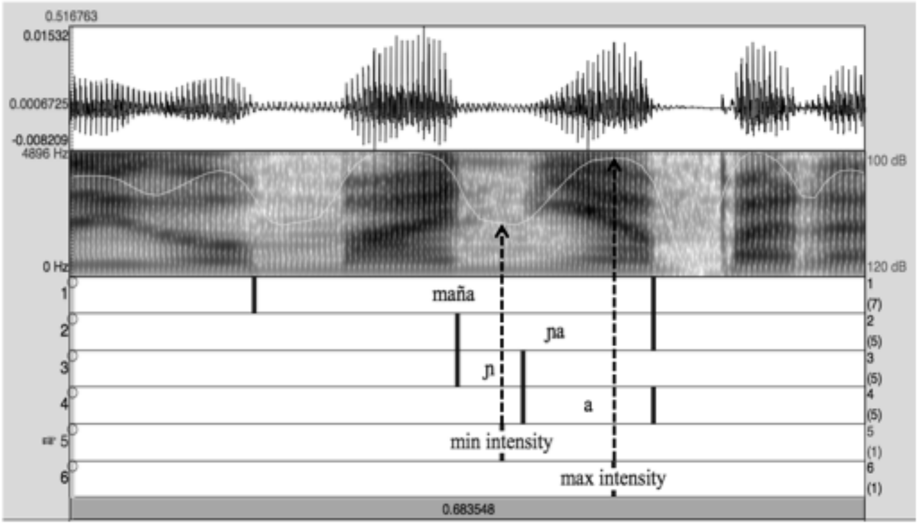

Figure 2. Example of an annotated token of /ɲ/ from speaker 5, MFS, in the word *maña* ‘skill’

4.4. Statistical analysis

Data were fitted to linear mixed-effects models setting “speaker” as a random effect in SPSS 20. The models were submitted to repeated measures ANOVA with measures from each token. The dependent variables were duration of the nasal segment, duration of the vocalic portion and difference in intensity.

Because sound differences in Argentine Spanish have been shown to previously vary by speaker sex (for intonation: Enbe & Tobin, 2008; for /s/: Fontanella de Weinberg, 1978; for palatal obstruents: Wolf & Jiménez, 1979), it was decided to include gender of the speaker as an independent variable, to account for any potential differences between males and females. Thus, the independent variables were the target nasal consonant (ɲ / n+j) and gender of the speaker (female / male).

5. Findings

In this section the results for duration of the test consonants are presented first, followed by duration of the vocalic portion, and difference in intensity.

5.1. Duration of the nasal segments

Mean duration of /ɲ/ and /n/ is shown in Figure 3. The results reveal that on average /ɲ/ is 5 ms longer than /n/. While across the sample /ɲ/ measures 59.9 ms (SD = 21), /n/ is 54.3 ms long (SD = 16). Despite this small difference, the independent variable “nasal consonant” was significant, $F(1, 710.014) = 32.938$, $p < .001$. This result indicates that across the sample /ɲ/ is systematically longer than /n/. As for differences by gender, females produced slightly longer segments than males, both for /ɲ/ and /n/. Females produce a /ɲ/ 61.8 ms long and a /n/ that measures 55.6 ms. For males, /ɲ/ is 58 ms and /n/ is 52.8 ms. The statistical analysis revealed that the independent variable “gender” was not significant. That is, males and females do not produce systematically different nasal segments.

The reader should note considerable variation in the realization of /ɲ/ and /n+j/. Figure 3 shows a great number of outliers, mostly with /ɲ/, which suggests that its realization is more unstable. Additionally, Figure 4 shows inter- and intra-speaker variation. The size of the whiskers for each individual speaker indicates that speakers have wide ranges in the length of the nasal segment, and that /ɲ/ and /n+j/ overlap to a large extent. Additionally, Figure 4 shows that two speakers, namely speakers 3 and 4, are producing longer segments, while speakers 1 and 2 are producing shorter segments.

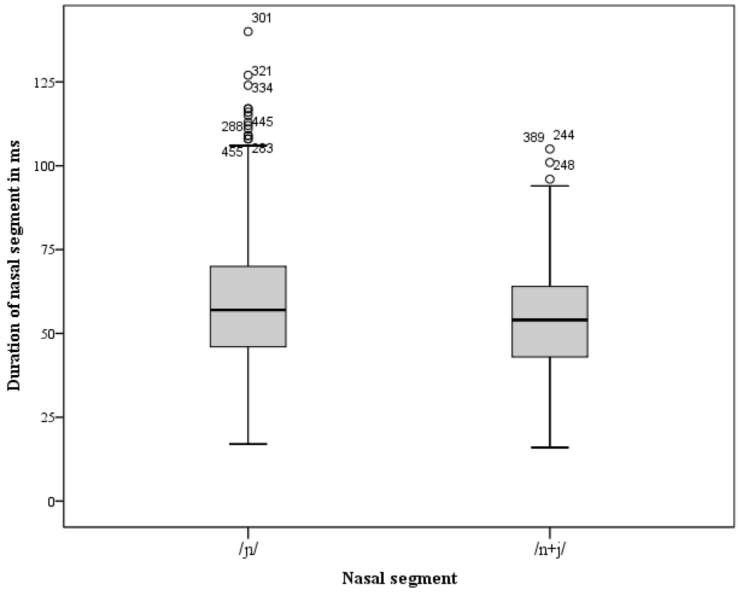

Figure 3. Boxplots for duration of target nasal segment in ms. N= 698

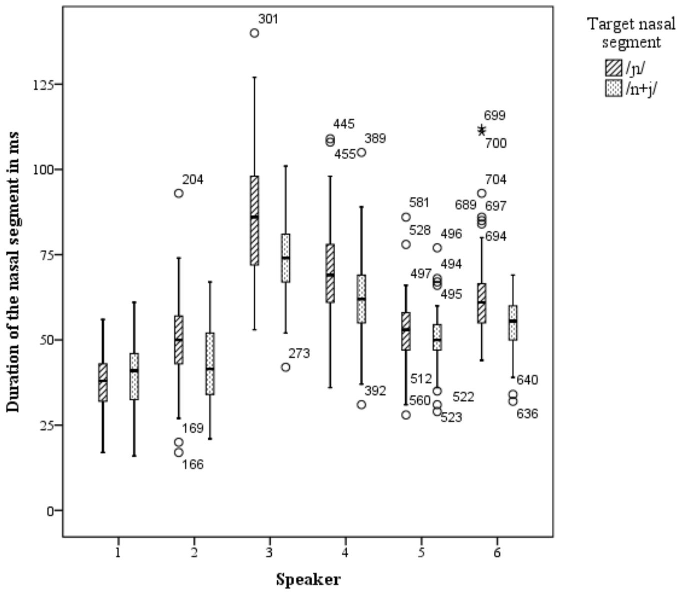

Figure 4. Boxplots of duration of nasal segment in ms per target nasal segment and per speaker. Speakers 1-3 are males. Speakers 4-6 are females. N= 698.

5.2. Duration of the following vocalic portion

Mean duration of the following vocalic portions, namely /a/ and /ia/, is shown in Figure 5. The mean value of the vocalic portion for /ɲ/ is 118.8 ms long (*SD* = 33), and that of /n+j/ measures 119.4 ms (*SD* = 35). With regards to differences according to gender, males produce longer following vocalic portion than females. For men, on average, the following vocalic portion after /ɲ/ and /n/ measures 128 ms (*SD* = 37.5) and 132 ms (*SD*= 44.6), respectively. In the case of women, the mean value of the following vocalic portion for /ɲ/ is 109 ms long (*SD*= 24) and 108 ms (*SD*= 17), for /n/. The statistical analysis revealed that neither independent variable (i.e, neither the target nasal consonant nor the gender of the speaker) was statistically significant. In other words, while on average the following vocalic portion is longer with /n+j/ than with /ɲ/, and women produce smaller portions, these differences are not systematic.

As with duration of the nasal consonant, Figures 5 and 6 show large variability. In Figure 5 the number of outliers stands out, which indicates the degree to which the data is spread out. Figure 6 shows mean duration values by speaker. Speaker 3, who produced the longest nasal segments, is also producing the longest following vocalic portions, which suggests that this particular speaker could be hyper-articulating.

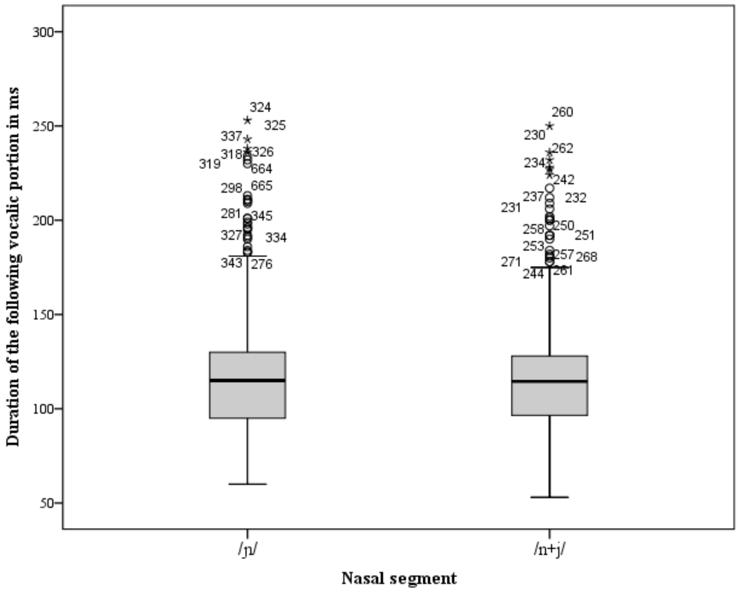

Figure 5. Boxplots of duration of the following vocalic portion per target nasal segment in ms. N= 698

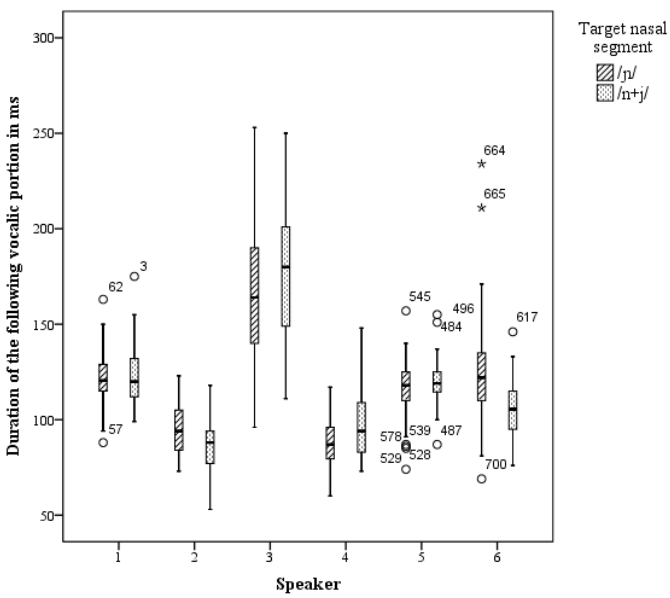

Figure 6. Boxplots of duration of the following vocalic portion in ms per segment and per speaker. The following vocalic portion with /ɲ/ is /a/, whereas that of /n/ is /ia/. Speakers 1-3 are males. Speakers 4-6 are females. N= 698

5.3. Difference in intensity as a reflection of oral impedance

Figure 7 presents the differences in intensity for /ɲ/ and for /n+j/. Figure 8 shows differences in intensity according to segment and speakers. The results reveal that /ɲ/ is slightly more constricted than /n+j/. The mean difference in the case of /ɲ/ is 8.88 dB (*SD* = 4.31), whereas with /n+j/ it is 8.65 dB (*SD* = 4.52). As with duration of the nasal segment, the independent variable "nasal consonant" was significant, $F(1, 710.005) = 8.504$, $p < .005$. Even though mean values are very similar, the statistical results indicate that /ɲ/ is systematically more constricted than /n+j/.

Mean values for female and male speakers are similar. For /ɲ/, mean value for females is 10.89 dB (*SD* = 4.75) and for men is 6.82 dB (*SD* = 2.49). In the case /n+j/, on the other hand, the difference in intensity for females is 10.67 dB (*SD* = 2.46) and for men, 6.43 dB (*SD* =2.46). These values suggest that females and males do not differ in the degree of oral impedance. In fact, and in tandem with durational measurements, gender was not found to be statistically significant in terms of difference in intensity measurements either. Thus, in terms of degree of oral impedance, men and women do not produce systematically different /ɲ/ and /n+j/.

Mean values per speaker in Figure 8 show that in all cases the palatal nasal presents a higher degree of oral impedance. The size of the whiskers shows the amount of intra-speaker variation, which indicates that the distribution is spread out at the individual level as well. Nevertheless, this phonetic cue also shows considerable inter-speaker variation. Speakers 1, 2 and 6 are producing the least constricted nasal segments, whereas speaker 5 produces the most constricted.

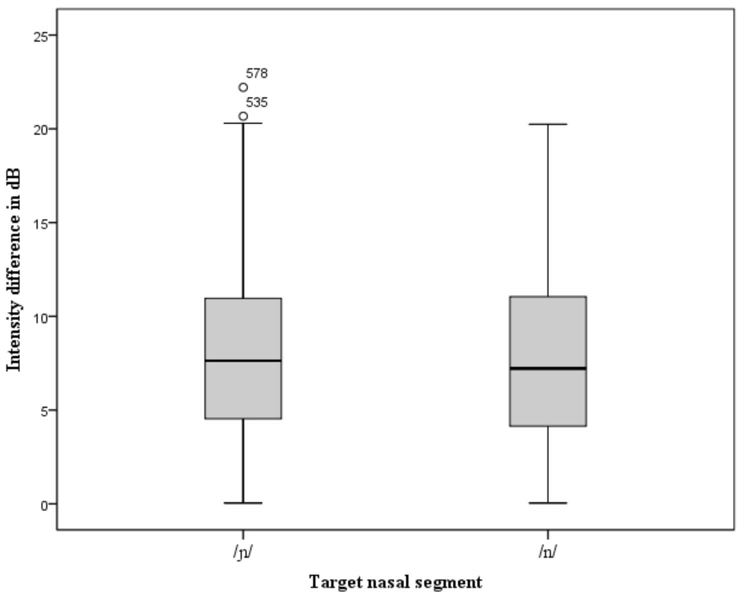

Figure 7. Boxplots of difference in intensity per target nasal segment in dB. N= 698

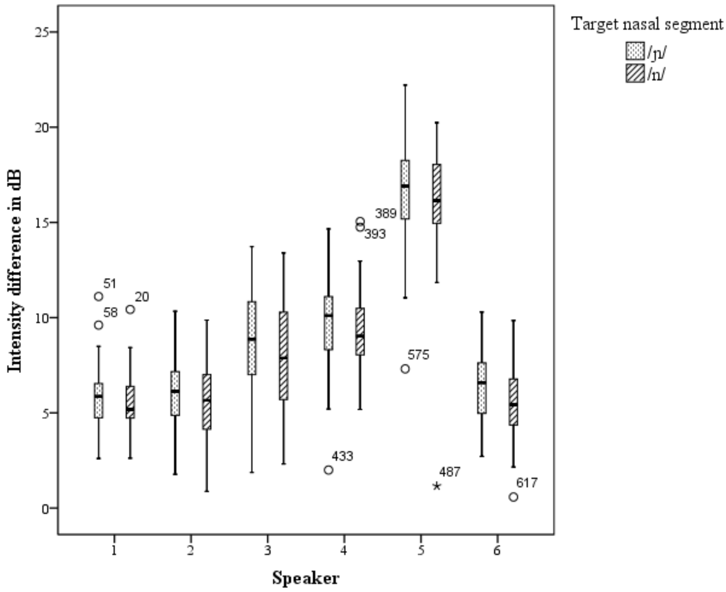

Figure 8. Boxplots of difference in intensity in dB, per segment and per speaker. Speakers 1-3 are males. Speakers 4-6 are females. N= 698

5.4. Summary of the results

Table 2 presents a summary of the results, before moving on to the discussion. Given that gender was not significant for any of the measurements, it is not included in the table.

Measurement	***M (SD)***		***n.df***	***d.df***	***F***	***p*-value**
	/ɲ/	**/n+j/**				
Duration of nasal segment (in ms)	59.9 (21)	53.4 (16)	1	710.014	32.938	<.001
Duration of following vocalic portion (in ms)	118.8 (33)	119.4 (35)	1	710.009	.002	n.s
Difference in intensity (in dB)	8.88 (4.31)	8.65 (4.52)	1	710.005	8.784	<.005

n.s= not significant; n.df= numerator degrees of freedom; d.df = denominator degrees of freedom

Table 2. Summary of results

6. Discussion

The primary aim of this study was to provide an initial acoustic analysis of /ɲ/ and /n+j/, as a first step in addressing the claims of phonological merger in BAS. For this purpose, three phonetic cues that previous literature has identified as cues for implementing the phonemic contrast between /ɲ/ and /n+j/ were investigated. These were duration of the nasal segment, duration of the following vocalic portion and different in intensity as a proxy for degree of oral impedance.

The research question asked whether /ɲ/ and /n+j/ were different in terms of the acoustic cues under examination. Mean values show that, as predicted based on the previous literature, the palatal nasal is longer, its following vocalic portion is shorter, and the difference in intensity is greater than with /n+j/. However, the differences between the two categories for each of the phonetic cues under study were very small. On average, the difference between categories in duration of the nasal segment is 5 ms; for the following vocalic portion the difference in duration is 0.6 ms; and, for degree of oral impedance the difference is 0.23 dB. Nevertheless, the statistical analysis revealed that the duration of the nasal segment and the difference in intensity were significant, but not the duration of the following vocalic portion. While statistical significance does not indicate phonemic affiliation, it does draw attention to the fact that these acoustic differences are systematic. In other words, in the data under analysis the palatal nasal appears to be systematically (slightly) longer and (minimally) more occluded than the alveolar nasal in the /n+j/ sequence. It is possible that an examination of other phonetic features (for example, formant transitions into the following vocalic portion) may reveal robust distinctions between /ɲ/ and /n+j/. To this end, future acoustic analyses should incorporate other measurements to further examine the alleged merger.

Despite these results, it should not be lost from sight that the fact that there are acoustic (statistical) differences between the categories under analysis does not automatically mean that these differences are phonological. While /ɲ/ and /n+j/ might be consistently different, the differences might not be perceptible. In other words, do listeners hear these differences? It is very well possible that these differences are below the threshold of perception, and as a result perceptually irrelevant. Nevertheless, research on the perception of incomplete neutralization shows that listeners can often make use of the small acoustical differences to distinguish between merging categories, though their performance is only above chance (Port & O'Dell, 1984; Warner et al, 2004, among others). Therefore, at this juncture, it is not possible to conclude that /ɲ/ and /n+j/ are contrastive until the perception of these categories has been addressed as well. This is a question for future research to examine.

The results show considerable variability. First, both segments present a wide range in their production as evidenced by the widespread whiskers in Figures 2 through 8. Additionally, the figures also show a great number of outliers, which points to the instability of these two categories. Variation at the individual level also offers evidence as to the instability of /ɲ/ and /n+j/. For the phonetic cues under analysis, speakers' productions of these two categories overlap consistently.

In addition to intra-speaker variation, there is substantial inter-speaker variability as well. Speakers appear to be doing different things. For example, the mean values for speakers 3 and 4 on all three acoustic cues analyzed are in the direction expected in light of the previous literature presented in Section 2 (i.e., for the palatal nasal, a longer nasal segment, a shorter following vocalic portion, and greater degree of oral impedance). For other speakers, on average, /ɲ/ and /n+j/ are articulated differently only in terms of the duration of the nasal segment and the degree of oral impedance (speakers 2, 5 and 6), or in terms of the duration of the following vocalic portion and the degree of oral impedance (speaker 1). It appears then that individual speakers employ different strategies. Still, it is evident that even though there is wide inter-speaker variation, no speaker produces robust differences between /ɲ/ and /n+j/. This inter-speaker variability goes in hand with the findings in Kochetov and Colantoni (2011), who show that some participants articulate /ɲ/ and /n/ differently, while others merge them by producing /ɲ/ as /n/ or by producing both as palato-alveolars. The results in the present study add evidence to the reported variability. Thus, future examinations of the merger of /ɲ/ as /n+j/ in BAS have to include the individual in the analysis.

Given that the participant sample included males and females, it was decided to include gender as a variable in the statistical analysis. Results show that the production of /ɲ/ and /n+j/ is not conditioned by gender. While overall females produce (to a small degree) longer nasal segments, and shorter following vocalic portions, the analysis of the data revealed that gender was not statistically significant for any of the phonetic cues examined here. This means that male and female speakers in the data set under study do not differ systematically in their production of /ɲ/ and /n+j/. However, speaker 3, a male, does not pattern with the males and sometimes exhibits even higher duration values than those of the females. Thus, it is possible that this one speaker is influencing the distribution of the data such that the differences between the genders are not statistically significant.

Going back to the issue of neutralization, the present study examined three hypotheses. According to the first hypothesis, in the case of a phonological merger, /ɲ/ and /n+j/ would not to differ in any of the phonetic cues. On the other hand, if /ɲ/ and /n+j/ were contrastive they would show systematic differences. The third hypothesis was that there would be small, yet statistically significant, acoustical differences. This third scenario is the one of incomplete neutralization. The results in the current study show that the contrast between /ɲ/ and /n+j/ is not robust. It was found that there are minimal differences between /ɲ/ and /n+j/. However, these differences are in the expected direction to claim that the sounds are contrastive, based on the previous literature on Spanish nasals. Even though differences are very small, they are systematic, as evidenced by the fact that they were statistically significant (in the case of the duration of the nasal segment and the difference in intensity.) For these reasons, the results reported here suggest that the contrast between /ɲ/ and /n+j/ is a likely candidate for incomplete neutralization. In order to claim that they are incompletely neutralized, other phonetic cues have to be examined. It is possible that /ɲ/ and /n+j/ exhibit more robust differences in, for example, formant transition. Therefore, future studies could continue to investigate these /ɲ/ and /n+j/ in greater detail.

Additionally, it should not be noted that incomplete neutralization is positional. That means that the phonological categories are contrastive in some environments but not others. For example, German stops are contrastive intervocalically, but are incompletely neutralized word-finally. The present study compared /ɲ/ and /n+j/, but excluded the examination of the alveolar nasal followed by a monophthong, that is /na/. This comparison is fundamental to establish the extent to which the palatal nasal has merged with the alveolar nasal in BAS, and under which phonological environments.

Furthermore, in cases where the language represents the phonological distinction in writing, research shows that differences result from hypercorrection while participants are reading. Specifically, Fourakis and Iverson (1984) found that in more naturalistic contexts, as opposed to controlled speech, the neutralization of German final obstruents was complete. Spanish represents the /ɲ/ and /n+j/ distinction in its spelling. The palatal nasal is represented with <ñ> and /n+j/ is represented with <ni>. Additionally, the task performed by the participants in the present study involved reading. Therefore, it is possible that /ɲ/ and /n+j/ may in fact by completely neutralized if we were to elicit more spontaneous speech. As previously mentioned, Malmberg (1950) pointed out that the accidental palatalization in fast and relaxed speech was common even among educated speakers and that it disappeared in slow or emphatic speech. Anecdotally, several speakers commented that they had read the carrier phrases making an effort to produce a distinction, even though participants in the present study were instructed to read as naturally as possible. Future research could address this issue by comparing data from more than one elicitation technique.

7. Final remarks

The present study examined three potential cues to the /ɲ/ and /n+j/ contrast in BAS: duration of the nasal consonant, duration of the following vocalic portion, and difference in intensity as a correlate of degree of oral impedance. Overall, it was found that /ɲ/ is systematically slightly longer and more constricted than the nasal in /n+j/. Nevertheless, the results show considerable inter- and intra-speaker variability in the production of both segments. The analysis also revealed that gender of the speaker did not account for the differences found between /ɲ/ and /n+j/.

The results in this study suggest that /ɲ/ and /n+j/ are incompletely neutralized. However, future research should investigate this possibility further by examining other phonetic cues, and investigating perception of these categories by native speakers of BAS.

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