Systemic Contrast and Catalan Rhotics*

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1. Introduction

Catalan, a Romance language spoken primarily in the northeast of Spain, has two contrasting rhotics: a tap [ɾ] and a trill [r]. The two sounds contrast only between vowels with the distribution otherwise being predictable. The facts closely parallel the better known facts of Spanish, and the problems they raise are similar. In this paper I take a new look at Catalan rhotics, arguing that we can achieve a better account of them if we explicitly acknowledge the role of contrast in their behavior. Specifically, the explanation calls on constraints requiring that contrast be maintained, on the one hand, and on constraints requiring that contrasts be perceptually distinct, on the other. The account is cast within Dispersion Theory (Flemming 1995, to appear), which is designed to express such notions. In approaching the Catalan facts in this way I follow Bradley (2001), who applies Dispersion Theory to Spanish rhotics. Some of the main conclusions we reach differ, all the same.

A good deal of recent work argues that both neutralization avoidance and perceptual distinctiveness play important roles in shaping phonologies. (Besides the above, see Ní Chiosáin and Padgett 2001, Sanders 2002, Padgett to appear-a,b, and Sanders in progress.) The theoretical framework of these works, Dispersion Theory, remains rather new, and this paper offers another case study. The appeal to contrast leads to a simpler and more explanatory account of Catalan (and Spanish) rhotics compared to previous ones. The analysis also illustrates how it is possible to incorporate more systematic phonetic detail into phonology, increasing our descriptive coverage, without predicting the overgeneration of contrast. This is possible because Dispersion Theory proposes constraints on the output that regulate contrast directly. Though the Catalan analysis would work reasonably well without this extra detail, the importance of phonetic detail to uncovering phonological generalizations in other languages is another emerging theme in recent phonology. (Besides the works cited, see Browman and Goldstein 1986 et seq., Steriade 1997, 2000a, 2001, Kirchner 1997, 2000, 2001, Boersma 1998, Zhang 2000, Flemming 2001, and Padgett 2002, among others.) This work implies that ignoring such detail should not be a goal.

Section 2 presents the Catalan facts, section 3 the analysis, and in section 4 I provide further discussion of the claims of the paper. Section 5 is the conclusion.

2. Catalan Rhotics

The facts involving rhotics in Catalan are very similar to those of Spanish, which are quite well known. The generalizations, and much of the data, presented here are due to Mascaró (1976), Wheeler (1979), Recasens (1986, 1991a, 1993), Serra (1996a,b), Bonet and Mascaró (1997), and Bonet and Lloret (1998).[1] There is a contrast between a tap and a trill, but only between vowels. Some (near-) minimal pairs are given in (1). It is frequently stated that this contrast occurs only within words, but later I will argue otherwise. The transcription [r:] denotes a 'strong' trill, on which see below.[2]

(1)	'sɛɾə	'wax'	'sɛr:ə	'saw'
	'miɾə	'(s/he) looks at'	'mir:ə	'myrrh'
	'paɾə	'father'	'par:ə	'grapevine'
	'moɾə	'blackberry'	'gor:ə	'(peaked) cap'

In every other context the distribution of rhotics is rule-governed. When it is the first (and only) onset consonant, a rhotic is strongly trilled, as in (2). The examples in (2)a are word-initial. Those in (2)b are syllable-initial, because Catalan does not allow [n], [l], or [s] to form an onset with a following rhotic. Those in (2)c are syllable-initial because the prefix-stem boundary corresponds to a syllable boundary.[3]

(2)	a.	'r:ɔʧ	'red'	b.	'on.r:ə	'honor'
		r:ə'fe	'to redo'		'foɬ.r:ə	'lining'
		r:u'ma	'Roman'		iz.r:ə'ɛɬ	'Israel'
	c.	pɾe.r:u'ma	'Pre-Roman'			
		sub.r:əgu'ɬar	'subregular'			

As the second element of an onset cluster, a rhotic is invariably a tap:

(3)	'pɾim	'thin'	te'atɾə	'theater'
	'fɾaŋ	'free'	'kabɾə	'goat'

In the coda, either before a consonant as in (4)a, or word-finally as in (4)b, there is dialectal variation. In Western Catalan, rhotics here are generally taps, as in many Spanish dialects. In Central Catalan, including the areas of Barcelona and Girona, they are weak trills, as shown here (Mascaró 1976, Wheeler 1979, Recasens 1986, 1991a, 1993, Hualde 1992).

(4)	a.	'formə	'shape'	b.	'kɔr	'choir'
		'kɔrs	'hearts'		ə'mor	'love'
					r:əgu'lar	'regular'

The distinction transcribed above between strong trill [r:] and weak trill [r] is commonly described, and is discussed in detail especially by Recasens (1986, 1991a, 1993). A strong trill contains 2-4 taps on average, a weak trill 1-2 taps (Recasens 1993). These transcriptions abstract away from even more phonetic variation, particularly in the coda. How strong a coda trill is depends in part on rate and style of speech, individual speakers, the constriction degree of neighboring consonants, and the location of stress. Allowing room for this variation, the distinctions described above remain systematic and well agreed upon.

We will also be interested in the phrasal phonology of rhotics. Here there is one phenomenon of note: the weak coda trill [r], found before a consonant or pause, is impossible when followed by a vowel-initial word. Here we find only the tap. Compare the isolation and pre-vocalic forms shown in (5)a. This prohibition against a trill is interesting, because it occurs in spite

of the syllable-initial status of the rhotic. In Catalan, a word-final consonant is always resyllabified as the onset of a following vowel-initial word. This syllabification is shown here. We might therefore expect these rhotics to be trilled, as those in (2)a are. Failing that, we might expect them to be weak trills as they are when these words appear in other contexts. Instead they are taps, and there is a contrast between such rhotics and underlying word-initial rhotics, as shown in (5)b.

(5) a.

mar	'sea'	ma.ɾ ədri'atik	'Adriatic sea'
kɔr	'heart'	kɔ.ɾ əmu'ros	'loving heart'
ə'mor	'love'	ə'mo.ɾ u'ma	'human love'

b.

*la **mà restà** en repòs*	['ma.r:əs'ta]	'the hand remained at rest'
*la **mar està** en repòs*	['ma.ɾəs'ta]	'the sea is calm'

It should be noted that in Catalan there is a pervasive process by which morphological-word-final rhotics delete. However, there are (quasi-)systematic classes of exception to this rule, depending on stress, the morphology, and other factors, so that there is ample data exemplifying the generalizations in (4) and (5).

3. Analysis

3.1 Theoretical context: Dispersion Theory

The analysis presented here is cast within Dispersion Theory (Flemming 1995, to appear), a theory which adapts the principles of Adaptive Dispersion Theory (Lindblom 1986, 1990) to Optimality Theory (Prince and Smolensky 1993). The constraints and discussion here more closely follow Ní Chiosáin and Padgett (2001) and Padgett (to appear-a,b), a particular development of the ideas of Dispersion Theory. Other work within Dispersion Theory includes Sanders (2002, in progress), and Bradley (2001).

Dispersion Theory explains many phonological patterns as the result of an interaction of conflicting functional constraints. These appeal to articulatory difficulty, perceptual distinctiveness of contrast, and neutralization avoidance. (This is not meant to imply that there are no other sources of constraints). Our interest here lies largely with the latter two classes of constraints. These require a 'systemic' understanding of wellformedness, an understanding in which output forms are evaluated in relation to other contrasting output forms. This is because neutralization avoidance and perceptual distinctiveness of contrast are inherently comparative notions.

Consider first neutralization avoidance. In Optimality Theory, contrast is understood to result from the workings of faithfulness constraints like that in (6)a. (I assume correspondence-theoretic faithfulness constraints, McCarthy and Prince 1995.) 'R' encompasses those phonetic properties distinguishing taps from trills (see below). I use the cover symbol 'R' for these properties, since for the most part there is no reason to distinguish them or take one property as basic. (But see section 4.3.) Following Padgett (to appear-a,b), I assume in addition the novel correspondence constraint *Merge shown in (6)b. As the name suggests, this constraint penalizes a merger of two input forms into one output, that is, neutralization.

(6) a. Ident(R): Corresponding input and output segments are identical in R.
b. *Merge: No output word has multiple input correspondents.

Consider the tableau below. Given distinct input forms /sɛrə/ and /sɛɾə/, considered simultaneously, three possible output scenarios are shown. In candidate (7)a each word is faithfully preserved. In (7)b, /sɛrə/ is faithfully mapped, but /sɛɾə/ is not: as the subscripts imply, this word has merged with /sɛrə/ in the output, both words now having the trill. In (7)c the opposite merger has occurred. To make clear the fate of input words, each word here is tagged with a subscript, not to be confused with the *segment*-specific subscripts usually employed in correspondence theory. Candidates (7)b-c violate *Merge. They each likewise violate Ident(R), since /sɛrə/ → [sɛɾə] in (7)b and /sɛɾə/ → [sɛrə] in (7)c. (On (7)d see below.)

(7)

	$sɛrə_1$ $sɛɾə_2$	*Merge	Ident(R)
a.	$sɛrə_1$ $sɛɾə_2$		
b.	$sɛrə_{1,2}$	*	*
c.	$sɛɾə_{1,2}$	*	*
d.	$sɛrə_2$ $sɛɾə_1$		**

The 'systemic' nature of *Merge should be clear. By its very nature, it operates with reference to *sets* of input and output forms, and not input-output mappings of *single* forms. This direct appeal to neutralization avoidance is a key element of Dispersion Theory, but it is potentially daunting at first blush: how many forms must we consider at once, and how do we decide what they are? Following Ní Chiosáin and Padgett (2001), and Padgett (to appear-a,b), I address these questions by making explicit the idealizations under which the analysis is carried out. In this paper, for example, we are interested only in forms differing in having /r:/, /r/, or /ɾ/. Further, it is important to single out a small number of contexts important to the distribution of these sounds, e.g., word-initial, intervocalic. Other variables, such as the remaining vowels and consonants in a word, the length of the word, and so on, are irrelevant. Given this idealization, the number of possible forms to consider will always be clear: for a given context, at most three. Stating this idealization makes clear what the range of possible inputs and outputs is, and how they are to be evaluated.

There is clearly overlap between *Merge and conventional Ident constraints. In fact, any time *Merge is violated, an Ident constraint must also be violated, since neutralization necessarily involves the alteration of some input property. But evidence nevertheless supports the existence of constraints like *Merge that penalize neutralization directly, as we will see (and as argued in Padgett (to appear-a)). It also seems clear that standard faithfulness constraints like Ident cannot be eliminated in favor of *Merge. A violation of Ident will often imply one of *Merge, but not inevitably so. Candidate (7)d above shows this dramatically; to rule out such switches of input

allegiance (without neutralization), Ident is necessary. Given Ident, such candidates will always be harmonically bounded by their surface-identical and more faithful counterparts, here (7)a.[4]

Dispersion Theory, like other generative theories of phonology, takes the domain of explanation to be the set of *possible phonological forms*. (See Ní Chiosáin and Padgett 2001 and Padgett to appear-a for discussion of this idea in generative phonology.) Given the novel appeal to sets of contrasting forms as inputs and outputs, two implications of this uncontroversial assumption are worth stressing in order to forestall confusion. First, the status of a derived output as an occurring or non-occurring lexical item of the language is irrelevant, so long as it is phonologically well formed (in which case it has the status of an accidental gap). For this reason contrast effects are not predicted to depend on vagaries of the lexicon. For example, if [sɛɾə] 'wax' contains invariably a tap in order to maintain a perceptual contrast with [sɛr:ə] 'saw', as I will suggest, it does not follow that [moɾə] 'blackberry' might vary its rhotic realization because there happens to be no lexical item [morə]. (Examples from (1)). Since phonology is about possible forms and not actual ones, [morə] *is* a predicted output, and there *is* a contrast to be maintained. It is sometimes convenient to entertain possible, but non-occurring, forms in analyses. Second, within an input or output set of forms, every form is unique. The English word 'bank' has only one underlying and surface representation, for example, in spite of having two (or more) independent meanings ('river shore' and 'financial institution'). In other words, homophony has no status in the theory. This follows once again from the focus on *phonological* forms and not lexical items. Imaginable mergers like /bæŋk_1, bæŋk_2/ → [bæŋ$k_{1,2}$] are therefore impossible. The reason for this is once again to detach predictions about the phonology from accidents of the lexicon. In the absence of evidence that languages repair homophony as in 'bank', I assume that principles of contrast, like other principles of phonology, govern possible words, not actual ones.

Dispersion Theory's appeal to the perceptual distinctiveness of contrast requires the 'systemic' view, just as the appeal to neutralization avoidance does. Flemming (1995, to appear) posits 'Minimal Distance' constraints relativized to specific acoustic-auditory phonetic dimensions such as vowel height and color. Consider the perceptual distinction between taps and trills, which differ in several respects. First and most obvious, taps lack the quasi-periodicity of trilling itself. Second, trills are invariably longer than taps; in fact, taps are noteworthy for their brief duration. The significance of duration can be seen also in the fact that trills frequently lenite to taps across languages, especially in intervocalic position, and lenition itself can be viewed as reducing constriction duration. (See discussion and references in Inouye 1995.) Third, trills are more tense articulations than taps. (See below.) Finally, taps are more sonorous than trills. This can be seen in two ways. First, taps, but more rarely trills, can be realized with no real closure at all. Second, trills are sometimes and in some contexts characterized by noise bordering on or amounting to frication. (For all of the observations above see Ladefoged and Maddieson 1996 and especially Inouye 1995; for Spanish the detailed phonetic observations of Blecua 2001, as well as discussion and references in Bradley 2001; for Catalan Recasens 1986, 1991a, 1993.)

For most of this paper, what matters to us are only two assumptions. First, the sound [r] lies perceptually in between [ɾ] and [r:], for the simple reason that it is intermediate in duration. (Throughout this paper it should be kept in mind that [r:] is used here for what is often transcribed [r], in order to distinguish it from the shorter trill, here [r].) Second, following Bradley (2001), these rhotics are perceptually most distinct when they lie between vowels. Given these

assumptions, the perceptually greatest contrast possible is one between [ɾ] and [r:] when between vowels. The constraint in (8) requires that a rhotic contrast be at least this perceptually distinct. 'Potential minimal pairs' are defined as two forms identical in all but one segment (see Padgett to appear-a,b). This constraint will play a crucial role in the account of Catalan rhotics, just as a similar one does for Bradley analyzing Spanish. A fuller discussion of Space constraints, and of rhotic contrasts in other positions and other languages, appears in section 4.

(8) SPACE_{R}: Potential minimal pairs differing in R differ at least as much as intervocalic ɾ - r: do.

The argument for the perceptual superiority of an intervocalic contrast rests, I suggest, on the durational component of the contrast. (See Bradley 2001 for other ideas.) Since perception of duration rests on perception of both a beginning and an ending, a contrast based on duration is most recoverable in contexts where these end points are clearly perceptible. Compare in this regard the contrast between singleton and geminate stops, which is generally based solely on duration (Kraehenmann 2001 and references therein). As is well known, this contrast is overwhelmingly preferred word-internally, and in fact between sonorants. In a detailed investigation of Swiss German, in which the contrast also occurs word-initially and -finally, Kraehenmann (2001) finds the contrast neutralized in three environments: phrase-initially; following an obstruent; and following a sonorant consonant when an obstruent follows. What the first two environments have in common, as Kraehenmann argues, is that the perceptual onset of the potential geminate is obscured, meaning that duration cannot be computed. What is key about the last environment, I suggest, is that it is the least sonorous of the remaining environments overall: in the remaining cases, either the left environment, the right one, or both, is more sonorous.[5] Since taps and trills are stop articulations too (trills involving a series of stops), it seems reasonable to infer a similar distributional preference for a tap-trill contrast, for similar reasons. The best possible environment, therefore, is the intervocalic one. Bradley (2001) provides typological support for this conclusion. His survey of languages shows that, among languages having a tap-trill contrast, it is only this environment that universally supports that contrast.

To see how Space works, consider the next tableau. Candidate (9)a violates this constraint twice, once for the [ɾ] - [r] contrast and once for the [r] - [r:] contrast. (Space compares every pair of words separately.) According to this constraint, only the contrast between (intervocalic) [ɾ] and [r:] is good enough. Candidate (9)b violates Space once and (9)c not at all, for reasons that should be clear. Candidates (9)d-e satisfy Space vacuously, because there is no contrast or because there is no minimal pair (respectively).

(9)

		Space
a.	sɛr:ə sɛrə sɛɾə	*!*
b.	sɛr:ə sɛrə	*!
c.	sɛr:ə sɛɾə	
d.	sɛɾə	
e.	sɛr:ə lɛrə	

The analysis to come will depend on just a few more constraints, shown below. The one in (10)a follows Bonet and Mascaró (1997) and Serra (1996a,b) (though they do not distinguish strong and weak trills). It also recalls aspects of the classic analysis of Spanish rhotics by Harris (1983) in its reliance on syllable structure. This constraint can be seen as one instance of a class of constraints motivated especially by Smith (2002). Smith observes that phonologically strong positions are sometimes subject to neutralization processes, contrary to expectations based on positional faithfulness theory (on the latter see especially Beckman 1997, 1998, and Casali 1996, 1997)). In all such cases, Smith argues, the relevant neutralization involves a perceptual augmentation of some sort, and this is motivated by a class of constraints requiring that some perceptually enhancing element occupy a strong phonological position. The long trill [r:] is certainly the most perceptually salient of the rhotics considered here, and the onset is a well known strong phonological position (see the positional faithfulness references).[6] It may be that constraints such as this should be reduced to dispersion-theoretic ones, but I leave this idea for another paper.

(10) a. $_{\sigma}$[r: A rhotic in syllable-initial position is [r:]
b. *r: >> *ɾ >> *r

Dispersion Theory posits a third class of constraints motivated solely by articulatory difficulty, as noted earlier. Of the rhotics considered here, it seems reasonable to posit that [r:] is the most difficult articulatorily. This is based on its greatest duration and the inherent tenseness of the trill articulation (Ladefoged and Maddieson 1996, and for Catalan Recasens 1986, 1991a, 1993). Based on its resistance to coarticulatory effects compared to the tap, Recasens (1991b) concludes that the trill requires more articulatory effort and control. Between [r] and [ɾ] it is more difficult to say. The weaker trill is presumably more tense than [ɾ] as well; but [ɾ] is a particularly fast articulation (see the references above), and quickness involves its own articulatory cost (see generally Boersma 1998, Kirchner 1998, and regarding the tap Bradley 2001). As we will see below, there is evidence that Spanish prefers [ɾ] over [r], while Catalan prefers the reverse. Given this fact, I assume no universal ranking between the two constraints *r and *ɾ. The ranking shown in (10)b therefore incorporates a combination of universal and Catalan-specific assumptions.

3.2 Within words

We now apply the constraints introduced to the facts of Catalan, beginning with the word-internal data. The facts of Spanish are nearly the same, and the account here should extend equally to Spanish, except for the differences noted below.

Let us begin with the intervocalic context, the only one permitting contrast. Focusing on this context alone, and given the three rhotics under consideration, a hypothetical minimal triplet such as /sɛr:ə/, /sɛrə/, /sɛɾə/ is a fully representative idealization. This input is shown in (11). But as we have seen, the constraint Space does not permit contrasts like (11)a-b. The fact that these are in fact ruled out in Catalan shows that Space outranks both relevant faithfulness constraints, *Merge and Ident(R).[7] For the time being I simply assume that input /r/ merges with [r:] rather than [ɾ] in such cases, but section 4.3 will provide some motivation. Of the candidates remaining, (11)c has the virtue of maintaining as much contrast as possible, and it wins.

(11)

	$sɛr{:}ə_1$ $sɛrə_2$ $sɛɾə_3$	Space	*Merge	Ident
a.	$sɛr{:}ə_1$ $sɛrə_2$ $sɛɾə_3$	*!*		
b.	$sɛr{:}ə_1$ $sɛrə_{2,3}$	*!	*	*
c. ☞	$sɛr{:}ə_{1,2}$ $sɛɾə_3$		*	*
d.	$sɛr{:}ə_{1,2,3}$		**!	**!
e.	$sɛrə_{1,2,3}$		**!	**!
f.	$sɛɾə_{1,2,3}$		**!	**!

Since the winning candidate violates the constraints *r: and *ɾ also, it follows that both of these are dominated by at least one of the two faithfulness constraints. For reasons to become clear later, I assume that this is *Merge, as shown below. Candidates (12)c-f repeat the most relevant candidates from above, (11)c-f. Recall that *r: >> *ɾ is universally given.

(12)

	$sɛr{:}ə_1$ $sɛrə_2$ $sɛɾə_3$	*Merge	*r:	*ɾ	Ident
c. ☞	$sɛr{:}ə_{1,2}$ $sɛɾə_3$	*	*	*	*
d.	$sɛr{:}ə_{1,2,3}$	**!	*		**
e.	$sɛrə_{1,2,3}$	**!			**
f.	$sɛɾə_{1,2,3}$	**!		*	**

Consider now word-initial position, where only the strong trill is possible. Candidates (13)a-c differ from (11)a-c in attempting the contrast in non-intervocalic position. Since Space requires contrasting rhotics to differ at least as much as *intervocalic* ɾ - r: do, this means more Space violations for (13)a, and more to the point, a fatal violation for (13)c. (Candidates like (13)b will no longer be shown below.) It is therefore up to the remaining constraints after *Merge to determine which rhotic is optimal. The sound [r:] is disfavored on purely articulatory grounds, as we have seen. But word-initial position is also syllable-initial, and the constraint $_{\sigma}$[r: favors [r:]. Assuming this constraint outranks *r: (compare (13)d to both (13)e-f), candidate (13)d wins.

(13)

	r:ɔʧ$_1$ rɔʧ$_2$ ɾɔʧ$_3$	Space	*Merge	$_{\sigma}$[r:	*r:	*ɾ	Ident
a.	r:ɔʧ$_1$ rɔʧ$_2$ ɾɔʧ$_3$	*!**		**	*	*	
b.	r:ɔʧ$_1$ rɔʧ$_{2,3}$	*!	*	*	*		*
c.	r:ɔʧ$_{1,2}$ ɾɔʧ$_3$	*!	*	*	*	*	*
d. ☞	r:ɔʧ$_{1,2,3}$		**		*		**
e.	r ɔʧ$_{1,2,3}$		**	*!			**
f.	ɾɔʧ$_{1,2,3}$		**	*!		*	**

The account of syllable-initial rhotics after consonants is precisely the same, as shown below. So is the account of forms like [sub.r:əgu'ɬar] 'subregular' from (2)c, not shown.

(14)

	onr:a$_1$ onra$_2$ onɾa$_3$	Space	*Merge	$_{\sigma}$[r:	*r:	*ɾ	Ident
a.	onr:ə$_1$ onrə$_2$ onɾə$_3$	*!**		**	*	*	
b.	onr:ə$_{1,2}$ onɾə$_3$	*!	*	*	*	*	*
c. ☞	onr:ə$_{1,2,3}$		**		*		**
d.	onrə$_{1,2,3}$		**	*!			**
e.	onɾə$_{1,2,3}$		**	*!		*	**

It would not do to rank $_{\sigma}$[r: above all faithfulness constraints, because then we would wrongly predict neutralization of the contrast even intervocalically. Tableau (15), (20) reconsiders the intervocalic facts with the entire hierarchy now. Compare (15), (20)b-c.

(15)

	sɛr:ə$_1$ sɛrə$_2$ sɛɾə$_3$	Space	*Merge	$_\sigma$[r:	*r:	*ɾ	Ident
a.	sɛr:ə$_1$ sɛrə$_2$ sɛɾə$_3$	*!*		**	*	*	
b. ☞	sɛr:ə$_{1,2}$ sɛɾə$_3$		*	*	*	*	*
c.	sɛr:ə$_{1,2,3}$		**!		*		**
d.	sɛrə$_{1,2,3}$		**!	*			**
e.	sɛɾə$_{1,2,3}$		**!	*		*	**

Tableau (15), (20) illustrates the first important advantage of the Dispersion Theoretic account. Harris's (1983) account of Spanish rhotics was an advance over earlier accounts in its appeal to the role of syllable structure. Still, Harris was not able to formulate the simple generalization here: a rhotic is a trill (in our terms [r:]) in syllable-initial position. This was for the simple reason that the generalization is untrue for words like [sɛɾə], where the rhotic is syllable-initial. For this reason Harris had to write two independent and more complex rules, one requiring the trill word-initially, and the other requiring the trill syllable-initially after a consonant (for (13) and (14) respectively). Lipski (1990), Serra (1996a,b), Bonet and Mascaró (1997), and Harris (2001) himself all note the loss of generality that results. The first three works argue for (the equivalent of) $_\sigma$[r:. However, all of these accounts founder on [sɛɾə] as well, requiring stipulations about the input for such forms in order to prevent a trill realization.[8] Lipski suggests that intervocalic taps are underlyingly linked to a single skeletal slot, and in order to block rule application assumes that association lines must be interpreted exhaustively, as in Hayes (1986). Serra (1996a,b), like Saporta and Contreras (1962) for Spanish, assumes that taps are syllabified as in [sɛɾ.ə], in the coda, in spite of their surface onset status, so that they will not succumb to $_\sigma$[r:. Bonet and Mascaró (1997) assume that taps are pre-specified as specifically tap, while rhotics otherwise are unspecified for 'R' and receive their values by rule. In the Dispersion Theory account, no stipulations about the tap are required at all, because of the appeal to the key role of contrast. The best generalization for Catalan (and Spanish) is that syllable-initial rhotics are (strong) trills *except where contrastive* (where they may also be taps). Nor does the qualification need to be built into the onset generalization. Rather, it follows from the interaction of constraints. A contrast only in intervocalic position is made *possible* by the perceptual goodness of contrast in that position, here captured by Space. It is made *necessary*, in spite of the demands of $_\sigma$[r:, by neutralization avoidance, or *Merge. The ranking *Merge >> $_\sigma$[r: ensures this.

Though he also gives a dispersion-theoretic account of rhotics (analyzing primarily Spanish), Bradley (2001) cannot appeal to the syllable-initial generalization. This is because he argues against the role of syllables in the account altogether. Bradley claims that two languages unrelated to Spanish, Ngizim (Afro-Asiatic, Schuh 1978, 1981) and Kairiru (Austronesian, Wivell 1981), both of which have a tap-trill contrast, prohibit specifically the tap adjacent to a homorganic consonant. Some representative examples from Ngizim are given below. The tap and trill are in contrast before labials (and dorsals), as shown in (16)a; before coronal stops, only the trill occurs, (16)b.

(16)	a.	kər.mai	'chieftainship'	b.	kur.na	'thorny tree'
		kaɾ.mu	'cut down'		*kuɾ.na	

Significantly, all of the relevant consonant-rhotic sequences are tautosyllabic in Kairiru, and none of them are in Ngizim (as indicated in (16)); in other words, syllabification is irrelevant in both languages, and only homorganicity is claimed to matter. Since [l,n,s] are just the Spanish consonants that are precisely homorganic with the tap and trill—all of these are alveolar, while [t,d] are dental—it follows that trills might be required after these sounds for this reason alone.

For several reasons, I do not follow Bradley in drawing this conclusion. First, I note that the facts regarding Kairiru are actually unclear. Wivell's (1981) statements (p.35) imply that *any* liquid may follow [t] and [s], the relevant consonants. Bradley infers a prohibition against [tɾ] and [sɾ] from the fact that no data are cited having these clusters. But Wivell (1981) contains only a tiny handful of examples having [t]- or [s]-liquid clusters of any kind, so that this inference is unsafe. In fact, the word [tɾausis] 'trousers' appears in another place in Wivell (p.212), though this is obviously borrowed.

Second, Ngizim and Kairiru differ from Spanish and Catalan in an important way: the tap and trill generally contrast when adjacent to consonants. This is seen for Ngizim in (16)a. This fact makes possible an alternative account: these languages might prohibit a *contrast* when adjacent to coronals (assuming this claim is correct for Kairiru at all), and this is *not* the same as prohibiting a *tap* next to coronals. This is because contrasts can be prohibited for perceptual reasons, as we have seen. I suggest in section 4 that [rt] and [ɾt] are not as distinct from each other as [rk] and [ɾk] are. Space constraints could therefore rule the former contrast out. Once a contrast is ruled out, of course, some constraints must favor the trill over the tap. But this need not say anything about place of articulation, or adjacent consonants, at all: perhaps $_{\sigma}$[r: generalized to onset position, whether syllable-initial or not, or a constraint favoring [r:] in any context since it is a more perceptible sound, are at work. The prohibition in Spanish and Catalan, on the other hand, has nothing to do with contrast, since there is no contrast next to a consonant regardless of place.

Third, the phonetic basis of Bradley's account of the Kairiru and Ngizim restrictions requires more investigation. He suggests that the homorganicity restriction is motivated articulatorily: the tap, an articulation that must be made quickly, is difficult when adjacent to a consonant of the same place. The idea is that a quick succession of gestures by the same articulator is more difficult than one by different articulators. In Ngizim and (possibly) Kairiru the tap is prohibited next to any coronal (coronal stop in Ngizim), and sub-coronal place distinctions are irrelevant. Extending the idea to Spanish and Catalan requires the claim that alveolar [l,n,s] are homorganic in the relevant sense, while dental [t,d] are not. It is not at all clear that a difference between dental and alveolar place is large enough to matter in this regard. This is especially true given the strong tendency for adjacent coronals to assimilate to each other. In English, [t] and [d] are partially or fully retracted before [ɻ] as in 'tree' (Catford 1977), and even in Catalan dental [t,d] are known to assimilate to become partially or fully alveolar preceding the rhotic in other contexts (Recasens and Pallarès 2001). (These authors test only word-final [t] before word-initial [r:].) Given this important difference in what 'homorganic' means for Spanish and Catalan, compared to Ngizim and Kairiru, the parallelism is once again not clear.

Finally, because he rejects the role of syllables for Spanish and Catalan, Bradley is forced to posit separate constraints for the post-consonantal trill and for the word-initial trill, analogously to Harris (1983). Given the above, it is unclear how well motivated this sacrifice is, and I prefer to hold to the simpler appeal to onset position. Having said this, I would add that it is worth exploring in future work alternative means of reducing direct reference to syllable structure, given recent work by Steriade (1997 et seq.) arguing for a cue-based approach to sound distribution—so long as the generality of $_{\sigma}$[r: argued for here could be preserved. This strategy jibes with that of Dispersion Theory, since the latter also roots explanations in perceptual effects.

What remains is to treat rhotics that are not syllable-initial. Words like [pɾim] 'thin' always have the tap. Here I adopt without further discussion the suggestion, due to Bakovic (1994) and Bonet and Mascaró (1997), that this follows from sonority. As we have seen, taps are more sonorous than trills. These authors suggest that trills, like nasals and obstruents, are not sonorous enough to occupy the second position of an onset, a matter of sonority distance. The relevant constraint, called 'Son' in the next tableau, is undominated.[9]

(17)

	pr:im$_1$ prim$_2$ pɾim$_3$	Space	Son	*Merge	$_{\sigma}$[r:	*r:	*ɾ	Ident
a.	pr:im$_1$ prim$_2$ pɾim$_3$	*!**	*!*		**	*	*	
b.	pr:im$_{1,2}$ pɾim$_3$	*!	*!	*	*	*	*	*
c.	pr:im$_{1,2,3}$		*!	**		*		**
d.	prim$_{1,2,3}$		*!	**	*			**
e. ☞	pɾim$_{1,2,3}$			**	*		*	**

Bradley (2001) argues against a sonority distance-based approach on the grounds that trills occupy second onset position in some languages, such as Basque. But the latter fact does not undermine the sonority distance idea; it merely suggests that other factors outweigh sonority distance in Basque. For example, if $_{\sigma}$[r: requires a trill in onset position whether syllable-initial or not, and this constraint outranks Son (unlike in Catalan), then the trill will appear instead of the tap in clusters.

Of more interest for what follows are rhotics in the coda. In Central Catalan these are weakly trilled. This will follow given a ranking *ɾ >> *r, such that [r] is in essence the default rhotic of Catalan. (The dominant position of *r: is taken to be universal, recall.) The opposite ranking holds in Western Catalan, and in many Spanish dialects. The fact that Central Catalan prefers the (weak) trill here plays an important role in the next section.[10]

(18)

	mar:$_1$ mar$_2$ maɾ$_3$	Space	*Merge	$_{\sigma}$[r:	*r:	*ɾ	Ident
a.	mar:$_1$ mar$_2$ maɾ$_3$	*!*			*	*	
b.	mar:$_{1,2}$ maɾ$_3$	*!	*		*	*	*
c.	mar:$_{1,2,3}$		**		*!		**
d. ☞	mar$_{1,2,3}$		**				**
e.	maɾ$_{1,2,3}$		**			*!	**

Before departing this section, consider once again the question of what constitutes legitimate inputs and outputs for this analysis. Following work cited earlier in Dispersion Theory, I have addressed this question by means of severe idealization. As we have seen, only three kinds of rhotic are entertained, [r:], [r], and [ɾ]. In addition, four contexts must be distinguished: intervocalic, syllable-initial, within an onset cluster, and word-final. The idealization therefore consists effectively of twelve words, as shown below. (For the phrasal facts, we will also have to consider word-initial versus -final status of a rhotic.) Though we considered [onr:ə] etc. above as well, these actually group together with [r:ɔtʃ] as syllable-initial.

(19) sɛr:ə r:ɔtʃ pr:im mar:
sɛrə rɔtʃ prim mar
sɛɾə ɾɔtʃ pɾim maɾ

The use of forms based on actual words carries no theoretical significance; rather, these stand in for phonologically possible forms, subject to the idealization. In fact, we could have relied on forms like [ər:a], [r:a], [pr:a], [ar:], and so on, instead, in order to eliminate irrelevant detail. It is also worth stressing that the results seen above do not depend in any way on the fact that we considered the contexts one at a time. Given the principle of richness of the base (Prince and Smolensky 1993), all of the forms in (19) are inputs, and they can be considered simultaneously. The tableau below illustrates by considering together just the intervocalic and word-initial contexts. Only a few representative candidate outputs are shown, but the point should be clear: the constraint hierarchy outputs just the desired forms. The violations marks incurred are just the sum of those for each context considered separately. The point of treating the contexts separately is only to avoid cluttered tableaux, making the analysis easier to follow.

(20)

	sɛr:ə$_1$ sɛrə$_2$ sɛɾə$_3$ r:ɔʧ$_4$ rɔʧ$_5$ ɾɔʧ$_6$	Space	*Merge	$_{\sigma}$[r:	*r:	*ɾ	Ident
a.	sɛr:ə$_1$ sɛrə$_2$ sɛɾə$_3$ r:ɔʧ$_4$ rɔʧ$_5$ ɾɔʧ$_6$	*!****		****	**	**	
b.	sɛr:ə$_{1,2}$ sɛɾə$_3$ r:ɔʧ$_{4,5}$ ɾɔʧ$_6$	*!	**	**	**	**	**
c. ☞	sɛr:ə$_{1,2}$ sɛɾə$_3$ r:ɔʧ$_{4,5,6}$		***	*	**	*	***
d.	sɛr:ə$_{1,2,3}$ r:ɔʧ$_{4,5,6}$		****!		**		****

3.3 Between words

The phrasal phonology of rhotics provides more support for the dispersion-theoretic account. Most of the phrasal phonology is already determined by the analysis already given, as we will see. What requires more discussion is an alternation between the weak trill and tap, as in [mar] 'sea' versus ['maɾ əs'ta] 'sea is', seen in section 2. Before a vowel-initial word, the trill is impossible. Our account for this will appeal to a distinction between lexical and postlexical phonology, as other accounts do. Before this account is presented, though, some background on syllabification, phrasal phonology, and Dispersion Theory is provided. It then turns out that the account for rhotics already motivated word-internally, with only minor modification, explains the weak trill-tap alternation.

3.3.1 Contrast, syllabification, and phrasal phonology

Imagine a language in which differently syllabified inputs /ka.pa/ and /kap.a/, each possible according to richness of the base, contrast at the surface.[11] Most phonologists assume that such a contrast, based purely on syllabification, is impossible. But given a ranking *Merge >> Onset, we seem to predict it, as shown below. It would be possible to avoid this problem by stipulating that *Merge considers only segmental (or featural) structure. (Compare generative phonology's traditional stipulation that syllable structure is not present underlyingly.) This is correct in effect (see below), but then why should this be so?

(21)

	kap.a$_1$ ka.pa$_2$	*Merge	Onset
a. ☞	kap.a$_1$ ka.pa$_2$		*
b.	kap.a$_{1,2}$	*!	*
c.	ka.pa$_{1,2}$	*!	

Within Optimality Theory, one approach to the problem of universally non-contrastive distinctions in phonology, due to Kirchner (1997), assumes that no faithfulness constraints exist that are relativized to the relevant features. McCarthy (to appear) claims in particular that faithfulness is not sensitive to input syllabification. Since *Merge is not relativized to phonological features in any case (I assume), this option does not help us solve the problem above. However, an alternative solution follows from the central principles of Dispersion Theory: 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. (See Ní Chiosáin and Padgett 2001, Padgett to appear-a,b.) Forms differing *solely* in syllabification, as [ka.pa] and [kap.a] do, are perceptually too similar to contrast. As we will see below, the qualification 'solely' here matters. Such contrasts are universally ruled out assuming that the Space constraint they violate is part of Gen. This means that pairs such as [ka.pa] versus [kap.a] can never be generated as part of candidate systems. Given this assumption, only candidates (21)b-c, repeated below as (22)a-b, are viable. Since [kap.a] is harmonically bounded by [ka.pa], it must always lose. Section 4.2 provides more discussion of Space constraints and universally non-contrastive distinctions.

(22)

	kap.a$_1$ ka.pa$_2$	*Merge	Onset
a.	kap.a$_{1,2}$	*	*
b. ☞	ka.pa$_{1,2}$	*	

As is well known, strings differing in morphological or syntactic structure *can* differ in syllabification. English phrases like *keep on* and *key pawn* differ in this way. Since Onset would require them to be the same (in this respect anyway), something must mitigate against resyllabification across word boundaries in English. A common approach to this sort of problem calls on alignment constraints (McCarthy and Prince 1993a), such as Align-R(Wd, σ), which requires that the right edge of a morphological word and a syllable coincide. This is shown below. (A word boundary is indicated by '|'.)

(23)

	kip ɔn	Align	Onset
a.	ki.p|ɔn	*!	
b. ☞	kip|.ɔn		*

Notice that English speakers can distinguish phrases like *keep on* from *key pawn*. If contrasts based purely on syllabification are impossible, how can this be? The answer, of course, is that phrases like this differ in other respects, most notably aspiration: [kʰip.ɔn] versus [kʰi.pʰɔn]. In English, voiceless stops are aspirated word- and stressed syllable-initially (see Ladefoged 1993, for example). Just as an aspirated-plain distinction suffices to support contrast within words in many languages, it suffices to distinguish these English phrases. These considerations suggest the possibility of an alternative, Dispersion Theoretic, explanation for word-syllable alignment effects like that seen in (23). Consider the next tableau, where the contrasting phrases are derived.

We return now to considering contrasting inputs and outputs simultaneously. In addition, subscripts now tag entire phrases. (Since inputs and candidate outputs in Dispersion Theory consist of sets of forms, this implies we consider sets of phrases for the evaluation of phrasal phonology. Sets of phrases can in principle be infinite, of course, but this does not distinguish them from sets of words. As discussed earlier, the domain of analysis is kept finite and manageable by means of severe idealization, focusing only on those aspects of phonology considered relevant.) For convenience, I encapsulate whatever constraints determine aspiration within one constraint 'Aspirate'. It is ultimately preferable to provide a full analysis of aspiration within Dispersion Theory (see Flemming 1995 for some discussion), though this would take us too far off course here. In candidate (24)a the phrases differ in syllabification, and Onset is violated, but *Merge is respected nonetheless, due to the aspirated-plain distinction. Candidates (24)b-c are alike in neutralizing the distinction between the phrases, in favor of aspirated or plain stops respectively, and so both violate *Merge. Candidate (24)d violates Aspirate, since [p] occupies the onset of a stressed syllable in the form [kʰi.pɔn]. This last candidate shows that it is more important to respect the phonology of aspiration than to respect Onset. In sum, if a language happens to have syllable-related processes that can perceptually distinguish onsets and codas, as English aspiration does, and if these processes, along with *Merge, outrank Onset, then the result is failure to resyllabify.

(24)

	kip ɔn$_1$ ki pɔn$_2$	*Merge	Asp	Onset
a. ☞	kʰip.ɔn$_1$ kʰi.pʰɔn$_2$			*
b.	kʰi.pʰɔn$_{1,2}$	*!		
c.	kʰip.ɔn$_{1,2}$	*!		*
d.	kʰi.pɔn$_1$ kʰi.pʰɔn$_2$		*!	

Both the Alignment approach and the contrast-based one are consistent with the account below, and this is not the place to reconsider Alignment in general. But the contrast-based analysis is pursued here out of interest: it raises the intriguing possibility that alignment of words and syllables is *not* dictated directly by alignment constraints, but rather follows indirectly as a kind of neutralization avoidance effect. The phrases *keep on* and *key pawn* syllabify differently because this, given the distribution of aspiration, preserves the contrast between them. This is reminiscent of an old idea that some aspects of phonology might have the function of demarcating word boundaries (Trubetzkoy 1969). This is worth exploring as an alternative to Alignment, because it roots alignment effects in the principle of neutralization avoidance, independently motivated here. In comparison, the Alignment analysis, though descriptively successful, leaves unanswered the question of *why* languages should strive to align syllable and word boundaries. It also makes no predictions about which languages will align and which will not. The contrast-based approach makes an interesting prediction: in the absence of processes capable of perceptually distinguishing onsets and codas, resyllabification across word boundaries *must* occur.[12] (If there is such a process, then resyllabification may or may not occur, depending on the ranking of Onset with respect to *Merge and the relevant markedness constraints.)

3.3.2 Catalan resyllabification and rhotics

In Catalan, word-final consonants *do* resyllabify as onsets of a following vowel-initial word. (See discussion in Harris 1993 and Palmada 1994, for example.) A phrase like *cap anyell* 'no lamb', for example, is pronounced ['ka.pə.'ɲeʎ]. The following word must indeed be vowel-initial: resyllabification will not occur otherwise, even if it would create an otherwise permissible onset. Therefore, *capració* 'no serving' is ['kap.r:ə.'sjo] and not *['ka.prə.'sjo].

Resyllabification causes neutralization of contrast: phrases like *cap atent* 'attentive head' and *ca patent* 'obvious house' are homophonous. Recall from the previous section that Gen does not provide candidates in which forms differ solely by syllabification. This means that Catalan phrasal phonology is like the hypothetical word-internal case of [ka.pa] versus [kap.a], as shown in (25). There is no choice but to merge, and a candidate respecting Onset harmonically bounds one that doesn't. In other words, Catalan is an example of a language in which resyllabification is inevitable, under the contrast-based account, since no phonology distinguishes the potentially contrasting forms.

(25)

	kap atent$_1$ ka patent$_2$	Onset	*Merge
a. ☞	ka.pə'ten$_{1,2}$		*
b.	kap.ə'ten$_{1,2}$	*!	*

Consider now the phrasal phonology of Catalan rhotics, in particular what happens when sequences including rhotics are created at word boundaries. First, suppose a rhotic is in a word-final coda, and either a pause or another consonant follows. (It doesn't matter whether the other consonant is in the same word or the following one.) Given the analysis of section 3.2, such forms are already accounted for: the rhotic remains in the coda and so is weakly trilled. Likewise, underlyingly word-initial rhotics will always be [r:], because resyllabification does not occur in sequences like *capració*, as shown in (26). Since Onset is already satisfied when a following word begins with [r:], resyllabification only causes a gratuitous *Merge violation.[13]

(26)

	kap r:asjo$_1$ ka pɾasjo$_2$	Onset	*Merge
a. ☞	kap.r:əsjo$_1$ ka.pɾəsjo$_2$		
b.	ka.pɾəsjo$_{1,2}$		*!

However, these forms reveal an important difference between the word-internal and phrasal rhotic facts. The contrast [VCr:V] versus [VCɾV] is impossible word-internally, due to Space, as we have seen. In order to allow it postlexically, something more must be said.

Given these facts, and more below, I assume a distinction between lexical and postlexical phonology within Optimality Theory. (See for example McCarthy and Prince 1993b, Itô and Mester 2001, and Kiparsky 1998.) Assuming this distinction, the input to the phrasal phonology is the output of the lexical phonology. Taking the latter to be what was derived in 3.2, a sequence like *capració* enters the postlexical phonology as /kap r:əsjo/, while *ca pració* is /ka pɾəsjo/. As the following tableau shows, if *Merge and Space switch ranking at the postlexical level, then this contrast will survive. This higher ranking for *Merge, I claim, is the only difference between the lexical and postlexical levels.

(27)

	kap r:asjo$_1$ ka pɾasjo$_2$	*Merge	Space	$_\sigma$[r:	*r:	*ɾ	Ident
a. ☞	kap.r:əsjo$_1$ ka.pɾəsjo$_2$		*		*	*	
b.	ka.pɾəsjo$_{1,2}$	*!				*	*

One can imagine other candidates that would satisfy Space, including one like [ka.r:əsjo$_1$, ka.ɾəsjo$_2$], in which input /p/ has deleted in order to create an intervocalic environment for the

rhotic contrast. But such a candidate also violates *Merge: though the idealizations here have focused on forms that differ only in rhotic type, the output in fact consists of all phonologically possible Catalan phrases. The phonology therefore includes mappings like /ka r:əsjo$_3$/ → [ka.r:əsjo$_3$]; for this reason, the mapping /kap r:əsjo$_1$/ → [ka.r:əsjo$_1$] *is* neutralizing. More generally, any attempt to save Space by altering the form of the words in (27) will violate *Merge if the output is identical to an independently licit phonological phrase. This suggests another strategy: altering the forms in a way that is *not* neutralizing in order to salvage Space. For instance, along with deletion of /p/ we might change a vowel to [ɨ], as in hypothetical candidate [kɨ.r:əsjo$_1$, ka.ɾəsjo$_2$]. Such a candidate can be ruled out, of course, by assuming that the relevant markedness constraints prohibiting such forms are undominated.

The most interesting case involving phrasal rhotics is precisely where resyllabification can and does apply, in examples like those seen in (5), e.g., *mar està* ['ma.ɾəs'ta] 'sea is'. Here only the tap is possible. This is surprising at first blush. We might instead expect either the weak trill, because this is what occurs in the same form [mar] otherwise, or a strong trill, because the rhotic is syllable initial.

Assuming the lexical versus postlexical distinction, a sequence like *mà restà* 'hand remained' enters the postlexical phonology as /'ma#r:əs'ta/, while *mar està* 'sea is' is /mar#əs'ta/. (Examples repeated from (5)b.) This is shown in tableau (28). I no longer consider candidates that disobey resyllabification: Onset is undominated in the analysis, and not shown. Candidate (28)a is perfectly faithful to the input in featural terms. But the analysis already given eliminates this candidate: [r] and [r:] are not perceptually distinct enough, even between vowels, as we have seen. In (28)b the rhotics are identical, obeying both Space (vacuously) and $_{\sigma}$[r:. But this neutralizes unnecessarily. The best candidate is (28)c, in which underlying /r/ has converted to [ɾ], therefore satisfying Space *and* *Merge.

(28)

mar əsta$_1$ ma r:əsta$_2$	*Merge	Space	$_{\sigma}$[r:	*r:	*ɾ	Ident
a. ma.rəsta$_1$ ma.r:əsta$_2$		*!	*	*		
b. ma.r:əsta$_{1,2}$	*!			*		*
c. ☞ ma.ɾəsta$_1$ ma.r:əsta$_2$			*	*	*	*

The restriction to tap in phrases like *mar està* follows immediately, with no additional machinery, from the dispersion- theoretic account given. In our terms the tap is required in order to preserve the contrast between underlyingly distinct forms, and to maintain it to the specifications of Space, just as within words. If this is correct, then it is not right, strictly speaking, to claim that rhotics contrast only within words in Catalan (or in Spanish, which behaves similarly). They also contrast in phrases, in just the environment we expect: intervocalically. What makes these facts different from /kap atent/ and /ka patent/, where neutralization occurs, is that here the phonology (qua constraint ranking) *does* provide a means of avoiding neutralization while respecting perceptual distinctiveness.

This represents an improvement over other existing accounts for these facts. The best known of these also relies on a distinction between lexical and postlexical phonology. Adapting Harris's (1983) treatment of Spanish, both Serra (1996a,b), and Bonet and Mascaró (1997) account for the facts by assuming the ordering of processes shown in (29). Word-initial trilling is taken to be a strictly lexical process, while the weak trilling characteristic of codas is assumed to be strictly postlexical. Rhotics in forms like those shown are underlyingly taps or unspecified for the tap-trill distinction. Given these assumptions, word-final rhotics enter as taps into the postlexical phonology, while word-initial rhotics are trilled, as shown. Resyllabification takes place postlexically, of course, so that the rhotic in *mar està* becomes word-initial only at this stage. Since word-initial trilling no longer applies, and postlexical coda trilling is no longer applicable, the rhotic remains a tap. (I make no distinction between strong and weak trill here, following the authors cited. I also ignore irrelevant processes like vowel reduction.)

(29)	/ma/ /ɾəsta/	/maɾ/ /əsta/	(Underlying representation)
Lexical	-- rəsta	-- --	Word-initial trilling
Postlexical	/ma rəsta/	/maɾ əsta/	(Input)
	--	ma.ɾəsta	Resyllabification
		--	Coda trilling
Output	[ma.rəsta]	[maɾəsta]	

The Dispersion Theory account does not require any ordering assumptions beyond the reranking of *Merge and Space postlexically already motivated. Indeed, there is no independent evidence for the proposed level distinction between word-initial and coda trilling: both are exceptionless processes confined to the word.[14] A more serious disadvantage for the alternative account is its assumption that coda rhotics are underlyingly not trills. An underlying trilled [r], for example, would proceed through the phonology unchanged, giving *[ma.rəsta]. But richness of the base (Prince and Smolensky 1993) requires that inputs like /mar/ in fact be considered, along with /maɾ/. In order to ensure that it does not survive to the postlexical phonology in phrases like *mar està*, the lexical phonology in the alternative account must actively *rule out* [mar]. But since [mar] *is* the required output before pause or a consonant, the postlexical phonology must ensure precisely the reverse in these contexts: that an input tap emerges as weakly trilled [r]. None of these complications is necessary under the account proposed here. A final argument for the proposed account is that it makes a direct connection between the word-internal and phrasal facts: the rhotic in [ma.rəsta] must be a tap for just the same reason the rhotic in [sɛɾə] must be: each is in contrast with a (strong) trill in the same environment. In the alternative account, the fact that the word-internal contrast must be between a tap and strong trill, and the fact that the rhotic in [ma.rəsta] must be a tap, have nothing in common.

An intriguing different approach to these facts is offered by Bradley (2001). Bradley capitalizes on an idea of Steriade (1999, 2000b), that (at least some) word-edge effects result

from a kind of paradigm uniformity. In particular, the citation (or isolation) form of a word can act as a base for the purposes of paradigm uniformity. Since words uttered in isolation are phrase-initial and -final, the prediction is that words embedded in phrases might behave as though initial or final, due to paradigm uniformity. Bradley argues that the tap pronunciation in phrases like *mar està* is just such a case. Recall that phrase-final rhotics cannot contrast, for reasons we have seen. Bradley argues by paradigm uniformity that word-final rhotics internal to the phrase therefore cannot contrast either. Given this assumption, it is up to markedness constraints to determine which rhotic will surface. Though a weak trill is required in other contexts, Bradley argues (independently) that taps are favored before a vowel. Due to this constraint, it is the tap that surfaces.

What is unusual about this line of reasoning is that what is preserved between base and related form is *crucially* not a certain feature or representational property, but *the lack of contrast per se*. It is not the trilled pronunciation of [mar] we wish to preserve in [ma.ɾəsta], but the rhotic's lack of contrastiveness. Another constraint then favors the tap. Unless further research motivates this appeal to a 'property' of (non)contrastiveness referred to by paradigm uniformity constraints, an account that avoids it, such as that offered here, seems preferable.

Before leaving this section I note that there is another reason for assuming the lexical versus postlexical distinction, apart from that seen above. Assuming only one level, richness of the base would dictate that we consider all six logically possible inputs shown in (30) for the intervocalic environment, rather than the two we have been considering. To simplify the tableau, I consider schematic inputs differing only in the crucial ways: as before, there are three input rhotic kinds; in addition, each rhotic appears either word-initially or word-finally in the input. The candidate outputs all respect resyllabification. The constraint rankings have reverted to those motivated word-internally. Candidate (30)a is untenable for familiar reasons. The difference between (30)b-c lies in the particular input-output mappings effected. Consider first (30)b. Here a tap-trill contrast is maintained, as in Catalan, but it is based on the underlying quality of the rhotic. (Here I assume that weak trills become strong ones; but the argumet is the same assuming they become taps, violating faithfulness equally.) This is in fact the most faithful mapping that respects Space. But Catalan works differently: whether a rhotic surfaces as a tap or trill depends not on its underlying quality but on its underlying *position*, word-initial versus final, as in (30)c. Such a candidate by its nature violates faithfulness more, and so cannot win. A postlexical derivation avoids this problem, because the inputs are narrowed down to /ar|a/ and /a|r:a/.

(30)

	ar:|a_1 ar|a_2 aɾ|a_3 a|r:a_4 a|ra_2 a|ɾa_3	Space	*Merge	₀[r:	*r:	*ɾ	Ident
a.	a.r:$a_{1,4}$ a.r$a_{2,5}$ a.ɾ$a_{3,6}$	*!*	***	**	*	*	
b. ☞	a.r:$a_{1,2,4,5}$ a.ɾ$a_{3,6}$		****	*	*	*	**
c. ☜	a.r:$a_{4,5,6}$ a.ɾ$a_{1,2,3}$		****	*	*	*	***!*

4. Theoretical implications

With the analysis of Catalan concluded, this section turns to larger theoretical implications. I take up three interrelated lines of discussion. Section 4.1 further compares the proposed account to a non-dispersion-theoretic alternative, arguing for the former. Section 4.2 considers the question of phonetic detail in the account, an important subtheme of this paper. Finally, in section 4.3 I discuss the well known claim, due originally to Harris (1983), that the intervocalic trill is underlyingly a geminate. As we will see, the appeal to Dispersion Theory and phonetic detail offers some advantages over this other approach, though a full comparison will require more than this paper.

4.1 Systemic contrast

Given its claims, arguments for Dispersion Theory come from facts that require a 'systemic' explanation, that is, facts that can be understood only by simultaneous appeal to forms in contrast. The underlying causes are in that sense *paradigmatic*. In contrast, phonology typically considers forms in isolation, and the causes sought are exclusively *syntagmatic*, that is, present in the relevant form itself.[15] Many processes can be explained syntagmatically, obviously: assimilations and dissimilations are (at least to a large extent) successfully handled in this way. But there are facts that cannot receive a plausible account by any appeal to local syntagmatic context. Besides well known inventory generalizations, such as the fact that languages prefer to contrast [i] and [u] rather than [y] and [ɯ], there are language-specific generalizations having this character, as argued especially in Padgett (to appear-a,b). Here I elaborate on this idea with respect to Catalan.

Consider an alternative approach to Catalan relying on positional faithfulness (Beckman 1997, 1998, Casali 1996, 1997). The central fact is the licensing of a rhotic contrast only between vowels. So rather than posit Space constraints, we might posit an Ident constraint relativized to just this position:

(31) Ident_{V_V}: Let S_O be an output segment in intervocalic position. Then S_O and its input correspondent S_I are identical.

Given this approach, we would not wish to consider all three rhotics as potential inputs, as we have so far. This is because undominated Ident_{V_V} would incorrectly predict a three-way contrast, as shown below. To save space I continue to evaluate the relevant candidates simultaneously. I also show only the crucial constraints.

(32)

	sɛr:ə$_1$ sɛrə$_2$ sɛɾə$_3$	Ident_{V_V}	$_\sigma$[r:
a. ☞	sɛr:ə$_1$ sɛrə$_2$ sɛɾə$_3$		**
b. ☞	sɛr:ə$_{1,2}$ sɛɾə$_3$	*!	*

But this is no problem in itself, since it is more conventional to assume that phonology makes available only the two segments [ɾ] and [r]. (For this section only, I now use conventional 'r' everywhere for 'r:'.) With this limitation built in to the theory, we predict a two-way contrast correctly:

(33)

	sɛrə$_1$ sɛɾə$_2$	Ident$_{V_V}$	$_\sigma$[r
a. ☞	sɛrə$_1$ sɛɾə$_2$		*
b.	sɛrə$_{1,2}$	*!	
c.	sɛɾə$_{1,2}$	*!	*

The account also correctly predicts no contrast in other contexts, since Ident$_{V_V}$ protects only intervocalic rhotics, as shown below. With the constraint ranking already given, the trill is correctly chosen in syllable-initial position.

(34)

	onra$_1$ onɾa$_2$	Ident$_{V_V}$	$_\sigma$[r
a.	onrə$_1$ onɾə$_2$		*!
b. ☞	onrə$_{1,2}$		
c.	onɾə$_{1,2}$		*!

Words like [pɾim] 'thin' can receive the same sonority-based explanation as in the Dispersion Theory account. The last purely word-internal context is coda position, as in [mar] 'sea'. We might derive [r] here by ranking *ɾ above *r, just as we did in the Dispersion Theory account:

(35)

	mar$_1$ maɾ$_2$	Ident$_{V_V}$	$_\sigma$[r	*ɾ	*r
a.	mar$_1$ maɾ$_2$			*!	*
b. ☞	mar$_{1,2}$				*
c.	maɾ$_{1,2}$			*!	

Since [r] is just the segment derived in other non-contrastive contexts, given no strong versus weak trill distinction, this suggests a simplification of the account: dispense with the constraint $_\sigma$[r, and let the ranking *ɾ >> *r account for the appearance of [r] everywhere outside of contrast. This would not work for most Spanish dialects or for Western Catalan, it should be noted, since

in those dialects it is the tap that appears word-finally. So the constraint $_{\sigma}$[r, or other principles deriving its effect, must be part of the universal constraint hierarchy in any case.

This account of Catalan is descriptively less adequate, since it fails to account for the systematic distinction between weak and strong trill. (See further discussion next section.) But putting this aside, problems arise when we factor in the phrasal facts once again. The issue, recall, is to ensure that only the tap appears before a vowel-initial word. Here Ident_{V_V} makes exactly the wrong prediction, as shown below. Once again I assume a postlexical derivation, with the input being the output of the lexical stratum. Since no distinction is made between coda and onset trills, and since Ident_{V_V} only requires faithfulness, we cannot acheive the desired dispersion effect.

(36)

mar əsta ma rəsta	Ident_{V_V}	*ɾ	*r
a. ☞ ma.rəsta ma.rəsta			**
b. ☜ ma.ɾəsta ma.rəsta	*!	*	*

Though the context is intervocalic, what the facts require is a *change* from /r/ to [ɾ], not faithfulness. This problem could be avoided by assuming that the output of the lexical stratum is [ɾ], an alternative we already discussed in section 3.3. But this solution raises the same objections noted there: it requires extra stipulations about the ordering of processes, and fails to make any principled connection between the lexical and postlexical facts, which are now only coincidentally similar. In the Dispersion Theory account, on the other hand, the tap is required in this context by markedness (in the form of Space), not faithfulness, for the very same reason it is required word-internally when between vowels: contrast must be perceptually favorable.

The phrasal facts also show that *Merge is crucial. Suppose we now grant that Space is operative, but replace *Merge with Ident (now without positional restrictions), keeping everything else the same. The result is shown in (37). Candidates (37)b-c now *tie* for faithfulness, leaving the decision to $_{\sigma}$[r:, which favors neutralization. (Even worse, given a suggestion I make about Ident in the next section, (37)c would be *favored over* (37)b.) The desired winner is in fact harmonically bounded by (37)c, and so can never win. The problem here is that Ident has no principled way of distinguishing /r/ → [r:] from /r/ → [ɾ]. But *Merge does: the first, and not the second, leads to neutralization of contrast, because a form with output [r:] *already exists*. Though another technical solution might be found for the problem with Ident, such as distinguishing Ident(r→r:) from Ident(r→ɾ) (assuming this works for the analysis generally), this is not preferable to the explanatory connection advocated here.

(37)

	mar əsta$_1$ ma r:əsta$_2$	Space	Ident	$_{\sigma}$[r:	*r:	*ɾ
a.	ma.rəsta$_1$ ma.r:əsta$_2$	*!		*	*	
b. ☜	ma.ɾəsta$_1$ ma.r:əsta$_2$		*	*!	*	*
c. ☞	ma.r:əsta$_{1,2}$		*		*	

4.2 Phonetic detail

A basic premise of distinctive feature theory is that a feature, or phonetic distinction, can be posited only when contrastive in at least one of the world's languages. Assuming that a three-way contrast like [ɾ] - [r] - [r:] is impossible (see below), we are therefore not permitted to entertain this distinction in the phonology at all. This is the reason phonology normally distinguishes only a single trill. But a good deal of recent work argues for another view.

First, it is *possible* to derive more phonetic detail in phonology, so long as output constraints circumscribe possible contrasts independently. We have seen that in Dispersion Theory constraints like Space do just that. Let us look at how this works in a bit more detail. For any phonetic dimension, Flemming (1995, to appear) posits a family of universally ranked Minimal Distance constraints (similar to Space), the number depending on the range of possible contrasts. Extending this idea to the rhotic facts, Bradley (2001) posits a family of similar constraints distinguishing three positions of likely contrast, in descending order: intervocalic, word-initial, and elsewhere. Bradley's typological survey of tap-trill contrasts shows that these positions define an implicational hierarchy of possible contrasts. In our terms (see Ní Chiosáin and Padgett 2001, Padgett to appear-a,b), this motivates the universally ranked family shown in (38)a, an expansion of (8). The subscripts to these constraints ultimately stand in for genuine perceptual distances, which can be determined only by experimentation and appeal to known perceptual data. Therefore Space$_{_\#}$ refers not to word-final position per se, but to a certain perceptual closeness which obtains when [ɾ] contrasts with [r] word-finally—or in other contexts, such as in clusters, since Bradley's typology does not motivated distinguishing between these. The result of such a family is that languages will enforce the greatest perceptual distance possible, subject to conflicting constraints. For example, with faithfulness (*Merge or Ident-R) lowest ranked, we predict intervocalic contrast only, as in Catalan or Spanish. With faithfulness ranked just above Space$_{V_V}$, we predict contrast word-initially also; and so on. (Contrast can be ruled out altogether if articulatory markedness constraints like *r: are undominated.) The universal ranking captures the cross-linguistic implications, as Bradley (2001) shows.

(38) a. [Space$_{_\#}$ >>] Space$_{\#_}$ >> Space$_{V_V}$ >> **Faith** *Contrast only intervocalically*
[Space$_{_\#}$ >>] Space$_{\#_}$ >> **Faith**>> Space$_{V_V}$ *...and word-initially*
[Space$_{_\#}$ >>] **Faith** >> Space$_{\#_}$>> Space$_{V_V}$ *...and word-finally/in clusters*

b. Spacing: VɾV.....VrV.....Vr:V >
#ɾV.....#rV.....#r:V >
pɾV.....prV.....pr:V >
tɾV...trV...tr:V

|----------| Distance in Gen

The diagram in (38)b sums up some assumptions following from Bradley's typology and the discussion in Inouye (1995). Besides what has been mentioned, it appears that a three-way contrast between [ɾ], [r], and [r:], is unattested in *any* context. Recall that [r] and [r:], as understood here, differ by less than two taps on average, [r] having 1-2 and [r:] 2-4 taps generally. Apparently this is not enough to sustain a contrast. This is not to say that trills cannot ever be distinguished by length alone. Finnish contrasts singleton and geminate [r]. But these differ by significantly more than 1-2 taps (Inouye 1995). Bradley also claims that tap and trill never contrast when adjacent to homorganic consonants. (Recall from section 3.2, though, that sources for only one language clearly support making this claim.) Taking up briefly a point made in section 3.2, Bradley assumes that this prohibition has an articulatory basis. As the diagram above suggests, I speculate instead that the basis is perceptual. The clusters [tr] and [tɾ] are plausibly perceptually close, because [tɾ] involves a sequence of coronal stop-vocalic release-coronal stop, just as a trill does. (The 'vocalic release' refers to the common short vocalic element intervening between a stop and a following tap, see discussion in Bradley 2001, for example.) In other words, [tɾ] already sounds trilled. Similar reasoning applies to [rt] versus [ɾt].[16]

The 'Distance in Gen' in (38)b indicates the minimum Space threshold possible in languages, enforced by Space$_{_\#}$. I assume that this most demanding Space constraint should be placed in Gen in Optimality Theory, rather than in the constraint hierarchy, meaning that candidates violating it would never be generated. This is Dispersion Theory's answer to the stipulation of distinctive feature theory that there is only one feature relevant to this contrast dimension. (It is a separate issue that phonologists have agreed very little on what that feature might be.) If Space$_{_\#}$ is in Gen, then candidates like [sɛr:ə, sɛrə, sɛɾə], which we have been entertaining all along, are in fact impossible, and only [sɛr:ə, sɛɾə] possible. Similarly, [tr:] versus [tɾ], could never occur. Returning to the main point, this is why it is *possible* to allow segments like [r:] and [r] into the phonology.

But it is also *necessary* to allow more phonetic detail into phonology than what is countenanced by distinctive feature theory. As many have argued (see the works cited in the introduction), this is necessary in order to capture phonological generalizations. I have not made this argument for Catalan. All preceding accounts of Catalan have referred only to [ɾ] and [r:] (the latter normally transcribed [r]), and even the Dispersion Theory account here could be maintained without the extra detail. As in other accounts, we could rely (probably implicitly) on a separate phonetic component to derive the weak trill [r]. That is, the phonology might output both [r:ɔʧ] 'red' and [mar:] (or [maɾ]) 'sea', leaving it to the phonetics to produce [mar]. But once we remove the barrier to non-contrastive detail by constraining possible contrasts, and given the ample independent evidence that such detail matters to phonology, this becomes a dubious approach to any case, including Catalan. We cannot know *a priori* which (universally non-contrastive) detail

will be crucial to phonological generalizations and which will not. Given this, it makes sense to incorporate the extra detail into the account from the start.

Yet this raises the question, how much detail should be derived? A conservative position (in this context!) is to open up to the phonology everything, contrastive or not, that appears *categorical*. This approach, which I assume here and in Padgett (2002), calls on the well known distinction between 'gradient' processes, which are treated as phonetic, and 'categorical' ones, treated as phonological. (Liberman and Pierrehumbert 1984, Keating 1988, Cohn 1990, Zsiga 1993, among many others.) Though there is variation in the realization of [r:], [r], and [ɾ] (just as there is variation in the realization of any segment), the distinctions between them are entirely systematic, as I have noted, and in this sense qualify as categorical. (Variation *within* these types, of course, can be gradient.) In this view, though the number of phonetic (or featural) categories is increased, it arguably remains finite and discrete. Others researchers, including Kirchner (1997, 2001), Boersma (1998), and Flemming (2001), take a less conservative position: gradient and categorical phenomena can, and should, be captured together. Either approach is consistent with the analysis offered here.

4.3 Geminates and [r:]

The best known alternative account for the distribution of Catalan rhotics is ultimately due to Harris (1969, 1983, 2002), who argues that there is only one underlying rhotic in Spanish—let us call it R, since Harris treats it as unspecified for the tap-trill distinction. A similar claim is extended to Catalan by Mascaró (1976) and Wheeler (1979). Under this view, the trill is underlyingly a geminate RR, so that Catalan [sɛ.r:ə] 'saw' is /sɛRRa/. Harris provides an impressive series of arguments in favor of this view. How does the Dispersion Theory account compare?

Some of the main arguments for the trill as RR are distributional. Though a rhotic can be followed word-internally by nearly any consonant, a sequence of two rhotics is unattested. Further, though Catalan has surface geminate sonorants (somewhat marginally, e.g., [pə'ɾɛnnə] 'perennial'), surface [ɾɾ] and [r:r:] are missing. These gaps disappear assuming that [r:] is RR underlyingly. Most obviously, we explain why [ɾ] and [r:] contrast only between vowels: this is just where other sonorant singletons and geminates (or in Spanish clusters of two sonorants) contrast. Since all agree that the surface trill in intervocalic position is a single segment occupying exclusively the onset position, this analysis requires a means of transforming the representation accordingly. Harris argues independently that a sequence of two rhotics in Spanish must surface as [r:], and Mascaró (1976) make a similar claim for Catalan. The reason for this is that phrases like Spanish *salir rápido* 'to leave rapidly' and *salí rápido* 'I left rapidly' are homophonous.

The fact that only a tap follows an onset consonant, as in Catalan [pɾim] 'thin', follows from the independently motivated syllable canons of the language: a word [pr:im] would be underlyingly /pRRim/, an unsyllabifiable sequence. Inputs like /maRR/ are likewise impossible, so that *mar* 'sea' is predicted to surface with a tap, as it can indeed in Spanish and some Catalan dialects. This analysis requires an extra rule to ensure a trill realization in Central Catalan. As we have seen it also requires two rules to ensure trilling word-initially, as in [r:ɔtʃ] 'red', and syllable-

initially after a consonant, as in [onr:ə] 'honor', positions where syllabification permits only singleton R.

In certain respects this account and the Dispersion Theory account are entirely consistent. Given Optimality Theory's tenet of richness of the base, we must in any case consider inputs to the grammar like /sɛɾɾa/, /sɛRRa/, and so on. Surface [sɛɾɾa] must therefore be ruled out, and the homophony of *salir rápido* and *salí rápido* (which obtains in Catalan equally) indeed motivate a mapping to [sɛr:a]. Dispersion Theory in fact makes possible a more principled explanation for the latter fact than in past accounts. Our account posits that [r] can never contrast with [ɾ] or [r:], because it is not distinct enough from either of them, differing by only 1-2 taps. More to the point here, Bradley (2001) suggests that a trill [r:] should be virtually indistinguishable from a sequence [ɾr:] (this assumes no pause intervenes, of course), because these likewise differ by only one tap. (My approach here differs from Bradley's, though, in not appealing to targeted constraints (Wilson 2001).) If $\text{Space}_{\_\#}$ belongs in Gen, as suggested above, then the input contrast shown in (39) cannot surface. Of the three viable candidates, all merged, the markedness constraints already motivated prefer (39)a. (Space is now explicitly given as Space_{V_V}, given the discussion last section.

(39)

salir r:apido$_1$ sali r:apido$_2$	*Merge	Space_{V_V}	$_{\sigma}$[r:	*r:	*ɾ
a. ☞ salir:apido$_{1,2}$	*			*	
b. saliɾapido$_{1,2}$	*		*!		*
c. saliɾr:apido$_{1,2}$	*			*	*!

Following Bradley (2001), we can now extend the same idea to hypothetical inputs like /sɛɾɾa/. The sequence [ɾɾ] is no trill from the articulatory perspective, but it does resemble trills in having successive short interruptions in air flow. Having two of these, it is most similar to [r]. Like [r] therefore, it is too similar to both [ɾ] and [r:] to contrast with either of these segments. This is shown in (40). (Here only the lexical derivation is shown; the postlexical mapping changes nothing.) Once again the fully faithful candidate is ruled out universally by $\text{Space}_{\_\#}$. Assuming we wish for /ɾɾ/ to surface as [r:] rather than [ɾ], however, something more needs to be said. As can be seen, (40)a-b are identical with respect to markedness. To choose (40)a, I take up again the discussion from section 3.1 of the properties of taps and trills. Though [r] and [ɾɾ] differ from [ɾ] and [r:] equally (I assume) according to duration, the trills and [ɾɾ] have in common the fact of trilling itself, or of trilling-like noise. If we factor Ident(R) into separate Ident(Duration) and Ident(Trill) constraints, then (40)a wins, as shown. This account implies that /r/ likewise should surface as [r:] rather than [ɾ], something I have been assuming all along. These changes do not affect the account of rhotics in other contexts.

(40)

	sɛr:ə$_1$ sɛɾɾə$_2$ sɛɾə$_3$	Space$_{V_V}$	*Merge	Ident(Dur)	Ident(Tr)
a. ☞	sɛr:ə$_{1,2}$ sɛɾə$_3$		*	*	
b.	sɛr:ə$_1$ sɛɾə$_{2,3}$		*	*	*!

In its favor, the Dispersion Theory account succeeds in unifying the word-initial and (post-consonantal) syllable-initial rhotic facts, as noted in section 3.1, something previous accounts have not managed to do. It also unifies the word-internal and phrasal facts in a novel way, as seen in section 3.2. The homophony of *salir rápido* and *salí rápido* also follows directly from the account, rather than requiring a separate rule as in Harris (1983, 2002). Finally the account arguably improves on Harris's insight that the distribution of [r:] mimics one of geminates. I argued in section 3.1 for a functional explanation of this similarity, involving the perceptual needs of a duration contrast.

Other differences between the accounts involve theoretical commitments. The Dispersion Theory account requires no ordering of processes except for a lexical-postlexical distinction. It is consistent with richness of the base: not only /sɛɾɾa/ may underlie [sɛr:a], but so may /sɛr:a/ (among other forms). In Optimality Theory, contrast is viewed as a result of the grammar rather than a stipulation on inputs (Prince and Smolensky 1993). The [r:] as geminate account crucially relies on rule ordering even *within* the lexical and postlexical levels, and as formulated is *not* consistent with richness of the base.

However, there are also three claims about rhotics (so far as I can tell) which the [r:]-as-geminate account explains, and which are not captured by the Dispersion Theory account so far.[17] Here I will briefly note them and suggest what I can. First, there are many related forms in Catalan like [kɔr] 'choir' - [kuɾal] 'choral', and [əmor] 'love' - [əmuɾos] 'amorous', in which the weak trill alternates with a tap. But there are no pairs like hypothetical [kɔr] - [kur:al], in which the weak trill alternates with a *strong trill*. Likewise for Spanish, there are pairs like [amoɾ] - [amoɾoso], having just taps, but no pairs like [amoɾ] - [amor:oso], where the tap alternates with a trill. Why should this be? According to Harris (1983, 2002), this is a matter of cyclicity. First, inputs like /amoRR/ cannot be syllabified, so only /amoR/ → [amoɾ] is possible for coda rhotics. Second, forms like [amoroso] are derived from stems like [amoɾ]. There is therefore no way for an alternation like [amoɾ] - [amor:oso] to arise. In Optimality Theory, facts such as these are typically accounted for by means of either output-output faithfulness (Benua 1997 and many others), or (in the case of inflectional paradigms) by paradigm uniformity requirements (especially Burzio 1996, Kenstowicz 1996, Steriade 2000a, McCarthy 2001). Addressing this challenge for the case at hand would entail integrating a theory of morphological relatedness into Dispersion Theory. This is an important goal, but one too large for the present paper.

The other problematic claims involve static generalizations. First, both Spanish and Catalan are said to prohibit trills following the diphthongs [ai] and [au] within words. There is no *[air:e] next to [aiɾe] 'air' in Spanish, for example. Harris derives this fact straightforwardly: *[air:ə] would be /aiRRe/ underlyingly, and [aiR] is not a possible syllable rhyme. The Dispersion Theory account as given so far offers no explanation for this fact. We might treat glides as different from vowels, and rule out *[ajr:e] versus [ajɾe] because the contrast is not intervocalic.

But taps and trills in contrast may be *followed* by glides, making this approach suspect. Even if the contrast *[ajr:e] versus [ajɾe] were ruled out, the predicted occurring form is *[ajr:e], since the rhotic is syllable-initial. These problems arise, of course, only if forms like [air:e] are indeed ungrammatical. Harris states that native speakers rejects them, but my own inquiries are not nearly so conclusive. In response to a written questionnaire I provided, six Spanish speakers rated the nonce forms *cairre* and *aurro* as 4 on average, on a scale of 1-5, where 5 meant "seems like a completely natural Spanish word". In fact, *no* words scored 5 on average, even seemingly pedestrian nonce forms like *brico*, *locha*, and *chiza* (all 3 or 4 on average). More investigation into the facts is clearly called for.

The same might be said about the last claim: there are no forms like **cámarra*, with antepenultimate stress, next to those like *cámara* 'chamber'. According to Harris (1983, 2002), this is because the former would be underelyingly [kamaRRa], with a heavy penult. Forms having heavy penults and antepenultimate stress are claimed to be ruled out generally, for metrical reasons, providing an explanation for this gap. If trills are single segments, on the other hand, we cannot appeal to the metrical generalization: [kámaɾa] and [kámar:a] are metrically the same. Bonet and Mascaró (1997) object to this line of argument, claiming that the segments [ʎ,ɲ,x] behave like [r:] in this regard: forms like [kámaxa] and [kámaɲa] are dispreferred. These segments are derived historically from clusters, but (the authors imply) shouldn't be treated as clusters today, meaning that an alternative account for *[kámar:a] must be possible as well. Harris argues that native speakers find *[kámar:a] worse than analogous forms involving [ʎ,ɲ,x]. Once again my own results are less clear: the nonce forms *cáma[r:]o*, *mára[x]o*, and *díre[ɲ]o* scored on average 2.7, 2.8, and 2.7 respectively.

Clearly there is more work to be done. But I hope to have shown that a Dispersion Theory approach to the Catalan and Spanish rhotic facts offers significant advantages over previous ones, and that it is therefore worth investigating further.

5. Conclusion

Significant progress can be made in explaining the behavior of rhotics in Catalan (and Spanish), given an explicit appeal to systemic contrast. Contrast matters in two ways: languages avoid neutralization (*Merge), and they enhance the perceptual distinctiveness of contrasts (Space). Though these principles have a certain history in phonology and phonetics, there is still little work seeking to apply them explicitly to the detailed patternings of specific languages (as opposed to cross-linguistic inventory generalizations, for example). The Catalan case study is interesting also because most appeals to dispersion involve vowel patterning, since the role of dispersion in this area is better understood. There is no reason why the same principles shouldn't matter to consonants as well, however, and it is to be hoped that more research will turn in that direction.

Following other work, I have also shown how better descriptive coverage of systematic distinctions in a language can be achieved, even when the distinctions involved are universally non-contrastive. Though an adequate explanation of most of the Catalan facts does not depend on this, such phonetic detail is crucial to capturing generalizations in many other languages. Given the latter fact, it is not safe to continue the tradition of ignoring non-contrastive but systematic distinctions.

Notes

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1. For glosses I rely also on Oliva and Buxton (1985). Many thanks to Blanca Palmada for providing some of the data, and for advice about transcriptions.

2. I abstract away from some sub-phonemic detail in transcriptions, including the realization of /b,d,g/ as approximants in some contexts.

3. See Serra (1996a,b) for an analysis of this fact in terms of alignment (McCarthy and Prince 1993a).

4. Thanks to Paul Boersma for helpful discussion of this point. An Ident violation can also be non-neutralizing, it is worth noting, given a suspension of richness of the base (Prince and Smolensky 1993). A mapping /W_i/ → [W_j] is not neutralizing if input /W_j/ does not exist (and nothing else surfaces as [W_j]). Richness of the base implies that input /W_j/ must indeed exist. Assuming lexical and postlexical strata (see below), however, by hypothesis the input to the postlexical stratum is *not* rich.

5. I assume here that a phrase-final stop, which is released in Swiss German, has in that sense a 'more sonorous' right-hand environment than one followed by an obstruent. On the importance of the release and its perceptual cues, see Kraehenmann.

6. As Bradley (p.c.) points out, [r:] is realized as a fricative in some Spanish dialects (normally considered substandard), and frication is another means of achieving perceptual salience in onset position.

7. In fact, I suggest in section 4 that a contrast between [ɾ] - [r], or [r] - [r:], is ruled out universally.

8. Bakovic (1994), who also capitalizes on the syllable-initial generalization, does not have this problem. But his account does not handle forms like *israel* or extend to the phrasal phonology, as Bradley (2001) points out.

9. The claim that trills are less sonorous than taps (and [l,j,w]) does not require that we agree with the other specific sonority-related proposals of especially Bonet and Mascaró (1997), which are not required for the account here.

10. If trills are less sonorous than taps, then for them to be preferred in codas, where more sonorous sounds are typically preferred (Clements 1990), it must be the case that *ɾ outranks not only *r but the relevant sonority-related constraints for codas.

11. Thanks to Travis Bradley for bringing issues of contrast and syllabification to my attention.

12. This predicts distinct behaviors within languages, not only across them. For example, what about English phrases like *see Mill* versus *seem ill*, for which no processes, I assume, cue the onset versus coda status of [m] (at least when stress is held constant)? The contrast-based approach to alignment predicts that resyllabification *should* occur in such cases. This is an empirical question, to use a time-honored phrase, and intutions about syllabification are notoriously unreliable—especially in the absence of phonological cues! For what it is worth, I cannot reliably distinguish the syllabification of such phrases.

13. The phrase /ka pɾasjo/ is hypothetical, but this is irrelevant: it is the set of possible words and phrases, not actual ones, that the theory must account for, as I have stressed.

14. The fact that coda rhotics can vary in degree of trilling in Catalan and Spanish, depending on style, speaker, and so on, is sometimes taken as evidence for the postlexical status of coda trilling. But in Central Catalan, as I have stressed, the weak trill [r] is the prototypical coda realization, and can therefore quite reasonably be taken to be the output of the lexical phonology. The fact that other postlexical, or perhaps phonetic, processes may alter this trill does not show otherwise.

15. The notable exception involves accounts of paradigm uniformity and output-output correspondence. Here, the forms compared are not unrelated contrasting forms, however, but morphologically related ones, and the relevant constraints are not ones requiring contrast, but just the opposite, constraints enforcing similarity.

16. In Ngizim [r] and [ɾ] *do* contrast before coronal fricatives [s] and [z]. This follows from this perceptual account.

17. For an account of [s]-epenthesis in Domincan Spanish within Dispersion Theory, another phenomenon raised by Harris, see Bradley (2002).

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