Nasal variability and speech style: an EPG study of word-final nasals in two Spanish dialects

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Nasal consonants are notoriously prone to variation caused by various phonetic and sociolinguistic factors. A study of nasal variability in Spanish is of particular interest, as Spanish dialects neutralize their three-way nasal place contrast in coda position to either alveolar or velar nasals. For example, in Peninsular and Argentine Spanish final nasals are realized as alveolar, while in Caribbean varieties as velar. A number of sociolinguistic studies have concentrated on nasal variability in velarizing dialects. However, cross-dialectal comparisons have mostly relied on auditory-based transcriptions of sociolinguistic interviews, and articulatory investigations of velarizing Caribbean dialects are so far lacking. The goal of this paper is to compare electropalatographic (EPG) data on the realization of the vowel + nasal sequence in word-final position in two Spanish dialects – Buenos Aires, Argentina and Havana, Cuba – across three different speech styles: reading a wordlist, reading a short text, and retelling a story. Data collected from three female speakers representative of each dialect showed the expected differences in the realization of the final nasal in Argentine (alveolar) and Cuban Spanish (velar). Unexpected realizations of alveolar nasals were found in one Cuban speaker's productions in specific segmental and prosodic contexts. Interesting style-related differences emerged between the dialect groups: whereas both groups showed more weakening in less-controlled tasks, the degree of weakening was considerably higher for the Cuban speakers. Finally, some previously undescribed contextual effects were observed; such as a higher rate of incomplete alveolar and possibly vocalized realizations of nasals between back vowels for the Argentine speakers, and blocking of velarization after front vowels for one of the Cuban speakers.*

1. Introduction

Nasal consonants have been shown to be particularly prone to contextual variation in many different languages. Nasals tend to exhibit a higher degree of linguopalatal contact in prosodically strong positions, show signs of deocclusivization in intervocalic position, assimilate in place and/or manner to a following consonant, or simply vocalize in

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prosodically-weak positions (Jun 1995, Fougeron 2001, Honorof 2003, Shosted & Willgohs 2006, Cho & Keating 2009, Shosted & Hualde 2010, among others). In addition to this phonetic variation, the production of nasal consonants is subject to variation caused by sociolinguistic factors, such as dialect and social class, as well as by speech style or rate (Cedergren 1973, Shockey & Farnetani 1992, Lipski 1994).

Spanish is a particularly interesting test case to study nasal variability. First, the language has a three-way place contrast in onset position between a bilabial, alveolar and palatal nasals (e.g., [ˈkama] *cama* vs. [ˈkana] *cana* vs. [ˈkaɲa] *caña* 'bed, grey hair, cane/pole'), which is neutralized to a single nasal place in syllable- and word-final position. When followed by consonants, nasals assume the place and sometimes the manner of those consonants (e.g., *un pan* [um pan] 'a piece of bread'; Navarro Tomás 1918; Quilis 1993). Before word-initial vowels or utterance-finally, nasals are realized as either alveolar or velar, depending on the variety ([pan] or [paŋ]). Second, numerous sociolinguistic studies have investigated factors conditioning the realization of final nasals in velarizing varieties. Previous research, however, has paid considerably less attention to the role of some contextual factors, such as the type of vowel preceding or following the nasal consonant and the role of prosodic variables, such as stress or the position in the utterance (see section 2.1 below). More relevant for the present volume, most previous studies relied on auditory impressions and transcription, or, at best, on acoustic analysis, providing conflicting results regarding nasal realization or the role of social class and style (see section 2.1 below).

The goal of the current paper is twofold. First, we investigate the realization of word-final nasals across dialects in non-velarizing (Buenos Aires) and velarizing (Havana) Spanish varieties. Second, we examine the variation of nasals in the two dialects across three different speech styles: the reading of a wordlist, the reading of a text and telling a story. As a method, we use electroplatography (EPG), which is particularly suited to study this type of variation. EPG allows one to capture both categorical and gradient variability in the degree of constriction; the latter can be easily missed either by the auditory transcriptions that have been used in previous sociolinguistic studies or by an acoustic analysis (see Wright & Kerswill 1989, Kerswill & Wright 1990). Phonetic EPG studies, however, usually focus on the analysis of words produced in isolation or embedded in a carrier sentence. Analyses of semi-spontaneous speech are few and limited to a handful of languages (Shockey 1991 on British English, Shockey & Farnetani 1992 and Farnetani 1995 on British English and/or Italian, Nicolaidis

2001 on Greek). None of the studies, to our knowledge, compare articulation of segments across various styles.

Drawing from the experimental design largely used in sociolinguistic research, we will compare here coda nasals produced in three different styles that are expected to vary in the degree of attention paid to speech (Labov 1972). As we will see in the results section (see section 5), and discuss in section 7, there are interesting pros and cons for the use of less controlled tasks to study phonetic variability. Before presenting the results we will provide a brief overview of sociolinguistic, instrumental and diachronic studies on the realization of coda nasals in section 2, followed by our predictions in section 3 and a discussion of the methodology at length in section 4.

2. Synchronic and diachronic variation in the realization of coda nasals

2.1. Coda nasals in Argentine and Cuban Spanish

Coda nasals are reported to be less constricted than onset nasals across Spanish varieties. Navarro Tomás (1918: §110), in his pioneering static palatography study of Peninsular Spanish, observed a general tendency to have a "relaxed" pronunciation in word-final codas, and even occasional velarized realizations. Beyond this general observation, Spanish dialects are known to differ in the realization of word-final coda nasals; indeed the realization of such nasals has been proposed as one of the features to classify dialects (Canfield 1981, Lipski 1994). Thus, a distinction can be drawn between dialects that have an alveolar realization, such as Argentine Spanish and many Peninsular dialects vs. dialects that favor a velar nasal, as most Caribbean and some Central American and Peninsular varieties (Lipski 2011, Ramsammy 2011).

Variation in the realization of final /n/ in Caribbean and Central American varieties has attracted the attention of sociolinguists from very early on, since velar nasals can be seen as an intermediate step towards nasal deletion, a process that has been completed in other Romance varieties, such as French or Portuguese. Moreover, given that deletion of final /n/ may have consequences for verbal morphology (final /n/ is a 3rd person plural marker in the verb; e.g., *canta* 's/he sings' vs. *cantan* 'they sing'), some of these studies have explored the role of the functional hypothesis as well, that is, whether the nasal is more likely to be maintained when it carries morphological information (e.g., Poplack 1980).

This body of research has resulted in several generalizations. First, velarization is the most frequent realization in Caribbean Spanish in general, and Cuban Spanish, in particular, with rates varying according to the study and ranging between 59% (Terrell 1975) to 83% (Hammond 1976) in absolute word-final and utterance-final position. Velarization is also frequent before vowels but is usually blocked before consonants, where assimilation in place to the following consonant applies (see Kochetov & Colantoni 2011a, Ramsammy 2011 for articulatory investigations of the phenomenon). The second most frequent variant is either the vocalizations and deletion are the most frequent realizations (not all studies make a difference between these variants), and alveolars come last, with reported frequencies of only 8% or less (Terrell 1975: 3-8% and Hammond 1976: 2%). The second interesting generalization is that although velarization is present in the speech of all socio-economic groups and is frequent in all styles (e.g., Cedergren 1973 for Panama Spanish), vocalization and deletion are more frequent in informal styles (see Cedergren 1973, Poplack 1980, but see Hoffman 2004 for Salvadorian Spanish) and among speakers with lower education (see Cedergren 1973). Finally, related to this, velarization seems to be a dialectal but not a sociolectal marker. As opposed to another well-known variable, coda /s/ deletion, the realization of final /n/ is not subject to hypercorrection in more formal styles, nor does it show convergence to alveolar realizations in dialect contact situations (see Hoffman 2004).

In spite of the amount of sociolinguistic research and the abundance of theoretical analyses (e.g., Piñeros 2006), instrumental works on the realization of nasals in velarizing dialects are scarce. Quilis' (1993: 239) acoustic investigation of Cuban Spanish revealed that the nasal before a pause is realized as velar, accompanied by heavy nasalization of the preceding vowel, or simply as nasalization on the vowel. Before word-initial vowels, however, he observed alveolar nasals in most cases. Unlike in Cuban, the realization of final nasal in Dominican Spanish was noted to be influenced by stress: with velar variants occurring before word-initial stressed vowels (e.g., *digan haga* [diɣan ˈaɣa] "say, 3PPL 'do it'"), and elided variants (nasalized vowels) before unstressed vowels (Quilis 1993: 240). Ramsammy (2011) is thus far the only articulatory study that specifically examined coda nasals in a velarizing dialect. He collected EPG data from two speakers of a velarizing and two speakers of a non-velarizing Peninsular dialects of Spanish spoken in Galicia. As expected, the first two speakers consistently realized a word-final nasal before a vowel (éN#a) as velar [ŋ], while the second two speakers realized it as alveolar [n] (cf. Honorof 1999 on a non-velarizing Peninsular dialect). The same respective realizations (although more constricted) were found in the utterance-final position (éN#), except for one of the velarizing speakers who unexpectedly favoured bilabial realizations ([m]).

Although there are no experimental studies on the realization of word-final nasals in Argentine Spanish, they are assumed to be alveolar (in non-assimilating contexts; see a note on Argentine Spanish in Martínez Celdrán et al. 2003). The exact realization of the alveolar articulation may also vary depending on the position. In Catalan, for example, final alveolar nasals are produced with less front lingual contact and less dorsopalatal contact compared to alveolar nasals in syllable onset position (see Recasens 2004). The realization of syllable-onset nasals in Argentine and Cuban varieties has been recently investigated using EPG in Kochetov & Colantoni (2011b). This study concluded that alveolar nasals are more anterior in Argentine than in Cuban Spanish, based on data from 5 and 3 speakers, respectively. It was also shown that the overall degree of dorsopalatal contact is smaller in the latter than in the former variety, indicative of greater coronal weakening in Cuban Spanish. The same Argentine and Cuban speakers also showed consistent, but somewhat different, patterns of assimilation of word-final nasals to following consonants (Kochetov & Colantoni 2011a).

2.2. Diachronic development of coda nasals

The variation witnessed in synchrony in Caribbean and Central American varieties has been attested in the evolution of Romance and Indo-European languages in general (Lipski 2011). Coda nasals have been lost in French, Portuguese and some varieties of Northern Italian. In these varieties, nasal deletion was accompanied by vowel nasalization. Hajek (1997), however, points out that in order to understand better the evolution of coda nasals it is important to separate vowel nasalization from nasal deletion, since the contexts that conditioned each process may not be the same. Indeed there are well-studied Romance varieties, such as Campidanese Sardinian, where most coda nasals have been lost but the phonemic status of nasal vowels is extensively debated (see Sampson 1999 and Frigeni 2009 for contrastive analyses).

As for contextual effects, generalizations coming from diachronic studies mirrored the results of sociolinguistic analyses. There is evidence that nasal deletion and vowel nasalization in Romance started in word-final position, albeit, as Hajek (1997) points out, this might be due to a peculiarity of Latin, where only nasal + fricative clusters were found word-internally. Given the well-documented constraints on the articulation of nasal + fricative sequences (e.g., Farnetani & Busà 1994, Busà 2007, Solé 2007), it is not surprising to learn that nasal deletion was already taking place in Latin (see Hajek 1997). Nasal deletion before fricatives was also attested word-finally. Indeed, there is evidence that this was the context targeted after absolute word-final position (Hajek 1997). The voicing of the following consonant also played a role in favoring deletion and nasalization, with both processes being more frequent before voiceless than before voiced stops (Hajek 1997, see also Beddor 2009 for experimental evidence in this regard).

Diachronic studies provide useful generalizations for the role of contextual factors, which are absent from sociolinguistic analyses. Indeed, the latter type of studies has largely focused on the role of a following vowel, pause or consonants, without making further distinctions between vowel types or addressing the role of non-segmental factors, such as stress. Two factors that have been consistently explored in synchronic studies will also be analyzed in the present study: the quality of the preceding vowel and stress. Researchers disagree as of whether nasal weakening happens more often when preceded by either high or low vowels. What is relevant for the present study is that a preceding low vowel has been frequently considered a trigger of nasal deletion in different languages (Chen 1975), including several Romance languages (Hajek 1997). In addition, diachronic studies have systematically analyzed the role of stress on nasal deletion and vowel nasalization. The generalization that emerges is that these processes were attested first in stressed syllables, spreading eventually to unstressed syllables (Hajek 1997: 99). This finding is interesting, especially considering the conflicting results reported in the few existing experimental studies summarized above.

3. Predictions

The first prediction to be explored in this study concerns the cross-dialectal differences in the realization of the word-final nasal. Based on the studies reported in the previous section, we expect to find alveolar realizations in Argentine Spanish and velar nasals in Cuban Spanish. If there is velar/alveolar alternation in Cuban Spanish (as in Dominican Spanish: Quilis 1993), and if this variation is socially conditioned, we expect alveolars to be more frequent in read speech, and especially in the wordlist.

With respect to style-related differences, we expect to find a greater rate of de-occlusivization and vocalization, or shorter nasal duration in less controlled tasks (see Shockey 1991, Shockey & Farnetani 1992). If the difference in place in the realization of the final nasal is simply a dialectal marker, we would expect velarizing and non-velarizing dialects to exhibit similar weakening patterns across different speech styles. However, if velarization is a step towards deletion, as it has been the case in other Romance languages, then velarizing dialects should be more variable than non-velarizing dialects.

Finally, prosodic and segmental factors are predicted to affect the weakening of coda nasals. Weakening may be blocked in prosodically strong positions in the text and the story (cf. Cho & Keating 2009, Fougeron 2001, see also Ramsammy 2011 on Peninsular Spanish). Reduction is more likely to happen in unstressed positions and between vowels (cf. Honorof 2003 on Peninsular Spanish). As for the specific vowel-effects, based on the evolution of nasal vowels in Romance languages (see section 2.2), we expect more weakening after back vowels and more contact after high front vowels.

4. Methods

4.1 Speakers, corpus, stimuli and procedure

In this study we use part of an EPG corpus of Spanish dialects (Colantoni & Kochetov 2011a,b), which includes read and semi-spontaneous speech from five speakers of Argentine Spanish from Buenos Aires, three speakers of Cuban Spanish from Havana, and a speaker of Peninsular Spanish from Madrid. For the present study, we selected a subset of 6 participants, 3 Argentine females (A1-A3) and 3 Cuban females (C1-C3). The speakers ranged in age between 23 and 42 years-old, had university education, and at the time of the experiment were residing in Toronto, Canada. They have lived outside their native countries from 2 to 6 years (on average 5 years), except for A3 who has been residing in English-speaking countries for 10 years. All the participants reported to use Spanish extensively on a daily basis, and reported no history of hearing or speech difficulties.

The development of the corpus began with a set of stimuli designed to test nasal and /s/ assimilation patterns (see Kochetov & Colantoni 2011a). The stimuli, of which 4 tokens were selected for this work (see Table 1, Set 1), were embedded into a carrier sentence and read three times.[1] Twelve repetitions were recorded for speakers A1-A3 and C1, and 6 repetitions for C1 and C2, yielding a total of 60 tokens for the analysis. The second set of stimuli (see Table 1, Set 2) included words that illustrated all the phonemic contrasts in Spanish (following Colantoni &

Steele 2004). Those words were embedded in a carrier sentence and read 3 times, and also read in isolation twice. A total of 5 different words are analyzed here. Speakers A1, A2, A3 and C2 participated in this task and a total of 160 words were analyzed (carrier sentence: 5 x 4 x 6 = 120; isolated words: 5 x 4 x 2 = 40). Throughout the paper we will refer to these reading tasks as 'the wordlist task'. The second task was also a reading task, but, in this case, participants read the short text "The North Wind and the Sun" (see Martínez Celdrán et al. 2003; the stimuli used are listed in Table 1). All participants read this text 3 times (for C2, one token of *quien antes* was mispronounced and therefore omitted from the analysis). Since this is a short text, we expected participants to become very familiar with it by the third round and to pay less attention to the words, especially compared to the words read in isolation.

Table 1. Words/utterances selected for the study, separately by task and phonetic context; numbers of elicited tokens by speaker is given on the right.

				A1, A2	A3	C1	C2, C3	All
Wordlist	1	aN#á	Diga**n** haga (otra vez)	12	12	12	6	60
		áN#á	Dirá**n** haga (otra vez)	12	12	12	6	60
		óN#ó 1	(Diga) fanfarró**n** otra (vez)	12	12	12	6	60
		óN#ó 2	(Diga) rató**n** otra (vez)	12	12	12	6	60
	2	áN#ó	(Digo) pla**n** otra (vez)	6	6	6	--	24
		óN#ó 3	(Digo) blasó**n** otra (vez)	6	6	6	--	24
		óN#ó 4	(Digo) ió**n** otra (vez)	6	6	6	--	24
		áN#	pla**n** (#)	2	2	2	--	8
		óN# 1	blasó**n** (#)	2	2	2	--	8
		óN# 2	ió**n** (#)	2	2	2	--	8
		All		72	72	72	24	336
Text		óN#a	co**n** ardor	3	3	3	3	18
		óN#é	conviniero**n** (en)	3	3	3	3	18
		éN#á 1	e**n** ancha	3	3	3	3	18
		éN#á 2	quie**n** antes	3	3	3	3	18
		íN#	por fi**n**	3	3	3	3	18
		All		15	15	15	15	90
Story		VN#V	various, see Table 2	--	17	13	--	30
		VN#	various, see Table 2	--	7	7	--	14
		All		--	24	20	--	44
All				87	111	107	39	470

A second stage in the development of this corpus involved the elicitation of more continuous speech, given that we had already informally observed differences between the reading of the wordlists and the text. Hence, we developed a set of testing materials that included a longer text ("Continuidad de los parques" by J. Cortázar, which will not be analyzed here) and a series of pictures, in order to elicit the story of "Little Red Riding Hood". All the Argentine participants and C1 completed these tasks, and each task involved two rounds of recordings. In order to be able to analyze a comparable number of tokens for Argentine and Cuban speakers, only the speech of A3 and C1 will be examined here. We divided the story into a set of 14 pictures, where each picture corresponded to a recording. Participants were free to tell the story as they liked, and even to re-invent the story. As expected, the words with final nasals obtained for each participant are very different; these items are listed in Table 2. What is important for our purpose here is that the speech elicited through the re-telling of the story can be considered semi-spontaneous and even spontaneous for some moments. This is evidenced first by the lexical choices (there were many occurrence of slang words) and the frequent jokes that participants made about the story characters. Second, a preliminary examination of the data revealed differences in the frequency of some processes. In particular, Cuban speakers tended to produce coda /s/ in read speech, while weakening it to [h] or deleting it in the story, indicative of a more casual speech style.

Table 2. A complete list of words/utterances from the story, separately by phonetic context and speaker; numbers of elicited tokens are given on the right.

Context		A3		C1	
VN#V	aN#a	sienta**n** a	1	iba**n** a	1
	áN#a	va**n** a	1		0
	aN#u	gusta**n** unas	1		0
	aN#i	seguía**n** intactas	1		0
	oN#a		0	se pusiero**n** a, se sentaro**n** a	2
	óN#u		0	co**n** una, co**n** un	2
	oN#e		0	comiero**n** el	1
	óN#e	co**n** el	3		0
	úN#o	u**n** hocico	1		0
	éN#u	e**n** una (2), e**n** un	3		0
	éN#é	e**n** eso (3), tambié**n** entra	4	e**n** ese (6)	6
	éN#e	e**n** el	1	e**n** el	1
	eN#i	reúne**n** y	1		0
	All		17		13
VN#	aN#	sienta**n** #	1	saliera**n**#	1
	áN#		0	pa**n**#	2
	oN#		0	saliero**n**#, pusiero**n**#, tomaro**n**#	3
	óN#	habitació**n** # (2), co**n** #	3	atenció**n**#	1
	éN#	bie**n** # (2), alguie**n** #	3		0
	All		7		7
All			24		20

In summary, we will be comparing the production of final nasals in three tasks. First, we will present the results of a wordlist task that was performed by all the participants included in the study (although to a different extent). Second, we will discuss the results of the second reading task, a short text, which was also completed by all our participants. In both cases, the same tokens were obtained for all speakers. Finally, we will analyze a sample of semi-spontaneous speech obtained from two of our participants (A3 and C1). The words analyzed here are, as expected, different for each participant.

4.2 Instrumentation and analysis

The corpus was collected using a WinEPG system by Articulate Instruments (Wrench et al. 2002), with simultaneous articulatory and acoustic data sampled at 100 Hz and 22,050 Hz respectively. The system uses acrylic artificial palates with 62 electrodes (the Reading model), custom-made for each speaker. Testing took place at the Linguistics Phonetic Lab at the University of Toronto. The software Articulate Assistant (Wrench et al. 2002) was used for data segmentation and analysis. All coda nasals were labeled with consonant duration defined based on acoustics, with reference to the EPG record. The onset of the nasal interval was taken as an abrupt decrease in amplitude in the waveform and an onset of nasal murmur in the spectrogram. The offset of the interval varied depending on whether the final nasal was followed by a vowel or by a pause. In the former case, the offset was marked when an abrupt increase in amplitude was detected. Before a pause, the offset of a nasal was marked when no signal was detected in the spectrogram and no contact was shown in the palates. In addition to the consonant interval, we also labeled the mid point of the acoustic nasal interval and the point of maximum contact within the nasal interval based on the EPG record. For the purpose of the study, we will report all the measurements taken at the midpoint.[2]

Following the few existing analyses of semi-spontaneous speech using EPG (Shockey 1991, Shockey & Farnetani 1992, Nicolaidis 2001), we will report here two sets of measurements, what we have called 'categorical' and 'continuous' measurements. The use of categorical variables is motivated by our need to compare our results across tasks, whereas the use of continuous variables should allow us to capture gradient differences in the degree of weakening.

The categorical analysis includes two main variants: alveolar and non-alveolar nasals.[3] A token was labeled as 'alveolar', if it showed an alveolar constriction, with at least 4 'on' electrodes within one of the first 4 rows of the palate. This category includes both nasals with complete closures and those partly de-occlusivized (see below). A token was labeled as 'non-alveolar' if it did not show such a constriction. This category includes both velar nasals and so-called 'vocalized nasals'. While we originally attempted to distinguish these two types (with 'velar' tokens defined by contact of at least 4 'on' electrodes within one of the last two rows of the artificial palate, and 'vocalized' tokens with less than 4 electrodes in any of the rows), this could not be always done reliably. This is because the velar closure is not always detected by the EPG palate, especially in the context of non-front vowels (e.g., Celata et al. in press).

In addition to the categorical variables, three continuous variables were included: the contact anteriority (CA), the quotient of activation (Q), and nasal duration (in seconds). The first two measurements were taken at the nasal midpoint and were designed to capture variability in the degree of constriction degree (Q) and constriction location (CA) across dialects, phonetic contexts, and speech tasks. CA was calculated as sums of activated electrodes in all 8 rows of the palate (following Fontdevila et al. 1994), indicative of the location of the frontmost position of the constriction.[4] Q was calculated as the number of 'on' electrodes divided by the total number of electrodes, 62, thus reflecting the overall degree of linguopalatal contact. Alveolar articulations are expected to show higher CA and Q values compared to velars and vocalized nasals. Among the latter two, velars were expected to have higher Q than vocalized vowels. Nasal duration was measured based on the acoustic record as described above. Raw, rather than normalized duration was used, since consistent normalization was not feasible across the different tasks and word items. To evaluate variability across the speakers and tasks, we also used a measure of variability based on standard deviations and means (variability = (SD/mean)*100) for each of the three continuous variables.[5] Values close to 0 indicate little variability in the data, while values close to 100 show a high degree of variability.

5. Results

The results are presented in this section separately by task: in section 5.1 (the wordlist), section 5.2 (the text), and section 5.3 (the story). A comparison across tasks and the discussion of the results is further given in section 6.

5.1. Wordlist

Figure 1 presents composite linguopalatal contact profiles for all of Set 1 and Set 2 items (listed by phonetic context) for Argentine speakers A1, A2, A3, and Cuban speakers C1, C2, and C3. It is clear from the figure that the primary difference between the two dialects is in the place of articulation of the final nasal. The consonant is consistently realized by the Argentine speakers as alveolar, with the constriction in the first 3 or 4 rows. In contrast, Cuban speakers C2 and C3 show contact mainly in the last 2 or 3 rows, indicative of a velar or vocalized realization of the nasal ('non-alveolar'). Peculiarly, C1 shows variation between the alveolar and non-alveolar realizations: some of her items have consistently alveolar constriction (e.g., *plan otra, blasón#*), others have consistently velar constriction, or possibly lack any constriction (e.g., *fanfarrón otra, ión#*), while most of her items display variation in place (e.g., *digan haga, ratón otra*).

Following the criteria described in section 4.2, all tokens were categorized into two types – alveolar and non-alveolar. These results are presented in Table 3, together with the rates of alveolar and non-alveolar realizations of nasals. Note that the alveolar rate is at 100% for A1 and A2, and 89% for A3, 51% for C1, and 0% for C2 and C3. The lower alveolar rate for A3 is due to several tokens of apparently vocalized nasals, all occurring between two back rounded vowels /o/ (*fanfarrón otra, ratón otra*, and *blasón otra*, but not *ión otra*). Individual token profiles for the two most variable items are shown in Figure 2. For C1, alveolar realizations occur in all contexts and are seemingly random or item-specific. One context that appears to favor alveolar realizations is the juncture between two stressed syllables (cf. *dirán haga* vs. *digan haga*), possibly due to a stronger prosodic boundary in this context. Individual token profiles for these two items are shown in Figure 2 (each palate here corresponds to the nasal midpoint for a single repetition of the utterance). Note that one of the tokens of *digan haga* (the 7th from the left) that shows up as alveolar in the figure also had a velar constriction prior to the midpoint, thus giving a velar-alveolar sequence [ŋn]. This token was classified in Table 3 as both alveolar and non-alveolar. Many of the non-alveolar tokens produced by this speaker are possibly vocalized rather than velar (having 4 or less 'on' electrodes in the last two rows). The rate of vocalization seems to be even greater for C2 and C3, who hardly have nasal tokens with clear velar contact.

Recall that the alveolar type category includes tokens with both complete and incomplete closure. The absolute majority of alveolar tokens in the data had complete closures (as seen in the profiles in Figure 1). Six incomplete alveolar tokens were produced by A3 (see e.g., the 8th token of *fanfarró**n** otra* in Figure 2) and one by A1. As with the non-alveolar (apparently vocalized) tokens, all of these were limited to the o_#o context (*fanfarrón otra*, *ratón otra*, and *blasón otra*).

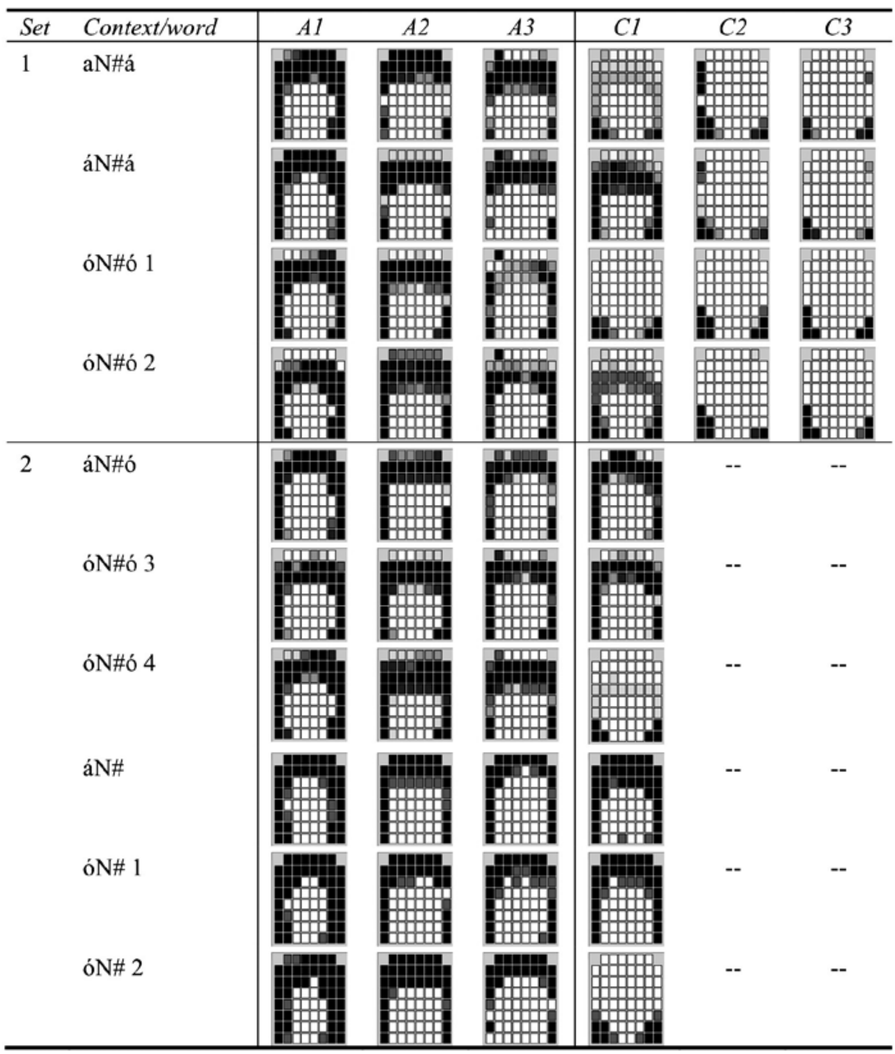

Figure 1. Mean linguopalatal contact profiles for wordlist items by speaker.

Table 3. A summary of nasal categorization by type (alveolar/non-alveolar) and alveolar rate (percent of alveolar realizations) for wordlist items.

SET	CONTEXT/WORD	A1	A2	A3	C1	C2	C3
1	an#á	12/0	12/0	12/0	4/9	0/6	0/6
	án#á	12/0	12/0	12/0	11/1	0/6	0/6
	ón#ó 1	12/0	12/0	6/6	0/12	0/6	0/6
	ón#ó 2	12/0	12/0	11/1	6/6	0/6	0/6
2	án#ó	6/0	6/0	6/0	6/0	--	--
	ón#ó 3	6/0	6/0	5/1	6/0	--	--
	ón#ó 4	6/0	6/0	6/0	1/5	--	--
	án#	2/0	2/0	2/0	2/0	--	--
	ón#	2/0	2/0	2/0	2/0	--	--
	ón#	2/0	2/0	2/0	0/2	--	--
	Total	72/0	72/0	64/8	38/35	3/21	0/24
	Alv. rate	100%	100%	89%	53%	0%	0%

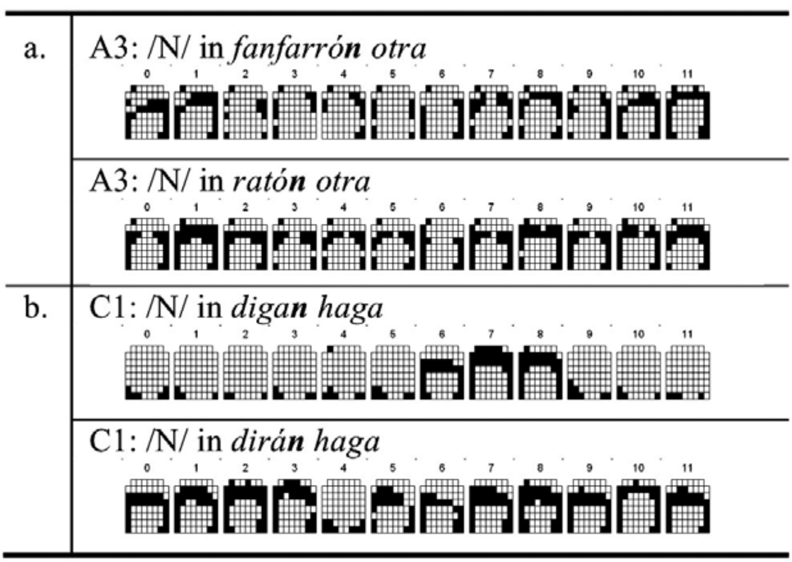

Figure 2. Linguopalatal contact profiles for 12 individual tokens (taken at the nasal midpoint) of selected, particularly variable, utterances produced by A3 (a) and C1 (b).

To further explore the data, we examined three continuous variables, i.e., Contact Anteriority (CA), Quotient of Activation over the entire palate (Q), and the Duration of nasal consonant (Dur) across all word items, separately for each speaker. Recall that the first two measures are based on the articulatory record and correspond to relative frontness/backness of the constriction and the degree of overall contact, respectively. The third measure is acoustically-based.

Means and variability values for the three variables are presented in Tables 1A, 2A, and 3A in the Appendix (available on line at: http://linguistica.sns.it/RdL/2012.htm). To examine differences across word items, ANOVAs with the dependent variable Word were performed separately for each participant and variable.[6] Bonferroni pairwise comparisons revealed that the nasal had significantly (at $p < .01$, adjusted for multiple comparisons) lower CA values between back rounded vowels than in the other contexts for two Argentine speakers, A1 (*blasón otra, ratón otra, fanfarrón otra*) and A3 (*blasón otra, ratón otra, fanfarrón otra, ión otra*). This corresponded to the gradient retraction of the alveolar constriction, presumably as a result of coarticulation to the adjacent back vowels. A similar effect, yet involving a categorical alveolar vs. non-alveolar difference, was shown by C1 for the items *fanfarrón otra* and *ión otra*. This speaker also showed a significantly lower CA for the unstressed-stressed context *digan haga* compared to the stressed-stressed context *dirán haga*. Also, C2 showed lower CA (and Q) for the items *fanfarrón otra* and *ratón otra* than *digan haga and dirán haga*, yet this can be due to the lateral contact in the latter items.

In terms of Q, values were significantly higher for some utterance-final nasals compared to nasals in the same words occurring pre-vocalically for A1 (*blasón, ión, plan*), A3 (*fanfarrón otra*), and C1 (*fanfarrón otra*). This can be attributed to prosodic effects in the utterance-final position, possibly combined with intervocalic weakening of nasals. In addition, A2 showed significantly more contact for the item *ión otra* than for some of the other intervocalic nasal items. This possibly reflects a more careful pronunciation of the less frequent technical word, or could be because the word is monosyllabic.

Utterance-final nasals (in *blasón, ión, plan*) were significantly longer than intervocalic nasals for A1, A2, A3, and C1. The difference between the two contexts was as high as 106 ms, 70 ms, 75 ms, and 97 ms, respectively. Consistently with the Q measure, A2 showed significantly longer nasal duration for the less frequent *ión otra*, compared to some other items with intervocalic nasals. The same difference was exhibited by A3. A shorter nasal duration in *blasón otra* compared to other contextually similar items was shown by A1 and C1. C3 showed a shorter duration of the nasal between back vowels (*fanfarrón otra* and *ratón otra*) than between central vowels (*digan haga* and *dirán haga*).

Finally in terms of variability, the main difference in articulatory measurements was between the two groups: the Argentine speakers had relatively low variability values (4.3-8.3 for CA and 11.5-19.7 for Q; see Tables A1, A2), while the Cuban speakers showed much greater variability (69.3-94.7 for CA and 24.2-60.8 for Q). Duration variability was higher for the speakers whose data included utterance-final tokens (A1-A3, C1; see Table A3).

Altogether, these results show two main contextual effects on the realization of final nasals. First, final nasals generally have a more backed constriction, less contact, and shorter duration between back vowels. This is also the context where some speakers showed incomplete alveolar closures and apparent vocalized nasals. Both gradient and categorical effects are therefore part of the same weakening process, motivated by coarticulation to adjacent back vowels. Second, final nasals (at least alveolars) have longer duration and often greater constriction in utterance-final position. This reflects the general prosodically-conditioned lengthening of word-final consonants. In addition to these two processes, we found some item-specific differences in the constriction location, degree, and duration. These differences are possibly correlated with lexical frequency of individual items or are part of lexical variation peculiar to this particular speaker.

5.2. Text

As mentioned in section 4.1, the "North Wind and the Sun" was read three times at the beginning of each testing session. Given some considerable within-item variability in continuous speech, it is of interest to examine linguopalatal contact profiles for individual tokens, rather than their averages. Token profiles are presented in Figure 3, arranged by word/context and speaker. It can be seen that, as before, the main difference is between the alveolar realizations of nasals by Argentine speakers and the non-alveolar (velar or vocalized) realizations by Cuban speakers, with the exception of C1. The latter speaker, again, exhibits both alveolar and non-alveolar tokens, yet there are only three alveolar tokens here, and all of them are produced after a front vowel (*en ancha* and *por fin*). Note that the alveolar closure in the last token is produced with a simultaneous velar closure. The consonant is thus a complex alveolar-velar nasal [n͡ŋ].

The consistent alveolar realization of final nasals by the Argentine speakers is reflected in the 100% alveolar rate shown in Table 4; the rate is only 20% for C1 and 0% for the other Cuban speakers. None of the Argentine speakers show non-alveolar tokens in this data set; note, however, that there are 2 tokens of alveolars with incomplete closure produced by A1. As before, a large portion of the tokens produced by Cuban speakers (especially for C2 and C3) lack a clear velar contact, thus possibly being vocalized. Cases of apparent vocalization are more common after the back vowel /o/. While this can be attributed to the greater coarticulatory effect of this vowel (see section 2), it is also possible that velar constrictions in this context are not detected by the palate (yet become apparent when the constriction is fronted next to front vowels). The fronting of the velar constriction is particularly notable after /i/ in *por fin*. The nasal here is presumably prepalatal for C1. For the Argentine speakers, the effect of /i/ is on the overall raising of the tongue rather than on the primary constriction.

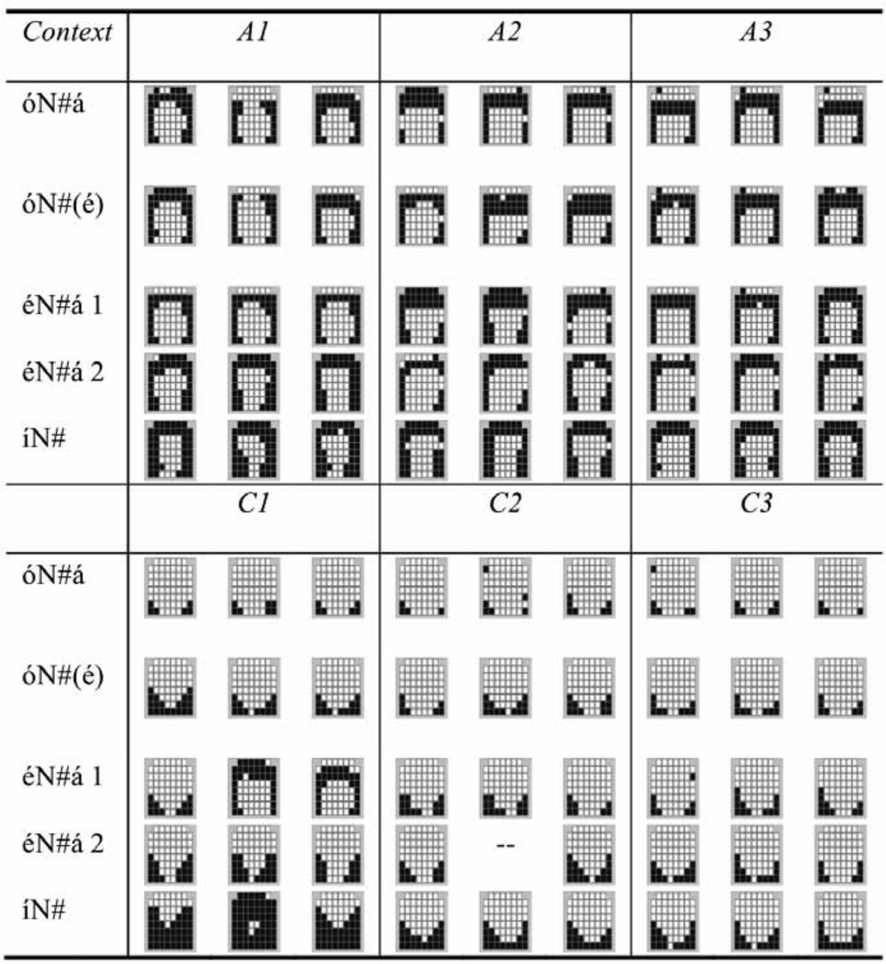

Figure 3. Linguopalatal contact profiles for individual tokens of the text items, reported separately by speaker.

Table 4. A summary of nasal categorization by type (alveolar/non-alveolar) and alveolar rate for text items.

CONTEXT/WORD	A1	A2	A3	C1	C2	C3
óN#á	3/0	3/0	3/0	0/3	0/3	0/3
óN#(é)	3/0	3/0	3/0	0/3	0/3	0/3
éN#á 1	3/0	3/0	3/0	2/1	0/3	0/3
éN#á 2	3/0	3/0	3/0	0/3	0/3	0/3
íN#	3/0	3/0	3/0	1/2	0/3	0/3
All	*15/0*	*15/0*	*15/0*	3/13	*0/15*	*0/15*
Alv. rate	*100%*	*100%*	*100%*	*20%*	*0%*	*0%*

Means and variability values for the three continuous variables are presented in Tables 4A, 5A, and 6A in the Appendix (available on line at: http://linguistica.sns.it/RdL/2012.htm). Bonferroni pairwise comparisons of the four items in terms of continuous variables (performed separately for each speaker; see section 5.1) showed that the final nasals in *por fin* and *convinieron (en)* had significantly longer duration for A3 and C1, likely due to a prosodic boundary placed after the target word. All Cuban speakers also showed a significantly greater constriction for the nasal in *por fin*, due to the substantial fronting of its constriction (see Figure 3). No other significant differences emerged, which can be attributed to the smaller sample size (3 tokens per item) and greater phonetic variability compared to the wordlist task.

As before, the measures of variability in CA and Q revealed much greater values for the Cuban speakers than for the Argentine speakers. Not surprisingly, C1 showed the highest variability among the Cubans. This speaker and A3 also showed relatively high duration variability values, consistent with the above noted prosodic duration differences.

Overall, the results for the text task show a pattern almost identical to the wordlist, with the exception of A3 and C1 who showed higher (100% vs. 89%) and lower (20% vs. 53%) alveolar rates, respectively. It is important to keep in mind the differences in phonetic contexts in both tasks: while all preceding and following vowels in the wordlist are back or central, there is only one item that exhibits the same context in the current task; in all the other items, the nasal is preceded and/or followed by front vowels. Front vowels appear to obstruct nasal weakening, and for C1 favor alveolar realizations.

5.3. Story

Turning to the last task, Figure 4 shows individual token profiles for all items produced by speakers A3 and C1. Recall that, for this task, we are only comparing the production of one Argentine (A3) and one Cuban participant (C1). A3 produced in total 24 tokens of final nasals in 11 phonetic contexts, while C1 produced 20 tokens in 9 phonetic contexts (see Table A7 for details). The profiles are arranged by intervocalic and utterance-final contexts, as well by preceding vowel. The categorization of nasals by type is given in Table 7A in the Appendix, together with the results for continuous variables. Of particular interest in Figure 4 is the considerable variability in the realization of nasals produced by A3. This speaker shows several non-alveolar nasals, most of which appear to be vocalized (having residual lateral context). There is also a non-alveolar with a clear velar closure (in *en una*; the items *en hocico* and *habitación#* have secondary velar constrictions, which could be due to the high tongue position for the preceding vowel), and an alveolar with an incomplete closure. As before, C1 shows variable alveolar or non-alveolar (velar or vocalized) realizations of the nasal. Notably, all non-utterance-final nasals preceded by back vowels lack the alveolar constriction; many of the nasals preceded by front vowels are realized as alveolar. Both alveolars and velars appear in the utterance-final position, and sometimes in the same lexical item (*pan#*). Overall, the alveolar rate for this speaker is 55%. The speaker also shows one incomplete alveolar closure.

Examining the continuous variables CA, Q, and Duration, utterance-final nasals produced by A3 had higher than average contact anteriority (i.e., more front constriction), greater overall degree of contact, and longer duration of the nasal interval (see Table 7A in the Appendix, available on line at: http://linguistica.sns.it/RdL/2012.htm). The difference between utterance-final and intervocalic nasals was particularly notable in duration, where the average difference was almost 100 ms. It should be noted that one pre-pausal token (*con…*) had a 454 ms long nasal, apparently caused by the speaker's hesitation. Excluding this token, the difference between the contexts is 58 ms. Further, the degree of contact was particularly low for nasals between low vowels (a_#a), and somewhat higher next to front and high vowels. C1 showed considerable variability in CA and Q due to the variable alveolar or velar/vocalized realizations. As it was the case for A3, C1's utterance-final nasals were substantially longer than intervocalic nasals, on average by 51 ms. These across- and within-speaker differences were reflected in the variability measurements: much higher CA and Q values for C1 than A1, and overall higher duration variability values for both speakers compared to the previous tasks (see Table 7A).

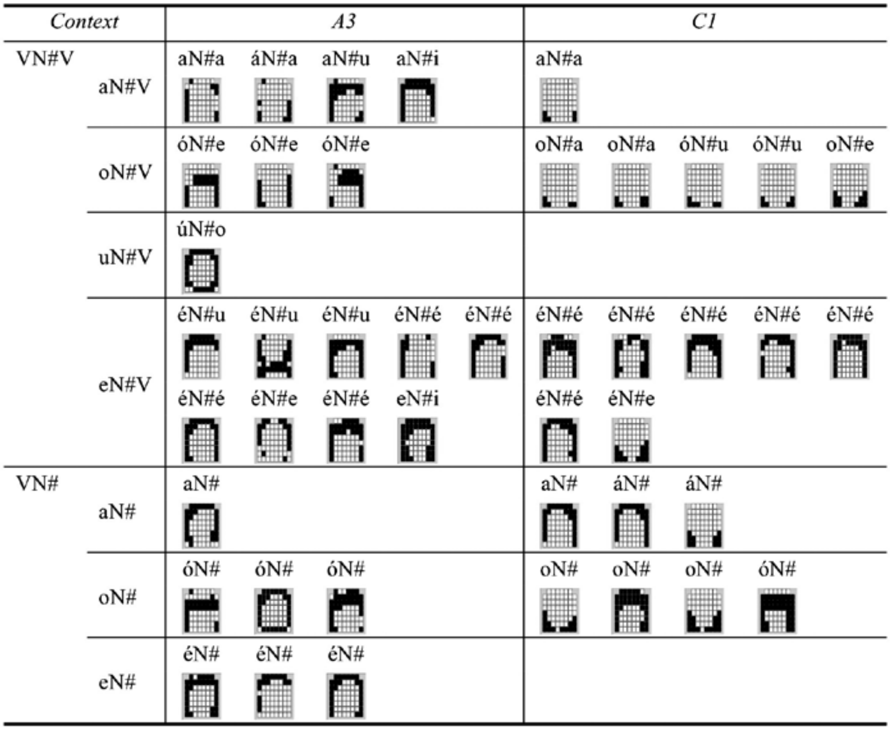

Figure 4. Linguopalatal contact profiles for individual tokens of the story items produced by speakers A3 and C1.

6. Comparison of the three tasks

A comparison of overall alveolar rate values across the tasks (three for A3 and C1, and two for the other speakers) is at first glance somewhat unexpected. Most speakers show no difference between the wordlist and the reading task, having either 100% (A1 and A2) or 0% (C2 and C3) alveolar rates. The two speakers that do show variation, exhibit an alveolar rate increase, rather than a decrease, in the text compared to the wordlist. While A3 shows the expected rate decrease in the story task (compared to the first two tasks), C1's rate in the story is about the same as in the word list. The lack of the expected trend, however, as we mentioned in section 5.2, can be in large part explained by the vastly different sets of phonetic contexts in items employed in the three tasks. The differences include preceding and following vowels, position in an utterance, stress, and prosodic boundaries (leaving aside more fine-grained differences in grammatical status and word frequency). Yet, some meaningful comparisons can be made, if context is taken into account. For example, an examination of final intervocalic nasals after non-front vowels (/a/, /o/, /u/) presented in Figure 5 shows that the non-alveolar rate for both A3 and C1 gradually increases, and, correspondingly, the alveolar rate decreases (apart from some deviation in the text task, which has only two appropriate tokens). The task, thus, shows the expected effects but, at least for nasal weakening, these are relatively subtle and are partly overridden by contextual effects (preceding vowel or prosodic position). Note that the task effect is also apparent in the measurement of duration variability, with A3 and C1 showing considerably higher values in semi-spontaneous speech compared to the reading tasks (see Tables 3A, 6A, and 7A).

Even though the differences across the tasks are not straightforward, all three exhibit clear contextual effects. In particular, there were substantial differences in the realization of coda nasals in word-final intervocalic (utterance-internal) vs. utterance-final positions. This effect, manifested in duration, degree of contact, as well as in the constriction location, was observed in all three tasks and for most of the speakers. The differences between intervocalic and utterance-final nasals over the entire corpus are summarized in Figure 6, separately for each continuous variable. The differences in CA and duration are lacking only for C2 and C3, who had consistent non-alveolar (velar or vocalized) realizations of the nasals, and whose sets included only three tokens of a single utterance-final item. The differences in CA and Q are particularly large for C1, as for this speaker the 'strong' utterance-final position favored the alveolar rather than velar/vocalized realization of the final nasal.

The second contextual factor identified in the study is the quality of the preceding vowel. Front vowel contexts were absent in the word-list task, but figured prominently in the text and story tasks, leading to greater degree of contact and somewhat more front articulation of alveolar constrictions. For C1, front vowels strongly favored alveolar realization of the nasal. Differences between back (and central) and front preceding vowel contexts over the entire dataset are shown in Figure 7. The reverse effect was observed between back rounded vowels (o_o). In this context, nasals were more retracted, less constricted, and shorter, often resulting in incomplete alveolar closures or possibly vocalizations (of both alveolars and velars). Both front and back vowel effects are clearly caused by the consonant coarticulation to adjacent vowels; yet in the case of C1, alveolar-velar alternations appear to be phonologized as categorical allophonic rules (which are nevertheless variable).

The final question we would like to address is whether the duration of final nasal consonant is intrinsically related to the degree of its constriction. In other words, does the decrease or increase of nasal duration – due to contextual or task factors – automatically lead to the decrease or increase in the linguopalatal contact? The presence or absence of this correlation can be examined in Figure 8, which plots the entire set of tokens in terms of Quotient of Activation and Duration separately for Argentine and Cuban speakers.[7] The plot for Argentine speakers shows that shorter or longer duration does imply greater or lesser degree of contact, as indicated by the line increasing in both Q and Duration. The correlation is not particularly strong, yet significant (Pearson Correlation, $r = .338$, $p < .001$). In contrast, the plot for the Cuban speakers shows no significant relation between Q and Duration, as indicated by the near-horizontal line (Pearson Correlation, $r = .005$, $p = .943$). This can be due to the alveolar and velar/vocalized variation in the C1 data, as a result of which the same duration can imply two vastly different Q values. It also appears that duration does not predict the constriction degree of velar/vocalized tokens for C2 and C3. It may, therefore, be the case, that the correlation between duration and constriction degree is limited to alveolar (coronal) consonants. Alternatively, the absence of a correlation in Cuban Spanish may be explained by the variability observed in this dialect. Whereas in Argentine Spanish alveolar nasals are the norm, in Cuban Spanish there are signs of an on-going change from alveolar to velar and then to vocalized realizations. Thus, if in Cuban Spanish there is variability between vocalized and non-vocalized realizations, Duration and Q should not be correlated.

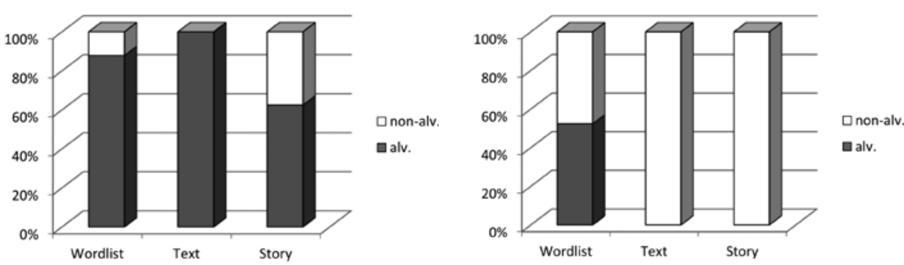

Figure 5. Rates of alveolar and non-alveolar realizations of final nasals produced in the intervocalic context after non-front vowels by speakers A3 (left) and C1 (right).

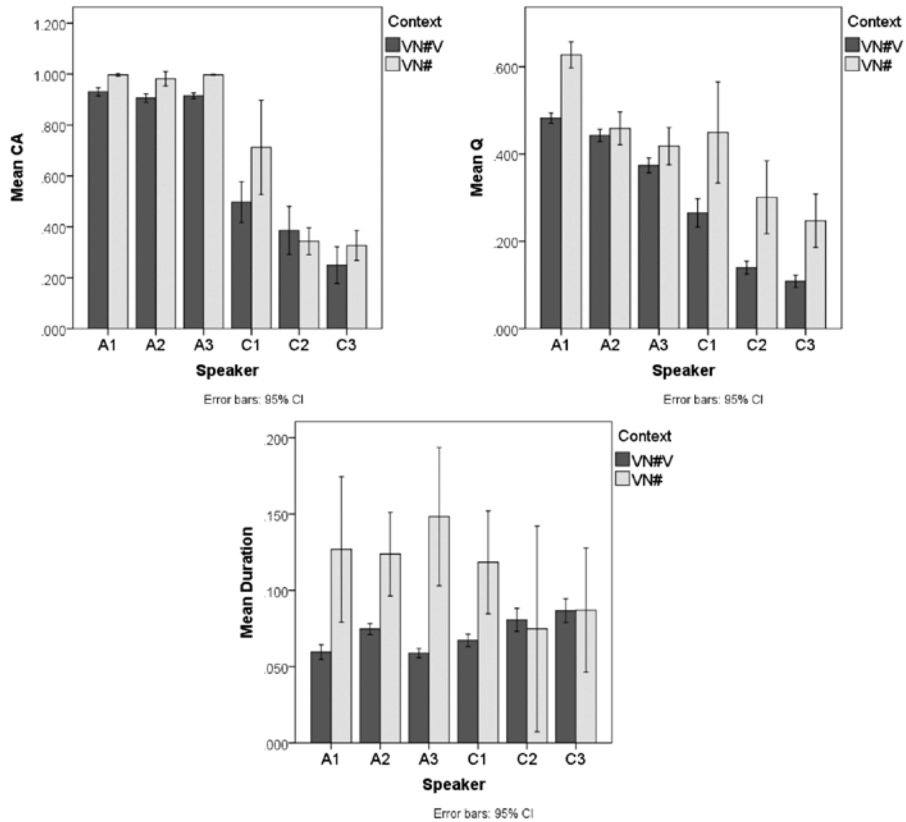

Figure 6. Mean Contact Anteriority (CA), Quotient of Activation (Q), and Duration (sec.) values, separately for intervocalic (VN#V) and utterance-final (VN#) nasals.

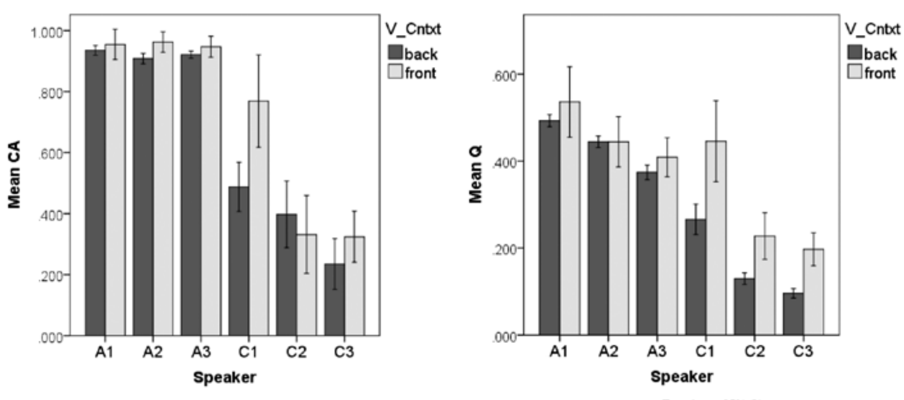

Figure 7. Mean Contact Anteriority (CA) and Quotient of Activation (Q) values, separately for nasals after back (non-front) and front vowels (both utterance-final and intervocalic contexts).

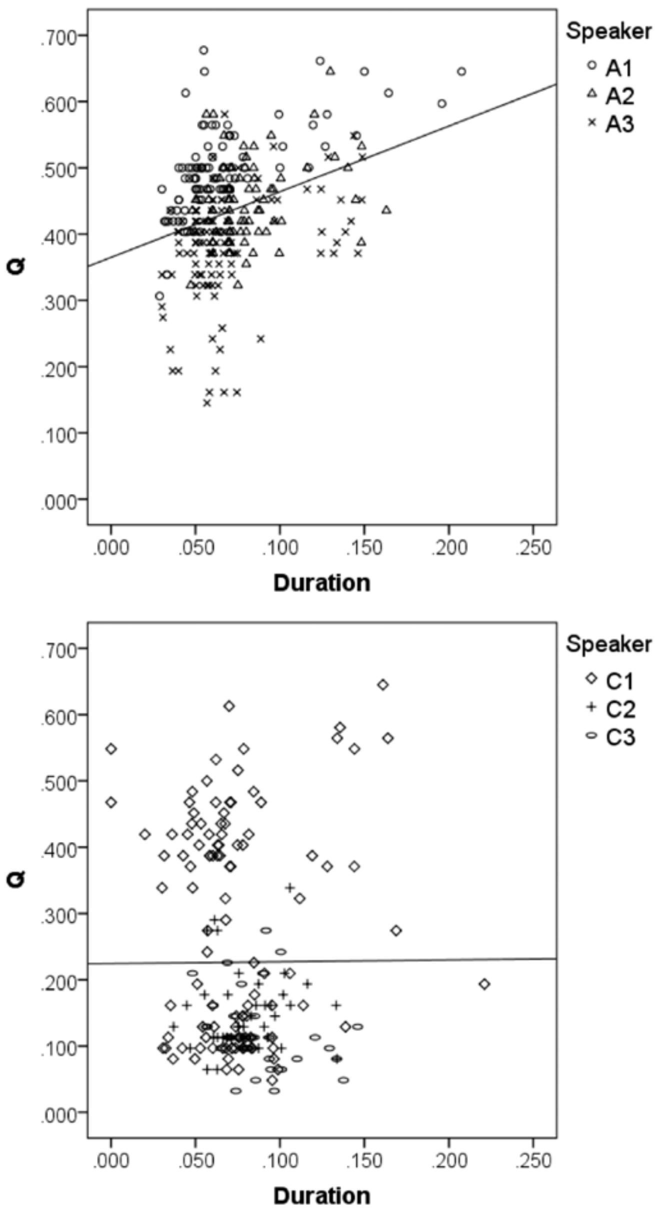

Figure 8. All tokens for Argentine (above) and Cuban (below) speakers mapped in terms of their Quotient of Activation (Q) and Duration (in ms) values.

7. General discussion

A general goal of this study was to compare the realization of word-final nasals in two Spanish varieties in a corpus that included different speech styles. Three sets of predictions were tested that had to do with (i) dialectal variation in the degree of weakening of the nasal; (ii) speech-style related variability; and (iii) the role of the segmental and prosodic contexts.

As in previous studies, the overwhelming majority of the realizations in Argentine Spanish were alveolar, whereas in Cuban Spanish non-alveolar (velar or vocalized) realizations were the most frequent. Although in Argentine Spanish one of the speakers (A3) produced some non-alveolar (vocalized) nasals in the wordlist and story, velar nasals were absent (except for one highly coarticulated token). Alveolar nasals were not expected in Cuban Spanish, according to most sociolinguistic studies (e.g., Hammond 1976 reports a 2% rate of alveolar nasals). Instrumental studies (Quilis 1993), however, reported the presence of alveolar tokens of word-final nasals, particularly when they were followed by word-initial vowels in connected speech. In our corpus, one of the speakers is responsible for all the alveolar tokens, namely C1. In her case, the presence of a following vowel does not seem to be the determining factor for the alveolar realization. Rather, alveolars are favored when the nasal is followed by a stressed vowel or occur next to front vowels. It is interesting to note that Ramsammy's (2011) EPG study of final nasals produced by two Galician Spanish speakers also revealed some unexpected variability. As was mentioned in section 2.1, one of his velarizing dialect speakers tended to produce a labial nasal in utterance-final position, while a velar nasal in final prevocalic position. The other speaker of this dialect produced velars in both contexts, and the two speakers of a non-velarizing dialect consistently produced alveolars. The results of both studies thus seem to suggest that velar realizations of final nasals in Spanish are inherently unstable and variable, compared to alveolar realizations. This is not surprising, if velar realizations are taken as an intermediate step towards nasal vocalization and deletion (Lipski 2011).

Speech style was expected to affect the overall degree of linguopalatal contact, with less contact observed in less-controlled speech. As mentioned, testing the role of style proved difficult given the characteristics of the corpus used in the present study. Indeed, we did not have identical contexts across styles. Some preliminary conclusions can be drawn, though, by analyzing the production of A3 and C1 in more compatible contexts, as illustrated in Figure 5. Here, we can see how general phonetic principles are interacting with dialect-specific differences. Specifically, non-alveolar rates are higher for both speakers in the story than in the wordlist (and the text for C1), as expected in less-controlled speech. While our method was not accurate enough to reliably distinguish between velars and vocalized nasals in Cuban productions, the overall lesser degree of contact in non-alveolar tokens for C1 (and apparently more so in the last two tasks) suggests a substantial rate of nasal vocalization. Nasal vocalization appears to be even more common for C2 and C3. While these observations need further instrumental (possibly acoustic) confirmation, we can make a preliminary conclusion that the weakening process is more advanced in Cuban than in Argentine Spanish and that it is probably conditioned by style. This is consistent with the previous studies (Cedergren 1973, Poplack 1980) that found a higher rate of vocalization in less formal tasks, even in the speech of highly educated speakers of Caribbean and Central American Spanish. What is interesting to see is that weakening in Cuban Spanish does not necessarily involve shorter durations but an overall lower degree of linguopalatal contact (see Figure 8).

Finally, contextual factors were expected to condition the overall degree of weakening. Previous articulatory studies had reported a higher rate of de-occlusivization of nasals in intervocalic position in Spanish (Honorof 2003, Shosted & Willgohs 2006), as well as in continuous speech in other languages (Shockey 1991, Nicolaidis 2001). What our results showed is that de-occlusivization is favored in some contexts and blocked in others depending on the quality of the surrounding vowels and on different prosodic conditions. For example, in the case of A3 de-occlusivization was favored by the presence of back vowels, as it has been reported in diachronic studies (e.g., Hajek 1997). In the case of C1, de-occlusivization was blocked in the context of front vowels (cf. Nicolaidis 2001 on Greek), where alveolar tokens were often found. In addition, for this speaker, stress had a significant role in blocking weakening, with more alveolar tokens attested in the context of stress clash (e.g., *dirán haga*).

Irrespective of the dialect, lengthening (often accompanied by tighter constriction) was frequent before a pause either to mark a strong prosodic boundary, as in the case of *por fin* in the text, or as a place-holder to allow re-structuring of a phrase, in the long nasal produced by A3 in the preposition *con* (see section 5.3). Overall, these effects are consistent with previous instrumental findings on Spanish (Ramsammy 2011) and other languages (Fougeron 2001, Cho & Keating 2009, among others).

Some additional linguistic factors, which were not initially considered in our predictions, were shown to play a role in conditioning nasal coda weakening. Among those factors are lexical frequency and word class. In particular, A3 showed weakening in the context of back vowels in all words but *ión*, which not only is a technical word but is also monosyllabic. Nasals in lexically unstressed words (i.e., prepositions in our case) also showed a higher than normal tendency to weaken, clearly observed in the story. Once again, these results reveal the great susceptibility of nasals to contextual variability and show how weakening may be conditioned by multiple segmental and prosodic factors.

8. Conclusion

In his recent textbook on sociophonetics, Thomas (2011: 17) comments that articulatory studies are not frequently used because most of the necessary information for sociophonetic analyses can be obtained with acoustic techniques. In the case of nasal coda weakening, it may be argued that even auditory transcription suffices. Indeed there is a considerable body of research that analyzes the sociolinguistic distribution of weakened variants. However, neither auditory transcriptions nor acoustic studies are able to capture the gradient nature of weakening processes, as has been convincingly shown in many articulatory phonetic studies (e.g., Wright & Kerswill 1989, Kerswill & Wright 1990, Ellis & Hardcastle 2002, Lawson et al. 2011). From an auditory point of view, it is difficult to determine the difference between less constricted nasals and vowels (or partly and fully assimilated nasals). Acoustic studies face the same problem; there are no reliable methods to capture different degrees of nasal constriction or gradient assimilation, although a combination of EPG and acoustic measurements, such as the consonant-vowel intensity ratio and the F1 bandwidth, may help obtain more definitive conclusions about the degree of nasal vocalization.

Can EPG play a more active role in sociophonetic studies? We believe so. In particular, we have shown that a variety of speech styles can be successfully elicited with this technique and surprisingly natural speech can be obtained even from participants who are not trained phoneticians. Indeed, none of our speakers were phoneticians, and this constitutes a point of departure from many EPG studies, including those earlier attempts to capture semi-spontaneous speech (e.g., Shockey 1991, Shockey & Farnetani 1992).

The relatively short period of recording time allowed by the system is certainly a shortcoming (however, this may not be a problem for more recent versions of WinEPG). The task used in our case to elicit semi-spontaneous speech was not conducive to obtaining a comparable number of tokens, but allowed us to envision new experiments, in which different speech styles can be incorporated. The elicitation of multiple speech styles and the variability obtained across tasks for the phenomenon under study as well as for other processes helped us uncover fine-grained variability in both Spanish dialects, while confirming some well-established cross-dialectal differences. Both the insights and the problems of the current study will hopefully allow us to design in the future more controlled and systematic investigations of the variation within and across Spanish dialects.

In just over a decade, the range of EPG studies has expanded dramatically, with researchers turning to study speech of increasingly diverse populations – from speakers of Australian aboriginal languages (e.g., Tabain 2009) to learners of English as a second language (e.g., Schmidt & Beamer 1998), and to clinical patients with cleft palate and other speech and hearing disorders (e.g., Lee et al. 2007). There is thus a clear potential for EPG, together with other methods of articulatory research, to become an important tool in the study of sociophonetic variation (see also Lawson et al. 2010, 2011), providing new insights that cannot be gained through the use of more traditional sociolinguistic transcription or acoustic analysis.

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Notes

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[1] The first two utterances from Set 1 were also used as controls for nasal assimilation in Kochetov & Colantoni (2011a).
[2] Our previous work on the corpus (Kochetov & Colantoni 2011a,b) revealed no substantial differences between the measurements at the consonant midpoint and at the maximum constriction (at least for intervocalic consonants). While we did not perform measurements of linguopalatal contact across the entire nasal interval, we do not expect them to deviate substantially from those for the midpoint or the point of maximum contact.
[3] For a similar analysis, see Wright & Kerswill (1989) and Kerswill & Wright (1990).
[4] Similarly to the Centre of Gravity metric (Hardcastle et al. 1991), CA serves to distinguish among lingual places of articulation. Since CA is calculated as a log of a weighted sum of contacts in palate rows (often performed separately for the anterior and posterior parts of the palate, CAa and CAp), it is capable of distinguishing more fine-grained place differences (Fontdevila et al. 1994). This was particularly important in our prior work on Spanish coronal contrasts and nasal assimilation.
[5] Thanks to Marko Liker for suggesting this measure of variability.
[6] There was a significant Word effect at $p < .01$ for all speakers and variables except CA for A2 and C3, Q for C3, and Duration for C2. The details of these analyses are not crucial for the discussion of differences among particular word items.
[7] Q rather than CA was plotted against Duration given previous findings of the relation between the degree of EPG contact and consonant duration (e.g., Farnetani 1995, Nicolaidis 2001).

Bibliographical References

BEDDOR Patrice 2009. A coarticulatory path to sound change. *Language* 85. 785-821.

BUSÀ Maria Grazia 2007. Coarticulatory nasalization and phonological developments: data from Italian and English nasal-fricative sequences. In SOLÉ Maria-Josep, Patrice BEDDOR & Manjari OHALA (eds.). *Experimental approaches to phonology*. Oxford: Oxford University Press. 155-174.

CANFIELD Lincoln 1981. *Spanish pronunciation in the Americas*. Chicago: University of Chicago Press.

CEDERGREN Henrietta 1973. *The interplay of social and linguistic variables*. Ithaca: Cornell University. PhD dissertation.

CELATA Chiara, Silvia CALAMAI, Irene RICCI & Chiara BERTINI in press. Nasal place assimilation between phonetics and phonology: An EPG study of Italian nasal-to-velar clusters. *Journal of Phonetics*.

CHEN Marilyn 1975. An areal study of nasalization in Chinese. In FERGUSON Charles, Larry HYMAN & John OHALA (eds.). *Nasálfest*. Stanford: Stanford University Press. 81-125.

CHO Taehong & Patricia KEATING 2009. Effects of initial position versus prominence in English. *Journal of Phonetics* 37. 466-485.

COLANTONI Laura & Jeffrey STEELE 2004. *The University of Toronto Romance Phonetics database.* http://r1.chass.utoronto.ca/rpd/

ELLIS Lucy & William HARDCASTLE 2002. Categorical and gradient properties of assimilation in alveolar to velar sequences: evidence from EPG and EMA data. *Journal of Phonetics* 30. 373-396.

FARNETANI Edda 1995. The spatial and the temporal dimensions of consonant reduction in conversational Italian. In *Proceedings of EUROSPEECH 95. IVth European Conference on Speech Communication and Technology* (September 18-21, 1995). Madrid, Spain. 2255-2258.

FARNETANI Edda & Maria Grazia BUSÀ 1994. Italian clusters in continuous speech. *Proceedings of ICSLP 94. 3rd International Conference on Spoken Language Processing* (September 18-21, 1994). Yokohama, Japan. Vol. 1. 359-362.

FONTDEVILA Jordi, Maria Dolors PALLARÈS & Daniel RECASENS 1994. The contact index method of electropalatographic data reduction. *Journal of Phonetics* 22. 141-154.

FOUGERON Cécile 2001. Articulatory properties of initial segments in several prosodic constituents in French. *Journal of Phonetics* 29. 109-135.

FRIGENI Chiara 2009. *Sonorant relationships in two varieties of Sardinian*. Toronto: University of Toronto. PhD dissertation.

HAJEK John 1997. *Universals of sound change in nasalization*. Oxford: Blackwell.

HAMMOND Robert 1976. The velar nasal in rapid Cuban Spanish. In LANTOLF James, Francine WATTMAN FRANK & Jorge GUITART (eds.). *Colloquium on Spanish and Luso-Brazilian linguistics*. Washington D.C.: Georgetown University Press. 19-36.

HOFFMAN Michol 2004. *Sounding Salvadorian: Phonological variables in the Spanish of Salvadorian youth in Toronto*. Toronto: University of Toronto. PhD dissertation.

HONOROF Douglas N. 1999. *Articulatory gestures and Spanish nasal assimilation*. New Haven: Yale University. PhD dissertation.

HONOROF Douglas N. 2003. Articulatory evidence for nasal de-occlusivization in Castilian. In SOLÉ Maria J., Daniel RECASENS & Joaquim ROMERO (eds.). *Proceedings of the XVth International Congress of Phonetic Sciences* (August 3-9, 2003). Barcelona, Spain. 1759-1762.

JUN Jungho 1995. *Perceptual and articulatory factors in place assimilation: An Optimality Theoretic approach*. Los Angeles: University of California at Los Angeles (UCLA). PhD dissertation.

KERSWILL Paul & Susan WRIGHT 1990. On the limits of auditory transcription: a sociophonetic perspective. *Language Variation and Change* 2. 255-275.

KOCHETOV Alexei & Laura COLANTONI 2011a. Spanish nasal assimilation revisited: a cross-dialect electropalatographic study. *Journal of Laboratory Phonology* 2. 1-38.

KOCHETOV Alexei & Laura COLANTONI 2011b. Coronal place contrasts in Argentine and Cuban Spanish: An electropalatographic study. *Journal of the International Phonetic Association* 41. 329-358.

LABOV William 1972. *Sociolinguistic patterns.* Philadelphia: University of Pennsylvania Press.

LAWSON Eleanor, Jane STUART-SMITH, James M. SCOBBIE, Malcah YAEGER-DROR & Margaret MACLAGAN 2010. Liquids. In DI PAOLO Marianne & Malcah

YAEGER-DROR (eds.). *Sociophonetics: A student's guide*. London: Routledge. 72-86.

LAWSON Eleanor, James M. SCOBBIE & Jane STUART-SMITH 2011. The social stratification of tongue shape for postvocalic /r/ in Scottish English. *Journal of Sociolinguistics* 15. 256-268.

LEE Alice, Fiona E. GIBBON, Lisa CRAMPIN, Ivan YUEN & Grant MCLENNAN 2007. The national CLEFTNET project for individuals with speech disorders associated with cleft palate. *International Journal of Speech-Language Pathology* 9. 57-64.

LIPSKI John 1994. *Latin American Spanish*. New York: Longman.

LIPSKI John 2011. Sociophonological variation in Latin American Spanish. In DÍAZ CAMPOS Manuel (ed.). *Handbook of Spanish sociolinguistics*. Oxford: Blackwell. 72-97.

MARTÍNEZ CELDRÁN Eugenio, Ana María FERNÁNDEZ PLANAS & Josefina CARRERA SABATÉ 2003. Castilian Spanish. *Journal of the International Phonetic Association* 33. 255-259.

NAVARRO TOMÁS Tomás 1918 [1970]. *Manual de pronunciación española*. Madrid: Concejo Superior de Investigaciones Científicas.

NICOLAIDIS Katerina 2001. An electropalatographic study of Greek spontaneous speech. *Journal of the International Phonetic Association* 31. 67-85.

PIÑEROS Carlos Eduardo 2006. The phonology of nasal consonants in five Spanish dialects. In MARTÍNEZ-GIL Fernando & Sonia COLINA (eds.). *Optimality-theoretic studies in Spanish phonology*. Amsterdam: John Benjamins. 146-171.

POPLACK Shana 1980. Deletion and disambiguation in Puerto Rican Spanish. *Language* 56. 371-385.

QUILIS Antonio 1993. *Tratado de fonética y fonología españolas*. Madrid: Gredos.

RAMSAMMY Michael 2011. *The realization of coda nasals in Spanish*. Manchester: University of Manchester. PhD dissertation.

RECASENS Daniel 2004. The effect of syllable position on consonant reduction (evidence from Catalan consonant clusters). *Journal of Phonetics* 32. 435-453.

SAMPSON Rodney 1999. *Nasal vowel evolution in Romance*. New York: Oxford University Press.

SCHMIDT Anna M. & Jessica BEAMER 1998. EPG treatment for Thai speakers of English. *Clinical Linguistics & Phonetics* 21. 389-403.

SHOCKEY Linda 1991. Electropalatography of conversational speech. In *Proceedings of the XIIth International Congress of Phonetic Sciences* (August 19-24, 1991). Aix-en-Provence, France. Vol. 3. 10-13.

SHOCKEY Linda & Edda FARNETANI 1992. Spontaneous speech in English and Italian. In *Proceedings of ICSLP 92. IInd International Conference on Spoken Language Processing* (October 12-16, 1992). Banff, Canada. 767-769.

SHOSTED Ryan & José Ignacio HUALDE 2010. The production and provenance of Spanish and Portuguese palatal nasals. In COLINA Sonia, Antxon OLARREA & Ana María CARVALHO (eds.). *Romance Linguistics 2009: Selected Papers from the 39th Linguistic Symposium on Romance Languages (LSRL)*. Amsterdam: John Benjamins. 43-62.

SHOSTED Ryan & Beatrice WILLGOHS 2006. Nasals unplugged: the aerodynamics of nasal de-occlusivization in Spanish. In DÍAZ-CAMPOS Manuel (ed.). *Selected Proceedings of the 2nd conference on laboratory approaches to Spanish phonetics and phonology*. Somerville, MA: Cascadilla Press. 14-21.

SOLÉ Maria-Josep 2007. The stability of phonological features within and across segments: The effect of nasalization on frication. In PRIETO Pilar, Joan MASCARÓ & Maria-Josep SOLÉ (eds.). *Segments and prosodic issues in Romance phonology*. Amsterdam: John Benjamins. 41-65.

TABAIN Marija 2009. An EPG study of the alveolar vs. retroflex apical contrast in Central Arrernte. *Journal of Phonetics* 37. 486-501.

TERRELL Tracy 1975. La nasal implosiva y final en el español de Cuba. *Anuario de Letras* 13. 257-271.

THOMAS Erik 2011. *Sociophonetics: An introduction*. New York: Palgrave Macmillan.

WRENCH Alan A., Fiona GIBBON, Alison M. MCNEILL & Sara E. WOOD 2002. An EPG therapy protocol for remediation and assessment of articulation disorders. In HANSEN John & Bryan PELLOM (eds.). *Proceedings of ICSLP 2002. VIIth International Conference on Spoken Language Processing - INTERSPEECH 2002* (September 16-20, 2002). Denver, Colorado. 965-968.

WRIGHT Susan & Paul KERSWILL 1989. Electropalatography in the study of connected speech processes. *Clinical Linguistics and Phonetics* 3. 49-57.