THE PHONETICS AND PHONOLOGY OF SPIRANTIZATION IN NORTH-CENTRAL PENINSULAR SPANISH

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1. Introduction[1]

It is well known that Spanish /b, d, g/ have continuant allophones in various contexts. This is usually referred to as *spirantization*, a type of lenition whereby stops weaken to fricatives (spirants) (Kenstowicz 1994: 35). This paper considers several phonetic and phonological issues related to spirantization in the North-Central dialect of Peninsular Spanish (henceforth NC Spanish).

NC Spanish shows an intriguing departure from spirantization. Typically /b, d, g/ are realized as continuants after vowels regardless of syllable position (1d-g); non-continuant allophones occur utterance-initially (1a-c).[2] Note that acoustic studies show that continuant allophones of /b, d, g/ are generally approximants, not fricatives (Martínez Celdrán 1984, Romero 1995).

(1)	Utterance-initially: [b, d, g]			After a vowel:		[β̞, ð̞, ɣ̞]	
(a)	*bota*	[ˈbo.ta]	‘boot’	(d)	*la bota*	[la ˈβ̞o.ta]	‘the boot’
(b)	*dota*	[ˈdo.ta]	‘dotes’	(e)	*la dota*	[ˈla.ð̞o.ta]	‘dotes her’
(c)	*gota*	[ˈgo.ta]	‘drop’	(f)	*la gota*	[la ˈɣ̞o.ta]	‘the drop’
				(g)	*pared*	[pa.ˈreð̞]	‘wall’

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[2] The data in this paper (unless noted otherwise) comes from Harris (1969), Jannedy, Poletto and Weldon (1994), Kenstowicz (1994), Harris-Northhall (1990), and the author’s fieldnotes from work with native speakers from Spain.

However, in NC Spanish words like *pared* 'wall' are pronounced with a fricated and devoiced /d/ rather than with a voiced approximant: [pa.'ɾeθ]. This process has been previously analyzed as phonological coda devoicing (Morris 2002). This paper provides an alternative phonological analysis where frication rather than devoicing is the phonological result of spirantization in coda position in this dialect.

Additionally, this paper examines two phonetic studies on coda /b, d, g/ and their implications for the phonology. These studies test the effect of stress, dialect and lexical frequency in the pronunciation of coda /b, d, g/. One main result from these studies is that NC Spanish can be divided into two different dialects regarding the realization of coda /b, d, g/: the Northern dialect, or Basque Spanish (the dialect of Spanish spoken in the Basque Country) and the Central dialect (the dialect of Spanish spoken in a large part of Castile). In Basque Spanish, coda /b, d, g/ are pronounced as voiceless fricatives, while in Central Spanish coda /b, d, g/ are mostly realized as stops or voiced fricatives (González 2002). This paper proposes a phonological analysis of spirantization for both dialects.

This paper is organized as follows. Section (2) makes clear the theoretical assumptions of this paper. Section (3) discusses the basic facts of spirantization in Peninsular Spanish and analyzes it in Optimality Theoretical terms. Section (4) discusses experimental research bearing on the nature and characteristics of frication and devoicing of coda /b, d, g/ in NC Spanish. Section (5) provides an Optimality Theoretic analysis of frication in the Northern dialect, and section (6) is the conclusion.

2. Theoretical framework

Section (2.1) is a brief introduction to the theoretical framework used in this paper, Optimality Theory. Readers already familiar with OT might want to skip to section 2.2. My assumptions about the relationship between phonetics and phonology are stated in section (2.2).

2.1. Optimality Theory

The phonological analysis in this paper will be couched within Optimality Theory (OT). Optimality Theory (Prince and Smolensky 1993) views phonological processes as resulting from the interaction of universal constraints. Constraints are potentially opposing forces that may stand in tension with each other; two examples are NO CODA, which penalizes codas, and MAX-IO, which prohibits deletion of segmental material. Cross-linguistic variation results from different ways of resolving tensions among constraints. This is expressed by different rankings of these constraints in a hierarchy. For example, a language that allows codas will rank MAX-IO higher than NO CODA (MAX-IO>>NO CODA), but a language that disallows codas will have NO CODA higher in the ranking than MAX-IO (NO CODA>>MAX-IO).

A central claim of Optimality Theory is that there are just two levels: input (which roughly corresponds to the underlying form) and output (surface form);

there are neither intermediate forms nor serial derivations. From the input form, a set of possible outputs or candidates are evaluated in parallel with respect to the constraint hierarchy in a language. The output that best satisfies the particular ranking in a language is chosen as the optimal form.

OT has three main components: Generator (GEN), Constraints (CON), and Evaluator (EVAL). GEN is a function mapping an input to a set of possible outputs. Constraints on GEN determine the set of possible inputs. CON is a set of universal violable constraints. EVAL is a function evaluating the output candidates generated by GEN with respect to a particular ranking of CON. There is no serial derivation; candidate evaluation proceeds in parallel with respect to the whole constraint hierarchy. A tableau shows the interaction of these three components with respect to a particular form (2).

(2) Interaction between GEN, CON, and EVAL in a tableau.

EVAL

/input/	CONSTRAINT 1	CONSTRAINT 2
☞ Candidate a		**
Candidate b	*!	

} CON

↑ GEN — EVAL

The tableau above represents a typical case of conflict between two constraints. Usually, only the most competitive or relevant candidates are shown in a tableau. The optimal candidate chosen from the set of generated candidates for a given input is indicated with ☞. The particular ranking among the constraints supplied by CON is shown by a left to right ordering of the constraints. In this particular tableau Constraint 1 is ranked higher than Constraint 2. This means that the satisfaction of this constraint has preference over the satisfaction of Constraint 2. An asterisk (*) indicates a constraint violation. Candidate (a) in the tableau violates Constraint 2, and candidate (b) violates Constraint 1. The exclamation mark (!) indicates that the violation of Constraint 1 is fatal, and that the candidate being evaluated (b) loses at this point. Even if candidate (a) has two violations of Constraint 2, it is selected over candidate (b) because Constraint 1 is ranked higher in the hierarchy.

Constraints are usually crucially ranked; this is indicated by a solid vertical line separating the relevant constraints. However, in some cases constraints might have the same weight or importance in a hierarchy. This is indicated by a discontinuous vertical line (one example is Tableau 5 in section 3.2 below).

The two basic types of constraints within OT are faithfulness and markedness constraints (Prince and Smolensky 1993). Faithfulness constraints conspire to pronounce the output as specified in the input. The constraint MAX-IO is one example of a faithfulness constraint. In this paper I assume the Correspondence Theory of Faithfulness (McCarthy and Prince 1995), whereby the input and the output are in a correspondence relation with each other.

Markedness constraints capture preferences in phonological well-formedness and in segment inventories. NO CODA is one example of a Markedness constraint. The interaction between faithfulness and markedness constraints captures phonemic and allophonic distributions in languages (Prince and Smolensky 1993, Kager 1999). More examples of this interaction are shown in the following sections.

2.2. The relationship between phonetics and phonology

Phonetic explanation is important in phonology. Many phonological processes have phonetic bases; articulatory and perceptual factors in many cases condition phonological phenomena (Browman and Goldstein 1990, 1992, Hayes 1997, Steriade 1999, among others). Within Optimality Theory this is captured through phonetic grounding (Archangeli and Pulleyblank 1994); a constraint can be motivated if it has a phonetic basis, that is, if it expresses a principle of ease of articulation or of maximizing perceptibility. However, I consider phonetics and phonology to be separate modules (Pierrehumbert 1980; Keating 1984, 1985, 1990; Kingston and Beckman 1990, Howe and Pulleyblank 2001, among others). Phonetics involves gradient and variable phenomena, whereas phonology is categorical.

Even if phonological and phonetic phenomena have the same (phonetic) factors, I defend treating categorical phenomena in the phonology, and gradient or variable cases in the phonetics. I assume that some phonetic detail is included in the phonological representation, including perceptual and articulatory factors, but not rate or register of speech (cf. Kirchner 1998). This paper assumes that variation within and across speakers in a linguistic community is not incorporated in the grammar unless a definite similar trend in the speakers exists.

3. Spirantization in Peninsular Spanish

Section 3.1 presents the basic facts of spirantization and provides an Optimality Theory analysis of these facts (sections 3.2, 3.3). Section 3.4 discusses the analysis of /ld/ sequences.

3.1. Basic facts

Spirantization is extremely variable across Spanish dialects (Amastae 1986, 1995, Carreira 1998, among others). I focus here on Castilian Spanish, the standard dialect spoken in Spain. A consonant phonemic inventory is given in (3):

(3) Consonants in Castilian Spanish (Martínez-Celdrán, Fernández-Planas and Carrera-Sabaté 2003: 255)

	Bilabial	Labio-dental	Dental	Alveolar	Palatal	Velar
Plosive	p b		t d			k g
Affricate					t͡ʃ ɟ͡ʝ	
Nasal	m			n	ɲ	
Tap or flap				ɾ		
Trill				r		
Fricative		f	θ	s		x
Lateral approximant				l	ʎ	

Castilian Spanish has phonemic voiceless and voiced stops, as shown by the minimal pairs /b̲ino/ 'wine' vs. /p̲ino/ 'pine', /mand̲a/ 'he sends' vs. /mant̲a/ 'blanket', and /mang̲a/ 'sleeve' vs. /mank̲a/ 'one-handed'. Voiced stops are realized as such in utterance-initial position and after nasals (4). They are realized categorically as voiced approximants [β̞, ð̞, ɣ̞] after vowels, approximants, fricatives and liquids (5). Note that while the allophone [d] is dental, [ð̞] is interdental.

(4) Distribution of [b, d, g]

	Initially		After nasal		After [l]	
(a)	[ˈbo.ta]	'boot'	[im.ˈbjer.no]	'winter'		
(b)	[ˈdo.ta]	'dotes'	[ˈan.da]	'beat it'	[ˈkal.do]	'broth'
(c)	[ˈgo.ta]	'drop'	[ˈten.go]	'I have'		

(5) Distribution of [β̞, ð̞, ɣ̞]

	After vowel		After approximant/fricative		After liquid	
(a)	[la ˈβ̞o.ð̞a]	'the wedding'	[ˈkaj.ɣ̞o]	'I fall'	[ˈkal.β̞o]	'bald'
(b)	[ˈa.ɣ̞o]	'I do'	[ˈdew.ð̞a]	'debt'	[ˈsal.ɣ̞o]	'I go out'
(c)	[θiu.ˈð̞að̞]	'city'	[ma.ra.ˈkaj.β̞o]	'Maracaibo'	[θer.ˈβ̞e.θa]	'beer'
(d)	[θiɣ̞.ˈθaɣ̞]	'zig-zag'	[aβ̞.ˈð̞i.ka]	'he abdicates'	[ˈbeɾ.ð̞e]	'green'
(e)	[að̞.ˈβ̞ien.to]	'advent'	[dis.ˈɣ̞us.to]	'trouble'	[kaɾ.ˈɣ̞ar]	'to load'

The distribution of /d/ stands apart in one respect. /d/ is realized as a stop after /l/ but as an approximant after /ɾ/; /b/ and /g/ are realized as approximants in both cases. Leaving aside this case for the moment, the generalization is that [β̞, ð̞, ɣ̞] occur after [+continuant] segments, and [b, d, g] elsewhere.

3.2. Allophonic variation between [b, d, g] and [β̞, ð̞, ɣ̞]

In OT, allophonic variation is captured through the ranking of markedness constraints above faithfulness constraints. For [b, d, g] and [β̞, ð̞, ɣ̞] the relevant faithfulness constraint is IDENT-IO [continuant] (McCarthy and Prince 1995), and the relevant markedness constraints *VOICED STOP and *[+son, +cont, -lat, -rhotic] (6).

(6)	IDENT-IO [continuant]	Correspondent segments have identical values for the feature [continuant]. *Let* x *be a segment in the input and* y *a segment in the output. If* xRy *and* x *is [γcontinuant], then* y *is [γcontinuant].*
	*VOICED STOP	Voiced obstruent stops are prohibited.
	*[+son, +cont, -lat, -rhotic]	[+son, +cont, -lat, -rhotic] segments are prohibited.

Voiced stops and consonantal approximants other than glides and liquids are cross-linguistically dispreferred (Maddieson 1984, Ladefoged and Maddieson 1996). Voiced stops in inventories imply voiceless stops and impose harder aerodynamic requirements (Maddieson 1984, Ohala 1983). In Spanish a voiced stop is preferred to an approximant in the absence of any preceding segment (i.e., utterance-initially). Tableau 1 shows that *[+son, +cont, -lat, -rhotic] outranks IDENT-IO [continuant], and Tableau 2 that IDENT-IO [continuant] outranks *VOICED STOP.

Tableau 1

*[+son, +cont, -lat, -rhotic] >> IDENT-IO [continuant]

/β̞as/ 'you go'	*[+son, +cont, -lat, -rhotic]	IDENT-IO [continuant]
☞ a. bas		*
b. β̞as	*!	

Tableau 2

IDENT-IO [continuant] >> *VOICED STOP

/bas/ 'you go'	IDENT-IO [continuant]	*VOICED STOP
☞ a. bas		*
b. β̞as	*!	

Candidate (a) is selected as optimal in Tableau (1). It is better to change the [continuant] specification from the input than to have an approximant in initial position. Tableau 2 shows that even if the input is changed, the right candidate is selected (Richness of the Base; Prince and Smolensky 1993). Previous analyses of spirantization differ in the choice of [b, d, g] or [β̞, ð̞, ɣ̞] as basic (Harris 1969, Lozano 1979, Mascaró 1984, among others); in OT a basic form is not necessary. Both [b, d, g] and [β̞, ð̞, ɣ̞] are possible inputs; which one is selected depends on the particular constraint ranking.

Voiced stops in Spanish are banned after [+continuant] segments. Context-sensitive constraints [A $_{o}$]/*voiced stop and [A $_{f}$]/*voiced stop capture this fact (7).

(7)	[A $_{o}$]/*voiced stop	A voiced stop is prohibited after an open segment (Vowels and approximants are open; Steriade 1993, 1994).
	[A $_{f}$]/*voiced stop	A voiced stop is prohibited after a fricative.

These two constraints are based on Aperture Theory (Steriade 1993, 1994). Their motivation is articulatory; it is hard to achieve the closure necessary for a voiced stop if the surrounding segments are not closed (Kirchner 1998). In Spanish, voiced stops are allowed utterance-initially and after segments with closure (nasals, other stops). Tableaux 3, 4 show that it is better to prevent a voiced stop after an open or fricative segment than to avoid an approximant.[3]

Tableau 3

$[A_o]$/*voiced stop >> *[+son, +cont, -lat, -rhotic]

/odio/ 'hatred'	$[A_o]$/*voiced stop	*[+son, +cont, -lat, -rhot]
a. odio	*!	
☞ b. oð̞io		*

Tableau 4

$[A_f]$/*voiced stop >> *[+son, +cont, -lat, -rhotic]

/disgusto/ 'trouble'	$[A_f]$/*voiced stop	*[+son, +cont, -lat, -rhot]
a. dis.gus.to	*!	
☞ b. dis.ɣ̞us.to		*

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[3] It might be desirable to generalize $[A_o]$/*voiced stop to all stops. However, voiceless stops are unrestricted in Spanish and IDENT-IO [continuant] is ranked low to allow for spirantization. A constraint like $[A_o]$/*stop would be problematic in that it would always choose a voiceless fricative rather than a voiceless stop after an open segment. This is shown in Tableaux A, B.

Tableau A

$[A_o]$/*stop >> IDENT-IO [continuant] (I)

/rata/ 'rat'	$[A_o]$/*stop	IDENT-IO [continuant]
! a. ra.ta	*!	
☞ b. ra.θa		*

Tableau B

$[A_o]$/*stop >> IDENT-IO [continuant] (II)

/raθa/ 'race'	$[A_o]$/*stop	IDENT-IO [continuant]
! a. ra.ta	*!	*
☞ b. ra.θa		

For this reason I formalize the constraints as $[A_o]$/*voiced stop and $[A_f]$/*voiced stop.

So far, the ranking is [A $_o$]/*voiced stop, [A $_f$]/*voiced stop>>*[+son, +cont, -lat, -rhotic]>> IDENT-IO [continuant]>> *VOICED STOP. Tableau 5 summarizes this ranking. Candidate (a) is selected as optimal since all other candidates violate high-ranked [A $_o$]/*voiced stop or [A $_f$]/*voiced stop.

Tableau 5

Summary ranking (I)

/abdikar/ 'to abdicate'	[A $_o$]/ *vd stop	[A $_f$]/ *vd stop	*[+son, +cont, -lat, -rhotic]	IDENT [cont]	*VOICED STOP
☞ a. aβ̞ð̞ikar			**	**	
b. aβ̞dikar		*!	*	*	*
c. abð̞ikar	*!		*	*	*
d. abdikar	*!				**

3.3. Phonemic distribution of /b, d, g/ and /p, t, k/

Phonemic distribution is captured in OT through the ranking of faithfulness constraints over markedness constraints (Prince and Smolensky 1993). The voicing contrast between stops is captured by a ranking where IDENT-IO [voice] (8) outranks *VOICED STOP; it is more important to keep the voicing specification from the input than to avoid voiced stops (Tableaux 6, 7).

(8) IDENT-IO [voice] Correspondent segments have identical values for the feature [voice].
Let x *be a segment in the input, and* y *a segment in the output. If* xRy *and* x *is [γvoice], then* y *is [γvoice].*

Tableau 6

IDENT -IO [voice]>> *VOICED STOP

/bino/ 'wine'	IDENT-IO [voice]	*VOICED STOP
☞ a. bino		*
b. pino	*!	

Tableau 7

IDENT -IO [voice]>> *VOICED STOP

/pino/ 'wine'	IDENT-IO [voice]	*VOICED STOP
a. bino	*!	*
☞ b. pino		

Spanish has voiced approximants but no voiceless ones, and voiceless fricatives, but (usually) no voiced fricatives. This is expressed through the following markedness constraints (9):

(9) *VOICELESS APPROXIMANT [+son, +cont, -voi] segments are prohibited
*VOICED FRICATIVE Voiced fricatives are prohibited.

Voiceless approximants are cross-linguistically dispreferred (Maddieson 1984). Voiced fricatives are more marked than voiceless fricatives (Maddieson 1984) and have conflicting aerodynamic requirements for voicing and frication; a pressure drop across the glottis is needed for voicing to occur, and at the same time high pressure is needed for frication (Ohala 1983, 1997, Smith 1997). Since in Spanish voiced fricatives are rarer than voiced approximants, then *VOICED FRICATIVE >> *[+son, +cont, -lat, -rhotic] (Tableau 8).

Tableau 8

VOICED FRICATIVE >>[+son, +cont, -lat, -rhotic]

/ada/ 'fairy'	*VOICED FRICATIVE	*[+son, +cont, -lat, -rhotic]
a. aða	*!	
☞ b. að̞a		*

Since Peninsular Spanish lacks a contrast between voiced and voiceless fricatives, I assume that *VOICED FRICATIVE>>IDENT [voice]. The constraint *VOICED FRICATIVE is not undominated, since voiced fricatives sometimes occur as allophones in Spanish (a word like *mismo* /mismo/ 'same' is usually pronounced [mizmo]; voiced fricatives may also occur as coda realizations of /b, d, g/). The comparison between candidates (a, b) in Tableau 9 shows that IDENT [voice] outranks *[+son, +cont, -lat, -rhotic]; it is more important to keep the input voice specification than to avoid a voiced approximant. This ranking does not produce a phonemic contrast between voiced and voiceless approximants in Spanish since *VOICELESS APPROXIMANT is undominated (no voiceless approximants ever occur in Spanish). Tableau 9 also shows that *VOICED FRICATIVE outranks *[+son, +cont, -lat, -rhotic] (cf. candidates a, d).

Tableau 9

IDENT [voice]>> *[+son, +cont, -lat, -rhotic]

/reð̞es/ 'nets'	*VLESS APPR.	*VD FRIC	IDENT [voice]	*[+son, +cont, -lat, -rhotic]
☞ a. reð̞es				*
b. reθes			*!	
c. reθ̞es	*!		*	*
d. reðes		*!		

After vowels /b, d, g/ are realized as voiced approximants, not as voiced fricatives (Tableau 10). So far *Voiced fricative and [A_o]/*voiced stop are not crucially ranked. Tableau 11 shows that /p, t, k/ are optimally realized as voiceless stops.

Tableau 10

No voiced fricatives

/redes/ 'nets'	*Voiced Fricative	[A_o]/*voiced stop	*[+son, +cont, -lat, -rhotic]
☞ a. reð̞es			*
b. reðes	*!		
c. redes		*!	

Tableau 11

Voiceless stops

/ata/ 'he ties'	Ident [voice]	*[+son, +cont, -lat, -rhotic]	Ident [continuant]
☞ a. ata			
b. ada	*!		
c. aθa			*!
d. að̞a	*!	*	*

In conclusion, Ident-IO [voice]>>*Voiced Stop captures the phonemic contrast between voiced and voiceless stops and the universal preference for the second. The ranking [A_o]/*voiced stop, [A_f]/*voiced stop>>*[+son, +cont, -lat, -rhotic]>>Ident-IO [continuant]>> *Voiced Stop accounts for allophonic variation between [b, d, g] and [β̞, ð̞, ɣ̞]. Undominated *Voiceless Approximant and high-ranked *Voiced fricative capture the universal dispreference for voiceless approximants and voiced fricatives and their absence or rarity in Spanish.

3.4. [ld] sequences

It was noted in section 2 that /d/ is pronounced as a voiced stop after /l/. This does not occur for /b, g/, which are pronounced as voiced approximants (Mascaró 1984, Palmada 1997, Kenstowicz 1994). This section explores two different solutions for this problem. The first relates the failure of spirantization in /ld/ to the assimilation of /l/ to /d/ in place features (Harris 1969, 1984; Mascaró 1984;

Padgett 1991; Palmada 1997; Kirchner 1998). Since /l/ triggers spirantization in most contexts I assume /l/ is [+continuant].[4]

The lateral approximant /l/ is alveolar (10a) but it can assimilate in place of articulation to a following interdental, dental or palatal consonant (10b-d) (Alarcos Llorach 1950, Quilis 1981, Martínez-Celdrán, Fernández-Planas and Carrera-Sabaté 2003; cf. Harris 1969).

(10)	Allophones of /l/ in Spanish ([̟] = interdental, [̪] = dental, [ʲ] = palatal)						
(a)	Alveolar:	*ala*	['a.la]	'wing'	*balsa*	['bal.sa]	'boat'
(b)	Interdentalised:	*alza*	['al̟.θa]	'raise'			
(c)	Dentalised:	*alto*	['al̪to]	'tall'			
(d)	Palatalised:	*colcha*	['kolʲ.tʃa]	'quilt'			

However, in a sequence /ld/ the lateral is dental rather than interdental and spirantization fails. To account for the distribution of lateral allophones and failure of spirantization in /ld/ sequences I propose the constraints LATERAL PLACE ASSIMILATION and *INTERDENTAL LATERAL (11).

(11)	LATERAL PLACE ASSIMILATION (LPA)	A lateral agrees in tongue tip orientation with an immediately following coronal (based on Gafos 1996)
	*INTERDENTAL LATERAL	Interdental laterals are prohibited.

Interdental lateral segments are not very common cross-linguistically; *INTERDENTAL LATERAL expresses this dispreference.[5] LATERAL PLACE ASSIMILATION is higher ranked than *INTERDENTAL LATERAL and will drive the selection of interdental laterals before interdental consonants (Tableau 12).

Tableau 12

LPA >>* INTERDENTAL LATERAL

/alθa/ 'raise'	LATERAL PLACE ASSIMILATION	*INTERDENTAL LATERAL
☞ a. al̟θa		*
b. alθa	*!	

However, if a lateral is followed by /d/, the lateral will be dentalised and spirantization will not apply, yielding [l̪d] rather than [l̟ð]. This can be captured by the ranking *INTERDENTAL LATERAL>>[A ̥]/*voiced stop (Tableau 13). Both [l̪d] and [l̟ð] respect LPA; the choice between the two falls to high-ranked

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4 See Harris (1969: 39) and Kirchner (1998) on a different approach, and Chomsky and Halle (1968: 318) for the dual patterning of /l/ as [+/-continuant] across languages.

5 Mark Jones recently posted a summary of reported occurrences of interdental /l/ in dialects of English and Italian in the Linguist List (http://www.linguistlist.org.issues/15/15-1836.html, and http://www.linguistlist.org.issues/15/15-1889.html).

Tableau 13

*Interdental Lateral>>[A $_o$]/*voiced stop

/kaldo/ ‘broth’	LPA	*Interd. Lateral	[A$_o$]/*voiced stop
☞ a. kal̪do			*
b. kal̟ðo		*!	

*Interdental Lateral, which dominates [A $_o$]/*voiced stop. The non-spirantized candidate is optimal in this case.

Note that to avoid a violation of [A$_o$]/*voiced stop, a voiceless stop could have been selected. This is not possible because Ident-IO [voice] outranks [A$_o$]/*voiced stop (Tableau 14).

Tableau 14

*IDENT-IO (voice)>>[A $_o$]/*voiced stop

/kaldo/ ‘broth’	LPA	*Inter. Lateral	Ident [voice]	[A$_o$]/*voiced stop
☞ a. kal̪do				*
b. kal̪to			*!	

In conclusion, LPA might drive a violation of high-ranked *Interdental Lateral; but if the candidates tie on LPA the choice rests on high-ranked *Interdental Lateral. Tableau 15 compares a wider range of candidates with respect to this ranking (Note that *Interdental Lateral and Ident [voice] are not crucially ranked).

Tableau 15

Summary tableau (II)

/kaldo/ ‘broth’	LPA	*Inter. Lateral	Ident [voice]	[A $_o$]/*voiced stop
☞ a. kal̪do				*
b. kaldo	*!			*
c. kalð̝o	*!			
d. kal̟ð̝o		*!		
e. kal̟do	*!	*		*
f. kal̪to			*!	

Candidates (b, c, e) violate LPA since alveolar [l] is followed by non-alveolar consonants. Candidate (d) violates *Interdental Lateral and (f) violates Ident [voice]. Thus, the optimal candidate is (a), which respects both LPA and *Interdental Lateral.

Note that in /lb/ and /lg/ sequences spirantization occurs since LPA is not relevant (/b, g/ are non-coronals) and any violation of *Interdental Lateral would be gratuitous (Tableau 16).

Tableau 16

/kalbo/ 'bald'

/kalbo/ 'bald'	LPA	*Interd. Lateral	$[A_o]$/*voiced stop
☞ a. kalβ̞o			
b. kalbo			*!
c. kal̟β̞o		*!	

Previous phonological analyses of spirantization have considered spirantization blocking in /ld/ as a homorganicity effect: /d/ fails to spirantize after /l/ because both share the same place of articulation (see, for instance, Carreira 1998, Kirchner 1998). An important assumption for this analysis is that /l/ is [-continuant] and that continuancy depends on place (Padgett 1994). This analysis predicts that spirantization will fail to apply in /dl/ sequences because they are also homorganic (Kirchner 1998). However, spirantization applies in this case, and a word like /adlatere/ 'inseparable companion' is realized as [að̞latere]. Under the approach proposed here [að̞latere] is not problematic; the choice of [ð̞] versus [d] is captured by high-ranked A_o/*voiced stop and the lack of interaction of LPA and *Interdental lateral for /dl/.[6]

A second possibility to account for [ld] is that [d] does not violate $[A_o]$/ *voiced stop in [ld] since [l] counts as a closed segment for [d]. This insight goes back to Mascaró (1984), who states that /d/ is a stop following /l/ because there is no airflow in the central dental region during the articulation of the lateral. Since airflow is essential for approximants and this is lacking when [l] precedes [d], the lateral acts as a stop with respect to [d]. In other words, spirantization occurs to make a segment more similar to the preceding segment. To spirantize /d/ after /l/ makes no sense, since the tongue tip is already in stop position. Spirantization would make the second consonant less similar to the first. How to precisely formalize this is a matter for further research. A ranking lattice for all constraints considered so far is given in (12).

6 Kirchner (1998: 148) suggests that paradigmatic faithfulness to the prefix [að-] in Spanish underlies spirantization for /dl/ cases.

(12) Ranking lattice for Castilian Spanish

* VOICELESS APPROXIMANT, LPA
|
*VOICED FRICATIVE, *INTERDENTAL LATERAL
|
IDENT-IO [voice]
|
[A $_o$]/*voiced stop, [A $_f$]/*voiced stop
| |
*[+son, +cont, -lat, -rhotic]
|
IDENT-IO [continuant]
|
*VOICED STOP

4. Coda /b, d, g/ in NC Spanish

Realization of coda /b, d, g/ in Spanish varies from dialect to dialect. Typically deletion takes place in codas in Andalusian and American Spanish. In Peninsular Spanish they are mostly pronounced as voiced approximants. Coda /b, d, g/ are realized as voiceless fricatives [Φ, θ, x] in NC Spanish (Hualde 1989, Martínez-Gil 1991, González 2002, Morris 2002). (13) compares the typical pronunciation of coda /b, d, g/ in three dialects of Peninsular Spanish:

(13) Realization of coda /b, d, g/

Peninsular Spanish	Andalusian Spanish	NC Spanish	Gloss
[pa.ˈɾeð̞]	[pa.ˈɾe]	[pa.ˈɾeθ]	‘wall’
[ˈkluβ̞]	[ˈklu]	[ˈkluΦ]	‘club’
[maɣ̞.ð̞a.ˈle.na]	[ma.ð̞a.ˈle.na]	[max.ð̞a.ˈle.na]	‘muffin’

Morris (2002) assumes that spirantization yields fricatives rather than approximants, and considers that coda /b, d, g/ in NC undergo devoicing. Thus, NC Spanish would be similar to languages like Dutch and Catalan, where obstruent voicing is neutralized in syllable-coda position and obstruents become uniformly voiceless (Mascaró 1984, Kager 1999). However, continuant allophones of coda /b, d, g/ are more often than not approximants (Martínez Celdrán 1984, Romero 1995). It would be expected that coda devoicing in NC Spanish would yield voiceless approximants, or even voiceless stops rather than voiceless fricatives.

Another consideration is that most words with coda /b, d, g/ in Spanish are stressed in the syllable containing these segments. Stress plays a role in the realization of /b, d, g/ in various Spanish dialects; in Castilian Spanish, onset /g/ in intervocalic position has a more complete closure and is more resistant to spirantization in stressed syllable than in unstressed syllable (Cole, Hualde and Iskarous 1998). In Colombian Spanish /b, d, g/ tend to be realized as stops in onsets of stressed syllables, but as approximants in onsets of unstressed syllables (Amastae 1986, 1995; Kim 2002). The question arises whether stress has an effect on the outcome of coda /b, d, g/ in NC Spanish.

The remainder of this section focuses on two phonetic experiments bearing on frication and voicing of coda /b, d, g/ in NC Spanish. Section 4.1 reports the main findings of the acoustic study in González (2002) concerning the effect of stress and dialect, and section 4.2 discusses a second acoustic study on the effect of lexical frequency. The phonetic and phonological implications of both experiments are discussed in section 4.3.

4.1. Stress and dialect effects in coda /b, d, g/

González (2002) reports an acoustic study that tests the effect of on frication and devoicing in coda /b, d, g/ in NC Spanish. This section summarizes the methodology of this study and the main results concerning stress and dialect; for further details I refer the reader to the original report.

This experiment tested nonce words because (i) very few Spanish words have /b/ or /g/ in syllable-final position and (ii) most words with /d/ in coda are stressed in that syllable, making the comparison between stressed/non-stressed pairs of words very limited. Thirty-six disyllabic words were constructed according to the independent variables (i) Target consonant (coda /b, d, g/); (ii) Preceding vowel (/a, i, u/), (iii) Target syllable stress (stressed/unstressed), and (iv) Word position (medial/final). Examples of the nonce words used include *La<u>b</u>ga Gota* (where the syllable containing coda /b/ is stressed) *and La<u>b</u>gán Gotera* (where the syllable containing coda /b/ is unstressed).

The context for the pronunciation of /b, d, g/ is post-vocalic (so that spirantization is triggered) and before /b/ (for coda /d, g/) or /g/ (for coda /b/); this avoids the possibility of regressive devoicing (cf. Morris 2002). The words were recorded using the sentence frame *Se llama* [...] /se.'ʎa.ma. [...]/ 'His name is [...]' to avoid the possible influence of stress from neighboring words.

The list was repeated seven times to obtain seven tokens for each word, yielding a total of 252 tokens. The order of the sentences was randomized for each block and speaker. Three filler sentences were included in the list, one at the beginning and two at the end of the list.

The analysis includes data from 9 subjects; six from the Basque Country (indicated as NOR 'Northern Spanish' below), and three from Madrid (indicated as CEN 'Central Spanish'). None of the speakers from the Basque Country are bilingual in Basque. Only university students or college graduates were selected due to the difficulty of the reading task, which included unfamiliar words with unusual stress patterns.

The dependent variables measured were (i) Vowel duration, (ii) Consonant duration, (iii) Presence or absence of frication, (iv) Presence of absence of voicing, (v) Voicing duration (in milliseconds), and (vi) Percent voicing (relative to total consonant duration). A four-factor full interaction ANOVA was run on the data using StatView (SAS 1999). The factors were preceding vowel, target consonant, target syllable stress and word position.[7] The result was considered significant if $p \leq 0.05$. Significant results are marked with * in the results tables.

[7] For two speakers a three-factor full interaction ANOVA was run instead due to the amount of missing values, with target consonant, target syllable stress and word position as factors.

The following discussion concentrates on two main findings: the effect of stress on each dependent variable, and dialectal differences. The main results concerning stress are summarized below:

- — For seven subjects, vowels were significantly longer in stressed syllables than in unstressed syllables ($p<.0001$). This result is consistent with previous observations that stress in Spanish increases vowel duration (Martínez Celdrán 1984: 246).
- — No significant effect was found for consonant length and stress overall; coda consonants are about the same length in stressed and unstressed syllables. For one of the speakers codas are longer in unstressed syllables (Sp3: $F(1, 165)=9.348$; $p=.0026$)).
- — The effect of stress on voicing is speaker-dependent. Six subjects lack significant differences in the number of voiced tokens as a function of stress. Two subjects have more instances of voiced tokens of /b, d, g/ in stressed position (Sp.3: $F(1, 176)=4.644$, $p=.0191$; Sp. 9: $F(1, 154)=14.385$, $p=.0002$); one subject shows the opposite pattern (Sp.2: $F(1, 182)=4.644$, $p=.0325$).
- — Four speakers showed a significant effect of stress on frication (Table 1): frication is more likely to occur in stressed syllables rather than stop or approximant realizations (Sp.1: $F(1, 186)=6.189$, $p=.0137$; Sp.2: $F(1, 182)=20.610$, $p<.0001$; Sp.3: $F(1, 176)=5.027$, $p=.0262$; Sp. 7: $F(1, 165)=6.901$, $p=.0094$). Speakers 4 and 5 follow the same pattern but a ceiling effect may be preventing the difference from being significant.

Table 1

Stress: Mean values for percent frication (by speaker)

			Stressed	Unstressed	*p*- value
*	Sp. 1	(nor)	99.1%	95.4%	.0137
*	Sp. 2	(nor)	93.1%	78.4%	<.0001
*	Sp. 3	(nor)	88.1%	76.7%	.0262
	Sp. 4	(nor)	95.9%	90.1%	.5720
	Sp. 5	(nor)	94.7%	90.9%	.2654
	Sp. 6	(nor)	65.4%	64.3%	.1071
*	Sp. 7	(cen)	75.2%	56.0%	.0094
	Sp. 8	(cen)	30.4%	34.4 %	.6657
	Sp. 9	(cen)	12.1%	14.3 %	.8831

A post-hoc examination of the speaker patterns suggests that speaker dialect played an important role in determining the patterns of frication and voicing. For this reason, the speakers were grouped into two dialects —North and Central— based on their geographical origins. Using Unixtat (Perlman & Horan 1986), a three factor full-interaction ANOVA with the independent variables consonant, stress, and dialect group was conducted for frication, voicing, voicing duration and percent voicing. *Speaker* was treated as a between variable for dialect and a within variable for stress and consonant. The main results are summarized below:

— Dialect has a robust effect on frication. Most instances of coda /b, d, g/ are fricated in the Northern dialect (70.6%) while only less than a third of tokens are fricated in the Central dialect (27.2%) (F (1, 7)=10.808, *p*=.013).
— Frication is also more likely in stressed syllables (60.3%) than in unstressed syllables (51.9%) (F (1, 7) = 10.750, *p* = .014).
— Frication was most likely for /g/ (68.7%), followed by /d/ (52.4%) and /b/ (47.2%) (F (2, 14) = 3.858, *p* = .046).
— Neither dialect, stress or consonant had any effect on voicing, voicing duration or percent voicing.

I suggest the following explanation for the finding that stress affects frication of coda /b, d, g/ but not voicing. Stress causes an increase in respiratory activity, which causes more airflow (Ladefoged 1967, 1993). A higher volume of airflow is conducive to frication. The supraglottal constriction has to be narrow enough to allow for the possibility of frication; if the constriction is wide, no pressure will build up, and frication will not occur, even in a stressed syllable (14).

(14) Hypothesized interaction between stress, frication, and constriction degree

	Wide Constriction		Narrow Constriction	
Syllable	Stressed	Unstressed	Stressed	Unstressed
	↓	↓	↓	↓
Airflow	Higher	Less	Higher	Less
	↓	↓	↓	↓
Frication	Not likely	Not likely	Likely	Not likely

Fricatives and approximants are traditionally described as having different constriction degrees; the first have narrower constrictions and produce turbulence; the second have wider constrictions and lack frication or turbulence. However, Romero's (1995) articulatory study on /b, d, g/ in Western Southern Spanish shows that there is *no* constriction degree difference between these two types of continuants; the difference between fricative and approximant allophones of /b, d, g/ is the duration of the constriction, not the constriction degree.

I assume, in accordance with Romero's findings, that the supraglottal configuration is the same for all continuant allophones of /b, d, g/. An initial simplifying assumption is that a similar glottal configuration also exists for the two. This yields a possible scenario, that shown in the right-hand part of (14). The results from this acoustic study show that stress has an effect on frication, but not on voicing. This suggests that more airflow in stressed syllables produces more frication.

4.2. Lexical frequency effects

A question arises as to the applicability of the results from the experiment just described to real words in Spanish. A second acoustic experiment was undertaken to examine the role of lexical frequency in the pronunciation of coda /d/ in the same dialect. This section discusses preliminary findings from this study.

The hypothesis is that the more frequent the word, the bigger the possibility that its pronunciation diverges from the standard (Hooper 1976, Pierrehumbert 2001, Bybee 2002). It is expected that frequent words in NC Spanish follow a different pattern of coda frication and devoicing than the nonce words tested in the first experiment.

Eight native monolingual Spanish speakers from the Basque Country were recorded reading a list of thirty bysillabic words with coda /d/ in medial and final sentence position in informal pronunciation. I will discuss the data from the first four speakers, all of whom belong to the Northern dialect. Fifteen of the words were frequent, and fifteen non-frequent. There were eight repetitions per token, totaling 480 tokens per speaker. Each sentence was randomized for each speaker and repetition.

Word selection was made through a questionnaire presented to five native speakers of Spanish (different from the ones recorded) about the relative frequency of 39 words. They ranked these words from 1 to 5 according to what they thought was the relative frequency of the words: 1 very rare; 2 rare; 3 frequent; 4 quite frequent, and 5 very frequent. Evaluation was highly consistent across subjects. The results were averaged and thirty words were selected (Table 2). All words are

Table 2

List of words

Non-Frequent words		Frequent words	
Word	Translation	Word	Translation
1. abad	'Abbot'	1. alud	'Avalanche'
2. abrid	'Open (plural imperative)'	2. bondad	'Goodness'
3. ardid	'Scheme'	3. ciudad	'City'
4. callad	'Shut up (plural imperative)'	4. David	'David'
5. efod	'Ephod'	5. edad	'Age'
6. golpead	'Strike (plural imperative)'	6. Madrid	'Madrid'
7. laud	'Lute'	7. maldad	'Evil'
8. matad	'Kill (plural imperative)'	8. mitad	'Half'
9. merced	'Grace'	9. pared	'Wall'
10. morid	'Die (plural imperative)'	10. piedad	'Piety'
11. parad	'Stop (plural imperative)'	11. salud	'Health'
12. talad	'Fell (plural imperative)'	12. tirad	'Throw (plural imperative)'
13. talmud	'Talmud'	13. usted	'You (formal)'
14. talud	'Slope'	14. verdad	'Truth'
15. vivid	'Live (plural imperative)'	15. virtud	'Virtue'

disyllabic and have the same stress pattern. Target /d/ occurs in the coda of the second syllable, which is always stressed. Since the task of finding relevant two-syllable words with these characteristics was hard, vowels were not controlled for.

Two sentence frames were used according to sentence position: final or medial (15). Note that target /d/ was always followed by [k] in an unstressed syllable:

(15) Frames

Final:	*Ahora escriba* […]. *Continúe.*	/a.ˈo.ɾa es.ˈkri.β̞a. […] kon.ti.ˈnu.e/
	'Now write […]. Continue.'	
Medial:	*Ahora escriba* […] *con el boli.*	/a.ˈo.ɾa es.ˈkri.β̞a. […] ko.nel.ˈβ̞o.li/
	'Now write […] with the pen'	

The independent variables were (i) Sentence position (medial/final) and (ii) Degree of frequency (frequent/less frequent). The dependent variables were (i) Duration of /d/, (ii) Presence/absence of voicing, (iii) Voicing duration; (iv) Presence/absence of frication, (v) Presence/absence of approximantization, and (vi) Presence/absence of stop closure.

A Marantz PMD 201 tape recorder and a Shure SM10 head-mounted microphone were used for the voice recordings. Subjects were asked to use an informal style of pronunciation. The data were digitized at a 22,000 Hz sampling rate using the Macquirer system. The statistical analysis was conducted using a two-factor full interaction ANOVA with Statview (SAS 1999). The effect was considered to be significant if $p \leq .05$. Table 3 shows the effect of lexical frequency in each dependent variable for the four speakers analyzed so far.

The statistical analysis does not show any effect of lexical frequency in any variable for any speaker; duration, voicing and frication of /d/ do not depend on whether the word is common or less frequent (the only exception was Speaker 1, for whom there was an effect of frequency on voicing; voicing of /d/ was more

Table 3

Effect of frequency in all dependent variables by speaker

Factor	Speaker 1		Speaker 2		Speaker 3		Speaker 4	
	Frequent	Non-Frequent	Frequent	Non-Frequent	Frequent	Non-Frequent	Frequent	Non-Frequent
Consonant duration	71 ms.	70 ms.	63 ms.	66 ms.	93 ms	94 ms.	53 ms.	55 ms.
Voicing	*97%	*100%	98%	100%	100%	98%	100%	99%
Voicing duration	16 ms.	21 ms.	21 ms.	24 ms.	58 ms.	58 ms.	43 ms.	42 ms.
Frication	93%	91%	90%	91%	92%	92%	24%	29%
Approximant	1%	1%	2%	3%	5%	4%	73%	64%
Stop	6%	8%	9%	6%	3%	4%	4%	8%

likely in non-frequent words (F (1, 377)=5.857; *p*=.016)). This indicates that the pronunciation of /d/ and by extension /b, g/ is the same for frequent and non-frequent words. These results appear to support the findings of the first experiment as extensive to all words in the language.

4.3. Phonetic and phonological implications

This section discusses the phonetic and phonological implications of both studies, focusing on the dialectal differences between the Northern and Central dialects of NC Spanish, the effect of stress on frication and the variability of this effect.

— Frication is more pervasive in the Northern dialect that in the Central Dialect; it occurs about 70% of the time in the Northern dialect but less than 30% of the time in the Central dialect. This suggests that frication is close to categorical in the Northern Dialect and variable in the Central dialect and supports the analysis of frication in coda /b, d, g/ in the grammar for the Northern Dialect, but not for the Central Dialect.
— Frication occurs about 60% of the time in stressed syllables, and only about 52% of the time in unstressed syllables. The difference between frication in stressed and unstressed syllables is significant but not very large, which suggests that the effect of stress should not be incorporated into the grammar.
— Voicing of coda /b, d, g/ in the Northern dialect occurs in 17% of the cases; in the cases where /b, d, g/ are realized as voiced, voicing is sustained for 9.5% of the total duration of the consonant. For the Central dialect, voicing occurs in 27% of cases, and it is sustained for about 21% of the total duration of the consonant. This suggests that voicing is gradient in both dialects, and slightly longer and more likely to occur in the Central Dialect.
— Lexical frequency is not a factor in the pronunciation of coda /b, d, g/. No difference is apparent between frequent and non-frequent words. By extension, the results from the first experiment can be extended to all words.

Summarizing, the grammar should capture the pervasiveness of frication of coda /b, d, g/ in the Northern dialect since it is close to categorical, but not in the Central dialect. The effect of stress on frication is aerodynamic and far from categorical and should not be included in the grammar. In the Northern dialect frication is pervasive and it is aerodynamically influenced by stress. Since voicing and frication have opposite aerodynamic requirements and stress does not appear to affect voicing, this argues against a phonological analysis of coda devoicing in this dialect.

For Central Spanish only three subjects were recorded, so the interpretation of the results for this dialect is tentative. Two patterns can be distinguished. Speaker 7 has a large number of fricative realizations of coda /b, d, g/ and considerable voicing (Table 4). Speakers 8 and 9 show a large number of stops and few voiced tokens. Additionally, many tokens of coda /b, d, g/ are missing for these speakers. More data from more speakers is needed to conclude which of these patterns is more widespread in Central Spanish.

Table 4

Realization of /b, d, g/ by speaker

		% VOICED	FRICATIVES	GLIDES	STOPS	MISSING
SP. 1	(NOR)	25.8%	216	6	0	30
SP. 2	(NOR)	3.4%	188	1	29	34
SP. 3	(NOR)	32.8%	176	22	15	39
SP. 4	(NOR)	21.3%	184	2	12	54
SP. 5	(NOR)	13.9%	207	9	7	29
SP. 6	(NOR)	36.5%	96	11	41	104
SP. 7	(CEN)	64.7%	132	24	45	51
SP. 8	(CEN)	22.9%	49	5	99	99
SP. 9	(CEN)	20.2%	25	0	165	62
TOTAL		100%	1.273	80	413	502

5. Analysis of coda frication of /b, d, g/ in Basque Spanish

This section suggests how to account for frication of coda /b, d, g/ in Basque Spanish in the phonology. Rather than considering this process as coda devoicing, I propose to analyze it through a dispreference for coda approximants and stops in this dialect (16).

(16) *[+son, +cont, -lat, -rhotic]/coda Avoid [+son, +cont, -lat, -rhotic] in coda
*[-son, -cont]/coda Avoid [-son, -cont] in coda

Perceptual considerations partially motivate the constraints in (16). Stops are less perceptible in coda position; their burst and transitions are better perceived before vowels (Steriade 1999). Non-liquid approximants are not very salient in coda position; they frequently delete or turn into stops. Both of these constraints outrank IDENT [voice] (tableau 17).

Tableau 17

*[+son, +cont, -lat, -rhotic]/coda, *[-son, -cont]/coda >> IDENT [voice]

/red/ 'net'	**[+son, +cont, -lat, -rhotic] $]_\sigma$	*[-son, -cont] $]_\sigma$	IDENT [voice]
a. reð̞	*!		
b. red		*!	
☞ c. reθ			*

The selection of voiceless fricatives in coda result from the interaction of markedness constraints against dispreferred voiceless approximants and voiced fricatives, and context-sensitive markedness constraints penalizing voiced approximants and stops in coda. In Tableau 18, candidate (d) violates IDENT [voice], but it is selected as optimal because the rest of the candidates violate higher-ranked constraints (in the following tableaux, *[+son, +cont, -lat, -rhotic] will be abbreviated to *ð̞, and *[+son, +cont, -lat, -rhotic]/coda to *ð̞]$_\sigma$).

Tableau 18

Realization of coda /d/ in Northern Spanish

/red/ 'net'	*VLESS APPROX	*VD FRIC	*ð̞]$_\sigma$	*[-son, -cont]]$_\sigma$	IDENT [voice]
a. red				*!	
b. ret				*!	*
c. reð		*!			
☞ d. reθ					*
e. reð̞			*!		
f. reθ̞	*!		*		*

Tableaux (19-22) show how the constraints *[+son, +cont, -lat, -rhotic]]$_\sigma$ and [-son, -cont]]$_\sigma$ interact with the rest of the ranking. Tableau (19) shows that /d/ surfaces as [ð̞] between vowels. Candidate (e) violates lower-ranked constraints than its competitors and is selected as optimal.

Tableau 19

Intervocalic /d/

/ada/ 'fairy'	*VLESS APPROX	*VD FRIC	*ð̞]$_\sigma$	*[-son, -cont]]$_\sigma$	IDENT [voice]	$[A_o]$/ *voi stop	*ð̞	IDENT [cont]
a. ada						*!		
b. ata					*!			
c. aða		*!						*
d. aθa					*!			*
☞ e. að̞a							*	*
f. aθ̞a	*!				*		*	*

Voiceless stops and fricatives are faithful to the continuant and voice specifications from the input (Tableaux 20, 21). Candidate (b) in tableau 20, and (d) in tableau 21 do not violate any constraints and are selected as optimal. After nasals, /b, d g/ are pronounced as voiced stops (Tableau 22). Candidate (a), which violates low-ranked *VOICED STOP, is selected as optimal.

Tableau 20

Intervocalic /t/

/rata/ 'rat'	*VLESS FRIC	*VD FRIC	*ð̞]$_\sigma$	*[-son, -cont]σ	IDENT [voice]	[A$_o$]/ *Vd stop	*ð̞	IDENT [cont]
a. rada					*!	*		
☞ b. rata								
c. raða		*!			*!			*
d. raθa								*!
e. rað̞a					*!		*	*
f. raθ̞a	*!						*	*

This analysis captures the phonemic distinction between /b, d, g/ and /p, t, k/, and between /p, t, k/ and /f, θ, x/. It also captures spirantization after open segments. Last but not least, this account captures frication in coda in Basque Spanish, through constraints penalizing voiced approximants and voiceless obstruents in this position. A ranking lattice for Basque Spanish is given in (17) (cf. with the ranking lattice for Central Spanish in (12)).

Tableau 21

Intervocalic /θ/

/raθa/ 'race'	*VLESS APPROX	*VOI FRIC	*ð̞]$_\sigma$	*[-son, -cont]σ	IDENT [voice]	[A$_o$]/ *Vd stop	*ð̞	IDENT [cont]
a. rada					*!	*		*
b. rata								*!
c. raða		*!			*			
☞ d. raθa								
e. rað̞a					*!		*	
f. raθ̞a	*!						*!	

Tableau 22

Voiced stops after nasals

/anda/ 'walk'	*VLESS APPROX	*VD FRIC	*ð̥]$_\sigma$	*[-son, -cont]$_\sigma$	IDENT [voice]	[A$_o$]/ *Vd stop	*ð̥	VD STOP
☞ a. anda								*
b. anta					*!			
c. anða		*!						
d. anθa					*!			
e. anð̥a							*!	
f. anθ̥a	*!				*		*	

(17) Ranking lattice for Basque Spanish

*VOICELESS APPROXIMANT, LPA

*[-son, -cont]$_\sigma$, *[+son, +cont, -lat, -rhotic]$_\sigma$, *VOICED FRICATIVE, *INTERDENTAL LATERAL

IDENT-IO [voice]

[A $_o$]/*voiced stop, [A $_f$]/*voiced stop

*[+son, +cont, -lat, -rhotic]

IDENT-IO [continuant]

*VOICED STOP

Future investigation will determine the correct analysis for coda realization in the Central dialect. If the pervasive pattern is that of speakers 8 and 9, where voiceless stops are frequent realizations of coda /b, d, g/, the constraint *[-son, -cont]$_\sigma$ will be ranked lower in the hierarchy. If the pervasive pattern is that of speaker 7, where coda /b, d, g/ are predominantly realized as voiced fricatives, both *[-son, -cont]$_\sigma$, and *[+son, +cont, -lat, -rhotic]$_\sigma$ will outrank *VOICED FRICATIVE.

6. Conclusion

This paper has considered the interaction between the phonetics and phonology of /b, d, g/ in two dialects of NC Spanish: the 'Northern dialect' or Basque Spanish, and the Central dialect. It has provided an OT analysis where the phonemic contrast of voiced and voiceless obstruents, the basic facts of spirantization, and the realization of /ld/ sequences are mainly explained through the interaction between markedness and faithfulness constraints.

This paper has also examined two acoustic experiments on the effect of stress, dialect and lexical frequency in the realization of /b, d, g/ in coda. It has been shown that the Northern dialect and the Central dialect differ as to the likelihood of frication for these consonants in this position; frication is close to categorical in the Northern dialect but not in the Central dialect. For this reason frication of coda /b, d, g/ is proposed to be encoded in the grammar in the Northern dialect. It has been argued that the realization of coda /b, d, g/ is not due to phonological coda devoicing. Rather, frication occurs to achieve maximal perceptibility in coda, and devoicing follows from the contradictory requirements for voicing and frication. Stress is shown to have an aerodynamic effect on coda /b, d, g/; it affects the likelihood of frication of these codas through the increase in airflow that accompanies stressed syllables. However, this effect is variable within and across speakers and it should not be encoded in the grammar.

Further research is needed to elucidate the role of coda devoicing in the Central dialect, since the three speakers analyzed for this dialect show opposite tendencies. Also, the complete analysis of the results for the experiment on lexical frequency will corroborate whether it can be dismissed as a factor in the pronunciation of coda /b, d, g/ in this dialect.

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