Continuancy and Resonance in Spanish

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1. Introduction[1]

Since the late thirties, a prolific body of work has centered on feature classification and organization (Chomsky & Halle, 1968; Clements, 1987; Jakobson, 1939; Jakobson et al., 1951; Jakobson & Halle 1956; McCarthy, 1988; Sagey, 1986, among others). There is a consensus about what features are necessary in phonological theory and how they are hierarchically organized (Hall, 2007; Keating, 1988; cf. Ladefoged, 2007). Feature organization is considered to be a universal property of language, with features divided into 'major' and 'non major' according to their role in phonemic contrasts, natural classes and phonological phenomena (Hall, 2007 and references therein).

This research on feature classification and organization has primarily focused on the analysis and formalization of specific phonological phenomena in a language or group of languages. For Spanish, this has mainly been attempted through rules (as in Cressey, 1978; Harris, 1969), syllabic approaches (Harris, 1983) and constraint based accounts (see for example Martínez-Gil & Colina, 2007). Much of this previous research classifies phonemes into their distinctive features and analyzes the featural changes involved in allophonic variation. However, what is generally missing is the investigation of the specific structuring of the phonological system; namely, whether a specific feature or group of features serve as the backbone of the phoneme inventory and of the phonological phenomena attested in the language, and whether this specific structuring is particular to Spanish or not.

This paper takes up some of these issues. More specifically, it examines the role of the features [sonorant] and [continuant] in Spanish and shows that both features cross-classify segments into four natural classes with distinct articulatory, acoustic, phonotactic and phonological properties (Table 1).

Table 1: Main natural classes and phonological properties[2]

Natural class		Distribution	Phonological phenomena
[+son, +cont]	[j, w, β, ð, ɣ, …]	Not utterance initial	Strengthening to [−son, −cont]
[+son, −cont]	[m, n, ɲ]	Unrestricted	Place assimilation (syllable final)
[−son, +cont]	[f, θ, s, x, h]	Unrestricted	Laryngeal (voicing, aspiration,…)
[−son, −cont]	[p, t, k, b, d, g]	Uncommon syllable final	Weakening; deletion

This paper also shows that continuancy and resonance actively interact in various phonological phenomena in Spanish. Based on these two facts, this paper proposes that [continuant] and [sonorant] are the 'backbone' or driving forces of Spanish phonology. This suggests that both features are equally relevant in the consonantal system of the language, against common assumptions within Feature Geometry Theory that [sonorant] is a root feature (Halle, 1992; Kaisse, 1992; McCarthy, 1988, among others), while [continuant] is not (Chomsky & Halle, 1968, pp. 298−317; Halle, 1992; Kenstowicz, 1994; Kenstowicz & Kisseberth, 1979; McCarthy, 1988).[3]

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[1] This paper benefited from the comments and questions from the audience at the Hispanic Linguistic Symposium, and from two anonymous referees. Any error is my responsibility.

[2] Unless stated otherwise, the phonetic symbols used in this paper conform to the conventions of the International Phonetic Association. Syllabification and primary stress are indicated in transcribed examples.

[3] In other approaches, [approximant] is considered a root feature together with [sonorant] and [vocoid] (Clements, 1990; Clements & Hume, 1995, p. 269).

The features [continuant] and [sonorant] share articulatory and acoustic properties due to the impact of stricture on the flow of air through the vocal tract.[4] For [sonorant], stricture contributes to the triggering or inhibition of spontaneous voicing. For [continuant], stricture results in the free or impeded passage of air through the vocal tract. Building on Aperture Theory (Steriade, 1993, 1994) and Clements & Hume (1995), this paper proposes an extended model of Aperture Theory where [±sonorant] and [±continuant] are associated to four different aperture degrees. This extended model relates phonological characteristics to stricture properties, achieving a representational union between phonetics and phonology. Additionally, it captures the main natural classes of Spanish segments outlined in Table 1, and also laterals, rhotics and affricates, which are aerodynamically complex.

The scope of this paper is restricted to synchronic consonantal phenomena in Spanish. Only consonants and consonantal phenomena are examined. It will be assumed that [+consonantal] distinguishes consonantal from vocalic segments, and that features other than place of articulation are binary. Finally, this paper focuses on the main sounds that occur in Spanish dialects, making no claim about the underlying form of phonemes in this language.

The organization of this paper is as follows. Section 2 considers resonance and continuancy in Spanish. Section 3 argues that both features interact in spirantization phenomena in the language. Section 4 proposes an extension of Aperture Theory where different aperture degrees pattern with [±continuant] and [±sonorant] specifications. An outline of how this model can be applied to Spanish is given in section 5, paying special attention to aerodynamically complex segments such as affricates, rhotics and laterals. Last but not least, section 6 offers some concluding remarks and points out various topics for further investigation.

2. Resonance and Continuancy in Spanish

Although active articulatory properties are emphasized in the influential *Sound Pattern of English (SPE)* in opposition to the acoustic based system of Jakobson et al. (1951), the common consensus is that [sonorant] and [continuant] have both articulatory and acoustic correlates (Kenstowicz, 1994, p. 19).

[+sonorant] segments are produced 'with a vocal tract cavity configuration in which spontaneous voicing is possible (…)' (*SPE*, p. 302). Included in this definition are vowels, glides, nasals and liquids with non radical constructions. [−sonorant] sounds include stops, fricatives, affricates, and liquids with radical constrictions, which are not conducive to voicing (Kenstowicz, 1994, p. 36). Acoustically, [+sonorant] sounds are characterized as showing clear formant structure, unlike [−sonorant] sounds (Davenport & Hannahs, 2005, p. 95; see also Fromkin, 2000, p. 582).

For [+sonorant], sounds, spontaneous voicing might arise through different articulatory gestures. For [+continuant] sonorants, articulators might come close, while for [−continuant] sonorants, spontaneous voicing is achieved through the opening of the nasal passage. A similar case applies to [−sonorant] segments; a total contact of the articulators occurs if [−continuant], but narrowing if [+continuant].

[+continuant] segments are produced in such a way that 'the primary constriction in the vowel tract is not narrowed to the point where the air flow past the constriction is blocked' (*SPE,* p. 317). Kenstowicz (1994, p. 27) proposes a more terse definition: a continuant is 'produced with a constriction blocking airflow'. [+continuant] sounds include vowels, glides, fricatives, and trills, while stops (oral/nasal/glottal), affricates, plausibly taps, and sounds with supplementary constrictions (clicks, implosives, ejectives,…) are [−continuant].

Although from an articulatory perspective [+continuant] and [−continuant] consonants are quite distinct, both classes do not clearly fall into separate groups acoustically. [−continuant] sounds might have a period of silence (if [−sonorant]) or formant structure (if [+sonorant]). Although a release bar might be present for both groups, this is not always the case. For [+continuant] sounds, no common acoustic characteristics apply either. Formant structure is generally present if [+sonorant], or friction noise if [−sonorant].

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[4] Other stricture features include [consonantal] and [approximant] (Kenstowicz, 1995, p. 480).

In Spanish, [+sonorant] segments include approximants and nasals, which are [+voiced] and show formant structure (Hualde, 2005, pp. 69, 142; Martínez Celdrán, 1991). The opposite holds for [−sonorant] segments (obstruents), which encompass fricatives and oral stops. In the following sections, each group is analyzed in turn.

2.1. [+sonorant] segments in Spanish

Two types of sonorants may be distinguished in Spanish: [+sonorant, +continuant] ('approximants' [β, ð, ɣ, j, w]), and [+sonorant, −continuant] ('nasal stops' [m, n, ɲ]). [+sonorant, +continuant] sounds do not generally occur utterance initially or after [+sonorant, −continuant] segments. In such cases, [−sonorant, −continuant] allophones surface instead (1).

(1) [−sonorant, −continuant] segments
a. Bote	[ˈbo.te]	'Boat'	Un bote	[um ˈbo.te]	'One boat'
b. Dos	[ˈdos]	'Two'	Un dos	[un̪ ˈdos]	'One two'
c. Gato	[ˈga.to]	'Cat'	Un gato	[uŋ ˈga.to]	'One cat'
d. Hielo	[ˈdʒe.lo]	'Ice cube'	Un hielo	[uɲ ʲ ˈdʒe.lo]	'One ice cube'
e. Hueso	[ˈgwe.so]	'Bone'	Un hueso	[uŋ ˈgwe.so]	'One bone'

In many dialects, [+sonorant, +continuant] sounds might not to be pronounced intervocalically, which can be considered an instance of deletion. This is especially common for coronals, such as dentals in Peninsular dialects (2a, b), and palatals in Central American Spanish (2c, d).

(2) Intervocalic deletion
a.	Amado	[a.ˈma.ðo]	~	[a.ˈmao]	'Loved'
b.	Partido	[paɾ.ˈti.ðo]	~	[paɾ.ˈti.o]	'Broken'
c.	Gallina	[ga.ˈji.na]	~	[ga.ˈi.na]	'Hen'
d.	Silla	[ˈsi.ja]	~	[ˈsi.a]	'Chair'

The class of [+sonorant, −continuant] segments [m, n, ɲ] is distributionally unrestricted, except for [ɲ], which is rare and does not occur in coda position. [+sonorant, −continuant] sounds trigger strengthening of an adjacent [+sonorant, +continuant], as shown in (1). They also undergo coda place assimilation across and within words (1, 3) (Hualde, 2005, p. 103).

(3) Coda place assimilation within word boundaries
a.	Campo	[ˈkam.po]	'field'	d.	Ansia	[ˈan.sja]	'anxiety'
b.	Énfasis	[ˈeɱ.fa.sis]	'emphasis'	e.	Ancho	[ˈan̠ʲ.tʃo]	'wide'
c.	Tanto	[ˈtan̪.to]	'so much'	f.	Hongo	[ˈoŋ.go]	'fungus'

2.2. [−sonorant] segments in Spanish

The class of [−sonorant] segments ('obstruents') comprises segments characterized by the absence of formant structure. Two types of obstruents occur in Spanish: [−sonorant, +continuant] or 'fricatives', and [−sonorant, −continuant] or 'oral stops'.

Distributionally, [−sonorant, +continuant] sounds are unrestricted, although [f, x] are rare syllable finally. Phonologically, [−sonorant, +continuant] sounds tend to weaken syllable finally. Depending on the dialect, these sounds might aspirate, delete, assimilate in voicing or geminate to a following consonant (4) (Hualde, 2005, pp. 112, 107–8, 159–61).

(4) Weakening of [−sonorant, +continuant]
a.	*Aspiration*	Espina	[es.ˈpi.na]	~	[eh.ˈpi.na]	'Thorn'
b.	*Deletion*	Espina	[es.ˈpi.na]	~	[e.ˈpi.na]	'Thorn'
c.	*Voicing assimilation*	Isla	[ˈis.la]	~	[ˈiz.la]	'Island'
d.	*Gemination*	Isla	[ˈis.la]	~	[ˈil̥.la]	'Island'

[−sonorant, −continuant] sounds or 'oral stops' [b, d, g, p, t, k] are not common syllable finally, except for [d]. In this position, they tend to delete, especially at the end of the word (5). If they do not delete, voicing tends to be neutralized, as in Panamanian Spanish (Hualde, 2005, pp. 103, 146).

(5) Syllable final deletion
    a.   Verdad   [beɾ.ˈð̞a]   'Truth'
    b.   Cognac   [ko.ˈɲa]   'Brandy'

Additionally, [−sonorant, −continuant] sounds tend to weaken intervocalically. If [+voice], weakening in this position results in the realization of [+continuant] allophones (6). If [−voice], intervocalic weakening might result in [+voice] outcomes, as in (7). Although intervocalic weakening for [−voice] appears to be more common in the Canary Islands and in Cuban Spanish, it can be observed in other dialects as well (Hualde, 2005, pp. 141−143 and references therein).

(6) Intervocalic weakening for [+voice]
    a.   Bota   [ˈbo.ta] 'Boot'   La bota [la ˈβ̞o.ta]   'The boot'
    b.   Dota   [ˈdo.ta] 'He equips'   La dota [la ˈð̞o.ta]   'He equips her'
    c.   Gota   [ˈgo.ta] 'Drop'   La gota [la ˈɣ̞o.ta]   'The drop'

(7) Intervocalic weakening for [−voice]
    a.   Paco   [ˈpa.ko]   [ˈpa.go]   'Paco'
    b.   Zapato   [sa.ˈpa.to]   [ˈsa.ba.do]   'Shoe'

As sections 2.1, 2.2 have shown, [sonorant] distinguishes between sonorants and obstruents in Spanish, two natural classes with specific articulatory, acoustic and phonological characteristics of their own. Together with [continuant], it cross-classifies the main consonantal classes of Spanish without crucially resorting to any other phonological feature. Additionally, both features interact in various phonological phenomena in Spanish, as will be shown in the following section.

3.   The connection of [continuant] and [sonorant] in Spanish

While [sonorant] is considered a major or 'root' feature in feature geometry models, [continuant] is usually placed lower in the feature hierarchy (see Hall 2007 for an overview). Indeed, the placement of [continuant] is contested; proposals range from placing it below the root node (Halle, 1992; Sagey, 1986), as a sister to Place features (Clements, 1987; Clements & Hume, 1995), or above or below Place (Padgett, 1994; Van de Weijer, 1992, respectively). This section discusses Spanish data that shows that [continuant] and [sonorant] closely interact in various phonological processes in Spanish, which suggests that they are more closely related in the feature hierarchy than previously assumed.

In most feature geometry models, the root consists on the features [sonorant] and [consonantal], which appear not to participate in assimilation, dissimilation or reduction processes independently of other features.[5] However, there is some evidence that in some languages [consonantal] can assimilate and dissimilate independently (Kaisse, 1992). This evidence is absent for the feature [sonorant], which leads Kaisse (1992) to propose a partially modified feature geometry model in which the root node consists on the feature [sonorant], while [consonantal] is placed below the root node, on the same level as [continuant], [lateral] and others.

There is phonological evidence in Spanish that suggests that [continuant] and [sonorant] are intimately connected. This data is related to 'spirantization', which refers to the alternation between oral stops [b, d, g] and their 'spirant' counterparts, which are [+continuant] (Kenstowicz, 1994). Under most accounts, Spanish spirantization occurs after a [+continuant] segment (see (6) above). However, many authors observe that the continuant allophones of [b, d, g] are acoustically approximants, since

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[5] In some models [approximant] is also part of the root node; see for example Clements & Hume (1995).

they show formant structure, lack spectral noise, have a short duration and a high degree of acoustic energy, and are voiced throughout (Baković, 1995; Hualde, 2005; Martínez Celdrán, 1984, 1991; Romero, 1994, 1995; Quilis, 1981). This supports a view of this process as involving stops and approximants rather than stops and fricatives, and consequently, a change in the specification of both [continuant] and [sonorant]. Specifically, although [+continuant] seems to be the trigger for spirantization, the target involves a change in both continuancy and resonance.

Spirantization, thus, attests to the close relationship between [continuant] and [sonorant] in Spanish. An interesting case is found in Western Andalusian Spanish, where spirantization also applies regularly for /b, d, g/ (Romero, 1994, 1995). In this dialect, approximants [ß, ð̞, ɣ] surface after [+continuant] segments as expected (8a, c, e). However, after a [+continuant, −sonorant], fricative variants [ß, ð, ɣ] surface instead (8b, d, f). This suggests a split of spirantization in this dialect in two different processes; one that assimilates [+continuant, +sonorant] from the previous segment, and another one that assimilates [+continuant, −sonorant] specifications.

(8) Approximant/fricative alternation   (based on Romero, 1995, pp. 2, 9)
   a. *Deban*   /deban/   [ˈde.ßan]   'let them owe'
   b. *Desván*   /desban/   [ˈde.ßan]   'attic'
   c. *Teide*   /tejde/   [ˈtej.ð̞e]   'Teide mountain'
   d. *Desde*   /desde/   [ˈde.ðe]   'from'
   e. *Riego*   /rjego/   [ˈrje.ɣo]   'I water'
   f. *Riesgo*   /rjesgo/   [ˈrje.ɣo]   'risk'

A third example is found in Northern Peninsular Spanish, where spirantization results in [+continuant, +sonorant] [ß, ð̞, ɣ] in onset position after a [+continuant] segment, but in [+continuant, −sonorant] [ɸ, θ, x] syllable finally, with a concomitant change from [+voice] to [−voice] (González, 2003). One example is 'verdad' *truth*, pronounced [ßeɾ.ˈð̞aθ] instead of [ßeɾ.ˈð̞að] (compare with [ßeɾ.ˈð̞a.ð̞es] *truths*). This case also attests to the close connection between continuancy and resonance in the phonological system of Spanish.

The three examples considered in this section show that [continuant] and [sonorant] interact in Spanish phonology. Previously proposed models of feature organization are not able to capture this interaction, unless they treat each feature change as separate phenomena, since [sonorant] is in the root node, but [continuant] is not. Stricture based models such as Aperture theory (Steriade, 1993, 1994) are better suited to capture it, as will be shown in the following section.

4. An extended model of Aperture theory

Although most feature based approaches recognize the relevance of [continuant] in the classification and analysis of natural classes, featural organization does not usually reflect this importance. One exception is found in stricture based accounts such as Aperture Theory (Steriade, 1993, 1994), which proposes a segment representation based on three aperture degrees (9).

(9) Aperture positions   (Steriade, 1993, 1994)
   A_o Closure   (minimal aperture)
          As in the closed phase of oral and nasal stops
   A_f Fricative   (intermediate aperture, sufficient to create turbulent airstream)
          As in fricatives and the second phase of affricates
   A_{max} Approximant   (maximal aperture for a consonant)
          As in oral sonorants and the release phase of stops

Under this approach, continuants only have one aperture node, A_{max} if approximants, and A_f if fricatives. On the other hand, plosives have two apertures; released stops have an oral closure A_o followed by an oral release A_{max}, and affricates have an oral closure A_o followed by A_f.[6]

Clements and Hume (1995) elaborate on Steriade's suggestion that aperture positions can be interpreted as root nodes characterized by appropriate feature values, proposing the features in (10):

(10) Aperture positions as root nodes (Clements and Hume, 1995, pp. 255)
  A_o [−continuant, −approximant]
  A_f [+continuant, −sonorant]
  A_{max} [+continuant, +sonorant]

Note that although Clements and Hume (1995, p. 269) do not consider [continuant] a major feature, this feature is relevant for the definition of all root nodes in (10). [sonorant] is used in the definition of A_f and A_{max} aperture nodes, but [−approximant] is mentioned in the definition of A_o to exclude laterals (Clements and Hume, 1995, p. 302). However, it is plausible to do away with [−approximant] and define aperture degrees with only [sonorant] and [continuant] if the typology of aperture nodes is extended. More specifically, an additional aperture node A_p ('p' for 'partially blocked') can capture cases where the vocal tract partially blocks airflow in one place while at the same time permits its passage through the side of the vocal or the nasal tract (for laterals and nasal stops respectively). Laterals and nasals would then be distinguished from oral stops in that they have two simultaneous apertures rather than two sequential aperture degrees. The proposed aperture node A_p would have the feature specifications [−continuant, +sonorant]. The proposed revised typology of aperture nodes and their feature specifications is given in Table 2.

Table 2: Revised typology of aperture nodes and root features

ABBREVIATION	APERTURE CHARACTERISTICS	ROOT FEATURES
A_o	Oral closure; total absence of oral airflow *Examples*: closed phase of oral stops and affricates	[−continuant, −sonorant]
A_f	Intermediate oral aperture; creates a turbulent airstream *Examples*: fricatives and the second phase of affricates	[+continuant, −sonorant]
A_{max}	Oral release ('Maximal aperture') *Examples*: approximants and the release phase of stops	[+continuant, +sonorant]
A_p	Airflow partially blocked at a point of the vocal tract *Examples*: laterals and nasal stops	[−continuant, +sonorant]

The extended Aperture model proposed here associates phonological features [sonorant] and [continuant] to differing four stricture properties encoded as aperture degrees. This association is aerodynamically motivated, since stricture is of paramount importance for both resonance and continuancy (section 2).

For Spanish, the addition of A_p results in a typology of aperture nodes that captures the differences among the natural classes outlined in section 2, and the phonological interaction between continuancy and resonance that emerges from spirantization phenomena described in section 3. The next section will examine how the model can account for the properties of aerodynamically complex segments in Spanish.

5. Applying the extended Aperture Theory model to Spanish

[continuant] and [sonorant] specifications are (relatively) unambiguous for nasals, approximants, fricatives and stops (section 2). Under the proposed extended model of Aperture Theory, these segments can easily be captured by A_p, A_{max}, A_f, and a combination of A_o and A_{max}, respectively. For

[6] Steriade (1994) leaves open whether approximants and vowels have different aperture positions, and whether there are other stricture distinctions within approximants.

laterals, rhotics and affricates, featural specification for these two features is more challenging. This section considers the aerodynamic and phonological properties of these segments in Spanish and outlines the way in which the extended Aperture Theory model is able to account for them.

5.1. Affricates

Palatal affricates [ʧ, dʒ] are [–sonorant] because they lack formant structure, but their continuancy status has been debated. It has been proposed that they have two continuancy specifications: [–continuant] for the stop phase, and [+continuant] for the fricative phase (Guitart, 2004, p. 123; Kenstowicz, 1994, p. 31; cf. *SPE*, p. 317). This can be straightforwardly captured under Aperture Theory through the combination of two aperture nodes: A_o and A_f (Steriade, 1993, 1994).

Phonological phenomena targeting affricates can be straightforwardly captured in this model. In Cuba and the Canary islands, a word like 'muchacho' *boy* is pronounced [mu.ca.co] (or [mu.ja.jo] with intervocalic voicing) instead of [mu.ʧa.ʧo]. In this case, the A_f node of the affricate is not realized. On the other hand, in Andalucia, Panama, New Mexico and parts of Chile, 'muchacho' is pronounced [mu.ʃa.ʃo] (Guitart, 2004, p. 123; Hualde, 2005, p. 152). In this case, the A_o node of the affricate is not realized.

The distributional alternates of the voiced affricate [dʒ] can also be captured in this model. [dʒ] occurs in variation with the plosive [ɟ] after nasals or in initial position. Both [dʒ] and [ɟ] have two aperture nodes; A_o followed by A_f (for [dʒ]), and A_o followed by A_{max} (for [ɟ]). In non nasal, non initial positions, the fricative [ʝ] or the approximant [j] occur as allophones (Hualde, 2005, pp. 165–166). Both variants can be captured straightforwardly with the loss of the A_o node, resulting in either an intermediate aperture (A_f) for the fricative, or a maximal one (A_{max}) for the approximant.[7]

Affricates are considered to be 'contour segments', which are crosslinguistically characterized by complex release and aerodynamic properties. In Aperture Theory (Steriade, 1993, 1994) oral stops are also considered to be contour segments because of their behavior in respect to nasalization, aspiration and glottalization. Some researchers leave open the possibility that other complex segment types might be added to this inventory (Clements & Hume, 2005, p. 256). Indeed, this has been proposed for Spanish rhotics (Baković, 1995; Guitart, 2004), as will be reviewed in the next section.

5.2. Rhotics

Rhotics are aerodynamically complex (Ladefoged and Maddieson, 1996, p. 232; Solé, 2002). Two rhotics occur in Spanish: the tap [ɾ], and the trill [r]. The tap [ɾ] involves a single rapid vertical upward-downward movement of the tip of tongue against the alveolar ridge.[8] For the trill [r], there are several rapid contacts of the tip of the tongue against the alveolar ridge. This precise articulatory gesture restricts coarticulation with adjacent sounds (Recasens and Pallarès, 1999).

Because of their voicing properties, Spanish rhotics are classified as [+sonorant], although formant structure is actually missing in both. Distributionally, both rhotics occur intervocalically. In most dialects, [ɾ] is generally found in onset clusters and syllable final position, although [r] is also a possible realization in these contexts (11 a, b). On the other hand, [r] always occurs word initially and after homorganic nasals and laterals, where [ɾ] is excluded (11c, d) (Baković, 1995; cf. Hualde, 2005, pp. 181–183).[9] This suggests that, at least phonologically, [ɾ] patterns with [+continuant] and [r] with [–continuant] (cf. *SPE*, p. 318).

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[7] Lozano (1979) and others note that the distribution of this set of sounds is similar to that of 'spirantization', since [–continuant] variants of the palatal occur after nasals and utterance initially, while [+continuant] allophones are found elsewhere. However, the palatal consonant has more variable pronunciations than [b, d, g] in several dialects; for example, [+continuant] variants [ʝ] or [j] can be found utterance initially in Castilian, side by side with [ɟ] or [dʒ] (Hualde, 2005, pp. 165–166). This suggests that both distributions are not fully identical.

[8] Cf. the English flap, where the tip of the tongue first retracts and then makes contact with the alveolar ridge.

[9] After [s, θ] the trill generally surfaces, although the fricative might delete, or an approximant rhotic be pronounced (Hualde, 2005, p. 193; Navarro Tomás, 1980; Solé, 2002, p. 685).

(11) Distribution of rhotics
    a. *Breve*   [ˈbɾe.ße]   'Brief'
    b. *Caer*   [ka.ˈeɾ]   'To fall'
    c. *Honra*   [ˈon.ra]   'Honor'   (cf. *[ˈon.ɾa])
    d. *Raro*   [ˈra.ɾo]   'Strange'   (cf. *[ˈɾa.ɾo])

Because of their distributional properties, Baković (1995) considers [ɾ] to be a rhotic approximant and [r] a rhotic stop. He proposes an aperture node A_{max} for [ɾ], and A_o followed by A_{max} for [r].[10] Dialectal variation for rhotics in Spanish is widespread (see Hammond, 2001, pp. 268–276; Hualde, 2005, pp. 187–188 for an overview), but Baković's approach can be extended to capture it. For example, in some Northern Peninsular dialects [ɾ] may variably strengthen to [r] in onset clusters and syllable finally, as in *breve* [ˈbɾe.ße], *caer* [ka.ˈer] (cf. 11a, b). This can be captured by an addition of the aperture node A_o in these cases. Rhotic assibilation (frication), common in areas of Central America and Chile and resulting in pronunciations such as *caer* [ka.ˈeř] (cf. 11b) can also be accounted for by the strengthening of the A_{max} node of the rhotic to A_f.

5.3. Laterals

Although alveolar lateral [l] is common in Spanish, its palatal counterpart [ʎ] is not. Because of their formant structure and voicing properties both are classified as [+sonorant]. [l] is unrestricted, unlike [ʎ], which can only occur as onset (Hualde, 2005, p. 180). This restriction suggests that [ʎ] patterns with [–continuant] consonants; thus, it is proposed that its aperture node is [A_p], that is, [–continuant, +sonorant].

In general, the continuancy status of laterals is not easily determined, neither in Spanish nor crosslinguistically (Kenstowicz, 1994, p. 36; *SPE*, pp. 317–318). Indeed, the continuancy of [l] seems to vary contextually in Spanish. Before coronals, [l] patterns with nasals in that it assimilates in place of articulation (12a–d) and blocks spirantization (12b). This suggests [l] is [–continuant]. Before non coronals, [l] does not assimilate in place (13) and triggers spirantization (13a, c). This suggests that [l] is [+continuant] in this context.

(12) [l] as [–continuant] before coronals
    a. *Balsa*   [ˈbal.sa]   'Boat'
    b. *Caldo*   [ˈkal̪.do]   'Broth'
    c. *Alza*   [ˈal̪.θa]   'Raise'
    d. *Colcha*   [ˈkolʲ.ʧa]   'Quilt'

(13) [l] as [–continuant] before non coronals
    a. *Alba*   [ˈal.ßa]   'Dawn'
    b. *Alfa*   [ˈal.fa]   'Alpha'
    c. *Alga*   [ˈal.ɣa]   'Seeweed'

This double patterning is consistent with the complex aerodynamic properties of [l], as noted by Mascaró (1984). In Baković (1995), Spanish laterals have an aperture configuration of A_o followed by A_{max}. In the extended Aperture Theory model proposed in section 4, laterals have a single aperture node rather than a sequence of two. However, this aperture node differs depending on the place of articulation of adjacent segments. Laterals are A_p ([–continuant, +sonorant]) before coronals, and A_{max} ([+continuant, +sonorant]) before non coronals. This varying aperture node is consistent with crosslinguistic variation of continuancy for laterals, and it captures spirantization facts in Spanish. Spirantization is triggered by a preceding [+continuant] specification (section 3), hence [l] blocks it before a coronal, but not otherwise.

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[10] Guitart (2004) does not explicitly mention aperture nodes, but takes both [ɾ] and [r] to have two articulatory phases: one plosive, and one approximant (Guitart, 2004, pp. 29, 59–61, 145). According to this, both rhotics would pattern with released stops, which distributionally does not seem to be the case in Spanish.

A varying aperture node might also explain the cooccurrence restrictions of [l] in complex onsets in Spanish. Complex onsets are formed of a stop followed by an [ɾ] or an [l] in Spanish; however, [l] is not permitted after a coronal (*dl, *tl) (see for example Hualde, 2005, p. 74).[11] This cooccurrence restriction can be easily captured if the aperture for [l] is variable. Namely, sequences *dl and *tl are out because the sequence A_o A_p is not permitted in Spanish. On the other hand, complex onsets with [l] (such as *bl, pl, cl, gl*) are allowed because the aperture combination A_o A_{max} is permissible in Spanish.

6. Concluding remarks

This paper examined the role of continuancy and resonance in Spanish and concluded that they are the backbone of the phonological system of this language. It showed that the interplay between [±sonorant] and [±continuant] results in four main natural classes, each with specific articulatory, acoustic, phonotactic and phonological characteristics. Both features, which share aerodynamic similarities regarding stricture, interact in various spirantization related phenomena in Spanish. This suggests that [continuant] and [sonorant] are closely connected phonetically and phonologically in the language.

Building on Steriade (1993, 1994) and Clements & Hume (1995), this paper proposes that [continuant] and [sonorant] are associated to Aperture degrees. It suggests the addition of a new aperture node A_p ('partial aperture') to capture the group of nasals and laterals, which share partial blocking of the airflow at a point of the oral tract concomitant with airflow release. A_p expands the typology of aperture nodes A_o, A_f, and A_{max} proposed in Steriade (1993, 1994) and permits a straightforward patterning of [±sonorant] and [±continuant] specifications with four aperture degrees.

The connection between the features [continuant] and [sonorant] with apertures degrees is not serendipitous, since stricture plays an important role in inducing or inhibiting the spontaneous voicing required for [±sonorant], and allowing or blocking the release of airflow relevant for [±continuant]. In this way, a representational union is achieved between phonological and phonetic properties, expressed as features and aperture degrees respectively.

Table 3 outlines the classification of the main sounds in Spanish phonology for their [sonorant] and [continuant] specifications and their related aperture degrees.[12] Aperture degrees for Spanish stops, approximants, fricatives, affricates and rhotics correspond to those proposed generally by Steriade (1993, 1994) and for Spanish in Baković (1995). The classification of aperture degrees varies only for nasals and laterals, for which this paper proposes a partial A_p aperture. This aperture node captures the stricture properties of nasals and laterals in contrast with that of stops and affricates (which have two sequential aperture nodes) and partially accounts for the distributional and phonological asymmetries concerning the lateral [l] in Spanish, as discussed in section 5.

Table 3

Aperture	Root features	Labial	(Inter) dental	Alveolar	(Alveo) Palatal	Velar	Glottal
A_m	[+sonorant, +continuant]	β̞	ð̞	(l), ɾ	j	ɣ̞, w	
A_p	[+sonorant, −continuant]	m		(l), n	ɲ, ʎ		
A_f	[−sonorant, +continuant]	f	θ	s	tʃ dʒ ʝ	x	h
A_o	[−sonorant, −continuant]	b p	d t	r	tʃ dʒ ɟ c	k g	

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[11] One exception is Mexican Spanish, where *tl* is attested word initially in words of Nahuatl origin such as *Tlapateria* 'paint store'. In the same dialect, word internal *tl* is syllabified as a complex onset, as in *atlas* ['a.tlas]. In other dialects word initial *tl* does not occur, and it is syllabified word internally as coda plus onset: *atlas* ['at.las] (Hualde, 2005, p. 74).

[12] In Table 2, A_o indicates the aperture of the first phase of stops and affricates; for affricates, their classification as A_f reflects their second aperture node.

Although this paper offers a preliminary investigation of the phonetic and phonological implications of the extended Aperture Theory model outlined in section 4, space constraints prevent a full exploration of this topic at this time. Important issues to explore in future research include both the crosslinguistic validity of this approach and its detailed formalization in a theoretical model such as Optimality Theory. Some of the important underlying questions underlying this investigation include whether feature organization and stricture properties are universal or language specific; whether a complete union can be achieved between phonological and phonetic representations, and the precise nature of representation in a theoretical model such as Optimality Theory.

From a psycholinguistic point of view, further investigation should explore the status of the feature [continuant]. Psycholinguistic research provides evidence that the feature [sonorant] is important for word recognition; for native speakers of both English and Spanish, word recognition is significantly easier within the sonorant categories rather than across (Marks et al., 2002). There is also evidence that consonants and vowels work differently for word recognition (Van Ooijen, 1996), which supports the status of [consonantal] as a major feature. It would be of interest to test whether [continuant] has a similar effect in word recognition, and, if it does, whether its effects are on a par with [consonantal] and [sonorant].

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Selected Proceedings of the 11th Hispanic Linguistics Symposium

edited by Joseph Collentine,
Maryellen García, Barbara Lafford,
and Francisco Marcos Marín

Cascadilla Proceedings Project   Somerville, MA   2009

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