Bradley, Travis G. In press. Experimental and Theoretical Approaches to Romance Linguistics, ed. by Randall Gess and Ed Rubin. Amsterdam: John Benjamins.

SYSTEMIC MARKEDNESS AND PHONETIC DETAIL IN PHONOLOGY[*]

TRAVIS G. BRADLEY
University of California, Davis

0. *Introduction*

In Articulatory Phonology (Browman & Goldstein 1989, 1990, et seq.), the grammar is assumed to operate on articulatory *gestures,* which are dynamically defined along both spatial and temporal dimensions and produce a constriction in the vocal tract. Bybee (2001) argues that a gestural analysis provides more insightful and coherent descriptions of most phonological phenomena than does an analysis based on features and segments. Many alternations that have previously been explained in discrete, phonological terms can be analyzed in terms of gestural overlap and/or reduction in casual speech. However, the status of gestural representations in the synchronic grammar remains controversial. Should gestures be phonological primitives as well as units of articulation, or is Articulatory Phonology better viewed as a model of phonetic implementation? If gestures are primitives, should they supplant segments or coexist with them? Should the temporal coordination of gestures be specified in underlying representation, or should it be determined by the grammar?

This paper presents a case study of external sandhi in Spanish that bears directly upon these questions. Spanish has a contrast between a tap [ɾ] and trill [r] between vocoids within the morpheme, which is neutralized in coda position. In the northern Peninsular Spanish varieties spoken in the Cantabrian province around Los Montes de Pas and Tudanca, infinitival *–r* is lost before a consonant-initial clitic pronoun or determiner but surfaces as [ɾ] or [r] in other coda environments, depending on the dialect (Penny 1969, 1978). While [ɾ] + consonant clusters exhibit an intrusive vowel between the two consonants,

[*] I would like to acknowledge Barbara Bullock, Lisa Davidson, Adam Greene, and Sharon Inkelas for helpful discussion about some of the ideas appearing in this paper. Thanks also to the audience of the 34th Linguistic Symposium on Romance Languages, held March 11-14, 2004, by the University of Utah in Salt Lake City. For their comments and feedback, I acknowledge in particular Gary Baker, Marianna Di Paolo, Haike Jacobs, Anthony Lewis, Kristie McCrary, Rafael Núñez Cedeño, and Donca Steriade, as well as two anonymous reviewers. I alone am responsible for any shortcomings in this paper.

other consonants appearing in first position fail to trigger vowel intrusion. The proposed analysis draws upon recent developments in gestural Optimality Theory (Davidson 2003, Gafos 2002, N. Hall 2003), as well as Padgett's (2003a,b,c) version of Dispersion Theory (Flemming 1995). Conflicting gestural constraints generate different patterns of temporal coordination. Minimal overlap produces vowel intrusion in [ɾ^{ə}C], partial overlap favors unreleased [C̚C], and complete overlap yields deletion of infinitival *–r* in the appropriate prosodic contexts. The central claim is that the phonology must incorporate phonetically detailed gestural representations in addition to segmental and prosodic structure. In Dispersion Theory, systemic markedness constraints regulate the perceptual distinctiveness of contrasts, making it possible to incorporate phonetic detail without overgenerating contrasts.

This paper is organized as follows. Section 1 presents the Peninsular Spanish data. Section 2 shows how Padgett's (2003c) Dispersion-theoretic analysis of Catalan rhotics also accounts for the patterns of intervocalic contrast and coda neutralization in the two Spanish varieties. Section 3 presents the gestural coordination framework of Gafos (2002) and develops an analysis of consonant cluster realization and of the external sandhi alternation. Section 4 further discusses the role of gestures, segments, and systemic markedness constraints in the phonology, and Section 5 concludes.

1. *Rhotic neutralization and external sandhi deletion in Cantabrian Spanish*

Many varieties of Spanish contrast an alveolar tap [ɾ] and trill [r] between vocoids within the morpheme (e.g., *ca*[ɾ]*o* "dear" versus *ca*[r]*o* "car"). The contrast is neutralized elsewhere, with [r] appearing in syllable-initial position and [ɾ] in the second position of complex onsets (e.g., [r]*osa* "rose", *hon*[r]*a* "honor" versus *t*[ɾ]*es* "three"). The realization of coda rhotics varies across dialects and speech styles. Penny (1969) notes that in Los Montes de Pas, trills surface frequently in preconsonantal and prepausal position (1a,b). Many of his examples also show coda taps, suggesting free variation.

(1)	a.	*birlar*	[birlaɾ]	"to pinch"
		cuerno	[kwernu]	"horn"
		cerner	[θirniɾ]	"to sift, sieve"
		tierno	[tjernu]	"tender"
	b.	*escupir*	[iskupir]	"to spit"
		empallar	[empayar]	"to press the grass"
		afeitar	[afitar]	"to shave"
		calor	[kalor]	"heat"

In contrast, Penny (1978) does not observe coda trills in the Tudanca variety, and transcriptions consistently show taps before consonants and pause (2a,b).

(2)	a.	*duerme*	[duɾme]	"s/he sleeps"
		morcilla	[moɾθiya]	"blood sausage"
		verde	[beɾðe]	"green"
		zurdo	[θuɾðo]	"left-handed"
		martes	[maɾtes]	"Tuesday"
		carne	[kaɾne]	"meat"
	b.	*pajar*	[paxaɾ]	"haystack"
		labor	[laβoɾ]	"job"
		mejor	[mehoɾ]	"better"
		calor	[kaloɾ]	"heat"

Unlike other Spanish dialects such as Castilian, both the Los Montes de Pas and Tudanca varieties exhibit deletion of infinitival *–r* before clitic pronouns (3a) and before definite articles heading a following noun phrase (3b).

(3)	a.	*ahogarme*	[axweɣame]	"to drown me"
		medirlo	[miðilu]	"to measure it"
		cansarse	[kansase]	"to tire"
		reírnos	[rinus]	"to laugh"
		lavarvos	[laβaβos]	"to wash yourselves"
		contarlos	[kontalus]	"to count them"
		quitarlas	[kitalas]	"to take them off"
	b.	*pintar la pared*	[pinta la paɾeð]	"to paint the wall"
		se va a pudrir la fruta	[se βaː puðɾi la fɾuta]	"the fruit is going to rot"
		comer los huevos	[kome luz ɣweβus]	"to eat the eggs"
		cocer las patatas	[koθe las patatas]	"to cook the potatoes"

Rhotic deletion in (3b) requires that the following determiner begin with a consonant. In standard Spanish, the masculine singular definite article is vowel-initial /el/. This form alternates with the allomorph /l/ in Cantabrian dialects, as well as other Leonese varieties spoken in northwestern Spain. Infinitival *–r* deletes before the consonant-initial allomorph in (4a) but is retained before the vowel-initial one in (4b) (Penny 1969: 58, 176).

(4)	a.	*destorcer*	[destoɾθe	“to shake the tail”
		el rabo	l raβu]	
		poner	[pone	“to put the stew on”
		el cocido	l kuθiu]	
	b.	*echar*	[etʃaɾ	“to add the litre of
		el litro	el litɾu	oil”
		de aceite	ðj aθajte]	
		coger el	[koxeɾ el	“to take the live
		sapo vivo	sapu βiβu]	toad”

While deletion is for the most part systematic, Penny’s phonetic transcriptions suggest that the process may in fact be optional for at least some speakers. The examples in (5), from Penny (1969: 176), show one of his informants from San Pedro del Romeral (southern Los Montes de Pas) pronouncing infinitival *–r* as a trill before a clitic pronoun.

(5)	*meterle en*	[meterle en	“to put it in
	el puchero	el putʃeɾo]	the cooking pot”
	tenerle	[tenerle	“to keep cooking
	cociendo	kuθjendu]	it”

Rhotic deletion is a synchronic process because underlying infinitival *–r* surfaces intact outside of the triggering environments. In addition to the context (4b), deletion fails to apply before consonant-initial words (6a), before vowel-initial words (6b), and in prepausal position (6c).

(6)	a.	*venga a da*[ɾ] *vueltas*	“it keeps spinning”
		hace[ɾ] *mañana una labor*	“to do a job tomorrow”
	b.	*para mete*[ɾ] *otro*	“to put another”
		tengo que hace[ɾ] *esto*	“I have to do this”
	c.	*solo lo vas a hace*[ɾ]	“Will you do it alone?”
		ha quedado a veni[ɾ]	“has agreed to come”

In sum, Spanish rhotics contrast between vowels but are neutralized in coda position. Cantabrian Spanish varieties show an external sandhi alternation in which infinitival *–r* optionally deletes before consonant-initial clitics and determiners. In the next section, I present a Dispersion-theoretic account of rhotic contrast and neutralization.

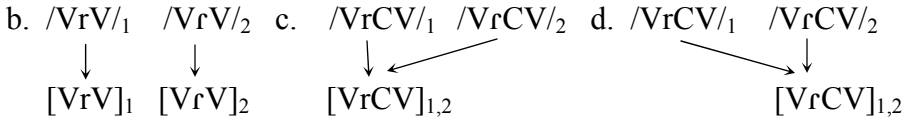
2. *Dispersion Theory and the Spanish rhotic contrast*

Initially proposed by Flemming (1995), Dispersion Theory (DT) incorporates the functionalist principles of Adaptive Dispersion Theory (Lindblom 1986, 1990) into Optimality Theory (OT; Prince & Smolensky 1993). Bradley (2001) applies DT to Ibero-Romance rhotics and situates Spanish within a broader typology of languages with tap-trill contrasts. Drawing upon this analysis, Padgett (2003c) develops a different account for Catalan. In this section, I apply Padgett's approach to the patterns of contrast and neutralization observed in Cantabrian Spanish rhotics.[1]

In standard OT, single input-output mappings are evaluated to optimize single words as outputs. In DT, contrast is a systemic notion requiring evaluation not of isolated forms but of the larger system of contrasts in which those forms exist. Sound patterns are explained by interaction among four basic imperatives: (a) avoid neutralization, (b) maximize the perceptual distinctiveness of contrast, (c) be faithful to underlying specifications, and (d) minimize articulatory effort.

Padgett (2003a,b,c) formalizes neutralization avoidance as a systemic faithfulness constraint, illustrated in (7). *MERGE evaluates *sets* of input-output mappings of idealized word shapes, which are tagged by subscripts. The sets in (7b-d) contain only two mappings since the relevant contrast is between a tap and trill. The fully-faithful mapping in (7b) satisfies *MERGE because the inputs /VrV/$_1$ and /VɾV/$_2$ remain distinct in the output. (7c,d) violate *MERGE because two words neutralize to one.

(7) a.*MERGE: No output word has multiple input correspondents.



The second type of DT constraint, systemic markedness, regulates the perceptual distinctiveness of contrasts. Padgett (2003c) proposes the constraint in (8), which requires a rhotic contrast to be at least as perceptually distinct as it is between two vowels.

(8) SPACE$_R$: Potential minimal pairs differing in R differ at least as much as ɾ–r do between vowels.

---

[1] Padgett (2003c) distinguishes between a strong trill [r:] and a weak trill [r] in Catalan, but I collapse the two here, since the "analysis would work reasonably well without this extra detail" (p. 1). Also, see Padgett (2003c) and Bradley (In press) for arguments favoring the DT approach to Spanish rhotics over previous generative accounts. Space limitations prevent such a comparison here.

'R' is a cover symbol denoting the auditory properties that distinguish taps from trills, such as duration and the presence of trilling-like noise. These properties are more available in intervocalic position. See Padgett (2003c) for discussion, as well as Bradley (2001) for typological support in favor of the superiority of intervocalic position. Since (8) is violated once for each pair of output words that attempts a tap-trill contrast in non-intervocalic position, the constraint allows contrast in (7b) but requires neutralization in (7c,d).

Neutralization avoidance and perceptual distinctiveness work in tandem with the non-systemic faithfulness and markedness constraints of standard OT. The present analysis requires the constraints in (9).

(9) a. IDENT(R): Corresponding input and output segments are identical in R.
b. *r
c. *ɾ

IDENT(R) favors identity between input and output rhotics. This constraint overlaps somewhat with neutralization avoidance in that a violation of *MERGE entails a violation of IDENT(R). However, non-systemic faithfulness is also necessary in order to keep input rhotics from switching in the output, i.e., /VrV/$_1$, /VɾV/$_2$ → [VrV]$_2$, [VɾV]$_1$. The markedness constraints in (9b,c) encode the articulatory cost of the two rhotics. The trill has a longer duration and requires precise articulatory control to sustain passive vibration of the tongue tip. On the other hand, the tap requires a ballistic movement of the tongue tip, and such quickness entails some degree of articulatory effort. For more on the articulatory characteristics of taps and trills, see Blecua (2001) and Bradley (2001). As shown in Tableau 1, the ranking of faithfulness above articulatory markedness constraints guarantees a contrast between [r] and [ɾ] in intervocalic position. *MERGE rules out candidates (c,d) of Tableau 1 because they neutralize the input contrast. The decision is passed to IDENT(R), which selects the fully faithful mapping in (a) of Tableau 1.

/VrV/$_1$ /VɾV/$_2$	*MERGE	IDENT(R)	*ɾ	*r
☞ a. [VrV]$_1$ [VɾV]$_2$			*	*
b. [VrV]$_2$ [VɾV]$_1$		*!*	*	*
c. [VrV]$_{1,2}$	*!	*		*
d. [VɾV]$_{1,2}$	*!	*	*	

Tableau 1: *Faithfulness outranking articulatory markedness*

The optimal output expresses the generalization that in Spanish, surface words can be contrastive based on a difference between [VrV] and [VɾV], where the exact nature of V is irrelevant. Accidental gaps in the lexicon are, of course, possible. For example, *perro* "dog" and *pero* "but" form a minimal pair, but *acera* "sidewalk" cannot because the form **acerra* is not an actual word in Spanish. As in any generative framework, the goal of DT is to derive all and only the *possible* words of a given language. The advantage of assuming idealized word shapes as in (7b-d) is that it focuses the analysis on only those aspects that are relevant, which is something phonologists already do. See Padgett (2003a,b,c) for more on the role of candidate idealization in DT.

To account for the neutralization of coda rhotics in (1) and (2), systemic markedness must outrank faithfulness. The contrasts attempted in Tableau 2 (a,b) violate SPACE_R because they are not perceptually distinctive enough in non-intervocalic position. Since the remaining candidates tie on faithfulness, both are possible winners depending on the ranking of non-systemic markedness constraints. The ranking of *ɾ » *r favors trills in Los Montes de Pas (c) of Tableau 2, whereas the opposite ranking favors taps in Tudanca candidate (d). The analysis of word-final codas would work the same as in Tableau 2, with both [Vr#] and [Vɾ#] as possible winners.

/VɾCV/$_1$ /VɾCV/$_2$	SPACE_R	*MERGE	IDENT(R)	*ɾ	*r
a. [VrCV]$_1$ [VɾCV]$_2$	*!			*	*
b. [VrCV]$_2$ [VɾCV]$_1$	*!		**	*	*
☞ c. [VrCV]$_{1,2}$		*	*		*
☞ d. [VɾCV]$_{1,2}$		*	*	*	

Tableau 2: *Systemic markedness outranking faithfulness*

Cases of free variation in Los Montes de Pas can be accounted for by leaving articulatory markedness constraints unranked. Since [VrC], [VɾC], [Vr#], and [Vɾ#] would all be possible outputs under such a ranking, one might expect to find any combination of these shapes in the realization of actual words. This accounts for the simultaneous appearance of preconsonantal trills and word-final taps, even within the same word, e.g., *birlar* [birlaɾ] "to pinch" and *cerner* [θirniɾ] "to sift, sieve" in (1a).

3. *Spanish clusters and Cantabrian external sandhi*

Let us examine the realizations of Spanish consonant clusters in greater phonetic detail. It has long been noted that the alveolar tap /ɾ/ appearing in a consonant cluster is usually accompanied by an intrusive vocalic element (Gili Gaya 1921, Lenz 1892, Malmberg 1965, Navarro Tomás 1918, Quilis 1988). In a recent typological survey, N. Hall (2003) classifies Spanish as a language

in which /ɾ/ is the only consonant to trigger vowel intrusion. Compare (10a), with intrusive [ᵊ], and (10b-e), in which there is no audible release between the consonants.

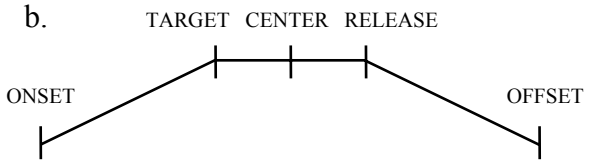
(10)	a.	*arma*	[arᵊma]	"weapon"
	b.	*arma*	[arˀma]	"weapon"
	c.	*alma*	[alˀma]	"soul"
	d.	*ambos*	[amˀbos]	"both"
	e.	*apto*	[apˀto]	"suitable, fit"

Penny (1969, 1978) does not specifically mention intrusive vowels in the Cantabrian dialects under consideration. However, subsegmental aspects of phonetic detail are typically omitted from general descriptive grammars, and transcriptions do not always indicate the type of transition occurring between two consonants. Based on an extensive acoustic study of Peninsular Spanish rhotics, Blecua (2001) concludes that vowel intrusion is an inherent characteristic of taps but fails to appear with preconsonantal trills. Therefore, I transcribe the clusters in (2a) and (6a) as [ɾᵊC] and those in (1a) and (5) as [rˀC].

Articulatory Phonology provides an attractive account of vowel intrusion in terms of the temporal coordination of adjacent consonant gestures. According to Steriade (1990), vowel intrusion results when an overlapping vowel gesture is heard during the open transition between two consonants. Languages vary systematically in the classes of consonants triggering vowel intrusion (N. Hall 2003). Such variation can be captured in the constraint-based framework developed by Gafos (2002). He proposes that gestural coordination is determined by alignment constraints of the form (11a), which make reference to temporal landmarks during the activation period of a gesture, shown in (11b):

(11) a. ALIGN(G_1, LANDMARK$_1$, G_2, LANDMARK$_2$):
Align landmark$_1$ of gesture$_1$ with landmark$_2$ of gesture$_2$.

b.



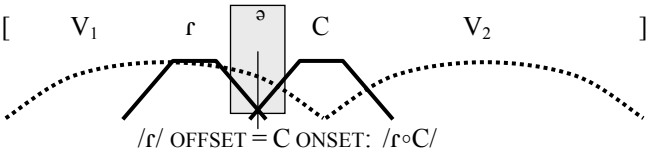
Researchers working within this framework have posited coordination relations for CV, VC, CC, and VV sequences (Davidson 2003, Gafos 2002, N. Hall 2003). I propose that an analysis of Spanish clusters requires the constraint in (12a), which specifies an OFFSET = ONSET coordination relation in /ɾC/ sequences. This ensures an open articulatory transition between /ɾ/ and the

following consonant, which I represent symbolically as /ɾ∘C/. Open transition allows the final portion of the tautosyllabic V_1 gesture to be perceived on the opposite side of the tap constriction as an intrusive vowel, indicated by the shaded box in (12b). It is important to note that the intrusive vowel is not part of the formal representation of segments. Rather, it is the acoustic consequence of the open articulatory transition between adjacent oral constriction gestures. (The distinction between gestures and segments is further discussed in Section 4.)

(12) a. ALIGN(/ɾ/, OFFSET, C, ONSET) — ɾC-COORD:
In a sequence /ɾC/, align the offset of /ɾ/ with the onset of C.

b. *Percept:* [V_1 ɾ ə C V_2]

Gestures:

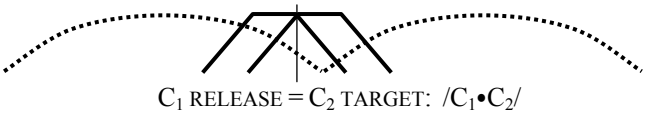


In contrast, (13a) favors a RELEASE = TARGET coordination relation in which C_1 is unreleased. Close transition, denoted by /C_1•C_2/ in (13b), prevents vowel intrusion.

(13) a. ALIGN(C_1, RELEASE, C_2, TARGET) — CC-COORD
In a sequence /C_1C_2/, align the release of C_1 with the target of C_2.

b. *Percept:* [V_1 C_1ˀ C_2 V_2]

Gestures:



The ranking of ɾC-COORD » CC-COORD captures the fact that in Spanish, /ɾC/ exhibits open transition and vowel intrusion, while other clusters do not. N. Hall's (2003) survey shows that across languages, vowel intrusion happens more with liquids than with other sonorants, and more with rhotics than laterals, except the alveolar trill. Cross-linguistic differences among vowel intrusion triggers can be captured by a universal hierarchy of constraints like (12a), each relativized to a different sonorant class. The ranking of (13a) with respect to this hierarchy would distinguish consonants that trigger vowel intrusion from consonants that favor close transition.[2]

Recall that in Cantabrian Spanish, infinitival *–r* is subject to optional deletion before consonant-initial clitics and determiners but that otherwise a rhotic is either a tap or trill in coda position. I assume that enclitics are adjoined to the

[2] This proposal diverges from N. Hall (2003: 28-30), who posits a hierarchy of constraints penalizing the overlap of different types of consonant gestures by a tautosyllabic vowel gesture.

prosodic word (PW) to form an outer PW (Loporcaro 2000, Selkirk 1995). This allows rhotic deletion before clitics to be characterized in prosodic terms as a domain-span rule applying to derived clusters within the PW. Consider the morphological and prosodic structure of the following input-output pairs, in which 'R' stands for both the tap and trill:

(14) a.	/duRme/		
	$(\text{duRme})_{\text{PW}}$	*duerme*	"s/he sleeps"
b.	/axwegaR+me/		
	$((\text{axweɣaR})_{\text{PW}}\text{me})_{\text{PW}}$	*ahogarme*	"to drown me"
c.	/daR bweltas/		
	$(\text{daR})_{\text{PW}}(\beta\text{weltas})_{\text{PW}}$	*dar vueltas*	"to spin"

The cluster in (14a) appears within the same PW in the output, and the one in (14b) is also internal to the outer PW created by clitic adjunction. However, rhotic deletion can affect only the derived cluster in (14b). In contrast, deletion cannot apply in (14c) because the derived cluster is not internal to the same PW.

How is the loss of infinitival *–r* in (14b) to be accounted for? Formal analyses of sandhi processes typically invoke spreading and/or delinking operations, the result of which is a categorical change in the associations among autosegments. A conventional view of segment deletion would involve the removal of a timing slot, resulting in the categorical absence of the segment from the phonological surface representation. However, Browman & Goldstein (1990) argue that in many cases of optional consonant deletion, an account in terms of gestural overlap is preferable. As an example, they cite the deletion of English final /t/ in the casual speech forms [mʌsbi] and [pɚfɛkmemɹi] versus the canonical forms [mʌst#bi] *must be* and [pɚfɛkt#memɹi] *perfect memory,* respectively. Articulatory measurements via X-ray pellet trajectories indicate that the tongue tip gesture for /t/ is still present in the casual speech form, although its acoustic effects are hidden due to overlap with the following bilabial closure. The deletion of /t/ is only apparent, since articulatory traces of the consonant remain.

The optionality of infinitival *–r* deletion in Cantabrian Spanish suggests the possibility of an account in terms of perceptual masking. Specifically, I propose the constraint in (15a), which requires an ONSET = ONSET coordination relation in /RC/ clusters that appear in the same PW domain. When ranked above ɾC-COORD and CC-COORD, this constraint requires complete overlap in such clusters, denoted by /ɾ⊗C/ and /r⊗C/ in (15b).

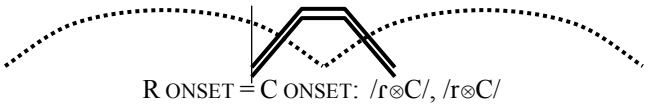
Since the tautomorphemic /RC/ clusters in (14a) are internal to the PW, they, too, fall within the purview of $\text{RC-OVERLAP}_{\text{PW}}$. The blocking of complete

overlap in such clusters is accounted for by a higher-ranked constraint, given in (16), which makes reference to input morphological structure.

(15) a. ALIGN(R, ONSET, C, ONSET) IN PW — RC-OVERLAP$_{PW}$:
In a PW-internal sequence /RC/, align the onset of R with the onset of C.

b. *Percept:* [V_1 C V_2]

Gestures:



(16) RECOVERABILITY IN μ — RECOV$_{\mu}$ (cf. Gafos 2002: 318):
In a tautomorphemic sequence C_1C_2, complete overlap between the associated gestures in the output is prohibited.

The proposal in (15) is consistent with Browman & Goldstein's account of optional deletion in external sandhi, whereby the final consonant gesture is still present but perceptually hidden. Such an explanation is based on the hypothesis in Articulatory Phonology that casual speech alternations involve changes in the magnitude and/or temporal coordination of gestures but that no gestures are literally removed from the articulatory plan. To be sure, further articulatory investigation is required to determine the extent to which Cantabrian infinitival *–r* patterns like English word-final /t/.[3] In any event, the gestural account is still compatible with the more conventional view of deletion as the delinking of a segment. Assuming a usage-based model of phonology, Bybee (2001: 76) argues that "[p]erceived deletion of this type can lead to actual deletion. If tokens with perceived deletion are frequent, a reorganization of exemplars will occur, with the eventual effect of the loss of the final [consonant]."

I illustrate the complete analysis below, focusing primarily on the Los Montes de Pas dialect for reasons of space. Gestural coordination constraints are now added to the hierarchy that was shown to account for rhotic contrast and neutralization in Section 2. Recall from Tableau 2 that coda neutralization is guaranteed by the ranking of SPACE$_R$ » *MERGE. Since the focus here is on preconsonantal rhotics, I limit the analysis to input pairs of the form /VrCV/$_1$ and /VrCV/$_2$ and consider only neutralized output candidates. Furthermore, I distinguish between articulatory and acoustic representations in the output. The

[3] Another prediction of the gestural model is that overlap between adjacent gestures engaging the same articulator will result in a 'blending' of gestural characteristics, which "shows itself in spatial changes in one or both of the overlapping gestures" (Browman & Goldstein 1990: 362). I leave it to future research to confirm whether infinitival *–r* and a following coronal exert any mutual coarticulatory influence.

clusters in '/…/' denote sequences of consonant gestures and their coordination relations, while corresponding acoustic forms are given in '[…]'.

Tableau 3 gives the evaluation of tautomorphemic PW-internal /RC/, as in *duerme* 's/he sleeps'. The first three candidates are eliminated by the articulatory markedness constraint against taps, and complete overlap in candidate (f) of Tableau 3 violates recoverability. The remaining candidates tie on RC-OVERLAP$_{PW}$, and lower-ranked CC-COORD selects the unmarked coordination in candidate (e). For Tudanca Spanish, the opposite ranking of *r » *ɾ would eliminate candidates (d-f), allowing lower-ranked ɾC-COORD to favor vowel intrusion in candidate (a).

/VrCV/$_1$ /VɾCV/$_2$	*ɾ	*r	RECOV$_\mu$	RC-OVERLAP$_{PW}$	ɾC-COORD	CC-COORD
a. /ɾ∘C/ [Vɾ$^{\partial}$CV]$_{1,2}$	*!			*		*
b. /ɾ•C/ [Vɾ$^{\gamma}$CV]$_{1,2}$	*!			*	*	
c. /ɾ⊗C/ [VCV]$_{1,2}$	*!		*		*	*
d. /r∘C/ [Vr$^{\partial}$CV]$_{1,2}$		*		*		*!
☞ e. /r•C/ [Vr$^{\gamma}$CV]$_{1,2}$		*		*		
f. /r⊗C/ [VCV]$_{1,2}$		*	*!			*

Tableau 3: *Prosodic structure: (…VRCV…)$_{PW}$ (=(14a))*

The analysis of heteromorphemic PW-internal /RC/, as in *ahogarme* "to drown me", is illustrated in Tableau 4. Again, articulatory markedness eliminates output candidates that contain a tap. Since infinitival *–r* and the following consonant belong to different morphemes in the input, RECOV$_\mu$ is now irrelevant. Lower-ranked RC-OVERLAP$_{PW}$ favors complete overlap of the cluster in (f), resulting in the perceived deletion of the rhotic. For Tudanca Spanish, high-ranking *r would eliminate candidates (d-f), allowing RC-OVERLAP$_{PW}$ to choose candidate (c).[4]

[4] Rafael Núñez Cedeño (personal communication) suggests that gemination of the following consonant is another plausible repair for derived rhotic + consonant clusters. In fact, total assimilation of infinitival *–r* to the clitic-initial consonant is attested in earlier stages of the language, presumably when Spanish still allowed geminate sonorants: *dezirlo* > *dezillo* "to say it", *hazerlo* > *hazello* "to do it", *considerarlo* > *considerallo* "to consider it" (Álvar & Pottier 1983: 182-4). Subsequently in Leonese dialects of northwestern Spain, geminate *–ll–* derived from infinitive + clitic combinations underwent the same reductive changes as other geminate laterals (see Zamora Vicente 1967: 124-7). A comprehensive diachronic analysis would take us too far afield, but see the Dispersion-theoretic accounts of Baker (2004) and Holt (2003).

/Vr+CV/$_1$ /Vɾ+CV/$_2$		*ɾ	*r	RECOV$_\mu$	RC-OVERLAP$_{PW}$	ɾC-COORD	CC-COORD
a. /ɾ∘C/	[Vɾ^{ə}CV]$_{1,2}$	*!			*		*
b. /ɾ•C/	[Vɾ^{ˀ}CV]$_{1,2}$	*!			*	*	
c. /ɾ⊗C/	[VCV]$_{1,2}$	*!				*	*
d. /r∘C/	[Vr^{ə}CV]$_{1,2}$		*		*!		*
e. /r•C/	[Vr^{ˀ}CV]$_{1,2}$		*		*!		
☞ f. /r⊗C/	[VCV]$_{1,2}$		*				*

Tableau 4: *Prosodic structure: ((…VR)$_{PW}$CV…)$_{PW}$ (=(14b))*

The optionality of infinitival *–r* deletion is accounted for by the fact that RC-OVERLAP$_{PW}$ can be ranked either above or below the gestural coordination constraints with which it conflicts. When it is ranked below CC-COORD, candidate (e) becomes optimal, with a preconsonantal trill surfacing before the consonant-initial clitic. This pattern is reflected in the Los Montes de Pas data shown in (5). For Tudanca Spanish, in which *r » *ɾ, it is sufficient that RC-OVERLAP$_{PW}$ rank below ɾC-COORD to generate the default coordination pattern for preconsonantal taps in candidate (a) of Tableau 4.

Recall that infinitival *–r* is subject to deletion not only before clitic pronouns but also before consonant-initial determiners, as in *pintar la pared* "to paint the wall" (3b). If determiners adjoin as proclitics to the following noun to form an outer PW, as in (17), then the derived /RC/ cluster would straddle the PW boundary, as in (14c).

(17) /pintaR la paɾed/ (pintaR)$_{PW}$(la(paɾeð)$_{PW}$)$_{PW}$

The problem is that RC-OVERLAP$_{PW}$ fails to produce deletion because the cluster is not internal to the same PW. One possibility is to relativize (15a) to the phonological phrase in order to allow for deletion across PW boundaries, but this would incorrectly predict deletion in phrases like *dar vueltas* (14c). Another approach is to formalize deletion in a way that targets /ɾ/ + lateral clusters within the phonological phrase, but this would predict deletion before any lateral-initial PW domain (e.g., *decir locuras* "to say silly things").

In his description of infinitival *–r* deletion in Leonese dialects of northwestern Spain, Zamora Vicente (1967: 160) claims that deletion occurs by analogy before the /l/ of a following definite article. This can be formalized via prosodic restructuring, whereby the determiner of the direct object noun phrase in (17) adjoins to the preceding PW, as in (18a).

(18) a. /pintaR la pareɾd/ ((pintaR)$_{PW}$la)$_{PW}$(pareɾð)$_{PW}$
b. /pintaR-la/ ((pintaR)$_{PW}$la)$_{PW}$ *pintarla* "to paint it"

Prosodic analogy is plausible inasmuch as the infinitive + determiner sequence in (18a) is *segmentally identical* to the corresponding infinitive + clitic sequence in (18b). On the assumption that analogical restructuring requires homophony, deletion is predicted not to apply before other function words (e.g., *pintar más paredes* "to paint more walls"). I leave it to future research to confirm or refute this empirical prediction.

Remaining to be accounted for is the maintenance of infinitival *–r* before a consonant in other phrasal contexts, as in *dar vueltas* "to spin". Since RC-OVERLAP$_{PW}$ is relevant only to clusters that are PW-internal, it follows that derived /RC/ sequences are not subject to the pressure of complete overlap across a PW boundary. As shown in Tableau 5 (e), CC-COORD ensures preconsonantal trills in Los Montes de Pas. I leave it to the reader to verify that in Tudanca Spanish, candidate (a) of Tableau 5 would be optimized by ɾC-COORD.

/Vr#CV/$_1$ /Vɾ#CV/$_2$	*ɾ	*r	RECOV$_\mu$	RC-OVERLAP$_{PW}$	ɾC-COORD	CC-COORD
a. /ɾ∘C/ [Vɾ̪CV]$_{1,2}$	*!					*
b. /ɾ•C/ [Vɾ̚CV]$_{1,2}$	*!				*	
c. /ɾ⊗C/ [VCV]$_{1,2}$	*!				*	*
d. /r∘C/ [Vr̪CV]$_{1,2}$		*				*!
☞ e. /r•C/ [Vr̚CV]$_{1,2}$		*				
f. /r⊗C/ [VCV]$_{1,2}$		*				*!

Tableau 5: *Prosodic structure: (…VR)$_{PW}$(CV…)$_{PW}$ (=(14c))*

4. *Gestures, segments, and systemic markedness in the phonology*

In this section, I argue that both gestures and segments are present in the phonological representation but are subject to different constraints interacting at the same level in the phonological grammar. I show how systemic markedness in DT keeps the grammar from overgenerating unattested contrasts based on differences in intergestural coordination.

Many phonologists assume a division between phonological and phonetic components in the grammar (see Liberman & Pierrehumbert 1984, Keating 1990, Cohn 1990). Underlying forms are devoid of non-contrastive properties such as syllabification or temporal relations between articulatory gestures. The phonological component derives a syllabified surface representation that is categorical, qualitative, and timeless, and phonetic implementation then sup-

plies gradient, quantitative aspects of non-contrastive detail to yield a fully-specified phonetic representation. Another common assumption is that underlying morphological structure is not present in the input to the phonetic component. The erasure of morphological boundaries at the end of each transformational cycle in SPE and the Bracket Erasure Convention of Lexical Phonology both predict that morpheme boundaries should be invisible to the phonetics.

The division between phonetics and phonology entails that morphological structure cannot influence gestural coordination. On this view, however, it is difficult to explain why complete overlap yields rhotic deletion in clusters derived by enclisis but not in morpheme-internal ones. If phonetic implementation has no access to underlying morphological structure, then forms like /duRme/ (14a) and /axwegaR-me/ (14b) should pattern together with respect to rhotic deletion. This problem does not arise in a unified model that incorporates gestural representations and constraints directly into the phonology (Davidson 2003, Gafos 2002, N. Hall 2003). In the present analysis, RECOV$_{\mu}$ in (16) makes reference to morphological structure in the input and is capable of blocking complete overlap in morpheme-internal /RC/ sequences. The blocking effect is possible only if the two constraints are able to interact at the same level in the phonological grammar, where underlying morphological structure is still accessible.

Any proposal to place gestural coordination within the purview of the phonology must also account for the facts that motivate a phonology-phonetics division. Evidence that gestural coordination belongs in phonetic implementation comes from the observation that vowel intrusion is in many ways invisible to the phonology, which tends to count the intrusive vowel and tautosyllabic vowel it copies as one. This suggests that vowel intrusion does not create a new syllable, unlike true phonological epenthesis of a nuclear vowel (N. Hall 2003). Three arguments from Spanish support this claim. First, intrusive vowels are never counted in stress computation. In Spanish, main stress is confined without exception to a three-syllable window at the right edge of the morphological word (Harris 1995: 869). If the intrusive vowel in *ártico* [ˈarᵊ.ti.ko] "Arctic" were to create a new syllable, then stress would fall outside the three-syllable window, yielding ungrammatical results: *[ˈa.ɾa.ti.ko]. Stress shift, *[a.ˈɾa.ti.ko], is an unattested repair strategy. Second, in the Spanish language game Jerigonza, often used by younger speakers as a secret speech code, intrusive vowels are invisible. In one version of the game, an epenthetic CV syllable is inserted to the right of every syllable boundary in a word. The consonant is from the set /p,t,k,tʃ/, and the vowel is a copy of the preceding syllable nucleus (Piñeros 1999). If the intrusive vowel in *carta* [kaɾᵊ.ta] "letter" were syllabic, then CV-insertion would also target this nucleus. Jerigonza word forma-

tion yields [karˤ.*pa*.ta.*pa*] instead of *[ka.*pa*.ɾa.*pa*.ta.*pa*], suggesting that the intrusive vowel is invisible.

Perhaps the best evidence for the invisibility of vowel intrusion is that gradient differences in intergestural timing are universally non-contrastive. N. Hall's (2003) cross-linguistic survey shows that in each language, vowel intrusion either always happens or never happens in a given environment. This places the intrusive vowel on a par with consonant release, which plays an important role in perceptual licensing of contour segments although it is never phonologically contrastive *per se* (Steriade 1993). Moreover, Spanish speakers are typically unaware of the existence of intrusive vowels in clusters containing /ɾ/. It seems unlikely that any language would have minimal pairs based solely on minute differences in the phonetic timing of adjacent consonant gestures.

In the model of Zsiga (2000), the phonology acts upon abstract features and segments, which are then mapped to gestures that are coordinated by language-specific alignment constraints in phonetic implementation. Following this model, the phonological invisibility of intrusive vowels is explained by the fact that they arise in the phonetics, where syllabification and stress constraints are no longer operative and where segments cease to be relevant after features are mapped to gestures. More recently, N. Hall (2003) argues against the necessity of a derivational mapping between featural and gestural representations. She argues instead for a unified model in which gestures are associated to segments, which in turn group together into higher prosodic constituents such as syllables, feet, prosodic words, and so on. If the constraints responsible for stress computation and for Jerigonza word formation refer only to higher prosodic structure, then it follows that they will be insensitive to any percepts arising from specific gestural coordination relationships. As we have seen, intrusive vowels are the acoustic consequence of non-overlapping consonant gestures and are not part of the formal representation of segments. In short, the invisibility of vowel intrusion requires not a 'derivational' difference between phonological and phonetic components but rather a 'representational' difference between segments and gestures in the phonological representation.

According to N. Hall, the universal non-contrastiveness of intergestural timing follows from the lack of faithfulness to gestural coordination relations in the input. If UG had a constraint such as IDENT(timing), then some language might rank it above gestural coordination constraints, thereby overgenerating a contrast based on gestural coordination. In a theory with systemic faithfulness, explaining the universal non-contrastiveness of a given property requires more than simply banning input-output faithfulness. As shown in Tableau 6, high-

ranking *MERGE overgenerates a contrast between [aɾˠ.ma], with /ɾ∘m/ in open transition, and [aɾˀ.ma], with /ɾ•m/ in close transition.[5]

/aɾ∘ma/$_1$ /aɾ•ma/$_2$	*MERGE	ɾC-COORD	CC-COORD
a. /ɾ∘m/ [aɾˠma]$_1$ /ɾ•m/ [aɾˀma]$_2$		*	*
b. /ɾ∘m/ [aɾˠma]$_{1,2}$	*!		*
c. /ɾ•m/ [aɾˀma]$_{1,2}$	*!	*	

Tableau 6: *Overgeneration of contrast based on intergestural timing*

This problem has a parallel in syllable structure. Most phonologists agree that syllabification in itself is not contrastive, given that no language permits a tautomorphemic contrast between *pa.ta* versus *pat.a* or *pa.kla* versus *pak.la.* If in some language *MERGE dominates syllable structure constraints, then input morphemes differing solely in the syllabification of intervocalic consonants would be contrastive in the output. Padgett (2003c) argues that forms differing solely in syllabification are perceptually too similar to contrast, and I propose the same type of explanation for intergestural coordination. According to Padgett, "impossible contrasts are the result of impossible perceptual distinctions, the jurisdiction of SPACE constraints. From this perspective, the problem is one of markedness, not faithfulness" (p. 15). In DT, universally imperceptible contrasts can be ruled out by placing the relevant SPACE constraints in GEN, making them inviolable.[6] In Tableau 7, the potentially contrastive pair [aɾˠ.ma] versus [aɾˀ.ma] is universally ruled out by inviolable systemic markedness. Even if input representations include gestural coordination relations, neutralization to the unmarked form is unavoidable.

/aɾ∘ma/$_1$ /aɾ•ma/$_2$	*MERGE	ɾC-COORD	CC-COORD
a. /ɾ∘m/ [aɾˠma]$_{1,2}$	*		*
b. /ɾ•m/ [aɾˀma]$_{1,2}$	*	*!	

Tableau 7: *Systemic markedness in GEN rules out imperceptible contrast*

[5] An anonymous reviewer questions the necessity of systemic faithfulness in this paper, especially since IDENT(R) alone seems to be sufficient in Tableaux 1 and 2. However, independent motivation for the existence of *MERGE is found in Holt (2003) and Padgett (2003a,c). Therefore, the overgeneration problem in Tableau 6 still remains and must be dealt with.

[6] It is possible that such inviolable SPACE constraints simply reflect the limits of the human perceptual apparatus, whereas only rankable and violable SPACE constraints are truly linguistic/grammatical.

5. *Conclusion*

As Bybee (2001: 57) notes, "[c]ases in which morphological status interacts with variable phonetic processes constitute important evidence against modularization. Phonetic implementation cannot be relegated to a derivative role in which it has no access to the lexical or morphological status of the elements upon which it works." In this paper, I have analyzed Cantabrian Spanish external sandhi deletion in terms of gestural recoverability and coordination constraints that are relativized to morphological and prosodic domains, respectively. Alternative approaches that view gestural timing as a low-level aspect of phonetic detail incorrectly predict that morphological structure should have no effect on phonetic realization.

Furthermore, I have shown that there is no danger in assuming phonetically rich gestural representations along with segments in the phonology. The fact that intrusive vowels are not part of the segmental representation accounts for their invisibility to phenomena that refer to higher levels of prosodic structure. In DT, inviolable SPACE constraints ensure that no language grammar can generate imperceptible contrasts based solely on differences in syllabification or gestural coordination – even if such differences happen to be present in the input. The combination of gestural and systemic phonologies provides a unified account of the Cantabrian Spanish data that captures the interaction among morphological, prosodic, and gestural structure without overpredicting the range of possible contrasts.

REFERENCES

Álvar, Manuel & Bernard Pottier. 1983. *Morfología histórica del español.* Madrid: Editorial Gredos.

Baker, Gary. 2004. "Dispersion and Duration in Geminate Sonorant Reflexes in the History of Spanish". Paper presented at the 34th Linguistic Symposium on Romance Languages, Salt Lake City, Utah, February 2004.

Blecua, Beatriz. 2001. *Las vibrantes del español: manifestaciones acústicas y procesos fonéticos.* Ph.D. dissertation, Universitat Autònoma de Barcelona.

Bradley, Travis G. 2001. *The Phonetics and Phonology of Rhotic Duration Contrast and Neutralization.* Ph.D. dissertation, Pennsylvania State University.

----------. In press. "Spanish Rhotics and Domincan Hypercorrect /s/". To appear in *Probus* 18:1.

Browman, Catherine, & Louis Goldstein. 1989. "Articulatory Gestures as Phonological Units". *Phonology* 6.201-252.

----------. 1990. "Tiers in Articulatory Phonology, with Some Implications for casual Speech". *Papers in Laboratory Phonology I: Between the grammar*

and physics of speech ed. by John Kingston & Mary E. Beckman, 341-386. Cambridge: Cambridge University Press.

Bybee, Joan. 2001. *Phonology and Language Use.* Cambridge: Cambridge-University Press.

Cohn, Abigail. 1990. *Phonetic and Phonological Rules of Nasalization.* Ph.D. dissertation, University of California, Los Angeles.

Davidson, Lisa. 2003. *The Atoms of Phonological Representation: Gestures, coordination, and perceptual features in consonant cluster phonotactics.* Ph.D. dissertation, Johns Hopkins University.

Flemming, Edward. 1995. *Auditory Representations in Phonology.* Ph.D. dissertation, University of California, Los Angeles.

Gafos, Adamantios. 2002. "A Grammar of Gestural Coordination". *Natural Language and Linguistic Theory* 20.269-337.

Gili Gaya, Samuel. 1921. "La r simple en la pronunciación española". *Revista de Filología Española* 8.271-280.

Hall, Nancy. 2003. *Gestures and Segments: Vowel intrusion as overlap.* Ph.D. dissertation, University of Massachusetts, Amherst.

Harris, James. 1995. "Projection and Edge Marking in the Computation of-Stress in Spanish". *The Handbook of Phonological Theory* ed. by John Goldsmith, 867-887. Cambridge, Mass.: Blackwell.

Holt, D. Eric. 2003. "The Emergence of Palatal Sonorants and Alternating-Diphthongs in Old Spanish". *Optimality Theory and Language Change* ed. by D. Eric Holt, 285-305. Dordrecht: Kluwer.

Keating, Patricia. 1988. "Underspecification in Phonetics". *Phonology* 5.275-292.

Lenz, Rodolfo. 1892. "Chilenishe Studien". *Phonetische Studien* 5.272-293.

Liberman, Mark, & Janet Pierrehumbert. 1984. "Intonational Invariance under Changes in Pitch Range and Length". *Language Sound Structure* ed. by M. Aronoff & R. T. Oehrle, 157-233. Cambridge, Mass.: MIT Press.

Lindblom, Björn. 1986. "Phonetic Universals in Vowel Systems". *Experimental Phonology* ed. by J. J. Ohala & J. J. Jaeger, 13-44. Orlando: Academic Press.

----------. 1990. "Explaining Phonetic Variation: A sketch of the H&H theory". *Speech Production and Speech Modelling* ed. by W. J. Hardcastle & A. Machal, 403-439. Dordrecht: Kluwer.

Loporcaro, Michele. 2000. "Stress Stability under Cliticization and the Prosodic Status of Romance Clitics". *Phonological Theory and the Dialects of Italy* ed. by Lori Repetti, 137-168. Amsterdam: John Benjamins.

Malmberg, Bertil. 1965. *Estudios de fonética hispánica. (= Collectanea Phonetica, I.)* Madrid: Consejo Superior de Investigaciones Científicas.

Navarro Tomás, Tomás. 1918. "Diferencias de duración entre las consonantes españolas". *Revista de Filología Española* 5.367-393.

Padgett, Jaye. 2003a. "Contrast and Post-Velar Fronting in Russian". *Natural Language and Linguistic Theory* 21.39-87.

----------. 2003b. "The Emergence of Contrastive Palatalization in Russian". *Optimality Theory and Language Change* ed. by D. Eric Holt, 307-335. Dordrecht: Kluwer.

----------. 2003c. "Systemic Contrast and Catalan Rhotics". Ms., University of California, Santa Cruz.

Penny, Ralph. 1969. *El habla pasiega: ensayo de dialectología montañesa.* London: Tamesis Books.

----------. 1978. *Estudio estructural del halba de Tudanca.* Tübingen: Max Niemeyer Verlag.

Piñeros, Carlos-Eduardo. 1999. "Head Dependence in Jerigonza, a Spanish-Language Game". *Advances in Hispanic Linguistics* ed. by Javier Gutiérrez Rexach & Fernando Martínez-Gil, 265-277. Somerville, Mass.: Cascadilla Press.

Prince, Alan, & Paul Smolensky. 1993. "Optimality Theory: Constraint interaction in generative grammar". Ms., Rutgers University & University of Colorado.

Quilis, Antonio. 1988. *Fonética acústica de la lengua española.* Madrid: Editorial Gredos.

Selkirk, Elisabeth. 1995. "The Prosodic Structure of Function Words". *Papers in Optimality Theory* ed. Jill Beckman, Laura Walsh Dickey, & Suzanne Urbanczyk, 439-470. Amherst, Mass.: Graduate Linguistics Student Association.

Steriade, Donca. 1990. "Gestures and Autosegments: Comments on Browman and Goldstein's paper". *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech* ed. by M. Beckman & J. Kingston, 382-397. Cambridge: Cambridge University Press.

----------. 1993. "Closure, Release, and Nasal Contours". *Nasals, Nasalization, and the Velum* ed. by M. Huffman & R. Krakow, 401-470. New York: Academic Press.

Zamora Vicente, Alonso. 1967. *Dialectología española.* Madrid: Editorial Gredos.

Zsiga, Elizabeth. 2000. "Phonetic Alignment Constraints: Consonant overlap and palatalization in English and Russian". *Journal of Phonetics* 28.69-102.