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Travis G. Bradley
The Pennsylvania State University

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0. Introduction

Rhotics are known for the considerable phonetic variety they exhibit across languages and dialects. Most of the world's languages exhibit a single type of rhotic sound, but some languages have more than one, usually contrastive in type rather than place (Ladefoged & Maddieson 1996:237). A number of languages have a phonological durational distinction between an extra-short apical tap and a sustainable multiple-cycle trill. These languages differ with respect to the environments in which rhotic duration contrast is maintained, and further differences are found in the phonetic outcomes of neutralization. In short, this paper is concerned with the expression of rhotic duration contrast and the phonetic nature of neutralization in contexts where the contrast is disallowed.

Section 1 of this paper explores patterns of tap/trill contrast and neutralization from Spanish, Basque, Kaliai-Kove, Palauan, Kairiru, Ngizim and Kurdish. Section 2 develops a phonetically-based Optimality-theoretic account of why these languages allow the tap/trill contrast where they do and of what happens in positions of neutralization. Section 3 accounts for the observed patterns in terms of interaction between faithfulness constraints that enforce contrast preservation and articulatory markedness constraints that trigger fortition to trill and lenition to tap. Section 4 discusses the special case of word-initial fortition in Kurdish. Finally, Section 5 summarizes the analysis.

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1. Cross-linguistic patterns of tap/trill contrast and neutralization

The post-SPE generative literature has devoted much attention to rhotics in Iberian Romance, which exhibits intervocalic tap/trill contrast and either predictable realization or stylistically-controlled variation in neutralizing environments. Contemporary analyses typically appeal to syllable structure and sonority principles to explain this pattern. For instance, Harris (1983) and Lipski (1990) both propose rules that operate on underlying taps as a function of syllabic position. The constraint-based approach of Morales-Front (1994) employs syllable-based markedness constraints on the surface distribution of tap and trill. Other accounts posit sonority differences between the two rhotics as a means of explaining their distribution within the syllable (Bakovic 1994, Bonet & Mascaró 1997).

Most recently, Bonet & Mascaró (1997) acknowledge that by limiting their empirical focus to the basic distribution of rhotics in Iberian Romance, they necessarily leave aside relevant facts from other languages "which have a somewhat different pattern, but which should be taken into consideration within a more comprehensive account of the phonology of rhotics" (103). In this section, I explore the basic word-level distribution of tap and trill in seven languages, focusing on where contrast is preserved and how it is neutralized in other positions.

1.1 Languages with intervocalic contrast

Several languages that possess contrastive tap and trill neutralize the contrast in all positions except intervocalic. Languages exhibiting this pattern include Basque (Hualde 1988, 1991, Saltarelli 1988), Catalan (Hualde 1992, Mascaró 1978, Wheeler 1979), Guajiro (Mansen 1967), (Brazilian) Portuguese (Azevedo 1981), and Spanish (Harris 1983, Morales-Front 1994). For reasons of space, this section draws upon data from Spanish and Basque only.[1]

Intervocalic contrast in Spanish is illustrated in (1) below. Rhotics are neutralized to trill word-initially (2a) and after homorganic (alveolar) consonants (2b).

(1) Tap/trill contrast between vowels in Spanish

pero	pero
'but'	'dog'

(2) Neutralization to trill word-initially and after homorganic consonants

a.	rosa	*rosa	'rose'
b.	onra	*onra	'honor
	alreðeðor	*alreðeðor	'around'
	izrael	*izrael	'Israel'

In all other positions, the phonetic realization of rhotics varies as a function of stylistic control. Variable lenition/fortition is observed after heterorganic (non-alveolar) consonants (3a), before any consonant (3b) and word-finally (3c).

[1] See Bradley (in preparation) for an exhaustive treatment of languages not discussed in this paper.

(3) Neutralization with stylistically-controlled variation elsewhere

a.	presjo	~	presjo	'price'[2]
	t̪res	~	t̪res	'three'
	krus	~	krus	'cross'
b.	arma	~	arma	'weapon'
	karne	~	karne	'meat'
	perla	~	perla	'pearl'
c.	amor	~	amor	'love'

Note that whereas trill is obligatory after other alveolar consonants, as seen in (2b), either tap or trill may surface before other alveolar consonants, as in [karne] and [perla] (3b).

Like Spanish, Basque also preserves contrast in intervocalic position, as shown in (4). However, Basque differs from Spanish in that rhotics in any other position are neutralized to trill. Although rhotics are absent from word-initial position in the native lexicon, recent loanwords from Spanish, seen in (5a), demonstrate that only trill may surface at the left word edge. Trill is also obligatory next to consonants in many dialects, shown in (5b) and (5c). All word-final rhotics are realized as trill, as shown in (5d).

(4) Tap/trill contrast between vowels in Basque

ere	ere
'also'	'to burn'

(5) Neutralization to trill in non-intervocalic positions

a.	radar	*radar	'radar'
	rasionalisasio	*rasionalisasio	'rationalization'
b.	a̪n̪d̪re	*a̪n̪d̪re	'woman'
	prantses	*prantses	'French'
c.	ar̪to	*ar̪to	'corn'
	tʃiʎarðeɣi	*tʃiʎarðeɣi	(a name)
d.	embor	*embor	'trunk'[3]

Adconsonantal fortition is different in Basque and Spanish. While Spanish exhibits obligatory fortition to trill only after alveolar consonants (2b), Basque trill surfaces adjacent to non-alveolar consonants, as seen in the clusters [d̪r, pr, r̪, rð] of (5b,c). Neither Hualde (1991) nor Saltarelli (1988) gives homorganic clusters containing a rhotic.

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[2] Morales-Front (1994:167) observes that the Spanish trill can surface in complex onsets in highly emphatic speech (e.g., *¡inc*[r]*eíbles p*[r]*ecios!* 'incredible prices!').

[3] Hualde (1991:13) notes that tap and trill do contrast in *stem-final* position, where vowel-initial suffixes place the rhotic in the contrastive intervocalic position:

		uninflected	absolutive singular
(1)	/ur/ 'hazelnut'	ur	ura
(2)	/ur/ 'water'	ur	ura

1.2 Languages with word-initial contrast

Another group of languages that possess contrastive tap and trill go one step beyond Spanish and Basque by allowing the contrast to be preserved in word-initial as well as intervocalic position. Data in this section are from two Austronesian languages, Kaliai-Kove (Counts 1969) and Palauan (Hagège 1986, Josephs 1990).[4] Kaliai-Kove maintains tap/trill contrast between vowels (6a) and word-initially (6b).

(6) Tap/trill contrast in Kaliai-Kove

a.	tʰuβura	tʰuβuru
	'our ancestors'	'location'
b.	ɾiki	roko
	'to shut'	'to guard'

Rhotics neutralize to trill elsewhere (7a-c), striking a parallel with the contexts of obligatory fortition in Basque (5b-d). There are no consonant clusters containing rhotics except for those involving the velar obstruents [k] and [ɣ], as seen in (7a,b). Rhotics do not cluster with homorganic consonants.

(7) Neutralization to trill elsewhere

a.	mokrup	*mokrup	'frog'
	ɣrem	*ɣrem	'somewhat; slightly'
b.	ᵐbarku	*ᵐbarku	'spirit mask'
	iɣarɣe	*iɣarɣe	'he copulates (durative)'
c.	tʰaβur	*tʰaβur	'shell trumpet'

Like Kaliai-Kove, Palauan maintains contrast between vowels and word-initially, shown in (8a,b). However, only tap surfaces in adconsonantal and word-final positions shown in (9a-c).

(8) Tap/trill contrast in Palauan

a.	bəras	kərəgar
	'rice'	'tree'
b.	ɾaktʰ	rom
	'sickness'	'liquor'

(9) Neutralization to tap elsewhere

a.	oŋraŋr	*oŋraŋr	'rafters'
b.	ʔarm	*ʔarm	'animal'
c.	kar	*kar	'medicine'

[4] Some Malayalam speakers also maintain a tap/trill contrast between vowels and word-initially (Kumari 1972).

While adconsonantal and word-final positions in Basque and Kaliai-Kove show neutralization to trill, they exhibit obligatory lenition in Palauan. Hagège (1986) notes that Palauan tends to avoid homorganic consonant clusters.[5]

1.3 Languages with contrast in heterorganic clusters and word-finally

The three languages discussed in this section move beyond all languages seen thus far by preserving tap/trill contrast in consonant clusters and word-finally: Kairiru (Wivell 1981), Kurdish (Abdulla & McCarus 1967) and Ngizim (Schuh 1978, 1981). The examples in (10) show intervocalic contrast, while those in (11) show contrast in heterorganic clusters and word-finally.

(10) Tap/trill contrast in between vowels

a.	Kairiru	marak	qɔrɛl
		'twine'	'plenty'
b.	Ngizim	saara	saaru
		'peer'	'loan'
c.	Kurdish	kərə	kərə
		'it is a donkey'	'he is deaf'

(11) Contrast in elsewhere environments

		C_V	V_C	V_#
a.	Kairiru	aqrei	forpru	ʃir
		'it is raining'	'spotted snake eel'	'swamp'
		qrap^{h}am	ɲarp^{h}uəp	jir
		'your'	'butterfly'	'hair'
b.	Ngizim	gamraariyak	karmu	zəgər
		'worn hoe blade'[6]	'cut down'	'time'
		—	kərmai	zəgar
			'chieftainship'	'north'
c.	Kurdish	brin	wirg	bar
		'wound'	'stomach, belly'	'load'
		brin	wirk	bar
		'to cut'	'temper tantrum'	'fledgling; bar'

There are differences among the three languages with respect to positions of obligatory fortition to trill. For Kurdish, Abdulla & McCarus (1967) do not explicitly mention homorganic clusters containing a rhotic. However, Ngizim and Kairiru both exhibit neutrali-

[5] Tap can appear before alveolar consonants in morphological derivatives exhibiting deletion of the root vowel, e.g. *rasm* 'needle' versus *rsm-em* [ɽsmem] 'your needle' (Hagège 1986:23). See Bradley (in preparation) on the behavior of rhotics in morphological derivation.

[6] This is the only word in Schuh (1981) with a rhotic in postconsonantal position. The lack of consonant + rhotic clusters in Ngizim may be due to fact that (i) CCV syllables are disallowed and that (ii) combinatorial possibilities in heterosyllabic sonorant + sonorant sequences are limited especially when nasals are involved (see Schuh 1978:280-283).

zation to trill in homorganic clusters. The clusters in (11a) above show that rhotic contrast is allowed heterorganic clusters in Kairiru. Wivell (1981) lists only three homorganic clusters, and each contains trill:

(12) Neutralization to trill after homorganic consonants in Kairiru

alsru	'he chops them down'
sru	'pair, brace'
wuntru	'I close the door'

The pattern of fortition in (12) mirrors the pattern of Spanish postconsonantal fortition seen in (2b). In both cases, tap is disallowed after another alveolar consonant.

In Ngizim, only trill surfaces before homorganic noncontinuants, shown in (13), while contrast is maintained before heterorganic consonants, as was seen in (11b).

(13) Fortition before homorganic noncontinuants in Ngizim

sərtu	*sərtu	'string beads'
bərdu	*bərɗu	'cut off in pieces'
gərnu	*gərnu	'scold'
gərɗu	*gərɗu	'cut notch in'

Kurdish differs from Kairiru and Ngizim in that it allows only trill in word-initial position, as in (14a). Kairiru and Ngizim preserve contrast there, as in (14b,c).

(14) Word-initial fortition in Kurdish

a.	Kurdish	*ɾəfiq	ɾəfiq 'friend'
b.	Kairiru	ɾamat 'person, male'	rakɛɲ 'councilor'
c.	Ngizim	ɾakau 'chase away'	rakka 'anklet for women'

1.4 Summary of tap/trill patterns

I now summarize the patterns of rhotic duration contrast and neutralization observed in Section 1. Positions of tap/trill contrast are shown in (15) below.

(15) Positions of tap/trill contrast preservation

	V_V	#_V	Heterorganic Clusters, V_#	Homorganic Clusters
Basque	yes	no	no	*n/a*
Spanish	yes	no	no	no
Kaliai-Kove	yes	yes	no	*n/a*
Palauan	yes	yes	no	*n/a*
Kairiru	yes	yes	yes	no
Ngizim	yes	yes	yes	no
Kurdish	yes	no	yes	*n/a*

The above typology suggests a continuum of positional tap/trill contrast maintenance along which languages may fall. There are implicational relationships among contrastive positions, as illustrated in (16):

(16) Position 1 (Intervocalic) > Position 2 (Word-initial) > Position 3 (Heterorganic clusters, Word-final)

Contrast in Position x implies contrast in Position y iff $y < x$.

If rhotic duration contrast is maintained in a given position, then contrast is also maintained in positions to the left. An obvious exception is Kurdish, in which tap and trill contrast in Positions 1 and 3 but not in Position 2, where fortition to trill is obligatory. In Section 4, I demonstrate how utterance-initial fortition makes the Kurdish system *harmonically incomplete* in the sense of Prince & Smolensky (1993:185).

Rhotic patterns in non-intervocalic positions are summarized in (17).

(17) Rhotics in non-intervocalic positions

	#_V	Heterorganic Clusters, V_#	Homorganic Clusters
Kairiru	contrast	contrast	fortition: alv_
Ngizim	contrast	contrast	fortition: _alv
Kaliai-Kove	contrast	fortition	*n/a*
Palauan	contrast	lenition	*n/a*
Kurdish	fortition	contrast	*n/a*
Basque	fortition	fortition	*n/a*
Spanish	fortition	lenition/fortition	fortition: alv_ lenition/fortition: _alv

As evidenced by Kurdish, Basque and Spanish, utterance-initial fortition is capable of neutralizing tap/trill contrast. In heterorganic clusters and word-final position, contrast may be (i) preserved (Kairiru, Ngizim and Kurdish), (ii) neutralized to trill (Kaliai-Kove and Basque), (iii) neutralized to tap (Palauan) or (iv) neutralized with variation between both (Spanish). While rhotics fail to cluster with homorganic consonants in some languages, trill is obligatory (i) after homorganic consonants in Kairiru and Spanish, and (ii) before homorganic noncontinuants in Ngizim. In Spanish, tap and trill vary before heterorganic and homorganic consonants.

2. A phonetically-based Optimality-theoretic account of tap/trill patterns

In the remainder of this paper, I develop an account of the patterns of tap/trill contrast and neutralization revealed in the previous section. My account assumes the Licensing-by-Cue framework of Steriade (1995, 1997), whose central assumption is that speakers possess knowledge of the physical conditions under which contrasts are implemented. Specifically, contrast is neutralized in positions where the relevant auditory cues are diminished, while contrast is licensed in positions where cues are perceptually salient.

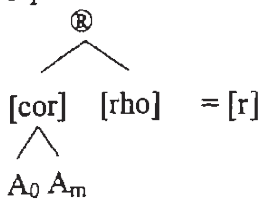
This view differs from Licensing-by-Prosody approaches, whereby sites of licensing and neutralization correspond to different positions within the syllable (see the syllable-based accounts of Iberian Romance rhotics discussed in Section 1). While prosodic licensing would have it that phonetic implementation is irrelevant to the determination of phonological contrasts, the cue-based approach ascribes a key role to the phonetics. Implementational constraints interact in the typical Optimality-theoretic (Prince & Smolensky 1993) fashion with the rest of the grammar to determine positions of contrast maintenance and neutralization.

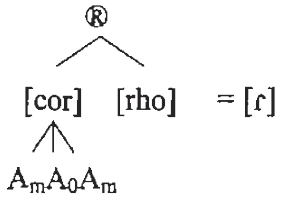
2.1 Phonological representation and perceptibility scale

Before proposing a cue-based account of the rhotic distributions presented in Section 1, we must first examine the articulatory and perceptual characteristics of tap and trill. Whereas the alveolar tap is characterized by an extra-short closure duration of approximately 20 ms for Castilian Spanish, the alveolar trill has a longer, sustainable duration of 85 ms with 3 occlusions on average (Quilis 1993:337-42). As Inouye (1995:55-6) argues, both the approach and release phases are crucial for successful articulation of the ballistic tap. On the other hand, the trill requires a tensed, controlled, and precise gesture in order to initiate passive vibration of the articulator by virtue of the Bernoulli effect. The trill is not simply a sequence of taps; the two rhotics involve completely different production mechanisms (Catford 1977:130).

The analysis presented here casts the phonological representation of tap and trill in terms of Aperture Theory, which encodes stricture via three degrees of aperture: oral closure A_0, release A_{max} (A_m) and an intermediate aperture A_f generating fricative turbulence (Steriade 1992, 1993). On the assumption that stricture is dominated by Place in the feature geometry, I adopt the Aperture-theoretic representation of trill proposed by Bakovic (1994), shown in (18a). Following Inouye (1995), I represent tap as a tripartite contour segment consisting of approach-closure-release, formalized in (18b).

(18) Aperture-theoretic representations of trill versus tap

a. 

b. 

[extra-short closure]

The crucial aspect of the representations in (18) is the manner in which aperture nodes encode a difference in duration. Whereas the dual flanking A_m branches of the tap in (18b) ensure the ballistic articulation and rapid transitions required for its extra-short closure duration, the trill is longer because it has only one A_m branch in (18a). These representations may be viewed as the Aperture-theoretic correlates of a privative feature contrast between two rhotics: tap is specified for [esc], but trill is not.

With respect to perception, Walsh (1997:96) notes that cross-linguistically, taps tend to prefer intervocalic position and avoid word edges in order to maintain voicing and enhance perceptibility. These positional preferences are referred to as *inter-sonority* and *anti-peripherality*, respectively. The tap is "a quick coronal interruption of surrounding segments" (Walsh 1997:141). Therefore, the tap's brief closure duration is cued by the rapid transitions between its alveolar contact period and the adjacent vowels. On the other hand, the trill can be said to possess internal durational cues, since its duration may be sustained. This contrasts with the alveolar tap, which requires some degree of surrounding sonority to ensure perceptibility of its extra-short closure duration.

Steriade (1997) proposes to implement the notion of cue-based licensing by characterizing the contexts where contrasts are more or less likely to be identified. For a given contrast, a perceptibility scale may be postulated, which is essentially a series of statements about the relative perceptibility of the contrast depending on the segmental context in which it is potentially manifested. Following the observations of Walsh (1997) regarding inter-sonority and anti-peripherality, I propose the perceptibility scale for rhotic duration contrast shown in (19).

(19) V_V ≻ #_V, C_V, V_#, V_C

According to this scale, contrastive duration of rhotics is more perceptible in intervocalic position than in positions where rhotics surface adjacent to a word edge or a consonant. Other evidence suggests that cross-linguistically, word-initial position is a perceptually prominent position in that more phonological contrasts tend to be licensed there. See Hawkins & Cutler (1988) and the studies cited therein for psycholinguistic evidence supporting the perceptual salience of word onsets. In the following section, constraints are proposed in order to account for the prominence of intervocalic and word-initial positions with respect to rhotic [esc] contrast.

2.2 Contrast preservation and articulatory markedness

The special nature of intervocalic and word-initial contexts can be captured by relativizing Optimality-theoretic faithfulness constraints to these positions and ranking them

higher than context-free faithfulness. Specifically, the PRESERVE (esc) constraints in (20) seek to maintain tap/trill contrast between vowels (20a) and word-initially (20b) over all other positions (20c), as formalized by the universal ranking in (20d).[7]

(20) Constraints on the preservation of tap/trill contrast
a. PRESERVE (esc/V_V)
Maintain rhotic [extra-short closure] contrast between vowels
b. PRESERVE (esc/#_V)
Maintain rhotic [extra-short closure] contrast after pause
c. PRESERVE (esc)
Maintain rhotic [extra-short closure] contrast elsewhere
d. Tap/trill contrast preservation hierarchy
PRESERVE (esc/V_V) » PRESERVE (esc/#_V) » PRESERVE (esc)

The ranking in (20d) directly captures the implicational relationships among contrastive positions shown in (16). This ranking derives from the availability of cues to rhotic [esc] contrast in each context. Intervocalic is the best of all contexts because flanking vowels ensure both the approach and release transitions of the [esc] rhotic. Similarly, the perceptual prominence of word onsets places word-initial above the elsewhere contexts.

Ranked against the perceptually-based contrast preservation constraints in (20d) are two kinds of articulatory markedness constraints relevant to apical constrictions, FAST and HOLD (Steriade 1995). The FAST constraints in (21) through (23) below penalize the rapid articulatory transitions of tap in different positions.[8] Context-free FAST in (21) encodes a general preference for the A_0A_m trill over the ballistic $A_mA_0A_m$ tap.

(21) FAST
Avoid faster-than-usual articulatory transitions

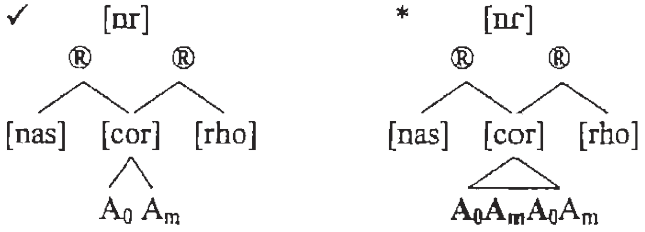
✓ r	* r
[cor]	[cor]
A_0 A_m	$A_mA_0A_m$

Tap is additionally penalized by the positional FAST constraints in (22) and (23). Since Place dominates stricture, Place-sharing entails stricture-sharing. FAST/SAME SITE in (22) bans the rapid A_m approach phase when it intervenes between two aperture positions of greater stricture under the same Place node. The offending $A_0A_mA_0$ sequence is shown in boldface.

[7] I assume that the PRESERVE constraints in (20) evaluate properties of sets of output forms, rather than properties of individual forms. That is, phonological contrast is evaluated directly between two output forms, not between input and output. The MAINTAIN CONTRAST and MINDIST constraints of Flemming (1995) and CONTRAST of Ní Chiosáin & Padgett (1997) also function in this way.

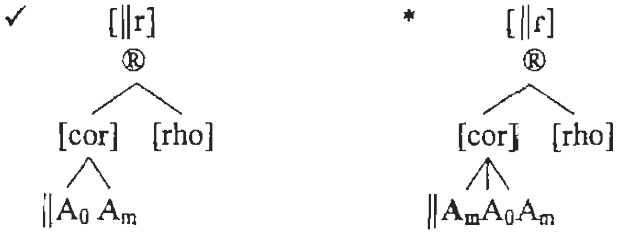
[8] The context-free FAST constraint in (21) is taken from Steriade (1995), but the context-specific FAST/SAME SITE in (22) and FAST/INITIAL in (23) originate with the present account.

(22) FAST/SAME SITE
Avoid faster-than-usual articulatory transitions in clusters involving the same articulator at the same constriction site



FAST/INITIAL in (23) mandates that segments begin with A_0 oral closure in the strong utterance-initial position and thus prefers trill over tap. Such a constraint is motivated by the fact that in Spanish, utterance-initial voiced stops fail to undergo spirantization, and word-initial vowels are preceded by glottal stops in the same context (see Bakovic 1994). Also see Keating *et al.* (1999) on cross-linguistic domain-initial articulatory strengthening. Finally, Paninian constraint ordering dictates that the context-specific FAST/SAME SITE and FAST/INITIAL constraints outrank the context-free FAST, as shown in (24),

(23) FAST/INITIAL
Avoid faster-than-usual articulatory transitions in utterance-initial position



(24) Paninian constraint ordering
FAST/SAME SITE, FAST/INITIAL » FAST

The second kind of articulatory markedness constraint is HOLD, shown in (25), which penalizes the longer constriction period of trill, thus favoring the [esc] tap.

(25) HOLD
Avoid a longer constriction

In Steriade (1995), HOLD and FAST are two instantiations of LAZY, the constraint on articulatory effort that favors lenition of articulatory gestures. It may seem counterintuitive to say that in tap/trill alternations FAST results in fortition, or neutralization to surface trill. However, FAST and HOLD differ in the way they evaluate the aperture structure of rhotics. While HOLD controls the duration of the A_0 closure phase of trill and tap in (18), FAST makes reference to the A_m approach phase. By favoring the absence of A_m under Place/stricture-sharing and in utterance-initial position over all other contexts, as captured by the ranking in (24), the FAST constraints prefer the A_0A_m structure of trill in (18a), more so in homorganic clusters and word-initial position than elsewhere. In other words,

HOLD and FAST both reduce effort but target different articulatory gestures, A_0 and A_m, respectively. Loss of the A_m approach necessarily causes an increase in the duration of the A_0 closure (see discussion of (18a) above).

3. Factorial typology and constraint evaluations

When HOLD and context-free FAST are ranked in various ways with context-free PRESERVE (esc), different rhotic patterns are generated for the elsewhere environments (i.e., heterorganic clusters and word-final position). As shown in (26), these patterns are typologically attested, as was revealed in Section 1.

(26) Constraint rankings affecting heterorganic clusters and word-final position

	Ranking	Effect	Languages
a.	PRES(esc) » FAST, HOLD	contrast	Kairiru, Ngizim, Kurdish
b.	FAST » HOLD, PRES(esc)	fortition	Kaliai-Kove, Basque
c.	HOLD » FAST, PRES(esc)	lenition	Palauan
d.	HOLD, FAST » PRES(esc)	lenition/fortition	Spanish

Similarly, when the positional contrast and fortition constraints on word-initial rhotics are re-ranked, as in (27), typologically attested behavior emerges. Compare the rankings in (26) and (27) with the summary in (17).

(27) Constraint rankings affecting word-initial position

	Ranking	Effect	Languages
a.	PRES(esc/#_V) » FAST/INITIAL	contrast	Kairiru, Ngizim, Kaliai-Kove, Palauan
b.	FAST/INITIAL » PRES(esc/#_V)	fortition	Kurdish, Basque, Spanish

The remainder of this section demonstrates how the above rankings account for the contextual behavior of tap/trill.

3.1 Intervocalic contrast

In Spanish, rhotic duration contrast is preserved between vowels because PRESERVE (esc/V_V) outranks HOLD and context-free FAST. In the winning candidate (28a), the ≠ symbol denotes contrast between the two surface forms (see Fn. 7). The neutralizing candidates (28b,c) fail to preserve contrast between vowels and are suboptimal.

(28) Intervocalic contrast in Spanish (see (1))

	PRES(esc/V_V)	HOLD	FAST	PRES(esc)
☛ a. VɾV ≠ VrV		*	*	*
b. VɾV	*!		*	*
c. VrV	*!	*		*

In non-intervocalic position, the decision falls to the lower-ranked markedness constraints HOLD and FAST, which together disfavor contrast. In Spanish, the constraints are unranked, as in (26d), and therefore fail to discriminate between neutralizing candidates. Variation between tap and trill is shown in clusters, (29b,c) and (29e,f), and word-finally (29h,i).

(29) Variable lenition/fortition elsewhere in Spanish (see (3a-c))

	PRES(esc/V_V)	HOLD	FAST	PRES(esc)
a. CɾV ≠ CrV		*	*!	
☞ b. CɾV			*	*
☞ c. CrV		*		*
d. VɾC ≠ VrC		*	*!	
☞ e. VɾC			*	*
☞ f. VrC		*		*
g. Vɾ# ≠ Vr#		*	*!	
☞ h. Vɾ#			*	*
☞ i. Vr#		*		*

After alveolar consonants, however, FAST/SAME SITE penalizes the $A_0A_mA_0$ sequence that arises in consonant + tap clusters under Place/stricture-sharing (see (22)). In the tableau in (30), brackets denote Place/stricture-sharing configurations. Neutralization to trill is optimal in (30c) because this candidate lacks the marked A_m approach.

(30) Fortition after homorganic consonants in Spanish (see (2b))

	FAST/SAME	HOLD	FAST	PRES(esc)
a. [Cɾ]V ≠ [Cr]V	*!	*	*	
b. [Cɾ]V	*!		*	*
☞ c. [Cr]V		*		*

With respect to word-initial position, Spanish has the ranking in (27b) which ensures fortition. Candidates (31a,b) both contain an the offending A_m in utterance-initial position. FAST/INITIAL prefers (31c) with trill in this position.

(31) Utterance-initial fortition in Spanish (see (2a))

	FAST/INITIAL	PRES(esc/#_V)	HOLD	FAST	PRES(esc)
a. ‖ɾV ≠ ‖rV	*!		*	*	
b. ‖ɾV	*!	*		*	*
☞ c. ‖rV		*	*		*

As in Spanish, PRESERVE (esc/V_V) outranks context-free markedness in Basque, preserving intervocalic tap/trill contrast. Basque also shares the ranking in (27b), with high-ranked FAST/INITIAL. Unlike Spanish, however, Basque has the ranking in (26b), in which context-free FAST outranks HOLD and PRESERVE (esc). Together, these two rankings ensure neutralization to trill in non-intervocalic positions, as shown in (32c,f,i,l).

(32) Fortition in non-intervocalic positions in Basque (see (5))

	FAST/INITIAL	PRES(esc/#_V)	FAST	HOLD	PRES(esc)
a. ‖ɾV ≠ ‖rV	*!		*!	*	
b. ‖ɾV	*!	*	*!		*
☛ c. ‖rV		*		*	*
d. CɾV ≠ CrV			*!	*	
e. CɾV			*!		*
☛ f. CrV				*	*
g. VɾC ≠ VrC			*!	*	
h. VɾC			*!		*
☛ i. VrC				*	*
j. Vɾ# ≠ Vr#			*!	*	
k. Vɾ#			*!		*
☛ l. Vr#				*	*

I assume that paradigm uniformity constraints generalize the utterance-initial realization of rhotics to all word-initial positions at the phrasal level (cf. Steriade 1995). Therefore, trill is obligatory in all word-initial positions regardless of the preceding phrasal context. See Bradley (in preparation) for a more detailed account of the phrasal behavior of word-initial and word-final rhotics.

3.2 Word-initial contrast

Kaliai-Kove and Palauan share the ranking in (27a). As shown in the tableau in (33), high-ranking PRESERVE (esc/#_V) ensures that the contrastive candidate (33a) wins over the neutralization candidates (33b,c).

(33) Word-initial contrast in Kaliai-Kove and Palauan (see (6b) and (8b))

	PRES(esc/#_V)	FAST/INITIAL
☛ a. ‖ɾV ≠ ‖rV		*
b. ‖ɾV	*!	*
c. ‖rV	*!	

The two languages differ in their ranking of context-free markedness constraints. Kaliai-Kove ranks FAST » HOLD, as in (26b), while Palauan has the opposite ranking in (26c). The result is neutralization to trill in Kaliai-Kove, similar to Basque (32f,i,l), but neutralization to tap in Palauan. The tableau in (34) demonstrates Palauan lenition.

(34) Lenition in elsewhere environments in Palauan (see (9a-c))

	PRES(esc/#_V)	FAST/INITIAL	HOLD	FAST ⋮ PRES(esc)
a. CɾV ≠ CrV			*!	*
☞ b. CɾV				* *
c. CrV			*!	*
d. VɾC ≠ VrC			*!	*
☞ e. VɾC				* *
f. VrC			*!	*
g. Vɾ# ≠ Vr#			*!	*
☞ h. Vɾ#				* *
i. Vr#			*!	*

3.3 Contrast in heterorganic clusters and word-finally

Kairiru and Ngizim allow tap/trill contrast in all positions except in homorganic clusters. In these languages, all markedness constraints except FAST/SAME SITE are ranked low against the contrast preservation hierarchy of (20d). Contrast is preserved between vowels and word-initially, similar to (28) and (33), respectively. Contrast is also preserved in heterorganic clusters and word-finally, as seen in tableau (35).

(35) Contrast in heterorganic clusters and word-finally in Kairiru and Ngizim (see (11a,b))

	PRES(esc)	HOLD ⋮ FAST
☞ a. CɾV ≠ CrV		* *
b. CɾV	*!	*
c. CrV	*!	*
☞ d. VɾC ≠ VrC		* *
e. VrC	*!	*
f. VrC	*!	*
☞ g. Vɾ# ≠ Vr#		* *
h. Vɾ#	*!	*
i. Vr#	*!	*

Under Place/stricture-sharing configurations, however, trill is obligatory. As in the case of Spanish homorganic clusters shown in (30), FAST/SAME SITE enforces neutralization to trill in homorganic clusters in Kairiru and Ngizim, shown in (36c) and (37c) below. These two languages differ from Spanish in that they preserve contrast in heterorganic clusters, shown in (36d) and (37d). Spanish, on the other hand, neutralizes contrast, as was shown in (29b,c) and (29e,f), respectively.[9]

(36) Fortition after homorganic consonants in Kairiru (see (12))

	FAST/SAME	PRES(esc)	HOLD	FAST
a. [Cɾ]V ≠ [Cr]V	*!		*	*
b. [Cr]V	*!	*		*
☞ c. [Cr]V		*	*	
☞ d. CɾV ≠ CrV			*	*
e. CɾV		*!		*
f. CrV		*!	*	

(37) Fortition before homorganic clusters in Ngizim (see (13))

	FAST/SAME	PRES(esc)	HOLD	FAST
a. V[ɾC] ≠ [rC]	*!		*	*
b. V[rC]	*!	*		*
☞ c. V[rC]		*	*	
☞ d. VɾC ≠ VrC			*	*
e. VɾC		*!		*
f. VrC		*!	*	

4. Harmonic incompleteness of the Kurdish system

According to Prince and Smolensky (1993:185), "harmonic completeness means that when a language admits forms that are marked along some dimension, it will also admit all the forms that are less marked along that dimension." Under the proposed system, contexts of rhotic [esc] contrast are the relevant dimension, as determined by the universally-fixed hierarchy of PRESERVE constraints in (20d). The hierarchy is harmonically complete because rhotic duration contrast in more marked positions (heterorganic clusters and word-finally) entails contrast in less marked positions (word-initially between vowels).

[9] Still unexplained is the fact that fortition is obligatory before homorganic noncontinuants in Ngizim ([gərnu] vs. *[gərnu] 'string beads' in (13)), but optional in the same context in Spanish ([karne ~ karne] 'meat' in (3b)). See Bradley (in preparation) for an account of this difference.

However, the fact that the preservation hierarchy itself is harmonically complete does not mean that harmonically incomplete languages are impossible. In fact, Kurdish allows contrast in heterorganic clusters and word-finally but neutralizes it to trill in the less marked word-initial position. This state of affairs emerges as an expected result, however, as soon as we acknowledge the interaction between FAST/INITIAL and the contrast preservation hierarchy in (20d). Kurdish shares with Kairiru and Ngizim the ranking of PRESERVE (esc) » HOLD, FAST in (26a). Like Spanish and Basque, however, Kurdish ranks FAST/INITIAL » PRESERVE (esc/#_V) in (27b). The combined result of these rankings is shown in the tableau in (38) below.

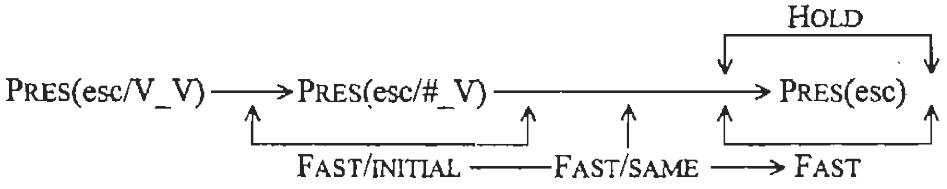
(38) Fortition word-initially but contrast elsewhere in Kurdish (see (14a) and (11c))

	FAST/INITIAL	PRES(esc/#_V)	PRES(esc)	FAST	HOLD
a. #ɾV ≠ #rV	*!			*	*
b. #ɾV	*!	*		*	
☛ c. #rV		*			*
☛ d. CɾV ≠ CrV				*	*
e. CɾV			*!	*	
f. CrV			*!		*
☛ g. VɾC ≠ VrC				*	*
h. VɾC			*!	*	
i. VrC			*!		*
☛ j. Vɾ# ≠ Vr#				*	*
k. Vɾ#			*!	*	
l. Vr#			*!		*

5. Summary

To conclude, this paper has examined patterns of rhotic duration contrast and neutralization in seven languages. These patterns are argued to emerge from the resolution of three conflicting forces, formalized as violable and interacting constraints in (39):

(39)



The PRESERVE hierarchy strives to maintain tap/trill contrast, more so in contexts of increased perceptibility. Interactions among this hierarchy and the articulatory markedness constraints FAST and HOLD were shown to generate the word-level distributions of tap versus trill in the languages surveyed. It was also shown that while the PRESERVE hierarchy is harmonically complete, interaction between FAST/INITIAL and PRES(esc/#_V)

can produce a language such as Kurdish, which is harmonically incomplete with respect to positions of rhotic [esc] contrast maintenance.

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Department of Spanish, Italian and Portuguese
The Pennsylvania State University
352 N. Burrowes Building
University Park, PA 16802

tgb114@psu.edu