Intervocalic velar nasals in Galician: Phonetic evidence for multiple syllabic affiliation*

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*The syllabic affiliation of intervocalic velar nasals in Galician, e.g. unha [úŋa] 'a, one (fem.)' has been a controversial topic amongst scholars for at least three decades. All solutions proposed to date (onset or coda affiliation) are costly from a phonological point of view as they run counter to well-attested principles of phonological theory, such as Structure Preservation (Kaisse and Shaw 1985; Kiparsky 1985; Mohanan 1986) and syllabic markedness generalizations (*VC.V). Recently, however, Colina (2004) has proposed an analysis that does not encounter the difficulties of previous accounts. Colina (2004) argues for an underlying velar nasal realized as a surface geminate that results from the assimilation of an epenthetic onset to the point of articulation of the preceding nasal. It was hypothesized that the phonetic level could provide additional support for the gemination proposal if there were duration differences between the surface geminate (underlying velar) and other context similar nasals syllabified in either onset or coda position. Hence the fundamental goal of this paper is to examine intervocalic nasals in forms such as unha, cunha, algunha from a phonetic point of view and determine whether there are differences between these forms and other intervocalic nasals. Ten native speakers of Galician were asked to read carrier phrases containing the target nasals in three different contexts: 1) hypothesized geminate (e.g. unha 'a'), 2) onset position (e.g. c'un amigo 'with a friend'), and 3) coda position c'un curandeiro 'with a folk healer' (coda). Phonetic analysis of the recordings reveals that there is a phonetic distinction in terms of length between multiply-linked velar nasals (surface geminates) and other intervocalic velar nasals, thus lending further support to the gemination proposal. The findings have implications for research on the phonology and phonetics of geminates.*

0. Introduction

The syllabic affiliation of intervocalic velar nasals in Galician, e.g. *unha* [ũɲa] 'a, one (fem.)' has been a controversial topic amongst scholars for at least three decades. All solutions proposed to date (onset or coda affiliation) are costly from a phonological point of view as they run counter to well-attested principles of phonological theory, such as Structure Preservation (Kaisse and Shaw 1985; Kiparsky 1985; Mohanan 1986) and syllabic markedness generalizations (*VC.V). Recently, however, Colina (2004) has proposed an analysis that does not encounter the difficulties of previous accounts. Using phonological arguments and historical and cross-linguistic facts as part of an optimality-theoretic account, Colina (2004) argues for an underlying velar nasal realized as a surface geminate. The surface geminate is the result of the assimilation of an epenthetic onset to the point of articulation of the preceding nasal. It was hypothesized that the phonetic level could provide additional support for the gemination proposal if there were duration differences between the surface geminate (underlying velar) and other context similar nasals syllabified in either onset or coda position. Hence the fundamental goal of this paper is to examine intervocalic nasals in forms such as *unha*, *cunha*, *algunha* from a phonetic point of view and determine whether there are differences between these forms and other intervocalic nasals as in the word *alemana*. The article is organized as follows: the first section contains a brief description of the phonological facts, a review of previous analyses, and a summary of the gemination proposal in Colina (2004). The second part of the paper focuses on the phonetic study: it includes a review of the literature, the methodology, results and conclusions in sections 2, 3, 4 and 5 respectively.

1. Intervocalic velar nasals in Galician: phonological analyses

1.1 Data

In Galician, a three-way phonemic distinction in nasals (bilabial, alveolar and palatal) (as in 1) is neutralized in the rhyme (2). Rhyme nasals surface with a velar point of articulation (the phenomenon is similar to that described in some varieties of Spanish, e.g. Cuban, Lipski 1994).¹

The simplest examples of velarization can be seen in word-final position before pause (2).

(1)	Martínez-Gil (1993) (Moaña dialect)		
	mora	[mó.ra]	'blackberry'
	nora	[nó.ra]	'daughter-in-law'
	ñopa	[ɲó.pa]	'short-sighted'
	cama	[ká.ma]	'bed'
	cana	[ká.na]	'cane'
	caña	[ká.ɲa]	'type of bra'

(2)	lan	[laŋ]	'wool'
	son	[soŋ]	'sound'
	ben	[beŋ]	'well'
	xoven	[ʃóβiŋ]	'young'
	irmán	[irmáŋ]	'brother'

Rhyme nasals surface as velars prevocally and across words. The same happens

(3)	inhumano	/in + uman + o/	[i.ɲu.na.no]
	benestar	/ben estar/	[be.ɲe.sta.r]
	tren alemán	/tren aleman/	[tre.ɲa.lé.man]
	alemán	/aleman/	[a.lé.man]

Thus, in lexical-phonological terms, nasals surface as velars in the rhyme by a cyclical rule that applies before prefixation as well as postlexically. Otherwise nasals are neutralized as word markers:

(4)	a.	cana	/kan +a/	[ká.na]
		cano	/kan +o/	[ká.no]
		pano	/pan +o/	[pá.no]
	b.	lambón	/lamb +on/	[lam.bón]
		lambona	/lamb+on +a/	[lam.bón.a]
		alemán	/aleman/	[alé.man]
		alemana	/aleman + a/	[alé.man.a]

- (1) Martínez-Gil (1993) (Moaña dialect)
mora	[mó.ra]	'blackberry'	
nora	[nó.ra]	'daughter-in-law'	
ñopa	[ɲó.pa]	'short-sighted (fem.)'	
cama	[ká.ma]	'bed'	
cana	[ká.na]	'cane'	
caña	[ká.ɲa]	'type of brandy'	
- (2)
lan	[laɲ]	'wool'	*lam, lan, laɲ
son	[soɲ]	'sound'	*som, son, soɲ
ben	[beɲ]	'well'	
xoven	[ʃóβiɲ]	'young'	
irmán	[irmáɲ]	'brother'	

Rhyme nasals surface as velars prevocally across prefixes and compounds and across words. The same happens before word-final epenthesis.²

- (3)
inhumano	/in + uman + o/	[i.ɲu.má.nu]	'inhumane'
		*[i.nu.má.nu]	
benestar	/ben estar/	[beɲis.tár]	'well-being'
		*[benis.tár]	
tren alemán	/tren aleman/	[tre.ɲa.li.máɲ]	'German train'
		*[tre. na.li.máɲ]	
alemán	/aleman/	[a.li.máɲi]	'German (masc.)'
		*[a.li.má.ni]	

Thus, in lexical-phonological terms, nasal velarization (NV) is a lexical, cyclical rule that applies before prefixation and compounding (Level 1) as well as postlexically. Otherwise nasals are not velarized before suffixes, such as word markers:

- (4)
a.	cana	/kan +a/	[ká.na] ~ *[káɲa]	'cane'
	cano	/kan +o/	[ká.nu] ~ *[ká.ɲu]	'pipe, gutter'
	pano	/pan +o/	[pá.nu] ~ *[pá.ɲu]	'cloth'
b.	lambón	/lamb +on/	[lambón]	'sweet-toothed (masc.)'
	lambona	/lamb+on +a/	[lambóna]	'sweet-toothed (fem.)'
	alemán	/aleman/	[alimáɲ]	'German (masc.)'
	alemana	/aleman + a/	[alimána]	'German (fem.)'

An important group of words, however, appear to undergo velarization before suffixation. These consist of the feminine forms of the indefinite article and its derivatives, as seen in (5–6).³

(5)	un	/un/	[uŋ]	‘a, one (masc.)’
	algún	/alx + un/	[al.xúŋ]	‘some, any (masc.)’
	nengún	/neng + un/	[niŋ.gúŋ]	‘none (masc.)’
	dun	/de un/	[duŋ]	‘of a (masc.)’
	cun	/kon un/	[kuŋ]	‘with a (masc.)’
	nun	/en un/	[nuŋ]	‘in a (masc.)’
(6)	unha	/un + a/	[úŋa] ⁴	‘a, one (fem.)’
	algunha	/alx + un + a/	[al.xúŋa]	‘a, one (fem.)’
	nengunha	/neng + un + a/	[niŋ.gúŋa]	‘none (fem.)’
	dunha	/de un + a/	[dúŋa]	‘of a (fem.)’
	cunha	/kon un + a/	[kúŋa]	‘with a (fem.)’
	nunha	/en un + a/	[núŋa]	‘with a (fem.)’

1.2. Previous accounts

While most scholars seem to agree that any valid account of the forms in (6) must be refer to some type of exceptionality (but see Castro 1989 below), there is in general no agreement in the literature as to what the syllabic affiliation of the velar nasal in these examples might be. Two positions have been adopted in the past to explain the syllabification facts: [ŋ] is in the onset and [ŋ] is in the coda. The issue bears on apparent violations of/exceptions to well-attested generalizations and/or universals of phonological theory. Those who argue that the velar nasal is in the coda still need to explain the resulting onsetless syllable and the extremely marked syllabification pattern in which an intervocalic consonant is syllabified as the coda of the first syllable, (e.g. [uŋ.a]). Thus, while the coda analysis captures the generalization that in Galician rhyme nasals are velars, it must also contend with an extremely rare, mostly unattested pattern of syllabification. The onset proposal does not incur syllabic markedness costs; however, the difficulties encountered are not any less serious. Since Galician does not have underlying velar nasals and NV is a lexical rule (cf. Martínez-Gil 1993), the presence of a non-underlying segment in the lexical domain constitutes a violation of Structure-Preservation (Kaisse and Shaw 1985; Kiparsky 1985; Mohanan 1986). In other

words, under the onset analysis, the Galician data contradict a well-known generalization with a lexical application do not normally part of the phonemic inventory of the language – thus, arguing that velar nasals are phonemic in Galician. A known contrast [uŋ.a] ‘a, some (fem.)’ subunc.)’

There is extensive descriptive work on the /coda debate. In most cases, however, the literature, presenting no arguments for the particular position (see Dapena 1976, Carballo Calero 1979 – coda – onset; see also Dubert 1998 for a comprehensive survey of the descriptive literature). Despite the lack of consensus, these studies are of value for they show that native speakers (most of this literature is written by Galician speakers of the language) to decide on the correct analysis. An informal survey of native speaker’s views by the authors confirms this view.

Within a Lexical Phonology framework, Castro (1989) explains that the difference between the two forms is the result of morphological adjunction. She claims that in [una] the thematic vowel is in the lexical stratum (level 1), leaving the nasalization applies; in [uŋa], however, the generalization applies, after nasal velarization. In addition, the marker adjunction postlexically (in morphological process), Castro’s proposal cannot account for *lambón*, *lambona* in (4b), which should be that forms with an alveolar nasal before an empty V in the masculine (e.g. *lambón* V). Castro’s solution is ad hoc, since there is no V in *lambón* (and not in *un*). Furthermore, there are numerous forms – those with alveolar nasal – that are exceptional, whereas *un/unha* and its derivatives

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	'a, one (masc.)'
ún]	'some, any (masc.)'
gún]	'none (masc.)'
]	'of a (masc.)'
]	'with a (masc.)'
]	'in a (masc.)'
] ⁴	'a, one (fem.)'
úña]	'a, one (fem.)'
gúña]	'none (fem.)'
a]	'of a (fem.)'
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words, under the onset analysis, the Galician data presented above appear to contradict a well-known generalization of phonological theory – that rules with a lexical application do not normally introduce segments that are not part of the phonemic inventory of the language. A third possibility, adopted in part in Colina (2004), is to allow velar nasals to be part of the phonemic inventory of the language – thus, arguing, on the basis of these examples, that velar nasals are phonemic in Galician, despite the existence of only one known contrast [uŋ.a] 'a, some (fem.)' ~ [u.na] 'join, (3rd person, sg. pres. subjunc.)'

There is extensive descriptive work by Galician scholars on the onset/coda debate. In most cases, however, this type of work is purely descriptive, presenting no arguments for the particular position adopted (e.g. Porto Dapena 1976, Carballo Calero 1979 – coda; Veiga 1976, Alvarez et al. 1986 – onset; see also Dubert 1998 for a comprehensive list of references on the descriptive literature). Despite the lack of specific phonological argumentation, these studies are of value for they suggest the inability of native speakers (most of this literature is written by Galician scholars who are also native speakers of the language) to decide on the syllabic affiliation of velar nasals. An informal survey of native speaker's syllabification intuitions carried out by the authors confirms this view.

Within a Lexical Phonology framework, and also arguing for onset affiliation, Castro (1989) explains that the difference between [una] and [uŋa] is the result of morphological adjunction taking place in different lexical strata. She claims that in [una] the thematic vowel attaches to the verb root in the lexical stratum (level 1), leaving the nasal in onset position before velarization applies; in [uŋa], however, the gender marker *-a* is attached postlexically, after nasal velarization. In addition to the difficulty of motivating word-marker adjunction postlexically (in most languages it seems to be a lexical process), Castro's proposal cannot satisfactorily account for forms like *lambón*, *lambona* in (4b), which should also have a velar nasal. She argues that forms with an alveolar nasal before the feminine word-marker, have an empty V in the masculine (e.g. *lambónV*). As Dubert (1998) also points out, Castro's solution is ad hoc, since there is no evidence to support the presence of V in *lambón* (and not in *un*). Furthermore, under this account, the more numerous forms – those with alveolar nasals before the suffix – are treated as exceptional, whereas *un/unha* and its derivatives are unexceptional.

Lipski (1976) reviews various phonological, historical, and cross-linguistic factors that may play a role in accounting for intervocalic velar nasals in Galician. Although he doesn't take a stance on the onset/coda debate, he

makes an important contribution by pointing out that the solution to the problem lies in 'the interaction of several factors...' (1976: 191)

Dubert (1998) presents a somewhat different proposal. In support of the onset analysis, he argues for an underlying velar nasal for the relevant forms (/un/ /u.ŋa/) which is then resyllabified after suffixation. This analysis faces several difficulties, among which is the loss of an important generalization – rhyme nasals are velar in Galician. Dubert's proposal does capture the need to somehow mark these forms as exceptional.

1.3. Colina (2004): Underlying velar nasals, output geminates

Colina argues that the forms in (6) differ from those in (4b) in that the relevant nasals in (6) are underlyingly velar. Her analysis involves a velar nasal with a multiply-linked supralaryngeal node, more specifically, a surface geminate. Gemination is the result of the assimilation of an epenthetic onset to the point of articulation of the preceding nasal.

Colina (2004) does not suffer from any of the drawbacks of previous accounts. The highly marked VC.V syllabification pattern and the onsetless syllable of the coda analysis are avoided because the second half of the geminate serves as an onset for the second syllable, [uŋ.ŋa]. At the same time, the output geminate serves to preserve the generalization that coda nasals are velar. In addition, in an analysis in which velar nasals are phonemic, there is no violation of Structure Preservation, given that velar nasals are part of the phonological inventory of the language. The velar + gemination account also captures native-speaker intuitions with regard to exceptionality of the forms in (6) (expressed through the underlying point of articulation). Exceptionality, however, is not random – it appears in forms that lost an intervocalic nasal at some point in their development from Latin. Finally, Colina's analysis accounts for ambiguous syllabification and native speakers' difficulty in assigning velar nasals to either coda or onset, while shedding light on related developments in other Romance languages. In what follows we summarize the main points of the formalization of the analysis to help the reader understand the motivation for the phonetic study that constitutes the basis of this paper. The reader is referred to Colina (2004) for a detailed optimality-theoretic analysis of the relevant historical and cross-linguistic data.

Colina's analysis draws on some well-known historical facts. The forms exhibiting ambiguous syllabification happen to be those that resulted from the loss of Latin intervocalic nasals among Galician and Portuguese dialects

and other Romance-speaking areas (Meyer 1962). The loss of intervocalic nasals initially resulted in vowel lengthening of the preceding vowel; the nasal later reappeared in Galician, Portuguese and Gascon, Latin's intervocalic nasals becoming a nasalized vowel (Williams 1962, Rohlfs 1969). For example, Latin *uma* became [uma], whereas in Gascon they remain [u.ŋa].

(7)	<i>Latin</i>	<i>Galician, Port., Gas.</i>
		(intermediate stage)
	unam	ũa

Colina (2004) argues that the deletion of the intervocalic nasal left behind an empty consonantal slot, with the vowel preceding it. In later diachronic stages, Galician, Portuguese and Gascon (the point of articulation of the intervocalic nasal in Galician and Gascon), which has been shown to allow empty slots, did not. This caused the reappearance of the nasal. In Galician, the back quality of [u] produced a velar, [+back] in Portuguese, [+round] produced a bilabial, [+labial]. In other terms, Colina (2004) proposes that the deletion of the intervocalic nasal is a conflict between markedness and faithfulness. The constraint requires minimization of effort and agreement with the input VCV, dominates the constraints that require preservation of the point of articulation (MAX-IO(Place)). Preservation of the point of articulation responds to IDENT-IO (Nasal) and its dominance over non-preservation of linear order (Linearity-IO) results in the entire nasal (high ranking of MAX-IO), leaving behind an empty slot with no point of articulation and no feature specification. The high, back vowel. Later in the history of Galician and Portuguese (not in Gascon which does not have any onset velar nasals, a high-ranking markedness constraint explains the preference for the labial rather than the velar of [u] in [ũa]. In Galician, [ũa], which was selected over an onset velar, is not selected because of the deletion facts in the language. Rhyme nasals are not in word-final position; therefore /un/, the

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and other Romance-speaking areas (Meyer-Lübke 1921). In Galician loss of intervocalic nasals initially resulted in vowel hiatus, with nasalization of the preceding vowel; the nasal later reappeared as a velar ([uŋa]). In Portuguese and Gascon, Latin's intervocalic nasals were also lost, leaving behind a nasalized vowel (Williams 1962, Røhlfs 1970); standard Portuguese forms became [uma], whereas in Gascon they remained as [ya].

(7)	<i>Latin</i>	<i>Galician, Port., Gas.</i> (intermediate stage)	<i>Galician</i> (final stage)	<i>Port.</i>	<i>Gas.</i>
	unam	ũa	uŋa	uma	ya

Colina (2004) argues that that the deletion of intervocalic nasals in Latin left behind an empty consonantal slot, with nasality preserved on the preceding vowel. In later diachronic stages, Galician and Portuguese recovered the point of articulation of the intervocalic nasal, while Gascon (Aranese Gascon), which has been shown to allow empty slots (cf. Hualde 1992), did not. This caused the reappearance of the nasal in the first two languages: the back quality of [u] produced a velar, [+back, +hi], in Galician, whereas in Portuguese, [+round] produced a bilabial nasal.⁵ In optimality-theoretic terms, Colina (2004) proposes that the deletion of intervocalic nasals reflects a conflict between markedness and faithfulness constraints. LAZY, which requires minimization of effort and agreement in aperture, favoring VV over VCV, dominates the constraints that require preservation of the point of articulation (MAX-IO(Place)). Preservation of nasality on the previous vowel responds to IDENT-IO (Nasal) and its domination over the constraint against non-preservation of linear order (Linearity-IO). In sum, rather than deleting the entire nasal (high ranking of MAX-IO), LAZY is satisfied by preserving a empty slot with no point of articulation and by nasality being transferred to the high, back vowel. Later in the history of the language the high ranking of a constraint against empty slots (*X) forces the reintroduction of a nasal in Galician and Portuguese (not in Gascon where *X would have a lower ranking). In Portuguese, which does not have any coda nasals and does not allow onset velar nasals, a high-ranking markedness constraint on velar nasals [*ŋ] explains the preference for the labial rather than the dorsal (+back) feature of [u] in [ũa]. In Galician, [ũa], which would avoid an onsetless syllable and an onset velar, is not selected because of velarization and syllabification facts in the language. Rhyme nasals are velarized in Galician, especially in word-final position; therefore /un/, the masculine singular form of the

indefinite article, is realized as [uŋ]. Thus the existence of an independent form [uŋ] is partly responsible for the velar nasal in the output [uŋ.ŋa] (high-ranked BASE-IDENTITY). The other half of the explanation has to do with syllabification. In Galician [ŋ] is not permitted in the onset, although it is well-formed as a coda (*_{Ons}[ŋ] >> *ŋ). A form like [ũŋ.a], however, would violate the highly-ranked ONSET constraint. The conflict is resolved by means of the ranking *_{Ons}[ŋ], ONSET >> DEP-IO(C), *ŋ which results in consonant epenthesis. The epenthetic consonant takes its features from the velar nasal and thus the resulting double-linked SL node satisfies the constraint against velar nasals in the onset *Align-Left (ŋ, σ) (abbreviated as *_{Ons}[ŋ]). *_{Ons}[ŋ] is defined, in accordance with the crisp version of alignment (McCarthy and Prince 1993: 10), as a constraint against a velar nasal being aligned with the syllable onset. Since doubly-linked [ŋ] is not 'crisply' aligned with the onset, it does not violate *_{Ons}[ŋ]. Lack of alternation eventually leads to phonemization of the velar point of articulation. Phonetic implementation of the doubly-linked [ŋ] produces a surface geminate.

Colina's account offers an explanation for contrasts like [ũŋ.a] vs. [ali.má.na]. Since [ali.má.na] does not result from the deletion of intervocalic nasals, the constraint against placeless slot is vacuously satisfied; as a result, there is no underlying velar specification to preserve and only velarization constraints are relevant (see Colina 2004 for the relevant tableaux and optimal candidate selection [ali.má.na] vs. *[ali.mán.ŋa]).⁶

2. A phonetic study of intervocalic velar nasals in Galician

2.1. Background: The role of duration in the description of geminate consonants

The goal of this section is to present some of the previous research that could be considered relevant in the study of the acoustic parameters related to syllabic affiliation. More specifically, we review studies analyzing consonant length since the present investigation is concerned with the duration of Galician nasals as potential evidence in support of the gemination proposal. Note that an exhaustive analysis of all the relevant work is not the objective pursued here.

To our knowledge, there are no phonetic studies examining the issue of gemination or double syllabic affiliation in Galician. There are relevant investigations for other languages, such as those of Lahiri and Hankamer (1988),

Esposito and Di Benedetto (1999), and Ham (2001). Lahiri and Hankamer (1988) study the phonetic difference between geminate and non-geminate consonants in order to observe whether the phonological distinction can be supported in phonetic terms. The phonological distinction between tautomorphemes is not reflected phonetically. The investigation is based on data from Bengali and Turkish. Lahiri and Hankamer tested 10 native speakers and three native speakers of Bengali. In both Turkish and Bengali the duration of the vowel preceding the geminate is an acoustic phonetic factor distinguishing between geminate and non-geminate consonants. Other acoustic measures such as vowel duration were not found significant overall. Lahiri and Hankamer conclude that the phonetic and phonological representation of geminates in terms of duration is different.

Esposito and Di Benedetto (1999) study the phonetic distinction between geminate and non-geminate consonants in sequences of vowel-consonant-vowel (non-geminate) and consonant-consonant-vowel (geminate cases) in Italian. They used the words *pappa* 'baby food', *fato* 'fate', and *fatto* 'fact'. Italian produced 324 utterances containing geminate and non-geminate consonants in the study. They also included a perceptual experiment to examine the acoustic phonetic cues examined in the production experiment. Native speakers of Italian participated. Esposito and Di Benedetto aim to define a closure length that functions as a cue for perceiving a geminate consonant. They manipulated the duration of the vowel as well as the length of the occlusion of the consonant. The findings of the production experiment indicate that the duration of the preceding vowel and the length of the preceding consonant are cues for perceiving gemination. Consistently, the results for the perceptual experiment indicate that when the preceding vowel is short the duration of the geminate consonant required perceiving gemination is also short. They also point out that in this case closure duration of the preceding vowel is a cue for perceiving gemination. Nonetheless, an increase in the duration of the preceding vowel also increases the threshold of the closure duration required for perceiving gemination.

Ham (2001) also reports similar results for German. In German consonants in Bernese (a dialect of Swiss German), and Madurese (an Austronesian language), closure duration was the acoustic cue for perceiving geminate and non-geminate consonants. The

the existence of an independent nasal in the output [uŋ.ŋa] (high- explanation has to do with syl- d in the onset, although it is well- ce [ūŋ.a], however, would violate conflict is resolved by means of), *ŋ which results in consonant s its features from the velar nasal de satisfies the constraint against) (abbreviated as *_{Ons}[ŋ]. *_{Ons}[ŋ] is ion of alignment (McCarthy and velar nasal being aligned with the ot 'crisply' aligned with the onset, ion eventually leads to phonemi- Phonemic implementation of the mate.

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description of geminate

of the previous research that could acoustic parameters related to syl- view studies analyzing consonant concerned with the duration of Gali- of the gemination proposal. Note ant work is not the objective pur-

ic studies examining the issue of Galician. There are relevant inves- e of Lahiri and Hankamer (1988),

Esposito and Di Benedetto (1999), and Ham (2001). Lahiri and Hankamer (1988) study the phonetic difference between geminate and non-geminate consonants in order to observe whether the phonological description of geminates can be supported in phonetic terms. They also analyze whether the phonological distinction between tautomorphemic, concatenated, and derived is reflected phonetically. The investigation is based on two different languages: Bengali and Turkish. Lahiri and Hankamer recorded three native Turkish participants and three native speakers of Bengali. The results indicate that in both Turkish and Bengali the duration of the consonant closure is the key acoustic phonetic factor distinguishing between geminate and non-geminate consonants. Other acoustic measures such as Voice Onset Time (VOT), and vowel duration were not found significant overall for both languages. Lahiri and Hankamer conclude that the phonetic analysis support the phonological different representation of geminates in terms of timing.

Esposito and Di Benedetto (1999) study the acoustic and perceptual distinction between geminate and non-geminate stops in Italian. They analyze sequences of vowel-consonant-vowel (non-geminate cases) and vowel-consonant-consonant-vowel (geminate cases) in words such as *papa* 'pope' and *pappa* 'baby food', *fato* 'fate', and *fatto* 'fact', etc. Six native speakers of Italian produced 324 utterances containing one of the target stops included in the study. They also included a perceptual study to verify the effect of the acoustic phonetic cues examined in the production experiment in which 20 native speakers of Italian participated. Specifically, Esposito and Di Benedetto aim to define a closure length that functions as a threshold for perceiving a geminate consonant. They manipulated the duration of the preceding vowel as well as the length of the occlusion portion of the stop consonant. The findings of the production experiment reveal that the closure length of the consonant and the length of the preceding vowel are acoustic correlates of gemination. Consistently, the results for the perceptual experiment indicate that when the preceding vowel is short the closure duration of the consonant required perceiving gemination is also short. Esposito and Di Benedetto point out that in this case closure duration of 165ms is the threshold for perceiving gemination. Nonetheless, an increase in the duration of the preceding vowel also increases the threshold of the closure consonant to 183ms.

Ham (2001) also reports similar results regarding the length of geminate consonants in Bernese (a dialect of Swiss German), Levantine Arabic, Hungarian, and Madurese (an Austronesian language of Indonesia). In all four languages, closure duration was the acoustical cue to distinguish between geminate and non-geminate consonants. The effect of the preceding vowel

was less consistent among languages. However, the general pattern observed indicates that vowels preceding voiced stops tend to be longer than those preceding voiceless stops.

In sum, empirical studies agree with the generalization that geminates "have between one and a half to three times the acoustic closure duration of the short stops in careful speech" (Ladefoged and Maddieson 1997: 92). Cross-linguistic evidence shows that geminate stops have a longer closure period than their single counterpart. Given that length could be playing a role in the distinction of the analysis proposed above for Galician, the present investigation addresses the following question: Are there phonetic differences in term of duration among nasals that could correspond to the differences in syllabic structure proposed for cases such as *algunha* 'some' (geminate), *c'un amigo* 'with a friend' (onset), *c'un curandeiro* 'with a folk healer' (coda)? Differences in duration are considered a parameter worth investigating as longer duration values for the hypothetical geminate velars would constitute a strong indicator of difference in syllabification when compared to velar nasals (otherwise identical) exclusively in coda or onset position.

2.3. Methodology

Ten native speakers of Galician were recorded for this study. They were all speakers of the dialect spoken in the western half of the province of La Coruña (Northwestern Spain).⁷ Participants read a total of 36 carrier phrases containing the target nasals in three different contexts: 1) geminate (e.g. *unha* 'a', *algunha* 'some', etc.), 2) onset position (e.g. *c'un amigo* 'with a friend'), and 3) coda position (e.g. *c'un curandeiro* 'with a folk healer'). 36 distractors were also included. The phrases were read three times by each speaker, producing a total of 216 tokens.

The material recorded was digitized in order to obtain measurements of duration of the target nasals. Pcquirer acoustical analysis software package was used for this purpose. Statistical analysis was applied to the data obtained from the ten speakers using Analyses of Variance (ANOVA).

2.4. Results and discussion

This section presents the findings of the acoustical analysis examining three different contexts in which Galician nasals may appear according to syllabic

affiliation. The results are based on duration of the target nasal tokens.

Table 1 and figure 1 show the results of the analysis according to different contexts: geminate (hypothesized geminate), onset, and coda.

Table 1: Mean duration (ms.) according to phonetic context

Affiliation	Mean
Hypothesized Geminate	81.89
Onset	62.93
Coda	55.8
ANOVA	F (2, 299) =

Figure 1: Nasal duration according to phonetic context

The results reveal that nasals in the geminate context have a longer duration of 81.89 ms, while nasals in onset position have a duration of 62.93 ms. In the case of nasals in coda position, the duration is 55.8 ms. These findings indicate a pattern where geminate nasals are longer than nasals in onset and coda positions. The 4 present examples of nasals in different contexts are coda and coda.

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Table 1 and figure 1 show the results of mean duration according to three different contexts: geminate (hypothesized), onset, and coda.

Table 1: Mean duration (ms.) according to Syllabic affiliation

Affiliation	Mean	Standard Deviation
Hypothesized Geminate	81.89	13.28
Onset	62.93	16.13
Coda	55.8	11.1
ANOVA	F (2, 299) = 107.93, P = .000

Figure 1: Nasal duration according to phonetic context

The results reveal that nasals in the geminate context have an average of duration of 81.89 ms, while nasals in onset position have an average duration of 62.93 ms. In the case of nasals in coda position, their average duration is 55.8 ms. These findings indicate a pattern according to which geminate nasals are longer than nasals in onset and coda position. Figures 2, 3, and 4 present examples of nasals in different contexts, namely geminate, onset, and coda.

Figure 2: Spectrogram of the word *algunha* 'some, any cooker'

Figure 2 shows the production of a velar nasal in the geminate context. The duration of the nasal is 121 ms. In this case, one can see the pattern found in the statistical results according to which nasals are longer.

Figure 3: Spectrogram of the phrase *c'unamigolo* 'with a friend'

Figure 3 shows the spectrogram for a velar nasal in onset position. Its duration is 64.3 ms. and thus shorter than the one in the word *algunha* 'some, any'.

The last spectrogram illustrates one of the examples in which the nasal is in coda position. In this case, the duration of the nasal is 45 ms. The three productions selected show the pattern found in the statistical analysis, namely that nasals in the geminate context are longer than onset and coda nasals. Even though we cannot establish a direct connection between duration and

syllabic affiliation, it can be argued that this reflects the existence of an empty slot in the syllable structure, which is filled by the phonetic features from the preceding velar nasal. This is in line with the claims by Colina (2004).

Figure 4: Spectrogram of the phrase *c'uncurandiro*

In summary, measurements of duration of nasals provide evidence to support the phonological analysis of the data. As *unha* 'a', *algunha* 'some' contain underlying geminates. Even though we have not carried out a perceptual analysis, our findings go along with the claims presented in the literature to which native speakers are unable to distinguish between velar nasals (Porto Dapena 1976, Carballo 1996, others). Further research will have to explore the relation between geminate nasals and onset and coda position in a perceptual analysis.

Observation of the data also suggests that geminate velar nasals are produced with an onset of silence. The spectrogram as milliseconds of silence. This provides support for the analysis in Colina (2004), where it is argued that surface geminates are the result of the addition of the place features of the preceding consonant. The total occlusion/stop (silence) is a common feature of the data. An alternative realization for an empty C slot is the geminate nasal. To examine the consistency as well as the pattern of the data and its relationship with the syllabic

syllabic affiliation, it can be argued that the results of the phonetic analysis reflect the existence of an empty slot in the syllable tier that takes its phonetic features from the preceding velar nasal as the formal analysis proposed by Colina (2004) claims.

Figure 4: Spectrogram of the phrase *c'uncurandeiro* 'with a folk healer'

In summary, measurements of duration can be taken as a piece of evidence to support the phonological analysis according to which cases such as *unha* 'a', *algunha* 'some' contain underlying velars realized as surface geminates. Even though we have not carried out a perceptual analysis, these findings go along with the claims presented in descriptive work according to which native speakers are unable to determine the syllabic affiliation of velar nasals (Porto Dapena 1976, Carballo Calero 1979, Veiga 1976, among others). Further research will have to explore whether the acoustic distinction between geminate nasals and onset and coda nasals can be supported by a perceptual analysis.

Observation of the data also suggests that there are cases in which geminate velar nasals are produced with an occlusion that can be assessed in the spectrogram as milliseconds of silence. This seems to offer additional support for the analysis in Colina (2004), more specifically for the proposal that surface geminates are the result of the adoption by an epenthetic consonant of the place features of the preceding consonant. Cross-linguistically, a glottal occlusion/stop (silence) is a common epenthetic consonant as well as an alternative realization for an empty C slot. Future research will have to examine the consistency as well as the patterns arising from the glottal stop data and its relationship with the syllabic affiliation of the nasals.

3. Conclusions

Phonetic analysis of intervocalic velar nasals in Galician supports the phonological analysis proposed in Colina (2004) in which the nasals in *unha* 'a', *algunha* 'some' are underlying velars realized as surface geminates. The results reveal that there is a phonetic distinction in terms of length between the *unha* nasals and velar nasals in other contexts. The phonetic evidence found seems to indicate that the latter are phonetically similar to phonological geminates in terms of length; they also are representationally similar in that they both contain a segment that is simultaneously parsed in two syllabic positions. The doubly-affiliated velar nasals of Galician, however, are phonologically different from geminates in that they are non-moraic and non-contrastive. The findings of the present paper have implications for research into the phonological representation of gemination and for the phonology/phonetics interface, since they suggest that certain phonetic properties could serve to convey phonological distinctions (Fourakis and Port 1986).

Notes

* The authors would like to thank Francisco Dubert, his colleagues and the students at the University of Santiago de Compostela, who helped us immensely with the data collection for this study. We also would like to express our gratitude to an anonymous reviewer for his comments and suggestions. All errors remain our own.

1. Galician is a Romance language of Northwestern Spain, closely related to Portuguese and spoken by approximately two and a half million people. Examples cited in this section (1.1) are from the Moaña dialect. Unlike other dialects, Moaña Galician has raising of /e,o/.
2. Word-final epenthesis is an optional process "introduced to satisfy foot binarity at the postlexical level of the intonational phrase (Martínez-Gil 1997:328)". As a result, articles, because of their NP-internal position, (never final in the intonational phrase) cannot undergo word-final epenthesis.
3. A few other examples can be accounted for through the influence of the spelling, e.g. *anelo* 'ring' vs. *anhelo* 'I wish' (these forms are monomorphemic).
4. Syllabification of the last two syllables in (6) is not indicated in the forms where syllabic affiliation is in question. /de/, /kon/, /en/ are posed as the underlying forms of the prepositions because they also surface as [deŋ], [koŋ] and [eŋ] in various other contexts, such as when no article follows (Carballo Calero 1979: 251 and following).

5. Additional support for this account can be found in the fact that an intervocalic nasal is preceded by a high, front vowel in *vinho* [bijo] (Williams 1962).
6. In forms where an intervocalic nasal was lost, selecting a velar articulation for the recovered nasal. However, BASE-IDENTITY does not play a role in this case, since the nasal that did not lose the nasal (due to its low position) outranks BASE-IDENTITY, e.g. /aleman-a/ [alimãna]. At the same time, the constraint against alveolar nasals in the coda (markedness) dominates IO-faithfulness. The preference for velar nasals in the coda (velarization) is the velar nasal at the postlexical level [ku.ŋa]. The relevance of the output-to-output (OO) constraint is due to the morphological word (IO are no longer relevant). Since what is being compared is the morphological word (prefixes and suffix endings), [alimana] is compared to the output of /aleman/ [alimaŋ], which is a morphological word.
7. Five subjects were from the town of Muros. One was from Corme, Carballo and Santa Comba. Their ages were five males and five females.

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5. Additional support for this account can be found in forms in which the intervocalic nasal is preceded by a high, front vowel, e.g. Lat. *vinum* > *vi_o* > Port. *vinho* [bijo] (Williams 1962).
6. In forms where an intervocalic nasal was lost, BASE-IDENTITY has the effect of selecting a velar articulation for the recovered nasal (vs. labial as in Portuguese). However, BASE-IDENTITY does not play a role in selecting [n] over [ɲ] in forms that did not lose the nasal (due to its low ranking). In these the faithfulness constraint requiring preservation of an underlying non-velar point of articulation outranks BASE-IDENTITY, e.g. /aleman-a/ [alemana] *[alimaɲa]. At the same time, the constraint against alveolar nasals in coda positions for coda nasals in Galician (markedness) dominates IO-faithfulness and *Coda [ɲ], resulting in the preference for velar nasals in the coda (velarization, [alimaŋ]). Preservation of the velar nasal at the postlexical level [ku.ŋa.mi.xo.lo] is a consequence of the relevance of the output-to-output (OO) constraint IDENT-OOMWd that refers to the morphological word (IO are no longer relevant in OO correspondence). Since what is being compared is the morphological word (including word markers and suffix endings), [alimana] is compared to the output of /alemana/ and not to the output of /aleman/ [alimaŋ], which is a different morphological word.
7. Five subjects were from the town of Muros. Others were from Laracha, Santiago, Corme, Carballo and Santa Comba. Their ages ranged from 52 to 23. There were five males and five females.

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